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EDP: Choices in Personal Computer Technology

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Choices in Personal Computer Technology

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In 1987 IBM introduced its newest family of personal computers, the PS/2. The PS/2 series was described by IBM as larger, faster, and more reliable; it was named by IBM's competitors – a "clone killer." It was said to be IBM's response to the legion of compatible machines that had eroded its share in the PC market. Unlike the PC, which could be built using "off-the-shelf'" parts, the PS/2 included new technology and design concept which reduced the level of "plug compatibility." One of the most significant changes was the introduction of the Micro Channel Architecture, which replaced the traditional Industry Standard Architecture.

Now, four years after the introduction of the PS/2, the debate continues over the relative merits of the PS/2's Micro Channel Architecture (MCA) versus the traditional Industry Standard Architecture (ISA) which is found in older PCs such as the PC, XT and AT, and in most IBM clones. This article discusses the differences between the Micro Channel Architecture and the Industry Standard Architecture and the merits of each. It then provides guidance to readers in the selection of an architecture that may best fulfill their processing needs.

MSA vs. ISA

One of the principle differences between systems making use of the Micro Channel Architecture and those that use the Industry Standard Architecture is the design of the bus. In a microcomputer, the bus is the component that ties the system together. Functioning like a roadway, it connects the microprocessor to internal memory, auxiliary storage devices, and input and output devices; and controls the flow of data to and from these components. In the first PCs it worked like an old country road, relatively unreliable and slow, sending data serially, bit by bit. Design enhancements increased the amount of data that could be passed using the bus and the rate at which data transfer could occur. Over the years, buses have gone from being "country roads" to eight, sixteen and even thirty-two bit "super-highways."

Performance differences between MCA and ISA machines result largely from differences in bus design which involve bus width and data transfer speed. Bus width describes the number of bits of data that can be transferred in parallel. The wider the bus the greater the amount of data that can be transferred simultaneously, and the faster the machine. ISA buses have been typically 8 or 16 bit buses, meaning that either 8 or 16 bits of data, the equivalent of one or two characters, may be transferred at the same time. In MCA machines, buses have doubled in size. With this new architecture, 32 bits or four characters may be transferred together.

Another factor that distinguishes MCA/ISA architectures is data transfer speed. The top speed at which classical PC/ISA computers transfer data is 16 megabits (16Mb) per second. The timing of data transfer is controlled by the operation of the bus clock, with the maximum bus clock speed being 10MHz. The classic AT/ISA bus has a standard speed of 8MHz which produces a transfer rate of 64Mb per second.

The MCA bus achieves improved transfer rates by introducing a new technique called data streaming, which is used in conjunction with multiplexing. In data streaming, the bus is dedicated to sending larger bursts of data between two components. Data streaming allows MCA machines to transfer data at an improved rate of one cycle per transfer. Processing overhead is further reduced by multiplexing in MCA machines. By multiplexing the address-bus during data streaming transfers, the MCA bus can be made 64 bits wide. Altogether, the one transfer per cycle rate, the 64 bit bus width and the 10MHz cycle, give MCA machines like the PS/2 a maximum possible throughput data rate of 80Mb per second. These are significant performance gains, both in the amount of data that can be transferred and the speed at which data transfer occurs.

In a move to counter the perceived market advantages of MCA, the Extended Industry Standard Architecture (EISA) was announced in 1988 by the so-called "Gang of Nine." This group, led by Compaq, includes AST Research Inc., Epson America, Hewlett-Packard Co., NEC Corp., Ing C. Olivetti & Co., Tandy Corp., Wyse Technology, and Zenith Data Systems. EISA was designed to provide features similar to those of MCA and to support "backward" compatibility, allowing ISA boards to be used in EISA machines. To date, however, the Extended Standard Industry Architecture has not gained a significant share of the market place, the installed base of EISA machines numbering only in the thousands. There is no available software (such as OS/2 for MCA machines) currently exploiting this technology nor are there any expansion boards on the market that capitalize upon this system's enhancements. While EISA in the future may be a technological alternative to MCA, this article focuses only upon MCA and ISA technology which are used in machines that today represent a significant market share.

Potential of MCA

System control is a feature which has been redefined in the MCA machine. In the older ISA machines the microprocessor performs all control functions. It manages everything that is going on in the machine and also sets the limits. It works in a serial fashion, processing one job after the other. Other components can do nothing without it and therefore are constrained by the speed of the microprocessor. This limitation has affected the speed of data transfer across the ISA bus. MCA machines have borrowed control concepts from mainframe computers. With the Micro Channel Architecture, the microprocessor and bus have been broken into separate subsystems, thereby allowing the overlapping of data transfers with other functions. Instead of being controlled by the microprocessor, the bus is now commanded by a series of several devices called bus masters. These bus masters move data across the bus from one component to another.

Another concept new to the MCA environment is that of bus slave. As the name implies, the bus slave responds to the commands of the bus master, sending and receiving the data that the bus master requests. A bus slave functions like any ordinary component in the PC environment. MCA machines are designed to support up to 15 bus masters/bus slave combinations. Their operation is controlled by a special system circuitry called the central arbitration point or CAP. If a bus master wants to take control of system communication, it must signal the central arbitration point (CAP). If the component has priority, it is defined as the controlling bus master and becomes the owner of the expansion bus and necessary components. Thus the Micro Channel Architecture approaches the data channel/priority interrupt capabilities found in mainframe computers – features which support a multitasking environment.

Performance in MCA machines is enhanced in several ways using the bus master. First, bus speeds are not limited by the speed of the microprocessor, as in ISA machines. In addition, MCA machines provide cache memory (limited, high-speed memory which holds data that is being moved across the bus). The bus, by using cache memory, may execute input and output operations without interrupting the processing of other components. The use of cache memory introduces the concept of parallel processing to the MCA environment.

In many ways the designers of the Micro Channel Architecture have borrowed processing concepts from the mainframe environment. Multitasking (accomplished using bus master/bus slaves) and parallel processing (done using cache memory) are common approaches in today's mainframe environment. The incorporation in the Micro Channel Architecture has resulted in the design of a machine that is significantly more powerful than its predecessors.

The Pros and Cons of MCA

MCA machines have several distinct performance advantages when compared with older ISA machines. First and foremost, their physical design supports faster operation. They allow larger bus widths, up to 64 bits, and have reduced the number of cycles required to transfer data from 2 to 1. In addition, MCA buses experience far less electromagnetic interference than ISA buses. This electromagnetic interference limits bus speed in classic, ISA-bus computers. Currently, MCA machines can operate up to 25% faster than AT machines. It is anticipated that with technology defined, but not yet implemented, gains of up to 800 percent will be realized.

Introduction of mainframe approaches like multitasking and parallel processing in the MCA design has increased significantly the throughput potential. Multitasking, which permits multiple jobs to be run at the same time, is accomplished by the bus master. The bus is no longer under the control of the microprocessor, as it is in ISA machines, but operates independently under the control of one of the 15 possible bus masters. Since the microprocessor is freed from the burden of data handling, it can now be used to execute other jobs. The use of cache memory also supports parallel processing of data. It allows for the queuing of data that is being sent or received. By doing this, a job's input or output operations can occur while processing is also going on and processing is not slowed by the system waiting to receive or send data over the bus.

The techniques of multitasking and parallel processing can give rise to significant performance gains. When IBM developed the MCA architecture, it was clear that the existing DOS environment was incapable of exploiting the power of the new hardware and did not support multitasking. Thus, IBM introduced a new operating system OS/2, which was designed to take advantage of the power to MCA technology. However, conversion to OS/2 requires a considerable investment of time, system skills, and money. Many PC users were reluctant initially to make that investment. The rate of conversion to OS/2 has been further reduced by the very successful introduction of "Windows," which has been seen by many as a way of getting "some of the benefits" of multitasking without having to pay the price for moving totally into the OS/2 environment.

Currently the techniques of multitasking and parallel processing still don't make much of a difference in systems performance under DOS. This is because new software and expansion boards are only now being developed that take advantage of these capabilities. In most instances, MCA machines are still being run under DOS. Since DOS is a single task operating system, even if multitasking capabilities are available in the hardware, the operating system software can not make use of them. Similarly, MCA machines do not make full use of parallel processing. Although this is a technique that will increase the throughput of data by the system, data throughput is not a problem with today's systems and expansion boards, since the current capacity of the older AT bus exceeds that of most expansion boards. Therefore the performance of microprocessor components such as the hard disk controller or the LAN adapter are not constrained by performance of the ISA/AT bus.

The Current Computing Environment

Today, only multiuser systems – networks and workgroup computers –

exploit the power that is made available using techniques like multitasking and parallel processing. Most single-user system requirements are already being met by the classic Industry Standard Architecture.

The MCA machine is designed to be potentially more reliable than its predecessors, functioning far longer without system failures and being easier to repair if system failure occurs. This can translate into substantial savings on repair costs, and less down-time when the computer is unavailable. Real-life reports, however, contradict proclaimed improvements in system reliability. PC Labs have recently evaluated the reliability of MCA systems. Testing shows that, for the most part, failures are not related to defects in MCA specifications, but to the inability of peripheral manufacturers to follow these specifications. Thus, while problems do not exist with the basic machinery, but problems continue to plague the expansion boards.

Connectivity is another major difference between ISA and MCA machines. On ISA boards there are .10 inches between contacts, while on MCA boards there are .05 inches. This means that older ISA expansion boards cannot be used in MCA machines. Thus, the Micro Channel Architecture foregoes all hardware compatibility with older machines and promises software compatibility only with ISA/AT computers. The MCA design has rearranged functions, as well as added new functions to enhance system operation. The cost for improved performance is paid by the user who is unable to transfer boards from older machines into the PS/2. And, although all major features are now available on MCA-compatible boards, the number of available ISA-compatible boards is many times greater than the number of MCA-compatible boards.

Another consideration separating MCA and ISA machines is cost. Although IBM does not disclose the cost or nature of its licensing agreements, costs can range from nothing (if cross-licensing agreements exist) to as much as 5 percent of the price of the finished computer. Today, manufacturers of IBM clones that incorporate MCA technology are harder pressed to compete only on cost, given the existence of these licensing fees and reported compatibility problems. MCA computers range in base price from approximately $5,000 to $12,000. This cost is approximately $1,000 to $2,000 more than the classic ISA/AT computer. It is also unlikely that manufacturers of MCA expansion boards will beginning deep discounts. The manufacture of boards for the classic machines is still more profitable.

Today's Acquisition Decision

Today, the microcomputer user is faced with the decision to invest in older, "tried-and-true" technology or move on to something "bigger-and-better." If this decision is made solely on the basis of hardware capability, the new MCA technology will be a sure winner. Theoretically, using an increased band width, reduced cycle time, bus master control, and cache memory, it should be no contest – the MCA computer is a faster machine that can support multiple users. In actuality, however, the ability of the MCA computer to realize these goals is limited by the availability of operating system software and bus mastering boards, that can be used for multitasking and parallel processing in the MCA environment. Both the system software and boards are inherently more complex and require a larger investment to develop. With the current MCA market only about 1/8 the size of the ISA market, there is less incentive to develop products that will cause the benefits of a Micro Channel Architecture to be realized.

The effects of this lack of support were driven home in the results of tests conducted by PC Labs in New York and PC LAN Labs in Florida in June 1990. This series of tests compared the operation of ISA and MCA machines in the performance of a variety of computing chores. Tests were developed to represent current PC environments: single user PCs running DOS and network servers using Novell's NetWare. Results of these tests showed that in a single user DOS environment there is no real difference in speed between ISA and MCA machines and if cost is factored in, ISA is the better choice. With today's applications and limited software/hardware support, the choice of bus makes no difference in overall system performance.

This conclusion holds true in the single user environment and the multiuser environment. Both ISA and MCA machines can be used in networks, as file servers, with up to 12 other workstations and still there are no performance differences. Performance differences between machines occur when they are used in larger LANs (more than 12 workstations). In this environment, a more sophisticated bus design can make a difference in performance. But, for the MCA machine to be a winner, it must be supported by the additional bus mastering expansion boards that take advantage of its high-performance features.

In the final analysis, MCA systems are technically superior, designed to meet high-speed, high-volume processing needs. Yet, to fully realize this technical superiority, a significant additional investment must be made in both hardware and software. In most instances, current user processing requirements are not so demanding as to justify this investment. Thus, unless an organization opts to install the more powerful operating system environment, traditional ISA technology remains a satisfactory alternative to more advanced MCA systems.

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