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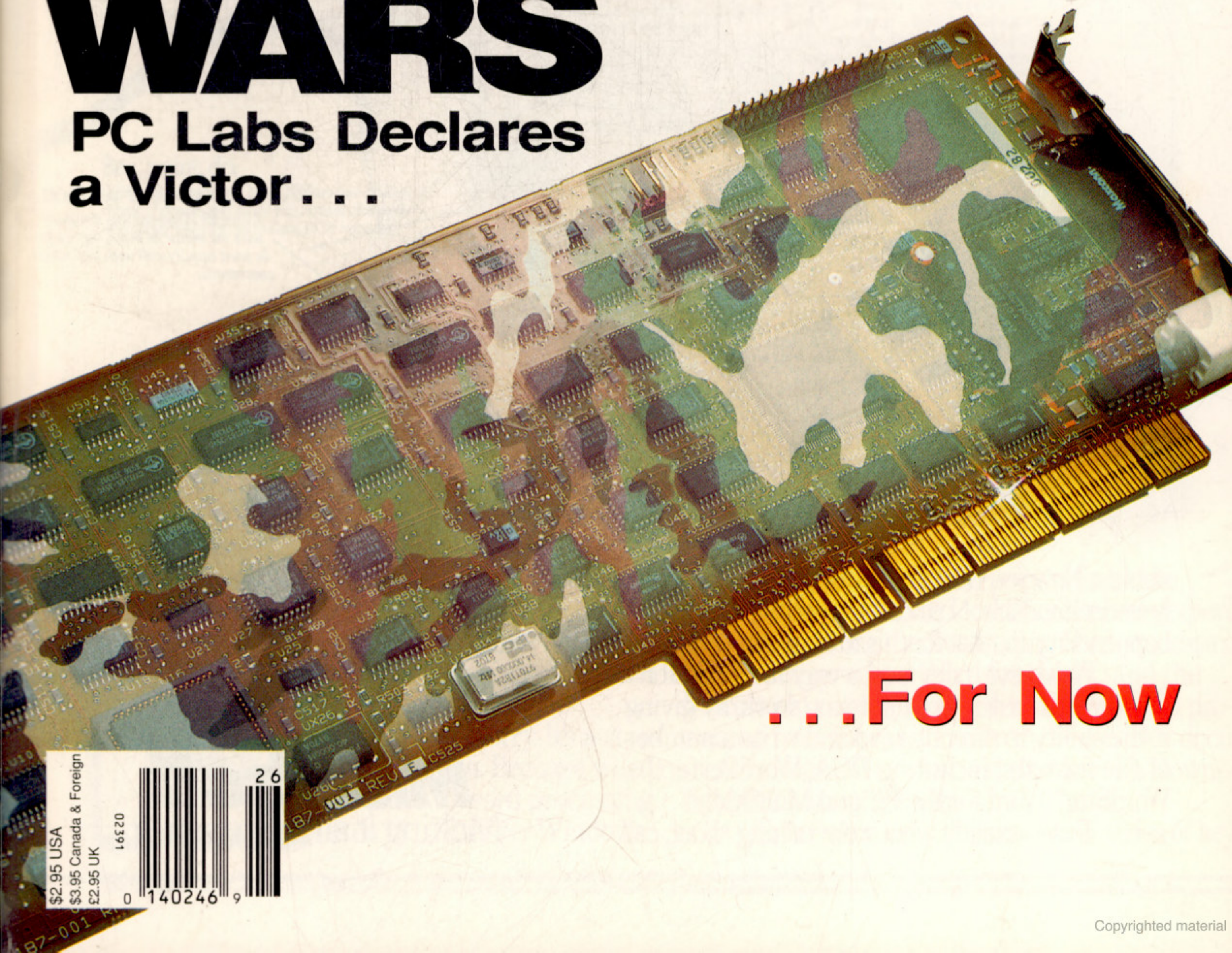
JUNE 26, 1990 THE INDEPENDENT GUIDE TO IBM-STANDARD PERSONAL COMPUTING VOLUME 9 NUMBER 12

EISA vs. ISA vs. Micro Channel

BUS WARS

PC Labs Declares a Victor . . .



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THE BUS WARS:

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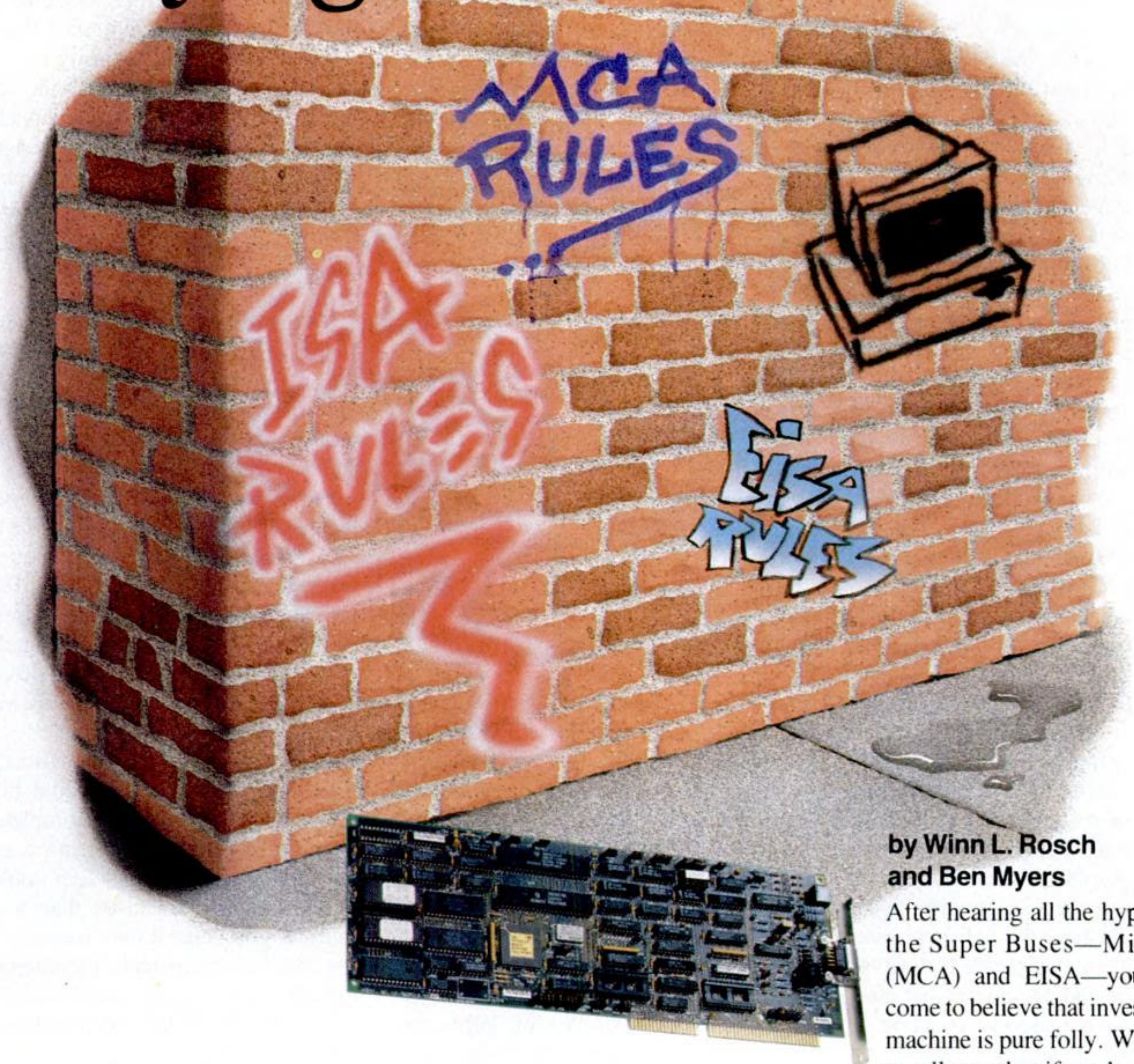


ILLUSTRATION: KEITH LO BUE PHOTOGRAPHY: RICK BECKER

PC Labs tests three battling bus designs and finds an unexpected winner in ISA. You may pay more for EISA and MCA, they won't give you better performance in a single-user DOS environment.

by Winn L. Rosch and Ben Myers

After hearing all the hype surrounding the Super Buses—Micro Channel (MCA) and EISA—you've probably come to believe that investing in an ISA machine is pure folly. Well, we're here to tell you that if you're a single user, upgrading today from your friendly ISA machine to a 32-bit bus architecture is simply a waste of valuable resources. No, we're not kidding.

And we're not just saying that the extra performance isn't worth the extra money. Through rigorous testing at two *PC Magazine* locations—PC Labs in New York and PC LAN Labs in Florida—we found that in a single-user DOS environment, and in network setups with up to a dozen workstations, no significant performance premium exists. When you consider the relatively small number of add-in boards for EISA and MCA, these architectures seem even less appealing. For now, and for some time to come, ISA is still your best bet.

As for medium-to-large local area networks, EISA and MCA do have the capability to add speed and functionality. But MCA's limited industry support and EISA's market immaturity are yet more deterrents to investing in them.

You may find these conclusions heretical or even illogical. Read on to see why we feel so strongly.

THE THREE CONTESTANTS

The contenders for your choice of expansion bus are, of course, the classic AT bus lately known as Industry Standard Architecture (ISA), Enhanced Industry Standard Architecture (EISA), and Micro Channel architecture (MCA).

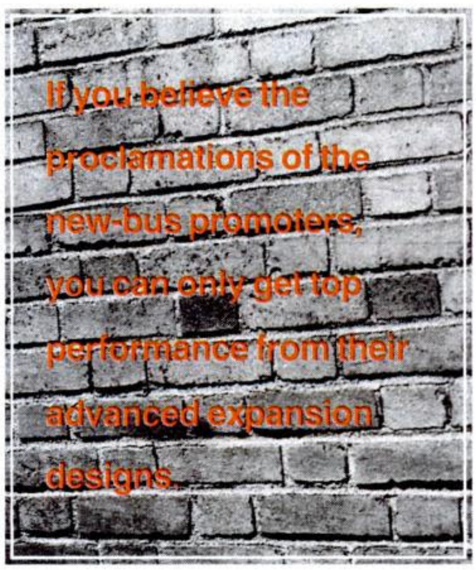
The first two trace their heritage back to the expansion bus of the original PC, the cobbled-together computer creation that was expected to sell barely 100,000 copies to die-hard electronics hobbyists and IBM employees. Its unexpected success ushered in the personal computer revolution—and the need to flood the market with machines actually designed to be business computers. That effort first brought forth the AT with its improved, 16-bit expansion bus and ability to address 16 megabytes of memory (compared with the 8-bit bus and 1MB limit of the original PC). The expansion bus these machines used is now universally acknowledged as the industry standard (except, of course, by those with their own fish to fry and apples to bake).

Shortly after the AT was introduced and microprocessors moved into higher-megahertz territory, the major shortcoming of the AT bus became apparent. It was too slow to keep up with the memory needs of 80286 microprocessors running faster than 8 MHz. Pushing the AT bus faster wouldn't work; companies like Dell Computer Corp. tried and discovered that most expansion boards failed at 10 MHz or higher.

Compaq Computer Corp. showed the world a better way with its Flex Architecture, which separated microprocessor memory from the general expansion bus. Through a direct route to the microprocessor, memory could operate at speeds as fast as available chips would allow. All current high-performance PCs now use a variation on this theme, packing megabytes of direct access memory on the system board and often adding proprietary slots for memory expansion.

This technique worked and still does. Even IBM now infuses its system boards with 8 or more megabytes of fast RAM. But today's 80386 and 80486 microprocessors hint at performance problems to come. The 16-bit data path and 24-bit addressing of the AT bus cannot take advantage of the full potential of these newer chips, which prefer a 32-bit data path and 32-bit addressing.

IBM's answer to the problems of the AT bus was the Micro Channel architecture, which brought a busload of disadvantages along with its greater data-moving capacity and other innovations. A total



break with the past, the Micro Channel was (and is) incompatible with PC and AT expansion boards. MCA may be technically advanced, but it makes designing expansion boards and compatible computers aggravatingly difficult. And being laced with proprietary IBM technology, it bears a hefty price because of the royalty that machine manufacturers must pay IBM to use the company's patented handiwork.

EISA was developed by the "Gang of Nine," a consortium of leading IBM-compatible PC makers led by Compaq Computer Corp., and was designed to offer the power of the Micro Channel without its disadvantages. EISA's forward-thinking features essentially duplicate those of the Micro Channel—a setup program, bus arbitration, shared interrupts—without the penalties. After all, the EISA architects could look to the Micro Channel for guidance as to what they could incorporate into their design. They benefited both from hindsight and from the admonition followed by all leading reverse engineers and burglars: steal only the best.

While they were running the Micro Channel's specifications through the Xerox machine, the EISA architects also choreographed a new dance, the patent-office sidestep. As a result of their fancy footwork, no royalties are required for using EISA technology (although other elements of EISA computers may require licensing and royalty payment).

For board designers, the best aspect of EISA is its backward compatibility. Expansion boards for the EISA bus don't have to be any more complex than traditional ISA boards. Although advanced EISA board designs are about equal in complexity to their Micro Channel counterparts, ordinary PC board designs still work for ordinary purposes. Engineers can get simple interface boards to market without a struggle.

THE PROMISE VS. REALITY

If you've been listening to the deprecations the two competing advanced-bus lobbies have been lobbing at one another, you've probably come to believe that the best reason for moving ahead to a new bus design is performance speed. IBM insisted that the Micro Channel can run circles around ISA. When EISA was introduced, the Gang claimed greater speed than IBM had provided. In answer, IBM infused even more speed into the Micro Channel (think of the new design as "Son of Micro Channel" or "Micro Channel II: IBM's Revenge").

According to the wild claims, these newfangled architectures could blast the text of a business plan or a complete novel from board to board in a fraction of a second. An ordinary spreadsheet could flash through the system faster than a leap of faith. If you believe the proclamations of the new-bus promoters, you can only get top performance from your next computer using one of their advanced expansion designs.

Unfortunately, specifications and reality coincide about as often as all the major planets conjoin. While numbers don't lie, often they don't reflect reality or your own expectations. The big numbers touted by manufacturers for expansion bus performance may not be relevant in everyday use of a computer. In fact, they may turn out to be theoretical constructs that will never be visible in the harsh light of the office—paper specs that are of no value when you need to get your work done and done quickly.

HOW TO TELL THEM APART: THE BUS CONNECTORS

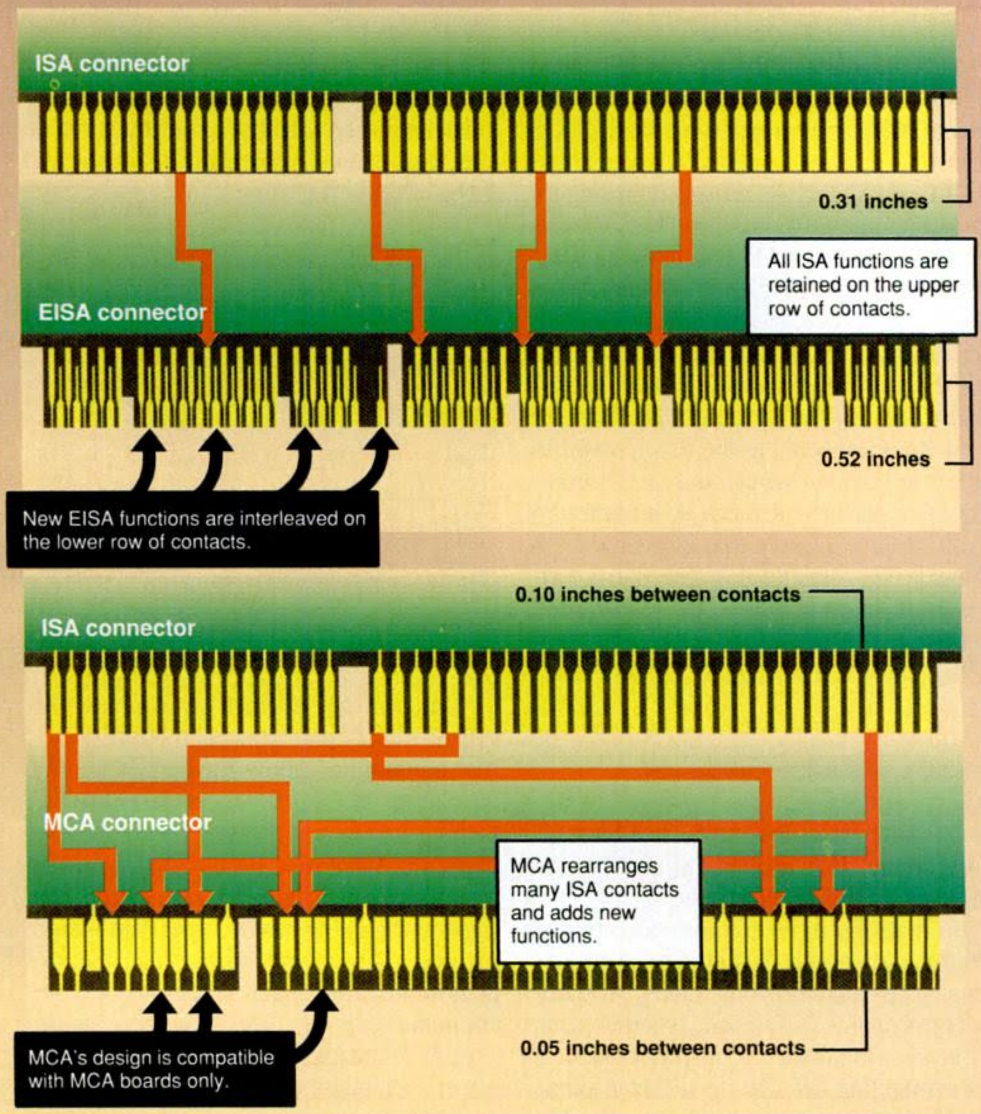
The telling difference among the three major bus options in the PC environment is the edge connector on each card.

The EISA connector was designed for full backward compatibility with ISA boards. All the connections of the ISA bus are present in their ordinary positions, but a new, lower row of contacts is added to link up the advanced functions of the bus. The developers linked these new contacts to the expansion board circuitry by interleaving their connecting traces between the ISA contacts on the card.

Micro Channel, on the other hand, forgoes hardware compatibility and guarantees only software compatibility with classic AT-bus computers. Thus, the MCA designers were free to alter the ISA layout completely, rearranging the functions of the contacts to minimize interference and to promote higher-speed operation. They added new functions as well.

The result is that Micro Channel boards work only in Micro Channel slots. EISA slots will accommodate both ISA and EISA expansion boards, but this is a one-way compatibility: EISA boards cannot be used in ISA expansion slots.

—Winn L. Rosch



WHAT LIES BEHIND THE NUMBERS

PC Labs set out to find the truth. Are the performance claims warranted? What do they mean to you as a user? And which bus is really faster?

To answer those questions, PC Labs developed new benchmark tests for evaluating bus performance, then ran them on two groups of machines chosen to highlight the differences among the buses. At one end were our *control group*, which were "uncooked" factory-stock base machines, identical except for their bus architectures; we stripped out all other differences. At the other extreme, we selected machines from the top configurations of the major vendors in each of the three bus categories, which we "cooked" by loading them with the fastest, cost-is-no-object performance-enhancing options available. We refer to these as our *enhanced* machines. These "cooked" computers were meant to probe the limits of the currently available technology.

For the factory-stock machines, PC Labs chose the ALR PowerCache 4 (MCA) and ALR PowerCache 4e (EISA), both from Advanced Logic Research. These twin towers are identical in microprocessor architecture and price ($14,989), and they use exactly the same cache, related circuitry, and cabinetry. We replaced the 4e's Hitachi hard disk with the Maxtor hard disk from the PowerCache 4 to eliminate even slight differences in configuration. We also operated the 4e in a degraded mode as an ISA computer to complete the three-bus comparison.

At the high end, the classic-bus choice was an Everex StepServer/Storage Dimensions FileMaster—a 33-MHz 386-based networked file server ($13,999)—which we also reconfigured and retested as a single-user system. In this form it was equivalent to the Everex Step 386/33 ($10,697) with an added Diamond SpeedSTAR VGA video controller ($590).

The Micro Channel standard-bearer was a $7,252 IBM 20-MHz 386-based PS/2 Model 80 enhanced with a Core International bus-mastering hard disk controller (model CNT-MCA, $495) and 650MB hard disk ($3,295). For our LAN server tests (Network Throughput Under Load), we upgraded the unit from 2MB to 8MB RAM. (IBM's new 25-MHz Model 80-A31 became available too late to be included in these tests.)

The EISA performance engine was Compaq's top-of-the-line Systempro, a 33-MHz dual-386 network-server monster with its performance-optimizing disk array. We tested this machine with its Intelligent Drive Array (IDA) for the LAN tests, and we replaced the IDA with a Compaq external 650MB ESDI hard disk for the DOS tests. (The Systempro is not designed as a DOS machine; the IDA lacks a DOS driver, and thus the overhead the IDA creates impairs system performance in DOS tests.)

We conducted our tests to represent today's prevailing PC environments: single-user PCs running DOS and network servers dishing up Novell's *NetWare*. What this testing revealed was often unexpected. For example, we found no need to factor out the differing microprocessor performance among the systems. The bus (or what was connected to the bus) proved to be the governing factor, and once microprocessor performance passed a minimum level—approximately that delivered by a 16-MHz 386—results converged to a definite limit. In other words, the tests zeroed in on the shortcomings of bus performance, and the results were disconcerting.

THE PERFORMANCE PUNCH LINE

And the winner is . . . . For speed alone, the bus race was a dead heat. And for real-world value, ISA proved the best bet for single-user DOS applications.

Information moved across each bus at about the same rate. With today's applications, your choice of bus makes virtually no performance difference, whether your PC is a world unto itself on your desk or a server handing off files to a dozen other PCs. Forget the claims and hype. The old classic AT bus still has a lot of life in it, enough that you'll not suffer for having it inside your next PC.

We found that larger LANs are another story, with possibly a different winner. In this type of bus-crunching application, a sophisticated bus design can really make a difference. In this capacity, MCA is slightly ahead of EISA, but each has its drawbacks in terms of industry support. Compared with ISA, a limited number of companies make boards for MCA machines, which may or may not influence your buying decision. As for EISA, the market is so young that boards that work at all are currently few, but the next year should see an influx of boards that support the Gang of Nine's venture. A well-designed bus can't improve performance without a selection of additional hardware that takes advantage of it.

TESTING STRATEGY

These conclusions were as hard to reach as they are to swallow. Although it sounds like sacrilege to recommend tired old ISA, this conclusion was borne out by some of the most extensive benchmark testing PC Labs has ever performed.

Our primary goal was to evaluate the effects of different expansion buses on actual computing chores. Instead of simply measuring bus operating speeds (just attaching a frequency counter will achieve that), PC Labs measured actual throughput—how much data an application can move through the bus in a specified period of time. Throughput, rather than theory, determines how much actual work your computer can do. The new benchmark tests were created to measure the throughput of each major element of a PC system: the microprocessor, the display system, the mass storage system, and the network interface.

The performance of the microprocessor and its associated memory were measured by PC Labs' Dryshell Processor test. (Although this test doesn't measure bus performance, its results help us to sort out the results of other tests.) This measure is based on Reinhold Weicker's Dhrystone test, originally published in the *Communications of the ACM* (October 1984), but modified so that the test code would not execute solely from cache memory.

The name Dhrystone is actually derived from another performance measure, the Whetstone test. The wet/dry pun contrasts the different aspects of performance measured by the tests. The Whetstone test investigates scientific and engineering processing capacity by evaluating mathematical performance. The Dhrystone measure looks at tasks more relevant to desktop computing: integer arithmetic, character-string handling, and function calls. Even seemingly mathematically oriented PC applications such as *Lotus 1-2-3* rely almost entirely on integer arithmetic rather than floating-point operations.

Because the traditional Dhrystone test runs in a relatively tight loop, it shows few performance differences between systems that have the same microprocessors and clock speed but that use disparate caching technologies and sizes. The tiny test simply runs entirely within the cache at the top speed of the microprocessor. PC Labs' Dryshell Processor test compensates for the small computational kernel by duplicating itself four times and dividing up the work among four copies of its algorithm.

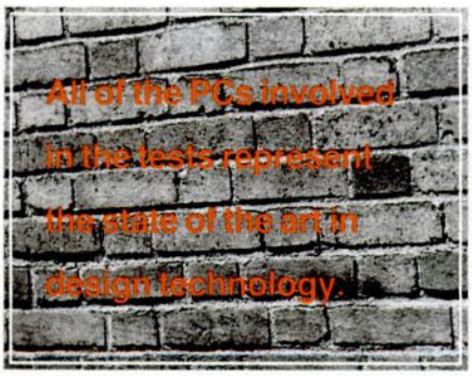
The Dryshell Processor test reflects the capabilities of the latest software for high-performance computers, in that it was written using simulated 32-bit mathematical instructions. The test was compiled using Microsoft C, Version 5.1.

To isolate the video system—specifically, VGA circuitry—from the rest of each computer undergoing evaluation, PC Labs developed a new measure of display speed called the VGA Controller Throughput test. This performance test measures the display system's maximum throughput in kilobits per second by repeatedly filling the screen with horizontal lines, rotating among 16 different colors.

The VGA Controller Throughput test stressed the display system well beyond the demand of any actual application. While the display speed of ordinary application software is limited by the microprocessor time required to generate screen images, the VGA performance test has no such overhead. Consequently, it is essentially independent of the system's microprocessor. For example, when we tried running the VGA test using the same video card in an 8-MHz 286 and in a 33-MHz 386, the results matched within 2 percent. The VGA test does not measure text processing speed, because the time to refresh a full character-based screen is minuscule compared with that required in drawing graphics images.

To separate mass storage performance from the rest of each system, PC Labs developed the Disk Controller Throughput test. This performance test reads and writes a sequential file in blocks of a predefined size. Sequential operations using a large block size (32K in this evaluation) minimize the mechanical limitations on hard disk performance—latency and seek times—and maximize the amount of data flowing from the disk into the host computer system. This allows the hard disk subsystem to push data across the expansion bus as fast as it possibly can. This is a true test of bus throughput as you would see it in actual use.

We also tested Disk Controller Operations per Second using a small block size (512 bytes) to measure the performance of the hard disk controller by maximizing the number of operations the controller needed to carry out. In effect, this test measures controller overhead as well as throughput. Using still smaller block sizes makes no sense, because the low-level format of PC hard disks does not permit reading or writing less than a single 512-byte sector at a time. Reading or writing blocks smaller than 512 bytes primarily measures DOS and microprocessor rather than disk performance.



To measure the maximum possible throughput of network data, PC Labs installed a network adapter card in each tested system, which then received data sent across the LAN in large blocks by three Compaq Deskpro 386/25s (with 3Com Etherlink II cards). The data transfers occurred as fast as Ethernet could carry them without packet collisions.

The sending and receiving programs established the NetBIOS sessions to carry out this exchange of data using the *NetWare* 2.15 IPX (Internet Protocol Exchange). Note that in evaluating test results the efficiency of the NetBIOS driver is as important to network throughput as the LAN card's hardware design.

We had no trouble running our Network Throughput Under Load tests, in which each tested system is configured as a server. But for the Network Adapter Throughput test, where the tested systems are set up as nodes rather than servers, we ran into problems when trying to test the EISA bus. We could find only one EISA Ethernet board on the market designed for nodes, and it could not complete our tests.

For our Network Throughput Under Load tests at PC LAN Labs, we set up each of the systems using *NetWare 386*, Version 3.0, and connected it to networks of zero, three, six, and ten constantly active nodes. (One exception was the Everex StepServer/Storage Dimensions Filemaster, which warranted testing under *NetWare 286*, Version 2.15, because the ROM in the high-performance hard disk controller was not yet compatible with *NetWare 386*.) The network carried out its transactions in block sizes of 512 bytes, 4K, and 16K, and we converted the transfer times into kilobit-per-second throughput figures.

PCs OF CHOICE

All of the PCs that were involved in these bus tests represent the state of the art in design technology. They use the latest, highest-performance microprocessors available—either 20- or 33-MHz 386 chips or 25-MHz 486s. The machines were equipped with 2MB to 12MB of high-speed RAM connected to sockets on the system board or dedicated memory expansion boards rather than the normal system expansion bus.

None of these machines stoop to using an ordinary ST-506 hard disk; all opt for at least one ESDI disk. The Systempro uses a tightly knit array of drives to optimize mass storage performance (we used a solo 650MB ESDI drive, however, when evaluating the Systempro as a single-user system). As the tests demonstrate, any of these machines would be an excellent anchor to hold a network faced by the most awesome gales of workstation demands. For single-user situations, some of these machines are actually overkill; the Systempro's full features don't come into play until it starts serving networks.

The ALR PowerCaches 4 and 4e are the PC equivalents of the World Trade Center—matched towers that are head and shoulders above all but a few competitors. Each machine is based on a 25-MHz 486 (the fastest version of the chip available at test time) coupled with a proprietary cache design that features a 128-bit-wide data path and a full 128K of 25-nanosecond static RAM cache.

These two machines have identical hardware. Each tower measures 23.5 by 7.5 by 18.5 inches (HWD), and each offers the same drive capacity. Four half-height drives fit into bays at the top front of the case. A single internal full-height bay swings out on a clever, hinged panel. Each of the half-height devices mounts to an individually removable shelf. The internal hard disk screws to the swing-out panel through six shock mounts.

When fully assembled, the ALR tower cases are fairly sturdy, although like most tower cases, they pale in comparison with the solidity of the Systempro. For example, the ALR half-height bays are weakly mounted on one side. Although these towers are structurally better than the company's past efforts, they still lack the quality we have a right to expect in a $15,000 computer.

The operating accoutrements of the two ALR systems are nearly identical as well. The main switch for the 220-watt 115/230-volt power supply is at the rear edge of the top of the case. Tiny power and drive activity LEDs are hidden at the top of the system's black sculptured front panel. Connectors for the standard input/output ports sprout from the center of the rear panel and include serial, parallel, mouse, and keyboard connectors (one of each). Both systems come with VGA.

While the EISA machine uses a standard 5-pin DIN connector for the keyboard, the Micro Channel machine uses a miniature DIN connector exactly like that of IBM's PS/2 series. The MCA tower comes with a 1.44MB 3.5-inch floppy disk drive; the EISA machine is equipped with a 1.2MB 5.25-inch drive.

The primary difference between the twins is the system board that lines the right side of the case. The Micro Channel machine uses a 14.5- by 11.5-inch board

PC MAGAZINE FACT FILE

ALR PowerCache 4
Advanced Logic Research Inc., 9401 Jeronimo, Irvine, CA 92718; (714) 581-6770.
List Price: With 25-MHz 80486, 8MB RAM, 330MB hard disk, 1.44MB 3.5-inch floppy disk drive, one serial and one parallel port, VGA color monitor, $14,989.

CIRCLE 409 ON READER SERVICE CARD

ALR PowerCache 4e
List Price: With 25-MHz 80486, 8MB RAM, 330MB hard disk, 1.2MB 5.25-inch floppy disk drive, two serial and one parallel port, VGA color monitor, $14,989.

CIRCLE 410 ON READER SERVICE CARD

SUMMARY OF FEATURES: EISA VS. ISA VS. MCA

To configure these computers for testing, PC Labs added hard disks and high-performance disk and video controllers from various vendors. In some cases, the tested configurations are not commercially available. See the fact files for pricing information.

Expansion bus type This review includes machines constructed around all three bus types: EISA, ISA, and MCA. Although the PowerCache 4e is an EISA machine, we also ran tests on a PowerCache 4e reconfigured as an ISA machine.

Case type indicates whether each computer has a small-footprint, desktop, or tower design.

386 chip set manufacturer indicates which company made the support logic that connects the CPU with the functions managed by the system board. Chip sets that use VLSI (very large-scale integration) technology reduce the discrete component count, which in turn helps to reduce power consumption and increase component life.

The **system RAM arrangement** is the method in which memory is addressed. Remember that CPU speed is usually faster than conventional memory speed.

Interleaved memory increases processing speed by dividing the memory into two or four portions that process information alternately. The CPU sends information to one section for processing while another section goes through a refresh cycle.

Page-mode memory allows back-to-back memory accesses within blocks of memory called pages without wait states.

Row/column is the traditional method of accessing data at a memory address, with the RAM being mapped as a matrix and a particular address being given using a row and a column number.

Wait states On the average, most machines run between zero and one wait state. The figures printed here were supplied by the respective manufacturers.

RAM packaging (and rated speed) Memory chips come in a variety of styles: DIPs, SIPs, and SIMMs.

The *dual in-line package (DIP)* is the traditional buglike computer chip sprouting 8, 14, 24, 40, or more metal legs (evenly divided between right and left sides).

Single in-line packages (SIPs) are single-package arrays of computer chip logic assembled so that all connecting legs are in a straight line, like the teeth on a comb. They can be individual chips or multiple chips on a small card, with a proprietary SIP connection.

Single in-line memory modules (SIMMs) are individual logic devices that are installed on their own small circuit board, creating a component module that can be plugged into a larger device. Their physical arrangement facilitates easy installation and replacement.

Chip size Kb and Mb refer to kilobits and megabits, respectively.

Processor RAM cache A processor RAM cache acts as a bridge between the CPU and the slower main memory. The cache comprises a small bundle (typically 32K to 128K) of fast SRAM chips. The cache controller is designed to predict and retrieve the data the CPU is likely to require next, thus preventing wait states. There are two varieties of controllers: discrete logic chips (designed by the individual manufacturers) and VLSI chips like the Intel 82385.

The **BIOS version and date** can affect PC Labs' benchmark test results. Those purchasing the same machine with a different BIOS version may encounter some variations in performance.

Setup can reside either on a floppy disk or in ROM.

Shadowing Shadow RAM is a technology that loads system BIOS and/or video BIOS directly into fast RAM on boot-up of the computer, offering enhanced performance speed at the cost of 384K of memory from the first 1MB of system RAM. The ability to disable shadowing is important with some applications to resolve memory conflicts.

Hard disk manufacturer Within the 386 PC environment, the three most common hard disk interfaces are *ST-506, SCSI (small computer system interface),* and *ESDI (enhanced small device interface).*

Both SCSI and ESDI require special hard disk controllers and cannot run off existing PC-XT or PC AT controllers. The *IDA (Intelligent Drive Array),* an EISA peripheral exclusively from Compaq, can control up to eight hard disks, treating them as one logical drive.

Bus speeds Bus speed becomes more important as computers run at faster clock speeds. A computer's bus speed may actually be too fast for expansion cards, most of which operate at 8 MHz. Note that the Micro Channel and ESDI buses operate at variable speeds, up to about 14.5 MHz.

The **display circuitry location** can be either on an expansion card or on the motherboard. Motherboard circuitry is often faster, but if it cannot be disabled it prevents upgrades.

Interface 16-bit video interfaces are typically faster than 8-bit because of their wider bandwidth.

FCC certification class Two classes of FCC (Federal Communications Commission) approval, Class A and Class B, may be given to computers. Class A approval signifies that a computer has sufficiently low radio-frequency emissions for operation in a business locale. The more stringent Class B rating allows home use as well, where computers are likely to be placed near radios and television sets.

Products listed in alphabetical order

	Advanced Logic Research Inc. **ALR Power Cache 4**	Advanced Logic Research Inc. **ALR Power Cache 4e**	Compaq Computer Corp. **Compaq Systempro**	Everex Systems Inc. **Everex Step 386/33**	Storage Dimensions Inc. **Everex StepServer/ Storage Dimensions FileMaster**	IBM Corp. **IBM PS/2 Model 80-111**
Expansion bus type	MCA	EISA (also configured as ISA)	EISA	ISA	ISA	MCA
TESTED CONFIGURATION						
Microprocessor	25-MHz 80486	25-MHz 80486	Two 33-MHz 80386s	33-MHz 80386	33-MHz 80386	20-MHz 80386
Case type	Tower	Tower	Tower	Desktop	Desktop	Tower
Dimensions (HWD, in inches)	23 x 7.5 x 18.5	23 x 7.5 x 18.5	23.5 x 7.5 x 22	6.5 x 21 x 16	6.5 x 21.2 x 16.5	23.5 x 6.5 x 19
Motherboard manufacturer	ALR	ALR	Compaq	Everex	Everex	IBM
386 chip set manufacturer	Intel	Intel	Compaq, Intel	Everex	Everex	IBM, multisource
System RAM arrangement	Interleaved, page-mode, row/column	Interleaved, page-mode, row/column	Page-mode	Row/column	Row/column	Page-mode
Wait states	0	0	0	0	0	0–2
MOTHERBOARD MEMORY						
Installed RAM	None	8MB	None	8MB	8MB	2MB (A), 4MB (B)
RAM packaging (and rated speed)	N/A	SIMM (100 ns.)	N/A	SIMM (100 ns.)	SIMM (100 ns.)	Proprietary memory modules (85 ns.)
Chip size	N/A	256Kb, 1Mb, 4Mb	N/A	1Mb	1Mb	1Mb
ADD-IN MEMORY BOARD						
Installed RAM	8MB	None	12MB	None	None	None (A), 4MB (B)
RAM packaging (and rated speed)	SIMM (100 ns.)	N/A	DIP (80 ns.)	N/A	N/A	DIP (85 ns.) (B)
Chip size	256Kb, 1Mb, 4Mb	N/A	1Mb	N/A	N/A	1Mb (B)
PROCESSOR RAM CACHE						
Cache controller manufacturer	ALR	ALR	Intel	Everex	Everex	N/A
Installed RAM	128K	128K	2 x 64K	128K	128K	N/A
RAM packaging (and rated speed)	DIP (25 ns.)	DIP (25 ns.)	SRAM (25 ns.)	SIMM (25 ns.)	SIMM (20 ns.)	N/A
Chip size	64Kb	4 x 16Kb	4 x 32 Kb	64Kb	64Kb	N/A
BIOS						
BIOS version and date	Phoenix 1.01.02 (December 1989)	Phoenix 0.10.02 (February 1990)	Compaq 386E (December 1989)	AMI F3-38 (1989)	AMI F3-38 (1989)	F801 (1987)
Setup in ROM	❑	■	■	■	■	❑
Password in ROM	■	❑	■	❑	❑	❑
Video shadowing/Can be disabled	■/■	■/■	■/❑	❑/❑	❑/❑	❑/❑
System shadowing/Can be disabled	■/■	■/■	■/❑	■/■	■/■	■/❑
HARD DISK						
Manufacturer	Maxtor	Maxtor	Compaq (A), Conner (B)	Seagate/Wren	Maxtor	Core
Disk capacity	330MB	330MB	650MB (A), 840MB (B)	330MB	2 x 155MB	650MB
Interface	ESDI	ESDI	ESDI (A), IDA (B)	ESDI	SCSI	ESDI
Controller location	Motherboard	Card	Card	Card	Card	Card
Controller manufacturer	Western Digital	Adaptec	Compaq	DTC	Storage Dimensions	Core
Integrated floppy/hard disk controller	■	■	❑	■	■	■
Drive bays	1 full-height, 4 half-height, 1 3.5-inch	1 full-height, 4 half-height, 1 3.5-inch	10 half-height, 1 one-third-height	5 half-height	2 full-height, 5 half-height, 5 3.5-inch	4 full-height

■—Yes ❑—No
N/A—Not applicable: the product does not have this feature.
(A)—This pertains to our DOS single-user tests and also to our Network Adapter Throughput test, where the computer was configured as a node on a network.
(B)—This pertains to our Network Throughput Under Load tests, where the computer was configured as a network server.

CONTINUES

SUMMARY OF FEATURES: EISA VS. ISA VS. MCA

Products listed in alphabetical order

	Advanced Logic Research Inc. **ALR Power Cache 4**	Advanced Logic Research Inc. **ALR Power Cache 4e**	Compaq Computer Corp. **Compaq Systempro**	Everex Systems Inc. **Everex Step 386/33**	Storage Dimensions Inc. Everex **StepServer/ Storage Dimensions FileMaster**	IBM Corp. **IBM PS/2 Model 80-111**
FLOPPY DISK DRIVES						
Type	1.44MB	1.2MB	1.44MB, 1.2MB	1.2MB	1.2MB	2 x 1.44MB
Manufacturer	TEAC	Fujitsu	Citizen, Canon	TEAC	TEAC	IBM
EXPANSION BUS	MCA	EISA (also configured as ISA)	EISA	ISA	ISA	MCA
Bus speeds (MHz)	Variable	8	8	11.1	16.5	5
Expansion slots	Four 16-bit, two 32-bit, one proprietary	One 8-bit, one 16-bit, six 32-bit, one proprietary	Seven 32-bit EISA, four proprietary	Two 8-bit, six 16-bit	Two 8-bit, six 16-bit	Four 16-bit, three 32-bit
Slots left free after hard and floppy disk drives, video, one parallel and two serial ports are installed	4	6	8	6	6	6
Ports originate on motherboard	■	■	■	❑	❑	■
VIDEO						
Display circuitry location	Card	Card	Motherboard	Card	Card	Card
Interface	16-bit VGA	16-bit VGA	16-bit VGA	16-bit VGA	8-bit monochrome	8-bit VGA
Manufacturer	ALR	ALR	Compaq	Diamond	Everex	IBM
Chip set manufacturer	Chips and Technologies	Tseng Laboratories	Compaq	Tseng Laboratories	Everex	IBM
NETWORK CONFIGURATIONS						
PC Labs configuration (A):						
Adapter	3Com Etherlink/MC	EISA: N/A; ISA: 3Com Etherlink II	N/A	3Com Etherlink II	N/A	3Com Etherlink/MC
Operating system	*NetWare 286*, Version 2.15	*NetWare 286*, Version 2.15	N/A	*NetWare 286*, Version 2.15	N/A	*NetWare 286*, Version 2.15
PC LAN Labs configuration (B):						
Adapter	Novell NE232	EISA: Novell NE3200; ISA: Artisoft NE2000	Novell NE3200	N/A	3Com 3C505	Novell NE232
Operating system	*NetWare 386*	*NetWare 386*	*NetWare 386*	N/A	*NetWare 286*, Version 2.15	*NetWare 386*
MISCELLANEOUS						
Coprocessor installed	N/A	N/A	80387-33, Weitek 3167-33	None	None	None
Power supply (watts)	200	300	300	200	200	225
FCC certification class	A	A	B	A	A	B

■—Yes ❑—No
N/A—Not applicable: the product does not have this feature.
(A)—This pertains to our DOS single-user tests and also to our Network Adapter Throughput test, where the computer was configured as a node on a network.
(B)—This pertains to our Network Throughput Under Load tests, where the computer was configured as a network server.

ENDS

with a single proprietary daughtercard for memory. This board bears sockets for 16 SIMMs (single in-line memory modules). The system board holds six Micro Channel expansion slots, two with full 32-bit connectors and four with 16-bit; two of the latter slots have the MCA video extension.

The PowerCache 4e EISA machine requires a larger system board measuring 14.5 by 14 inches, overlaid with a second 12- by 7-inch board that chiefly holds memory—a total of 32 SIMM sockets. Of its eight slots, six use 32-bit EISA connectors, one is 16-bit, and one is 8-bit. Both systems use Intel VLSI chips, a Phoenix BIOS, and a Dallas clock/CMOS module.

The exact match of these systems' architectures allowed PC Labs to control all factors in system design, the only variable being the bus. In fact, during evaluation the same hard disk was alternately used in both systems to eliminate any differences arising from variations in disk performance.

Visually, EISA and MCA diverge most markedly in the size of their motherboards. The EISA motherboard is larger not because it is more complex than its MCA counterpart, but because the expansion board is larger—as is the slot—and requires a larger plane inside the machine. These differences have no effect on price, with one exception. The smaller MCA system board fits in a desktop package, which lowers the cost of the ALR base system with monitor from $11,989 to $10,489 (with a 120MB hard disk in lieu of the 150MB model that comes standard in the tower).

COOKED ISA

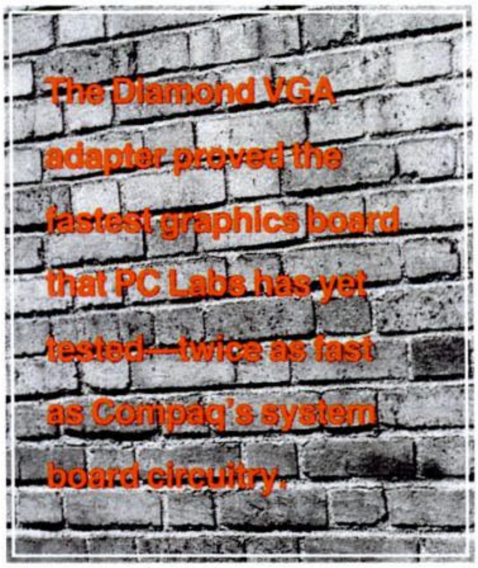
In the "cooked" category, the most mundane and least costly choice is the Everex Step 386/33. The company's basic configuration, with no hard disk, 2MB of RAM, and a 64K cache, costs $6,299. The extra 6MB RAM, 330MB hard disk, quadruple cache, and Diamond SpeedSTAR VGA controller drive the price up to $11,287.

Almost prototypical of the ISA school, the Step 386/33 looks like an ordinary AT clone: its 6.5- by 21- by 16-inch case has an AT layout (three half-height bays on the right, all with front-panel access, and a full-height internal bay). Inside, the 12- by 14-inch system board looks conventional enough with its pin-in-hole components, even the familiar Tadiran battery Velcroed to the side of the 200-watt power supply for maintaining the CMOS setup memory. Most of the chips are PLAs (programmable logic arrays, standard chips that create custom circuit configurations), making up for the dearth of VLSI on the board. Memory is confined to the space behind the hard disk, where eight SIMM sockets are available. The 8MB system board capacity can be doubled with a proprietary high-speed memory expansion board.

The standard eight expansion slots are installed, six with 16-bit interfaces, two with 8-bit. In the evaluation system, three were filled by a VGA adapter, a hard disk controller, and an input/output adapter with two serial and one parallel port.

The indicator panel that hides behind a sliding smoked plastic door in the front panel distinguishes the Step 386/33. In addition to the expected keyboard lock and power and disk activity indicators, it also includes an alphanumeric display and three LEDs to indicate speed.

The interior of the Step 386/33 is distinguished by its scalable memory cache, the component that makes the machine really cook. The Step 386/33 runs at a higher-than-average bus speed of 11.1 MHz but will automatically switch to 8.5 MHz if any incompatibilities arise. For testing, we used an optional Diamond VGA adapter (which will be released by the time this issue hits the newsstands); it proved the fastest graphics board that PC Labs has yet encountered—twice as fast as Compaq's integrated system board circuitry.



PC MAGAZINE FACT FILE

Everex Step 386/33
Everex Systems Inc., 48431 Milmont Dr., Fremont, CA 94538; (415) 498-1111.
List Price: With 33-MHz 80386, 8MB RAM, 330MB hard disk, 1.2MB 5.25-inch floppy disk drive, two serial and two parallel ports, VGA color monitor (without video controller), $10,697.
Tested With: Diamond Computer Systems Inc.: SpeedSTAR VGA video controller with 1MB RAM, $590.

CIRCLE 412 ON READER SERVICE CARD

PC MAGAZINE FACT FILE

Everex StepServer/Storage Dimensions FileMaster
Storage Dimensions Inc., 2145 Hamilton Ave., San Jose, CA 95125; (408) 879-0300.
List Price: With 33-MHz 80386, 8MB RAM, two 155MB hard disks, 1.2MB 5.25-inch floppy disk drive, two serial and two parallel ports, monochrome monitor, $13,999.

CIRCLE 413 ON READER SERVICE CARD

COOKED MCA

Our souped-up Micro Channel machine is IBM's veteran 20-MHz PS/2 Model 80 enhanced with a 16-bit bus-mastering Core 15-MHz ESDI hard disk controller and matching hard disk. Little changed from the original 16-MHz Model 80, the 20-MHz machine is built inside the same stalwart plastic tower that also serves as the foundation for the much-maligned Model 60. The 23.5- by 6- by 19-inch case accommodates two 3.5-inch floppy disk drives on slide-in front-panel sleds and two full-height 5.25-inch drives in a subchassis frame (one with front-panel access).

The 11- by 15.5-inch system board is cleanly laid out in mostly surface-mount components and IBM ASICs (application-specific integrated circuits) that incorporate VGA, serial and parallel port, and floppy disk control circuitry. The eight expansion slots provide three 32-bit and five 16-bit connections, one of the latter having a video-extension connector.

PC MAGAZINE FACT FILE

IBM PS/2 Model 80-111
IBM Corp.; contact your local authorized IBM dealer; (800) IBM-2468.
List Price: With 20-MHz 80386, 2MB RAM, 115MB hard disk, two 1.44MB 3.5-inch floppy disk drives, one serial and one parallel port, VGA color monitor, $7,252.
Tested With: Core International Inc.: CNT-MCA bus-mastering hard disk controller, $495; 650MB hard disk, $3,295.

CIRCLE 414 ON READER SERVICE CARD

COOKED EISA

Any way you look at it, the Compaq Systempro is an awesome machine, including its $41,143 tested-configuration price (the base price is $15,999). The intent behind its design is obvious: the Systempro is the ultimate PC. It is designed as a network server, and many of its advanced features (such as its drive array) won't come into play in single-user operation. No DOS driver is available for the drive array, so we conducted the single-user performance tests with a Compaq-supplied external high-performance hard disk.

That said, the Systempro looks as if it benefits from the craftsmanship of out-of-work builders of tanks and battleships who were displaced by the peace raging in Europe. Few mountains are as solid. The 23.5- by 7.5- by 22-inch aluminum chassis has its own unique design, with an angled set of bays for three removable-media drives at the top and a hidden nest for eight hard disks inside the bottom. A 300-watt power supply fills the top of the case.

The Systempro's floppy disk drives are one-third-height devices (the 3.5-inch and the 5.25-inch drive in the evaluation system both used high-density disks). Only the first slot is actually one-third-height; the second bay is half-height, with a thin panel filling the gap between disk drive and bay. A DC-600-style streaming tape backup unit also graced the front panel.

The eight internal drive bays are not remarkable, but the drives' electrical link-up is. Multiple hard disks inside the Systempro can be synchronized to function as a single, large hard disk array using Compaq's Intelligent Drive Array Controller. The largest array currently available uses four disks to yield 840MB.

PC MAGAZINE FACT FILE

Compaq Systempro
Compaq Computer Corp., P.O. Box 692000, 20555 SH 249, Houston, TX 77269-2000; (713) 370-0670.
List Price: With two 33-MHz 80386s, 12MB RAM, 840MB hard disk, 150/250MB tape drive, 1.44MB 3.5-inch and 1.2MB 5.25-inch floppy disk drives, two serial and one parallel port, VGA color monitor, 80387-33 coprocessor, Weitek 3167-33 coprocessor, $41,143. Also tested with ESDI 650MB hard disk, $9,399.

CIRCLE 411 ON READER SERVICE CARD

The system board inside measures 11 by 15.5 inches. Microprocessors—the Systempro can use one or two—reside on proprietary processor boards. The evaluation system includes two 33-MHz 386 processor boards, one equipped with matching-speed Intel 387 and Weitek 3167 coprocessors. Both CPU boards also bear Intel 82385 cache controllers and 64K static RAM caches. A proprietary memory board comes with two memory modules, each containing 2MB RAM. An additional dual-socket proprietary memory module containing 1-megabit (1Mb) chips holds an additional 8MB, yielding a total of 12MB RAM.

I/O ports (two serial, one parallel), a floppy disk drive controller, and fast VGA circuitry are built into the system board. Besides four proprietary slots (three of which are filled, two with CPU boards and one with memory), seven full 32-bit EISA slots are located on the system board.

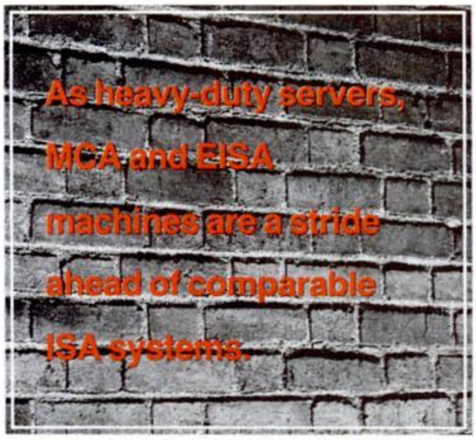
SURPRISING RESULTS

The single-user tests of these six systems confirmed past evaluations and expectations as far as microprocessor and video performance are concerned. The 486 microprocessor proved its mettle in the ALR machines, using its burst mode to blast ahead of 386 processors running at faster clock speeds. Certain expansion boards shone, like the lightning-quick Diamond VGA adapter in the Everex machine—twice as fast as even the tightly integrated 16-bit VGA circuitry of the Systempro—while a vintage 8-bit VGA connection shackled the Model 80 like a ball and chain. In fact, we found the Diamond VGA was nearly 13 times as fast as the Model 80's video card.

As testing became increasingly bus-dependent, however, the differences between the test machines evaporated. Put identical high-speed hard disks in machines with the same microprocessors and cache architectures and the bus doesn't matter, as our three ALR machines demonstrate: with a few exceptions, the test results are nearly indistinguishable.

The bottom line for people using DOS applications is: put your money in good video controllers, put your money in plenty of RAM, but don't spend more than the price of a good ISA machine to get a performance bonus from MCA or EISA.

Yet that's not the end of the story. Run *NetWare* on one of the evaluation systems



and link it to a number of nodes and you begin to see the differences between architectures. To pursue this idea, PC LAN Labs ran benchmark tests on each of the six reviewed machines. The EISA and MCA servers used appropriate Novell 32-bit adapters, and the ISA servers used a 3Com 3C505 16-bit adapter. The suite that provided the load for the servers included four 25-/33-MHz 386 PCs, two 20-MHz 386s, and five Dell System 200s with 12-MHz 286 CPUs.

The results show that as servers, the MCA and EISA machines are a stride ahead of comparable ISA systems, with MCA edging out EISA—given the network adapters and driver software used. We should emphasize that a single tweak, like rewriting the driver software of a LAN adapter, could alter the EISA/MCA performance relationship. But the general advantage of these bus architectures over ISA in a heavy-duty server is logical and is supported by the test scores.

These results also show that with to-

PC LABS BENCHMARK TESTS: EISA VS. ISA VS. MCA

The Challenge of Testing: EISA vs. ISA vs. MCA

Our bus architecture tests had two parts: we configured three control-group machines—identical except for their buses—to isolate and measure bus performance, and we configured "enhanced" machines to push each bus to its limits. We performed all of our tests on both sets of machines.

The control-group systems consisted of Advanced Logic Research's ALR PowerCache 4 (MCA) and 4e (EISA), two 25-MHz 486s with identical architectures. By downgrading the 4e, we were able to test it as an ISA machine as well. Each of these machines was equipped with 8MB RAM, a 330MB (formatted) ESDI hard disk from Maxtor, and a VGA color monitor.

For an enhanced MCA system, we used the 20-MHz IBM PS/2 Model 80-111 with 2MB or 8MB RAM, plus Core 650MB hard disk and controller, and VGA color monitor. Our enhanced EISA system was the Compaq Systempro with two 33-MHz 386 processors, 12MB RAM, VGA color monitor, and two coprocessors, along with an external 650MB ESDI hard disk (for DOS single-user tests) or an Intelligent Drive Array and 840MB hard disk (for Network Throughput Under Load server tests).

As for ISA, we ran the DOS single-user tests on the Everex Step 386/33 with 8MB RAM, 330MB ESDI hard disk, Diamond SpeedSTAR VGA video controller (which is slated to ship by the time this issue goes to press), and VGA color monitor. For the Network Throughput Under Load tests we used the Everex StepServer/Storage Dimensions FileMaster with a 33-MHz 80386, 8MB RAM, two 155MB SCSI LANstore hard disks, 128K cache, and monochrome monitor.

For LAN tests, we chose the following network boards: For the Network Adapter Throughput test, we equipped the ALR PowerCache 4 and IBM Model 80 with the 3Com Etherlink/MC. The ISA-configured ALR PowerCache 4e and the Everex Step 386/33 used the 3Com Etherlink II; the other ALR PowerCache 4e and the Compaq Systempro had no network board installed, since no available EISA Ethernet boards could complete our tests.

Three Compaq Deskpro 386/25s, with 3Com Etherlink II network boards, were connected to an Ethernet hub, which was then connected to each test machine. The test ran under the *NetWare* 2.15 IPX (Internet Protocol Exchange) and NetBIOS.

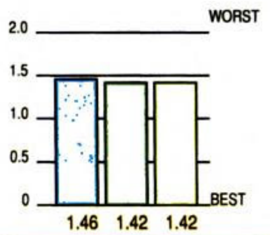
For the Network Throughput Under Load server tests, the ALR PowerCache 4 and the IBM Model 80 used the Novell NE232; the ISA-configured ALR PowerCache 4e used the Artisoft NE2000, while the Everex StepServer/Storage Dimensions FileMaster used the 3Com 3C505. The ALR PowerCache 4e and the Compaq Systempro used the Novell NE3200. We ran all these server tests using *NetWare 386* except when testing the Everex StepServer/Storage Dimensions FileMaster; this we tested under *NetWare 286*, Version 2.15, because the ROM in the high-performance hard disk controller was not yet compatible with *NetWare 386*.

Our standard suite of benchmark tests revealed few performance differences attributable solely to differences in bus architecture. Nonetheless, in this ALR family of machines, the ISA- and EISA-based platforms performed identically—and outperformed the MCA machine on the majority of tests.

PROCESSOR AND MEMORY BENCHMARK TESTS

80386 Instruction Mix — Elapsed Time (seconds)

The **80386 Instruction Mix** benchmark test times a series of tasks specific to the 80386 chip. Since this test shows how the CPU operates in the context of the bus, processor, system memory, and motherboard architecture, a faster time means better overall computer performance.

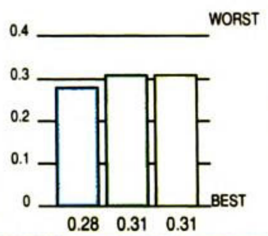


Floating-Point Calculation Without Coprocessor

The **Floating-Point Calculation Without Coprocessor** benchmark test sets up a floating-point emulation program in RAM and then exercises the processor and tests RAM access speeds during floating-point calculations.

Conventional Memory — Elapsed Time (seconds)

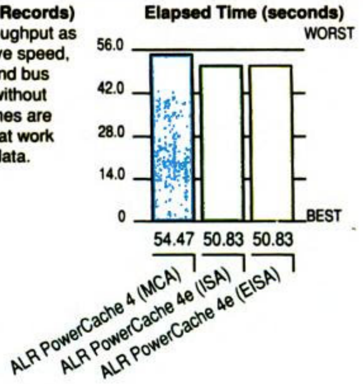
The **Conventional Memory** benchmark test measures the read/write speed of the first 640K of memory. Slower relative times can indicate the presence of memory wait states or memory chips rated at slower access speeds.



DISK BENCHMARK TESTS

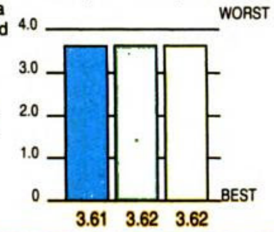
DOS File Access (Small Records)

The **DOS File Access (Small Records)** benchmark test times disk throughput as a result of mechanical disk drive speed, hard disk controller function, and bus speed. The test is performed without software disk caching. Fast times are advantageous for programs that work with many short segments of data.



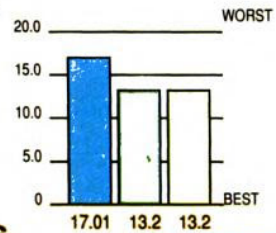
DOS File Access (Large Records)

The **DOS File Access (Large Records)** benchmark test times disk throughput as a result of mechanical disk drive speed, hard disk controller function, and bus speed. This test minimizes the effect of small hardware caches on disk subsystem performance. It is performed without software disk caching. Fast times are advantageous when large files are loaded.



BIOS Disk Seek — Elapsed Time (milliseconds)

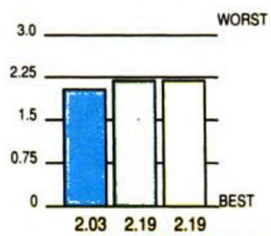
The **BIOS Disk Seek** benchmark test measures mechanical track-to-track disk drive access times. Fast times are helpful with programs such as databases, which often store and must later find data in many separate places on a drive.



VIDEO BENCHMARK TESTS

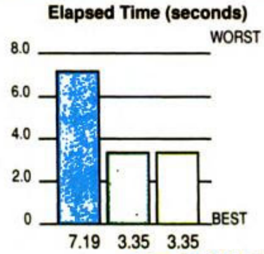
Direct to Screen — Elapsed Time (seconds)

The **Direct to Screen** benchmark test indicates the speed of the video adapter memory. Good scores indicate that information can get to the screen quickly, particularly for programs that avoid the computer's BIOS and go directly to the screen.



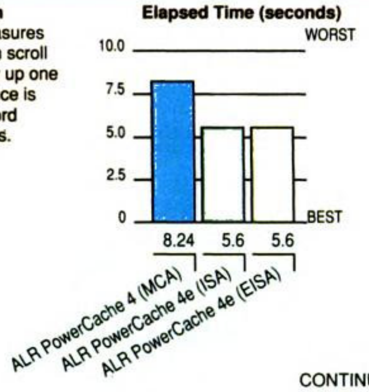
Video BIOS Routine Without Scrolling

The **Video BIOS Routine Without Scrolling** benchmark test measures how quickly the BIOS on the video adapter writes text data to the screen. Fast video writing helps with programs that show full or partial screens of data without scrolling the screen.



Video BIOS Routine with Scrolling

The **Video BIOS Routine with Scrolling** benchmark test measures how fast the video adapter can scroll the screen, moving the display up one line at a time. Good performance is helpful for scrolling through word processing or spreadsheet files.



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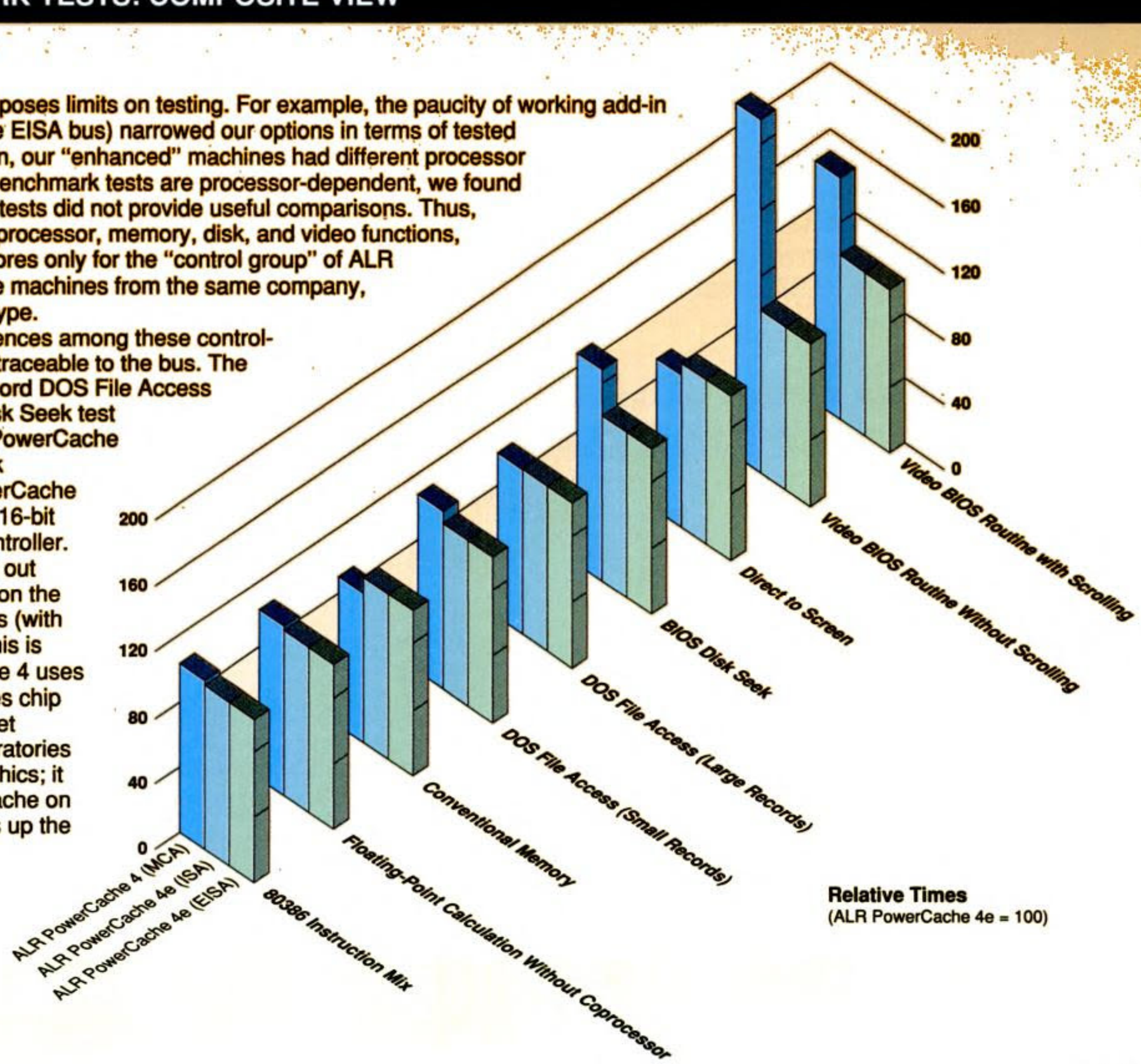
PC LABS BENCHMARK TESTS: COMPOSITE VIEW

New technology often imposes limits on testing. For example, the paucity of working add-in boards (especially for the EISA bus) narrowed our options in terms of tested configurations. In addition, our "enhanced" machines had different processor speeds; as most of our benchmark tests are processor-dependent, we found that the results on those tests did not provide useful comparisons. Thus, on our standard tests of processor, memory, disk, and video functions, we are publishing the scores only for the "control group" of ALR PowerCache PCs—three machines from the same company, identical except for bus type.

Even so, some differences among these control-group machines are not traceable to the bus. The results for the Small-Record DOS File Access test and for the BIOS Disk Seek test differ because the ALR PowerCache 4 uses a DMA 16-bit disk controller while the PowerCache 4e uses a more efficient 16-bit programmed I/O disk controller.

The machines turned out markedly different times on the Video BIOS Routine tests (with and without scrolling). This is because the PowerCache 4 uses a Chips and Technologies chip set, while the 4e's chip set comes from Tseng Laboratories and is optimized for graphics; it has a small amount of cache on the chip, and this speeds up the video function.



ENDS

day's level of CPU performance, the hard disk array remains the biggest bottleneck. The next most significant limitations are imposed by the LAN adapter and data bus; CPU power falls after all of these in the rank order of subsystems that influence server throughput. In the future, you'll run more applications on server CPUs and this order of importance will change, but today you would be wise to spend your server money buying disk, bus, and LAN adapter throughput.

UNFULFILLED PROMISES

Reconciling these results and the bus promoters' lavish promises of improved performance requires careful analysis of the technology, the claims, and today's applications.

The theoretical underpinnings of the claims are solid. Both EISA and MCA claim to move bytes faster than could ever be possible in classic-bus computers. The

claims make sense for a number of reasons. First, both buses potentially double the width of the expansion channel, from the classic bus's 16 bits to the full 32-bit capacity of today's latest microprocessors, the Intel 386 and 486. In addition, they alter the timing of the signals on the bus and the protocols used for transferring data across the bus.

The maximum speed at which classic-bus computers can transfer data between expansion boards is 16 megabits (16Mb) per second. Each transfer requires two cycles of the bus clock; the 16-bit bus can move two bytes in this period, and the typical maximum bus clock speed is 10 MHz. (Some machines offer higher speeds, but they may suffer compatibility problems with some expansion boards.) The standard 8-MHz speed of the classic AT bus yields a slightly lower 64Mb per second maximum transfer rate.

EISA preserves the 8-MHz bus speed of the classic AT bus. (Because the EISA bus is generally operated synchronously with the system microprocessor, its actual speed is usually a submultiple of the microprocessor clock; thus, 25-MHz computers offer 8.33-MHz bus speeds and 33-MHz machines offer 8.25-MHz bus speeds. These fractional differences are negligible in terms of overall system performance.)

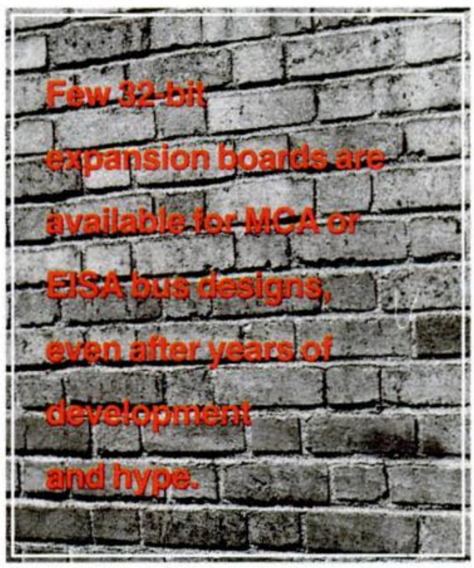
But EISA doubles the bus width, which immediately doubles the potential transfer rate (to 128Mb per second). It also includes an advanced operating mode that allows transfers to be made at a rate of one per cycle, achieving throughput rates as high as 256Mb to 264Mb per second (depending on the exact speed of the bus).

As originally conceived, the Micro Channel specification operated with 10-MHz bus cycles with a 32-bit data path and two cycles per transfer, achieving a 160Mb-per-second transfer rate. In the three years since its introduction, IBM has refined (read: changed) the MCA specification to add more transfer speed. Some 16-MHz (and potentially 33-MHz) machines can use a technique called matched memory mode, which reduces the bus cycle time by 37.5 percent and commensurately increases data transfer rate. Using a technique called streaming data mode, the Micro Channel cuts the overhead to achieve a rate of one cycle per transfer for the movement of sequential data. And by multiplexing the address bus during streaming data transfers (using the 32 address lines of the bus as data lines during the transfer), the Micro Channel offers what is essentially a 64-bit data path. Together, the one-transfer-per-cycle rate, effective 64-bit bus width, and 10-MHz cycle time yield a maximum possible throughput data rate of 80MB per second.

Look at real-world issues and the expansion products that are available today, and the claims disappear faster than spirits exposed to sunlight. For example, no available PC hardware can take advantage of the Micro Channel's streaming data modes, and only memory boards have been designed to use matched memory mode. Similarly, EISA's high-speed data transfer protocol has yet to see commercial application.

Bottom line: today the two buses have effectively the same data transfer rate, 20MB per second (assuming a 10-MHz cycle time in each case). This is, in fact, only a doubling of the transfer speed of the classic AT bus. Once you consider that precious few 32-bit expansion boards are available for either advanced bus design, one fact stands out: even today, after three years of development and hype (in the case of the Micro Channel, at least), for practical purposes you'll win no raw performance advantage by using an advanced expansion bus.

As severe as the limits today's hardware impose on the expansion bus may seem, they pale in comparison to the inherent data throughput restrictions imposed by existing hardware standards. Because of these standards, even existing PC ex-



pansion boards do not push the classic AT bus to its limits. For example, the fastest PC expansion option you're likely to install is an ESDI hard disk.

The current top throughput rate for an ESDI drive is 20 megabits per second (at 20 MHz, the latest technology). Network adapters load the expansion bus even less. For example, the fastest an Ethernet adapter can possibly transfer data is 10Mb per second. Because of Ethernet's operating overhead (messages are sent as separate packets, with dead time between to allow multiple adapters to arbitrate for network time), a real-world network cannot attain even that speed except for short, packet-length bursts. The classic AT bus as it currently exists has more than five times the bandwidth required to sustain these worst-case loads. Clearly, the bus is not the performance limit with this hardware.

BOARD PLAY

The conclusions derived from these numbers are obviously contrary to the practical experience of anyone who has plugged boards into a high-performance computer. For example, an 8-bit hard disk controller board is likely to turn in performance far worse than a 16-bit controller.

A number of factors contribute to the real-world performance difference you'll see when shifting from an 8-bit controller to a 16-bit controller. The biggest limit is imposed by the disk controller itself. If an expansion board cannot keep up with the rest of the computer system, it adds wait states to the system's operation. In fact, many system boards automatically add wait states to transfers from 8-bit expansion boards to insure that the system doesn't overwhelm the laggardly electronics of the expansion board. That's a key issue: expansion boards and not the expansion bus today create the most bothersome slowdowns in bus performance.

The Micro Channel attacks this problem head-on: you simply cannot use old, slow expansion boards in a Micro Channel computer. Instantly the speed limit imposed by old boards is broken. The penalty, of course, is that you cannot use older boards—even the quickest old boards—at all. But while you certainly won't want to plug a nine-year-old, performance-robbing serial card into a state-of-the-art 486-based PC, there are a lot of ISA expansion boards that you might want to use. Even after the three years that MCA has been on the market, the variety of boards available to fit classic-bus expansion slots is still many times greater than the number of options for MCA boards—and some rate as speed demons in their own right (for example, the ISA Diamond VGA adapter).

EISA gives you access to any old board you want to plug into your system—an option you won't want to exercise indiscriminately for performance reasons. But the capability is there.

NO ONE'S MASTER

Besides raw speed, the two new expansion bus designs also offer an advanced feature called bus mastering. The concept of bus mastering is elegant; it separates a computer's microprocessor from the expansion bus and in effect makes the chip work as if it were an expansion board itself. That puts the microprocessor and all the expansion slots on an equal footing and lets other microprocessors (or other devices, such as Direct Memory Access controllers) take direct control of the bus.

Having the microprocessor yield up control of the bus is much like having a corporate executive delegate authority to a department manager: the executive has

PERFORMANCE TESTS: EISA VS. ISA VS. MCA

PC LABS

For single DOS users there is no appreciable advantage to choosing a system other than ISA, especially when costs are factored in.

The **Dryshell Processor** test exercises integer arithmetic, character-string handling, and function calls, all of which are fundamental building blocks for commercial nonscientific applications. The program compensates for the small amount of code in the Dhrystone computational kernel by duplicating it four times and dividing the work among four copies of the Dhrystone algorithms. The test is written using 32-bit mathematical instructions to reflect the capabilities of the latest software for high-performance computers. A higher score indicates a better processor.

The **VGA Controller Throughput** test isolates the VGA Controller from the processor and measures its maximum throughput by repeatedly filling the screen with horizontal lines, rotating among 16 different colors. As with all of these throughput tests, higher scores indicate better performance.

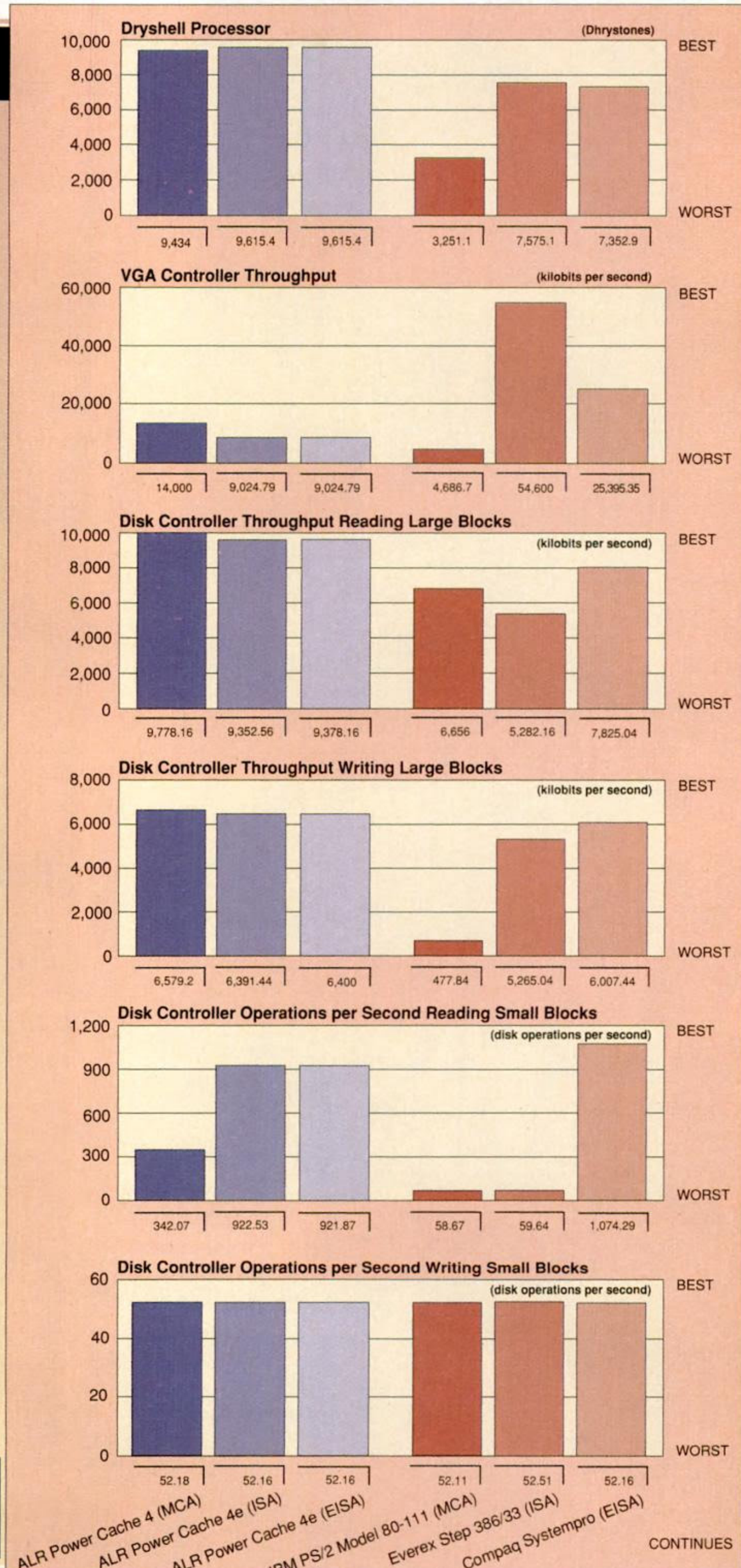
The **Disk Controller Throughput Reading Large Blocks** test reads a sequential file containing 30 blocks, where each block is a 32K record. The test, which runs for 30 seconds, minimizes hard disk latency time, minimizes hard disk seek time, and maximizes the amount of data flowing between the disk controller and PC memory.

The **Disk Controller Throughput Writing Large Blocks** test is the same as the above reading test except that this test writes the sequential file instead of reading it. Keep in mind that reading is almost always faster than writing, because writing requires the operating system to update its file allocation table (FAT) or the equivalent.

The **Disk Controller Operations Reading Small Blocks** test reads a sequential file containing 2,048 blocks, where each block is a 512-byte record, and measures the maximum number of disk operations per second. Since the low-level PC hard disk format does not permit reading or writing less than a single 512-byte sector at once, this test determines the peak number of operations per second that a disk controller can sustain.

The **Disk Controller Operations Writing Small Blocks** test is the same as the above reading test except that this test writes the sequential file instead of reading it.

CONTROL GROUP
ENHANCED MACHINES



CONTINUES

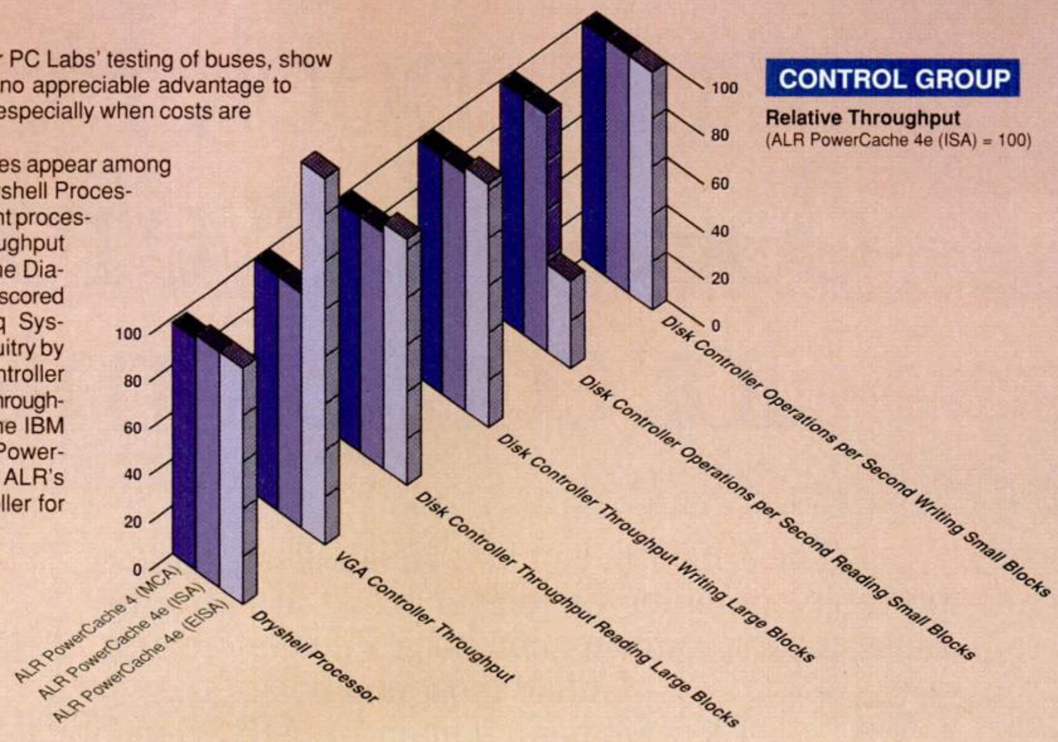
PERFORMANCE TESTS: COMPOSITE VIEW

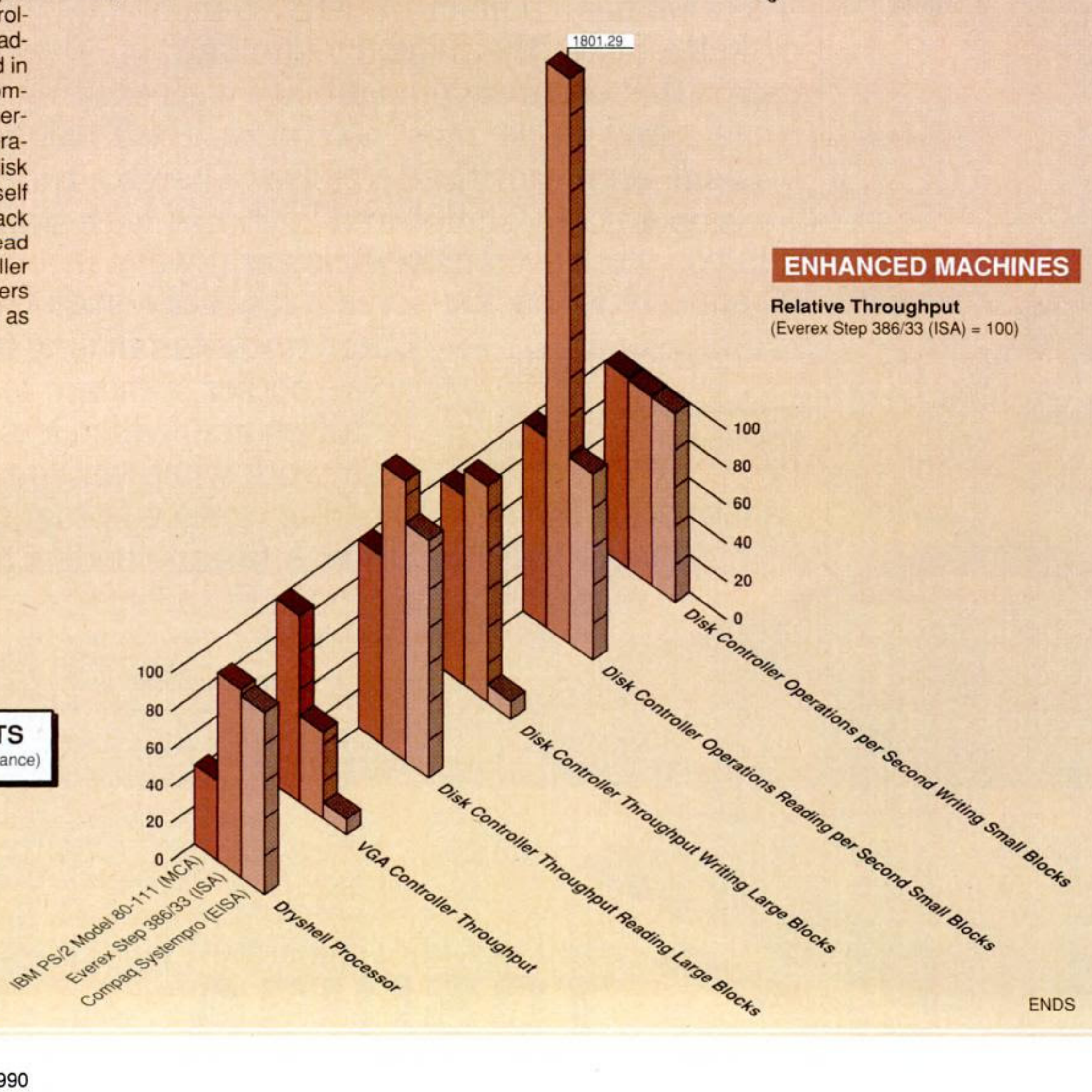
PC LABS

These tests, created specifically for PC Labs' testing of buses, show that for single DOS users there is no appreciable advantage to choosing a system other than ISA, especially when costs are factored in.

Although performance differences appear among the enhanced machines on the Dryshell Processor test, this is caused by the different processors. On the VGA Controller Throughput test, the Everex Step 386/33 with the Diamond SpeedSTAR Video Controller scored impressively, besting the Compaq Systempro's integrated 16-bit VGA circuitry by 115 percent. In fact, Diamond's controller achieved more than eleven times the throughput of the 8-bit video controller in the IBM PS/2 Model 80. The gap in the ALR PowerCache 4 and 4e results is caused by ALR's optimization of the 4's video controller for graphics, which is what our tests stress.

Most hard disks rotate at 3,600 rpm (60 revolutions per second), which means that without any assistance from disk-caching schemes, the maximum possible performance is 60 operations per second. Since the Disk Controller Operations per Second Reading Small Blocks test resulted in far higher scores for the Compaq Systempro and ALR PowerCache 4e (roughly 1,000 operations per second), either the disk controller or the disk drive itself reads and caches a full track whenever the first sector is read from the track. Disk controller and disk drive manufacturers typically refer to this method as track buffering.





THROUGHPUT TESTS
(Taller bars mean better performance)

ENDS

NETWORK BENCHMARK TESTS: EISA VS. ISA VS. MCA

PC LABS

All of our work in preparing this article convinced us that for up to 12 workstations, the best value for your investment in servers lies with ISA.

The **Network Adapter Throughput** test measures the throughput of the network adapter when installed in a node. The tested machine's network adapter card is bombarded by very large blocks of data that are sent across the LAN by three other 386 ISA PCs. Novell's *NetWare* 2.15 IPX (Internet Protocol Exchange) with Novell NetBIOS emulation provides the software underpinnings for this test.

The **Network Throughput Under Load** test loads network cards, media, and access protocols but places a small load on the server. While the timed station transfers files, load stations read and write 1-byte data files, creating a high volume of data packets and increased activity on the network.

To obtain the Network Throughput Under Load figures, we run a general test program performing a sequential create, a sequential read, a sequential write, a random read, and a random write of a large file. The record sizes used in these activities systematically rotate among 16K, 4K, and 512 bytes. Usually a 1MB file is used, but this size may be adjusted for unusually fast or slow networks.

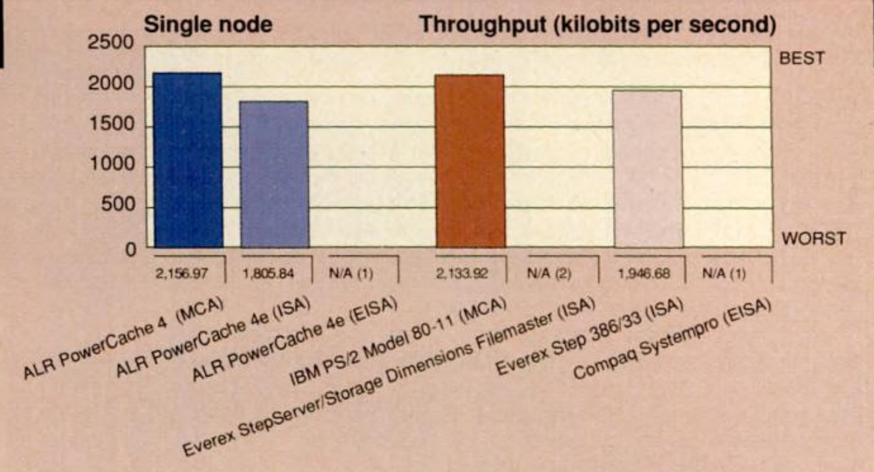
While the general test program is run, we load the network with the Network Throughput Under Load program. The results shown represent the average throughput over a period of time sufficiently long to ensure consistency.

CONTROL GROUP
ENHANCED MACHINES

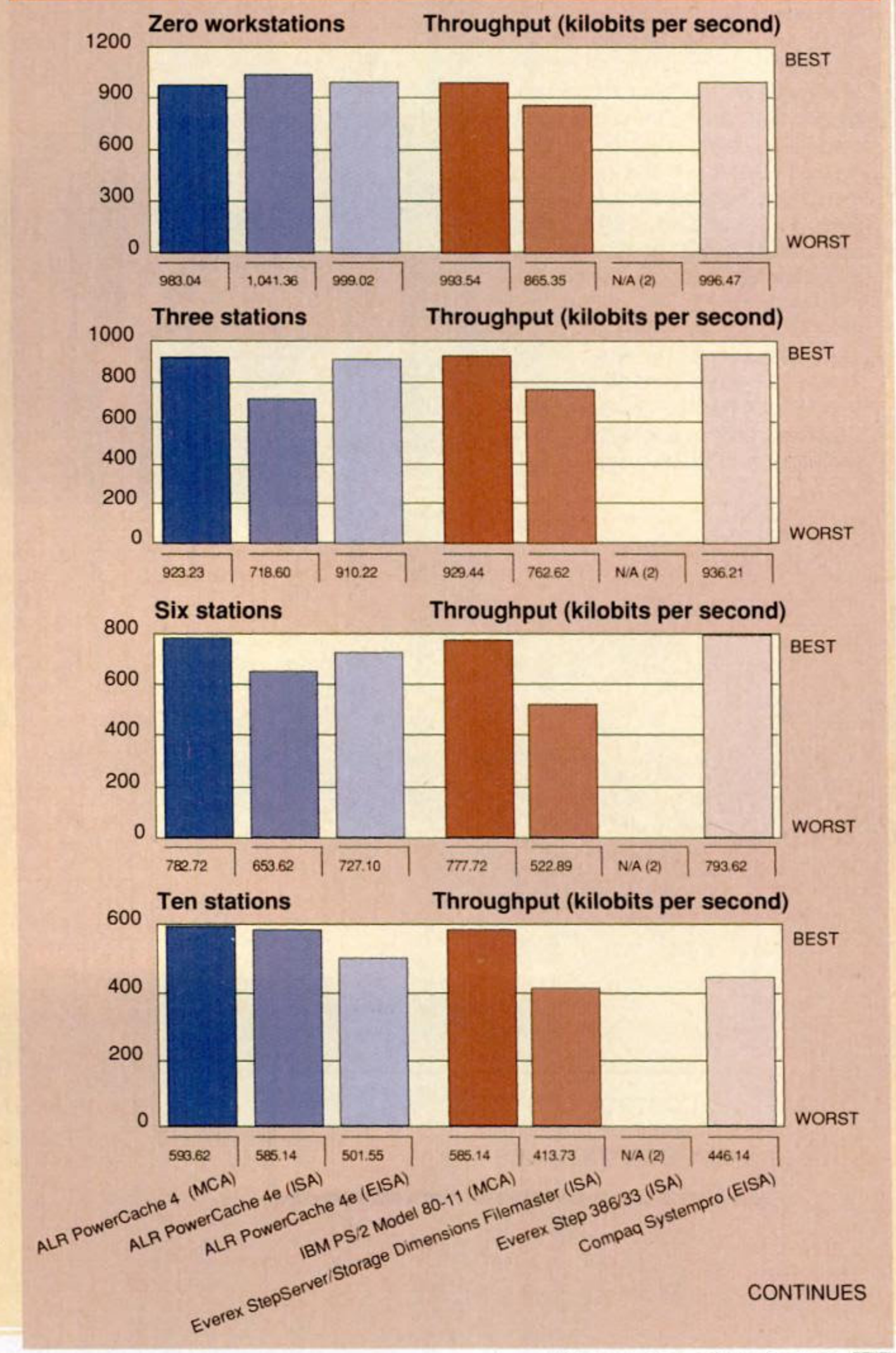
N/A (1)—Not applicable: this configuration could not complete the test.

N/A (2)—Not applicable: this configuration was not used for this test.

NETWORK ADAPTER THROUGHPUT



NETWORK THROUGHPUT UNDER LOAD



CONTINUES

NETWORK BENCHMARK TESTS: COMPOSITE VIEW

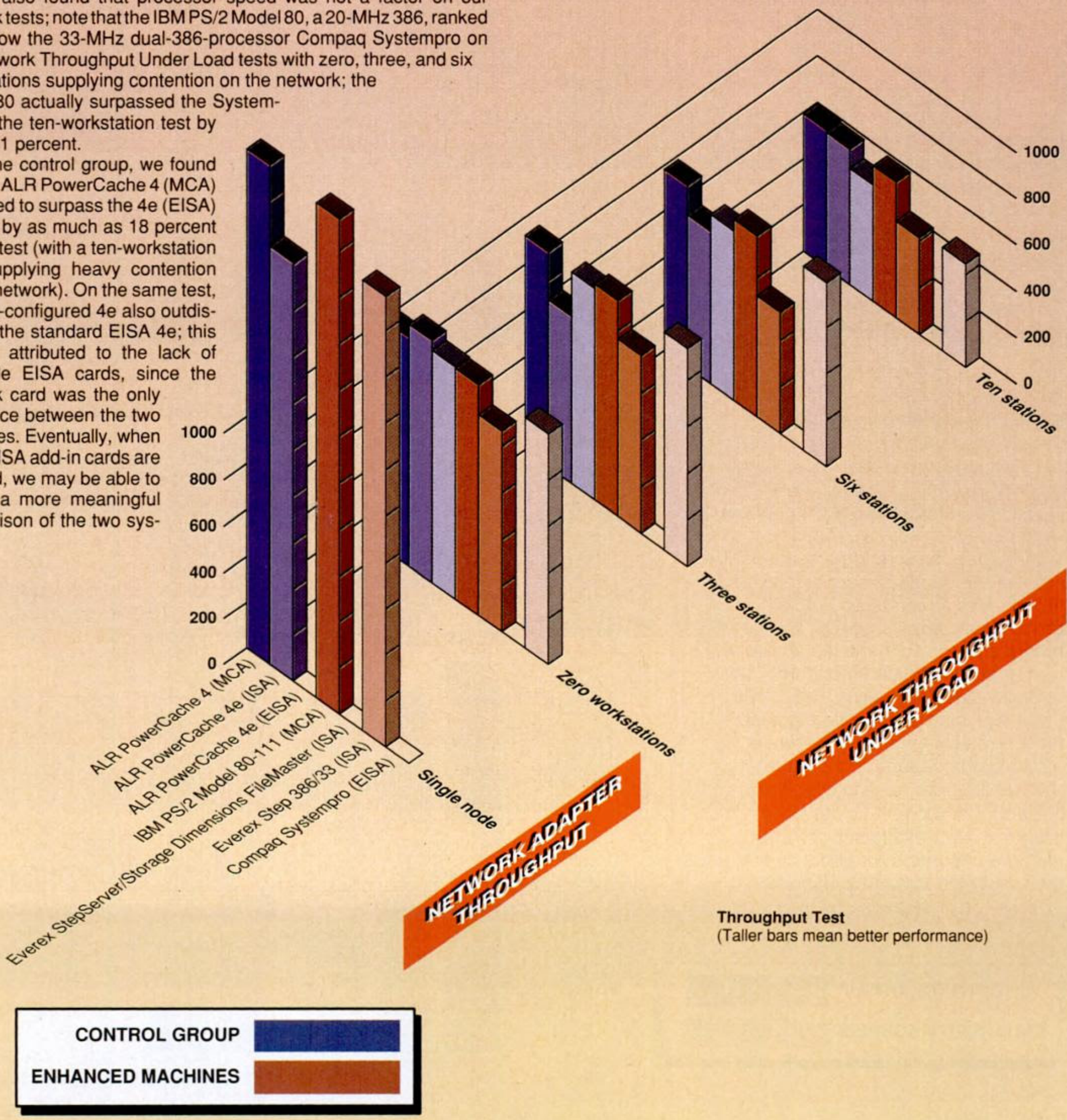
PC LABS

In evaluating bus technology for network servers, we took into account not only the test scores but the cumulative experience of PC LAN Labs and our team of reviewers. We are convinced that for networks with up to 12 workstations, EISA and MCA offer no significant advantage over ISA to offset their extra cost. When going to larger networks you will start to see the benefits of these newer architectures, as foreshadowed by their scores on some of the performance tests. It is also likely that EISA throughput will eventually improve as more boards become available.

We also found that processor speed was not a factor on our network tests; note that the IBM PS/2 Model 80, a 20-MHz 386, ranked just below the 33-MHz dual-386-processor Compaq Systempro on the Network Throughput Under Load tests with zero, three, and six workstations supplying contention on the network; the Model 80 actually surpassed the Systempro on the ten-workstation test by about 31 percent.

In the control group, we found that the ALR PowerCache 4 (MCA) managed to surpass the 4e (EISA) system by as much as 18 percent on one test (with a ten-workstation load supplying heavy contention on the network). On the same test, the ISA-configured 4e also outdistanced the standard EISA 4e; this can be attributed to the lack of available EISA cards, since the network card was the only difference between the two machines. Eventually, when more EISA add-in cards are shipped, we may be able to supply a more meaningful comparison of the two systems.

In our Network Adapter Throughput test, where the machines were configured as nodes on a network rather than servers, we were not able to report results for the PowerCache 4e for lack of an Ethernet EISA card that could complete our tests. Thus, we were looking at just two computers in each group, but the results may be revealing. The MCA machine outpaces its ISA competitor by a margin of over 19 percent for the control group and nearly 10 percent for the enhanced machines.



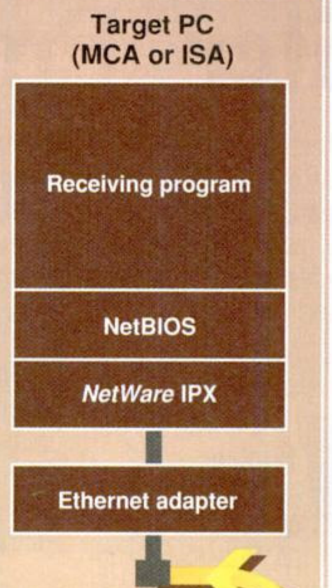
ENDS

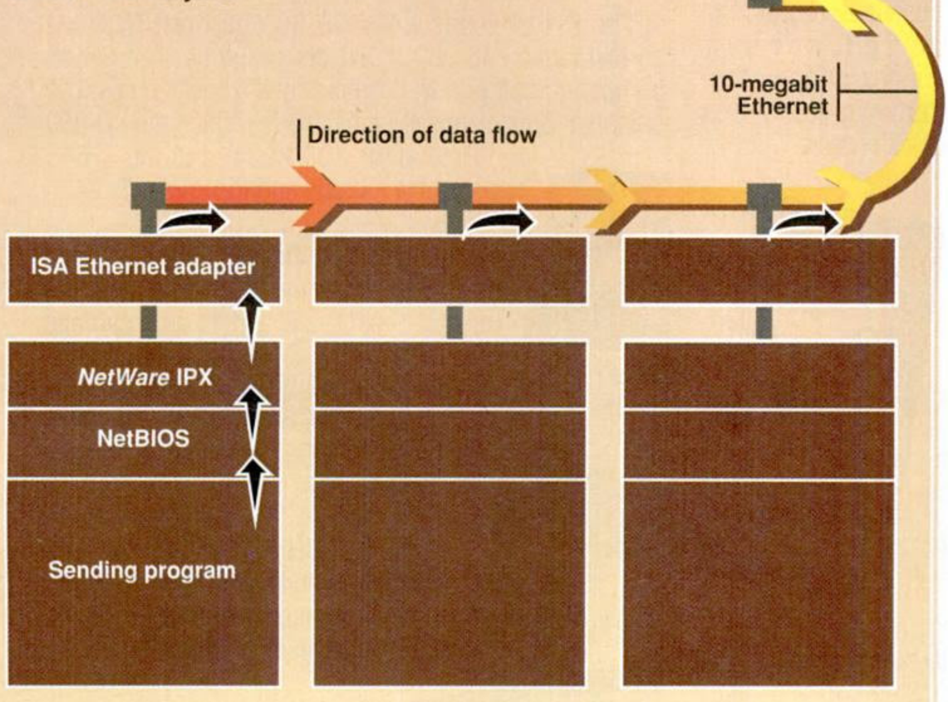
BOMBARDING THE BUS: THE TESTING PROCESS

PC LABS

The Network Adapter Throughput test is a good measure of a PC's ability to operate in a network environment. If you invest in a high-end EISA or MCA machine the chances are you'll use it as a server.

In this test, the PC operates as a node on a network. Copies of the sending program running in three Compaq Deskpro computers bombard the target PC's LAN card with packets of data. The receiving program in the target PC takes the data from the LAN card as quickly as possible, allowing it to receive additional packets. This setup, intentionally bereft of accesses to other devices, isolates the LAN card in the target PC and measures the throughput of the LAN card and its supporting driver.—**Ben Myers**



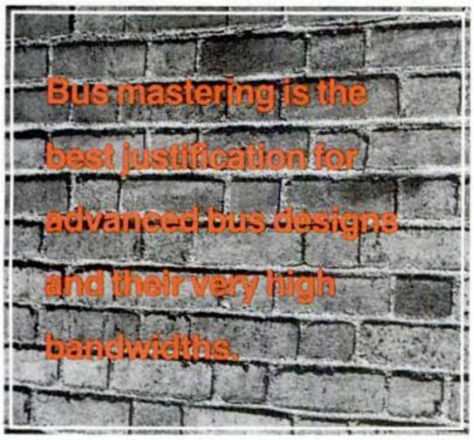


Source PCs (Compaq Deskpro 386/25s)

more time to take care of other work. Relieved of the responsibilities of bus control, the microprocessor in a bus-mastering system has the potential to carry out its functions faster. Moreover, the mastering design allows many separate but equal (or even unequal) microprocessors to be plugged into expansion slots. Such designs can theoretically offer multiprocessing and parallel processing inside the chassis of a single PC. With several microprocessors passing data around, an increased bandwidth is called for, probably more than the classic AT expansion bus can supply.

Bus mastering is thus the best justification for the existence of advanced bus designs and their very high bandwidths. Unfortunately, the number of Micro Channel bus-mastering expansion boards available today is minuscule, particularly when you consider how long Micro Channel computers have been available. This scarcity presumably stems from several causes. Bus-mastering expansion boards are inherently more complex and difficult to design. Soldering some components to a sheet of glass epoxy is just not enough. Bringing a bus master to life also requires programming expertise to develop the software that controls its operation.

The market for bus-mastering expansion boards is also small, giving board developers less incentive to develop new products. The total installed base of Micro Channel computers in the United States is



about 3 million—versus around 23 million classic-bus computers. As we go to press, the installed base of EISA computers numbers in the thousands.

Even if you should find and buy a bus-mastering expansion board for your computer, you're apt to be disappointed. You won't see much of a performance difference. DOS and bus mastering are contrary concepts. DOS harks back to the days when it was amazing that a personal computer could do even one thing at a time. DOS forces programs that execute under it—which means every one of the significant PC applications you can buy today—to serialize all of their input and output operations. All the data that's pushed across the expansion bus has to march under the gun single file.

WHITHER TECHNOLOGY

Notwithstanding all of the above arguments, advanced bus designs are not the work of the devil. Nor are they a fraud foisted off on unsuspecting users by snake-oil salemen. They do offer a substantial technological leap ahead of the classic AT bus—which means that a very limited quantity of current software and expansion hardware can take advantage of them.

Just remember that the classic AT bus is far from dead, and it remains a viable option for expansion, with the possible exception of high-end networks. While you won't be disappointed in the performance of either an EISA or Micro Channel personal computer, an ISA machine will do the job just as well and with far broader industry support and hardware options.

If you're opting for the most cost-effective high-performance strategy with today's DOS or smaller LANs, your best bet is to stick with the classic AT bus; as for the additional $1,000 to $2,000 you'd have paid for an advanced-bus computer, you can invest it in memory. Use the extra RAM as a software disk cache; you'll see more of a performance increase than you would get with the most advanced bus-mastering disk controllers, even those with a hardware cache. Should you change over to an advanced operating system, those extra bytes of RAM won't be wasted.

If you're in the market for a network server, even a 12-MHz 286 computer will deliver adequate performance, assuming that your LAN does not include more than a dozen workstations. (Strange as it may seem, you're likely to need more processor power in workstations than in the server!) Remember, *NetWare 286,* Version 2.15, runs in protected mode, so the advantage of using *NetWare 386* is small (about 10 to 15 percent in PC LAN Labs' testing).

Large networks are another story. Along with multisystems—multitasking, multiuser, and multi-microprocessor computers—large networks benefit from the new bus designs. The software you need to tap that performance has been slow in arriving, but software has to come of age sometime. Even small networks will someday need more server power as more system functions are run on the server. When network monitoring, managing, or communications software lives on the server, you'll need all the processor power you can get.

Next on the PC Labs Bus Wars agenda is a test of the three bus architectures running under OS/2 and Unix, providing you with the picture outside the DOS world. By the time we finish, EISA may have done some growing, so that we can cross off the unavailability of boards from its list of troubles. For now, stop kicking yourself for not investing in the new and improved architectures for a single-user DOS environment. You can do without the bruises, and so can your wallet. ■

Winn L. Rosch is a contributing editor of PC Magazine. *Ben Myers is an owner of Spirit of Performance Inc., a Harvard, Massachusetts–based firm specializing in benchmark tests and performance measurement.*