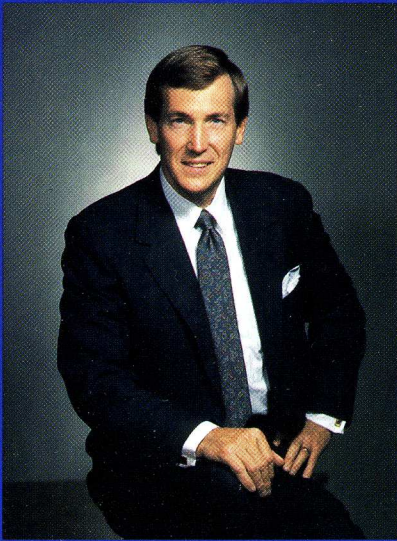


IBM



AIX



Welcome to **AIX**—a comprehensive source of information about IBM's Advanced Interactive Executive (AIX™) operating system.

In **AIX** you'll find a definitive discussion of the AIX operating system and all the related industry issues. You'll read about IBM's strong commitment to AIX and the strategy that is driving our commitment. You'll also find an overview of current AIX features, a summary of the evolution of AIX, and a look at AIX trends for the 90s.

In addition, you'll learn about the relationship between AIX and IBM's Systems Application Architecture (SAA) and our support of open systems as well as the key academic and business partnerships that IBM has formed as part of our ongoing development of AIX.

And, through a series of customer profiles, you'll find examples of the many advanced application solutions that AIX already supports in a broad range of industries.

AIX is a valuable resource of authoritative information on IBM's AIX operating system. I invite you to read it and share it with your colleagues and customers.

A handwritten signature in cursive script that reads "George H. Conrades". The signature is written in dark ink on a white background.

George H. Conrades
IBM Senior Vice President
General Manager, U.S. Marketing & Services
International Business Machines Corporation

AIX: An Idea Whose Time Has Come

IBM's Advanced Interactive Executive (AIX) operating system represents a major new opportunity for the company and its customers. Never before has a single vendor established such a robust, well-supported version of the UNIX operating system across such a wide range of systems, from desktop computers to one of the industry's largest commercial processors.

The Advanced Interactive Executive: A New Dimension of IBM Leadership 4

Millions of customers choose computer systems designed and built by IBM. Now customers who want systems with a UNIX operating system can get the best from IBM, too.

Exhibiting Commitment 6

Did IBM really display 10,000 square feet of networked AIX solutions at the 1988 UNIX EXPO? See for yourself.

"IBM's Unix" 10

Here's what respected industry analyst Judith S. Hurwitz says about AIX in Patricia Seybold's *Unix In The Office*.

The Booming Opportunity for AIX — And What's Behind It 12

The market for derivatives of the UNIX operating system is growing faster than the computer market as a whole. Here are the reasons why.

Portability, Scalability, and Interoperability 14

If you want open systems, you want the unmatched portability, scalability, and interoperability of AIX.

Is IBM Serious About AIX? Absolutely. 15

Those who doubt IBM's commitment to AIX are ignoring obvious evidence — and IBM's own history.

IBM'S AIX Strategy

The AIX operating system establishes a new standard for versions of the UNIX operating system. AIX also breaks new ground by embracing a family of major IBM hardware platforms — the PS/2, the RT, and the System/370. The driving force behind both these major advances: meeting customer needs.

IBM's AIX Strategy 20

AIX combines IBM's established expertise in operating system design, hardware architecture, and distributed network computing.

AIX PS/2 23

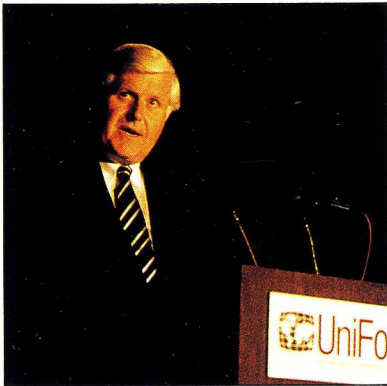
AIX PS/2 is the solution for customers seeking an entry-level multi-user, multi-tasking virtual memory operating system for IBM 386-based PS/2 computers.

AIX/RT 24

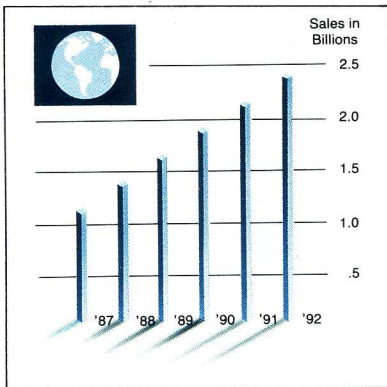
AIX/RT is ideal for customers seeking a multi-user, multi-tasking system or a technical workstation, with advanced graphics capability and additional data storage capacity on a mid-range system.

AIX/370 25

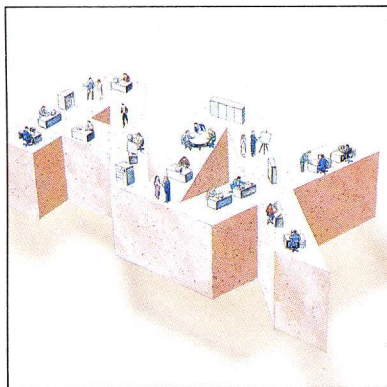
AIX/370 is the answer for customers seeking a version of the UNIX operating system with the computing power and data storage capabilities of IBM S/370 systems.



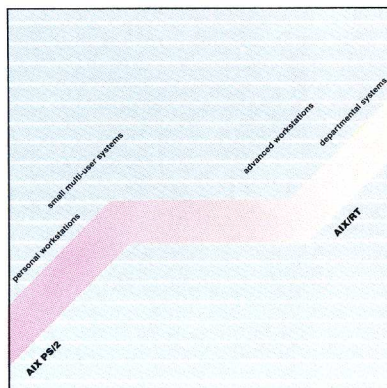
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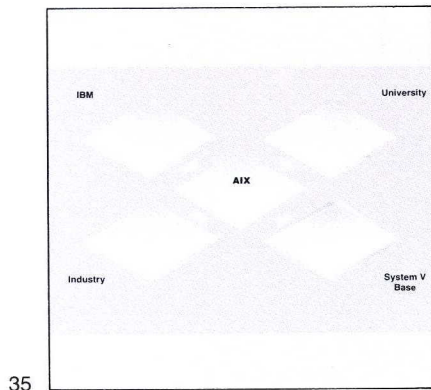


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T A B L E O F C O N T E N T S



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The AIX Family Definition 26

The AIX Family Definition establishes a common environment across the PS/2, the RT, and System/370 computers.

AIX: Extending the Power of the UNIX Operating System 28

AIX introduces new features, functions, and enhancements to the UNIX operating system, especially in the realm of distributed network computing.

“TCF: A Distributed Model” 33

Here’s what Patricia Seybold’s *Unix In The Office* says about AIX’s Transparent Computing Facility.

This is A Manual People Will Read 34

AIX documentation has set new standards for clarity and ease of use.

The Evolution of AIX 35

AIX is the culmination of two decades of evolution, resulting in the most robust, adaptable derivative of the UNIX operating system yet.

More Than Just An Operating System 39

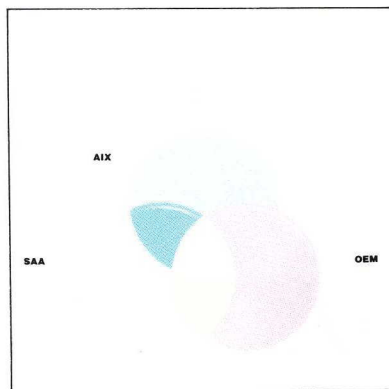
The UNIX operating system may be the only system of its kind that comes with a new philosophy and style of programming.

AIX Faces The Future 40

Larry Loucks, Director of Software Architecture, IBM Entry Systems Division, shares his views on AIX trends for the 1990s.



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P A R T T H R E E

New Roles, New Relationships

The emergence of AIX as an IBM computing environment is a major development for IBM and its customers. The impact of this development on IBM includes broad participation in open systems and standards efforts, and important new relationships with computer industry innovators in the public and private sectors. These changes are already resulting in benefits for IBM’s customers, who enjoy a richer set of choices for meeting their computing needs.

AIX and IBM 46

AIX joins Systems Application Architecture (SAA) as an IBM strategic computing environment. AIX and SAA represent complementary strategies that together will meet customer needs more effectively than ever before.

AIX and Open Systems 48

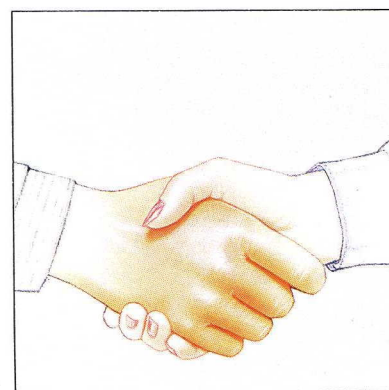
IBM has made AIX compatible with all major derivatives of the UNIX operating system. IBM is a sponsor of the Open Software Foundation and is a full participant in efforts like the IEEE’s POSIX and X/Open.

IBM’s AIX Partners 52

IBM has forged alliances with major universities and leading technology companies to make AIX the best it can be.

Everybody Agrees On X 53

The X Window System, a graphical windowing system developed at MIT and included in AIX as X-Windows, has won the support of most major computer companies.



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P A R T F O U R

AIX At Work

The true test of any operating system is how it performs on the job. IBM customers have been working with AIX on the RT since 1986; through joint development and study projects, selected IBM customers have put AIX to work on PS/2 and System/370 processors as well. On all three platforms AIX is delivering the benefits of the UNIX operating system in a powerful package that includes IBM innovation, service, and support.

AIX Goes to the Office — and the Laboratory, the Publications Department, the Repair Shop 56

AIX is going to work in hundreds of applications, from the executive suite to the garage down the street.

Meeting the Chip Design Challenge: AIX at Intel Corporation 57

The world's most profitable maker of microprocessors is using AIX to help design the follow-on to its power-packed, super-popular 386 microprocessor chip.

One Good Architecture Deserves Another: AIX at Skidmore, Owings & Merrill 60

An international architectural design firm chooses AIX to leverage the value of its people, its capital, and its information.

Smooth Sailing For Technical Publications: AIX at Newport News Shipbuilding 63

A top U.S. shipyard publishes scores of manuals for the high-tech vessels it designs and builds for the U.S. Navy. AIX is helping streamline the publications process.

Making TRACS: AIX at Work for Genuine Parts Company 66

The largest U.S. distributor of aftermarket auto parts is helping its customers enter the information age with AIX on the PS/2.

P A R T F I V E

Additional Information

AIX Resource Guide 70

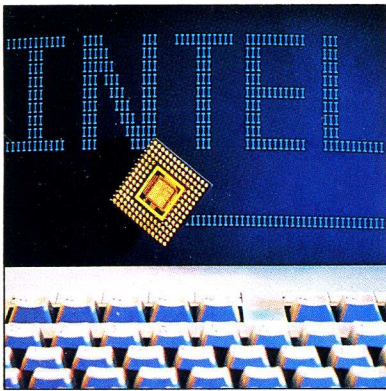
IBM provides a host of AIX-related courses and publications for people inside and outside the company.

AIX Glossary 72

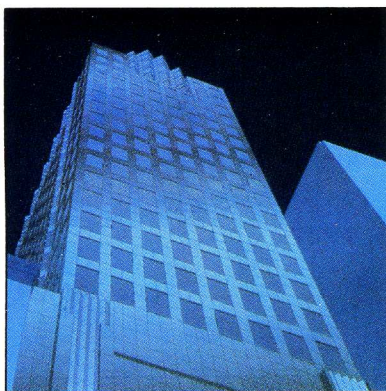
This helpful collection of definitions includes an illustrated explanation of the basic structure of UNIX operating systems.

Index 80

Can't find that name or idea you remember reading about? Look it up in the index.



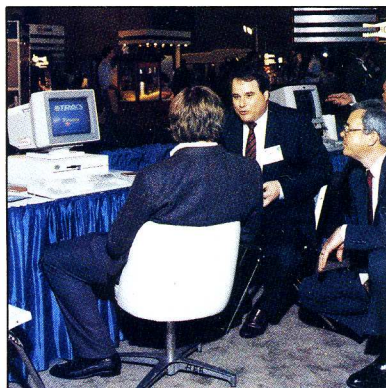
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Welcome to AIX.

PART ONE

AIX: An Idea Whose Time Has Come

International Business Machines Corporation's (IBM®) Advanced Interactive Executive (AIX™) operating system represents a major opportunity for the company and its customers. Never before has a single vendor established such a robust, well supported version of the UNIX® operating system that spans IBM's range of processors. That range includes 386™ microprocessor models of the Personal System/2® (PS/2®), the RT® system, and the complete line of System/370™ (S/370) mainframes.

Part One of AIX demonstrates that AIX is indeed an idea whose time has come. "A New Dimension of IBM Leadership" provides an overview of the major issues treated throughout AIX, and includes a review of AIX by a respected industry observer. "The Booming Opportunity for AIX and What's Behind It" explores the growing popularity of UNIX operating systems. "Is IBM Serious About AIX? Absolutely." gives abundant evidence that IBM is committed to AIX, and to its AIX customers, for the long term.

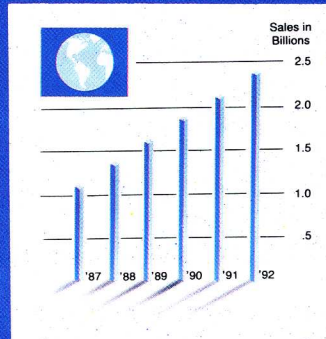


IBM has spared no expense in its commitment to AIX.



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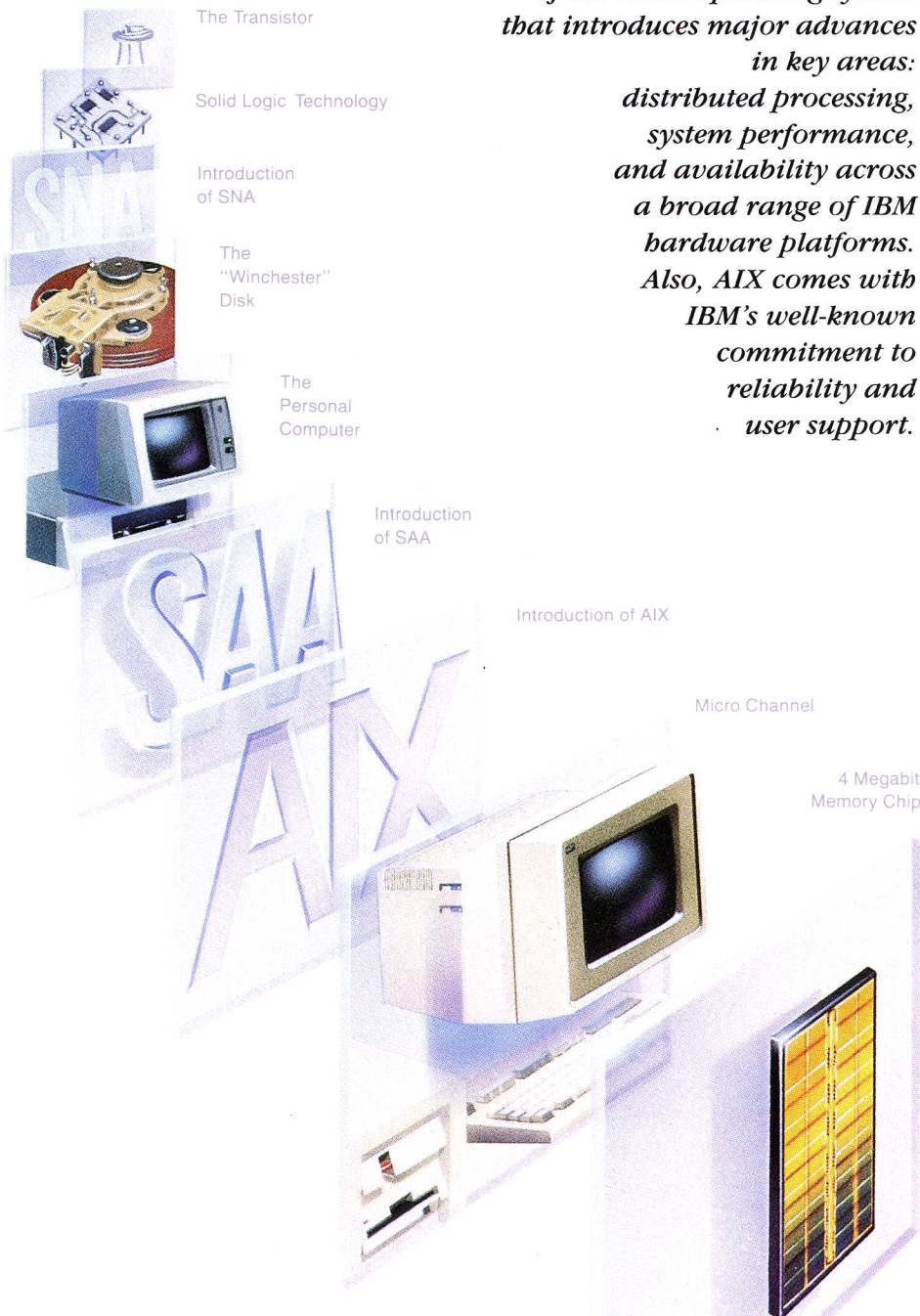
Worldwide sales of computer systems that include some form of the UNIX operating system are projected to more than double between 1987 and 1992 . . .



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The Advanced Interactive Executive: A New Dimension of IBM Leadership

75 Years of Innovation



The Transistor

Solid Logic Technology

Introduction of SNA

The "Winchester" Disk

The Personal Computer

Introduction of SAA

Introduction of AIX

Micro Channel

4 Megabit Memory Chip

AIX joins a long line of innovative technology developments from IBM.

The AIX operating system offers the high quality and innovation that IBM's customers have come to expect.

AIX is a leading-edge derivative of the UNIX operating system that introduces major advances in key areas: distributed processing, system performance, and availability across a broad range of IBM hardware platforms. Also, AIX comes with IBM's well-known commitment to reliability and user support.

Ten years ago the world was just awakening to the personal computer revolution. Almost overnight, it seemed, PCs appeared on millions of desktops, bringing a new kind of computing power to countless users in virtually every industry. IBM was a powerful force in the PC revolution, developing innovative, high-quality products that were snapped up by eager customers worldwide. Some industry observers, in fact, credit IBM's commitment to the personal computer with changing the face of computing.

As the 1990s approach, many in the computer industry believe that IBM is poised to do it again. This time the focus is on the AIX operating system — an operating system that may do for derivatives of the UNIX operating system what the IBM Personal Computer (IBM PC) did for personal computers.

Achieving Hardware-Independence

The UNIX operating system was created roughly a generation ago. For most of the program's formative years its commands were cryptic, its structure was unconventional, and its documentation was comparatively loose. Nevertheless, UNIX software offered a key benefit: it could be used, with relatively minor modifications, on nearly all kinds of computers. In practical terms, this means that application programs running under UNIX software can also be moved, or "ported," to different hardware platforms.

The hardware-independence built into the UNIX operating system gives the system great appeal for customers seeking "open systems" — the freedom to run their application programs on hardware from more than one vendor. In fact, customer interest in derivatives of the

UNIX operating system appears to be taking off. Analysts today estimate that sales of computer systems using these derivatives will grow to a quarter of the entire worldwide computer market by the early 1990s.

Introducing AIX

With the introduction of AIX, IBM stands to benefit strongly from that growth, because AIX extends the capabilities of the UNIX operating system further than ever before. First of all, AIX combines the best features of the major derivatives of the UNIX operating system now available. But IBM has also developed important new extensions and enhancements for AIX, including advances in transparent file sharing and distributed processing. Of course AIX also offers the advantages common to all IBM products: quality, reliability, and service.

AIX's greatest distinction, however, lies in IBM's decision to announce AIX for three strategic computer architectures: 386-based models of the Personal System/2, the Reduced Instruction Set Computer (RISC) RT system, and the System/370. In other words, AIX provides a single operating system environment on IBM desktop computers, high-function workstations, and the company's largest processor, the Enterprise System/3090™ (ES/3090).

IBM has publicly stated its commitment to make AIX the best version of the UNIX operating system available today. Early signs of success are already coming in.



The Open Software Foundation™ (OSF™), for example, last year chose AIX as its core operating system technology. OSF was formed in 1988 to develop a high-quality operating system through a truly open vendor-neutral decision process involving computer companies, academic institutions, and numerous computer buyers.

Ensuring Compatibility

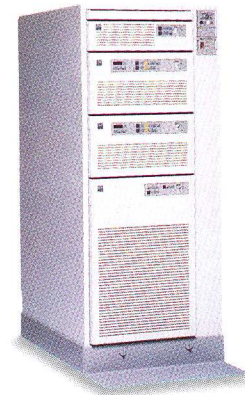
IBM has improved the quality of the UNIX operating system it licenses from AT&T®, but it has not departed from the basic philosophies that underlie the system. "We've done a lot to improve and develop the code," says Larry Loucks, Director of Software Architecture, IBM Entry Systems Division. "Even so, AIX is an enhanced version of the UNIX operating system and will continue to be." IBM customers who are familiar with UNIX variants developed at AT&T, at the University of California at Berkeley, and at other locations will find that AIX incorporates the best of those versions.

IBM is also extending AIX toward its Systems Application Architecture™ (SAA) family of products, so that IBM customers can build the best computing environment for their business. "IBM has decided to invest in two complementary operating system architectures: SAA and AIX," says Mike Saranga, Assistant General Manager of Development Operations, IBM Personal Systems. "People want UNIX operating system environments to do some things and SAA to do others. We're making sure that AIX and

SAA will coexist and work together very well." (See Part Three, "AIX and IBM.")

A Commitment To The Future

IBM has made a major investment in AIX to ensure that AIX provides major benefits to the company's customers. IBM has committed the people and capital necessary to improve the original UNIX software code, and to optimize AIX for three widely different computer



ES/3090™

architectures. IBM is also participating fully in industry standards efforts and with major industry consortiums. Finally, IBM is continuing to develop AIX, to enhance the program itself and also to extend its

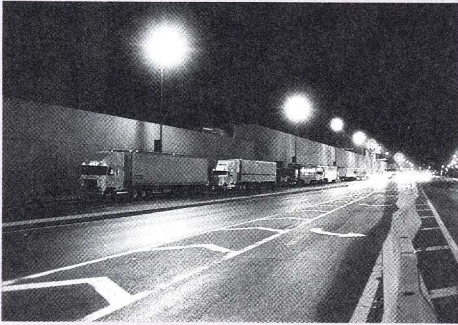
capabilities through hardware development, application development, and strategic business partnerships.

"Some of the things we've done to develop AIX might not look to people like the old traditional IBM way of doing things," says Saranga, but if you look at the product you'll see the same things you're used to seeing from us: quality, reliability, and leadership."

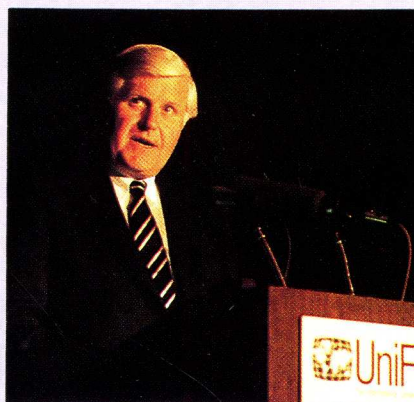
In the end, it may be IBM's emphasis on quality, reliability, and industry leadership that propels AIX to the forefront of all derivatives of the UNIX operating system. With those same advantages, after all, the IBM PC became the most successful product in one of the fastest growing computer markets ever. ■



Personal System/2



Exhibiting Commitment

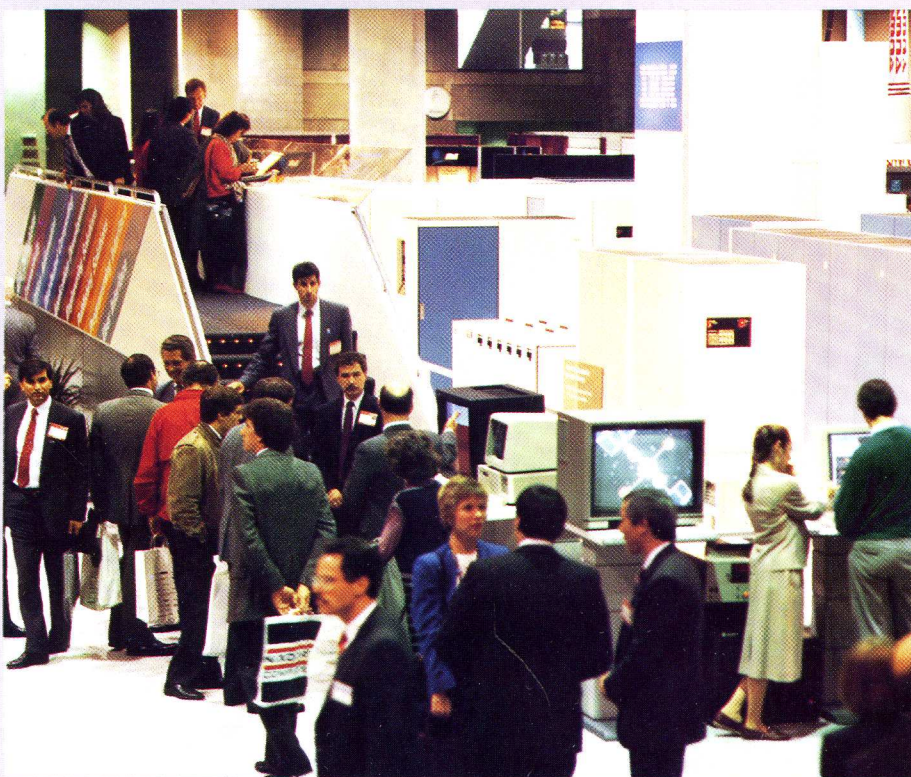


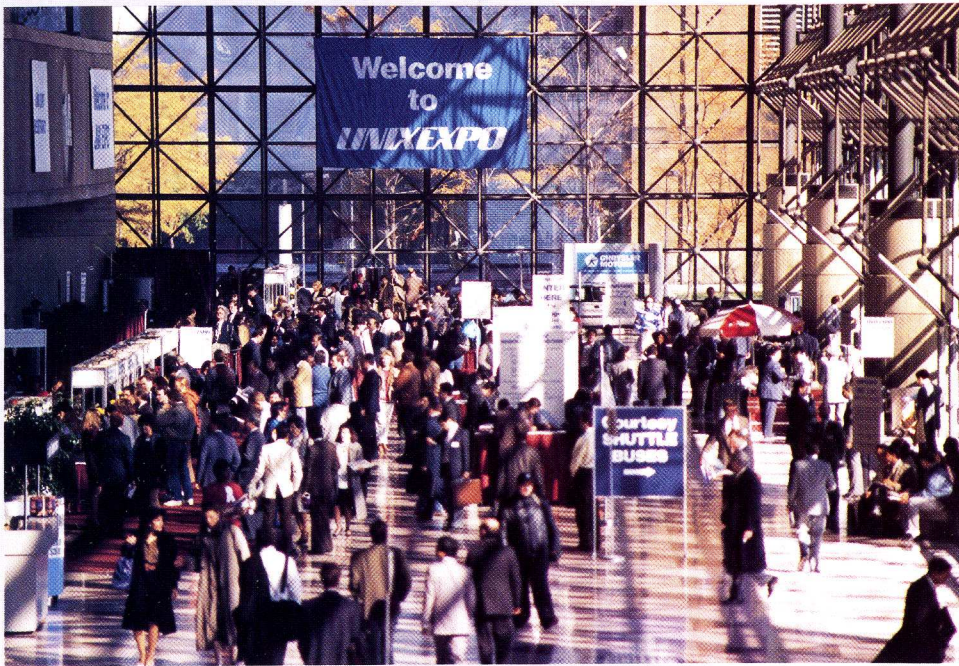
Terry Lautenbach, IBM Senior Vice President, addressing the 1989 UniForum.

With an increasing focus on its AIX offerings, IBM has stepped up its participation at major UNIX operating system business shows. Most recently, the 1989 UniForum (held in San Francisco in February) was an opportunity to demonstrate AIX on all of its platforms, running AIX applications on eighty RTs and PS/2s, many of which worked cooperatively with remotely attached ES/3090s. Terry R. Lautenbach, IBM Senior Vice President and General Manager, IBM United States, was the keynote speaker on the opening day.

“Frankly, I wouldn’t be up here today if IBM weren’t dead serious about AIX,” Lautenbach told the audience. “We are increasing our commitment to the open software environment, setting aggressive targets for ourselves, and stepping up the pace of our investments.” Toward the close of his remarks, Lautenbach acknowledged the competition among the many available versions of the UNIX operating system. Still, he left no doubt as to his own expectations. “For IBM’s part, we intend to compete, compete fairly, but compete fiercely. And then we will let the marketplace decide.”

IBM’s exhibit at UniForum closely followed the model of the fifth annual UNIX EXPO, held in New York in the fall of 1988. This was the largest EXPO yet, and one that many attendees will remember for its largest exhibit: IBM’s AIX showcase.





To show the world just how committed to AIX the company really is, IBM put on display nearly 10,000 square feet of networked hardware and software solutions featuring AIX. Perhaps the most convincing element was an ES/3090 Model 600E — one of the industry's largest computers — connected with IBM Enter-

prise System/4381™ and Enterprise System/9370™ mid-range systems, RT and PS/2 systems, and ASCII display terminals. An IBM Application System/400™ (AS/400), running Operating System/400™ (OS/400) and sharing data with an RT, was also part of IBM's EXPO network.

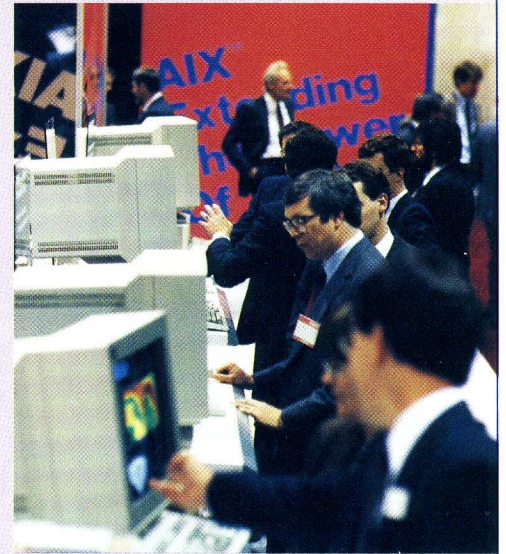




With more than 130 computers in the exhibit, IBM representatives were kept busy demonstrating AIX and a wide range of related software products throughout the three days of the show. More than 50 IBM business partners also exhibited applications programs written under AIX, ranging from office automation solutions to database management systems to sophisticated scientific and technical packages. At one point during the EXPO, representatives of a company marketing a tape back-up and archival utility ported their product to all three of IBM's AIX platforms — the PS/2, RT, and ES/3090 — in under an hour.

An entertaining highlight of the IBM exhibit was a videotape presentation that compressed three days of exhibit construction into a riveting two-minute montage, backed by energetic passages from a Beethoven symphony. This crowd-pleasing program was a magnet throughout the EXPO, and many of the people who stopped to watch it stayed on to hear an IBM marketing representative give a brisk AIX introductory pitch supported by videotaped customer testimonials.





A big crowd also gathered to hear James A. Cannavino, who was at that time President of IBM's Data Systems Division, address the first of the EXPO's two plenary sessions, on "Large Systems in the UNIX System Environment." "IBM entered the UNIX operating system world a number of years ago," Cannavino told the overflow audience, "for the best and most obvious reason. Our customers asked us to." Cannavino then detailed IBM's recent work on AIX, its commitment to standards, and the strength of IBM's AIX family, before offering examples of how IBM customers are using AIX on large systems.



James Cannavino, President of IBM's Entry Systems Division, addresses the 1988 UNIX Expo.

Near the close of his address, Cannavino emphasized IBM's commitment to AIX as a strategic architecture. "I know there are many computers down there on the exhibit floor," he said. "There are workstations and PCs from dozens of companies. But I really want you to stop by the IBM booth and see **my** personal computer — the ES/3090 600E."

The audience laughed and Cannavino smiled, but there was no doubt he was serious as he continued. "It's the second largest commercial mainframe in the industry, second only to the ES/3090 600S that we are currently shipping. It weighs 15 tons, and it took four tractor trailers and a flat-bed truck to get it here. I hope it makes the point — once and for all — that IBM is very serious about AIX."



UNIX IN THE OFFICE

PRODUCTS • TRENDS • ISSUES • ANALYSIS

IBM's Unix

Moving to Distributed Network Computing

Excerpts from **IBM's Unix**
by Judith S. Hurwitz

Reprinted with permission from Patricia Seybold's Office Computing Group
Unix In The Office, Vol 3 No. 4, April 1988.

IBM has a new vision: to become a premier Unix systems vendor with a large installed base. It is not as though IBM just discovered Unix. Over the years, Big Blue has made numerous, albeit half-hearted, attempts to penetrate the market.

So, what's different now? IBM has realized that, in order to move from the traditional time-sharing system concept it has mastered over the past 20 years, it must come up with a different approach. The approach that will propel IBM into the next generation of computing — Distributed Network Computing (DNC) — will be Unix. In turn, DNC will lead IBM to the next generation of computer software: cooperative processing and workgroup software. In a nutshell, the company has begun to make such a strategy a reality by establishing a family of Unix products. As part of this family approach, IBM is:

- Incorporating industry standards at all levels
- Providing a consistent version of the operating system from the low end (PS/2 and RT PC) to the high end (System/370 line)
- Adding sophisticated networking
- Offering traditional VM customers who are interested in Unix a low-risk migration path
- Providing bridges to SAA

IBM is so serious about Unix that it has publicly stated that its Advanced Interactive Executive (AIX) Family Definition will have equal status with its sacred Systems Application Architecture (SAA). Now that's commitment! IBM defines the AIX Family Definition as "a framework for building portable, consistent AIX applications now and in the future for IBM System/370 (9370, 4381; and 3090), Reduced Instruction Set Computer (RISC) architecture, and Personal System/2 (PS/2) 80386 computing environments." Like SAA, the AIX family definition defines the complete systems environment. It will include operating system calls, high-level languages, programming interfaces, distributed processing and networking capabilities, and a common user interface. The AIX definitions are based on Unix, industry standards, and IBM extensions. As part of the definition, IBM has emphasized that through "networking and distributed processing capabilities, systems will be able to transparently share presentation graphics, data, and other available resources. Transparent to AIX users, the local system extends beyond the processor boundary, and the system becomes a network of attached processors."

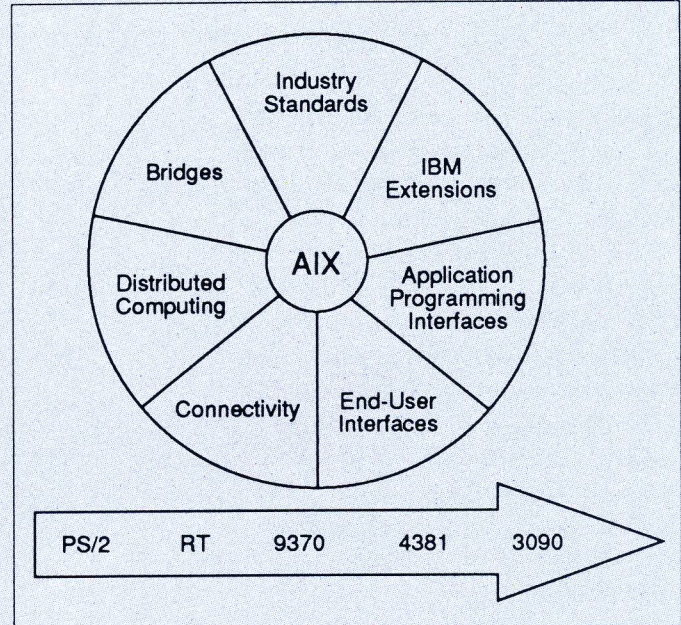
Recognizing a Growing Market

IBM made the decision to commit extensive resources to Unix more than three years ago when it began to notice that it was getting more and more requests from customers for better Unix support. These demands came primarily from IBM's customers in the industrial sectors, such as process control — a market that has benefited from the high-end Unix workstation market. Slowly, however, the demand has begun to extend to some areas of the commercial sector as well. The combination of growing customer demand with market projections of a 25 to 30 percent growth rate for the Unix market in general is propelling IBM into this marketplace. IBM is paying attention to market projections of International Data Corporation (IDC) that the U.S. Unix market will be worth \$9.5 billion by 1990.

Future Directions

On the surface, it appears that IBM is simply jumping into a hot market. No doubt this is true. However, IBM has a more subtle reason for entering the Unix marketplace. With its rich set of communications software, the company is moving fast to embrace the client/server architecture that is key to the cooperative computing model. IBM has made it clear with SAA that cooperative processing between the front end (PS/2) and the mainframe is strategic. SAA, however, is a solution for a particular set of customers that wish to continue in the proprietary, true blue mode. It is the only way that IBM systems with a variety of operating systems can appear to have applications and network transparency. It is a necessary move for a company strapped with too many operating systems and too many types of hardware.

Ironically, Unix sets IBM free. It allows the company to explore a new frontier of cooperative and distributed network computing and to move to the distributed computing model. We believe that IBM holds a vision of workgroup computing. It will be through its Unix AIX Family that this vision will first be likely to see applications that make deliberate use of the flexibility of TCF [Transparent Computing Facility; a networking feature of AIX]. These applications could make use of CPU cycles on 9730s [sic] as well as 3090s. Specialized industrial applications will probably surface first; however, we eagerly anticipate the emergence of some leading edge products for the knowledge [sic] worker.



IBM's vision of Unix.

Conclusion

IBM is embarking on a new direction in its history. For the first time, the company is looking to the standards environment to take it into the future. Indeed, it is a sign of the times. There was a time when this one computer giant could dictate what industry standards would apply. Needless to say, these standards were such products as SNA and CICS. The world is changing, and IBM has caught on.

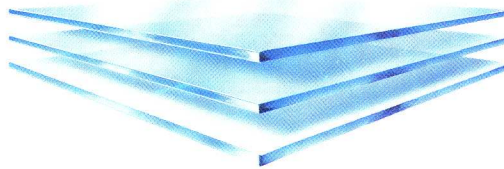
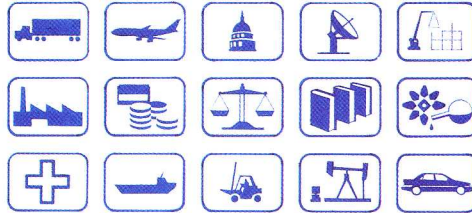
We believe the strategy of having a cohesive software offering across platforms with strong network underpinnings is a sound and sensible strategy. TCF is a wonderful product for the 370 class of systems. It also makes good use of the PS/2 as a front end processor for keystroke-intensive jobs.

From a hardware perspective, IBM has done its homework. By hosting AIX on top of VM, IBM has a unique opportunity to lure its current and large customer base to try Unix. This offers the possibility of selling even more hardware and software if and when these customers begin to develop clusters of systems for a variety of applications. Indeed, this strategy could breathe new life into the high end of IBM's product lines. It could also attract a new set of users to Unix who will feel reassured that Unix has the IBM seal of approval. One could draw an analogy with the way IBM fueled the acceptance of the PC.

The Booming Opportunity for AIX — And What's Behind It

The market for versions of the UNIX operating system — and AIX — is growing faster than the computer market as a whole, and there are plenty of reasons why.

In 1980, there were an estimated 10,000 computer systems running versions of the UNIX operating system. Most of those systems were within AT&T or university computer science departments. By 1990, the total number of such systems is projected to grow to 1,800,000 — and nearly a million of all those new systems may be installed during the last two or three years of the decade. Clearly the opportunity for versions of the UNIX operating system — and for AIX — is booming.



The Numbers

The sudden and explosive popularity of UNIX operating systems has created a boondoggle for market researchers. It seems that everyone is rushing to buy intelligence that might help them take advantage of the boom. Though the numbers don't always match up, they do tend to tell the same basic story: the market is growing faster — some say much faster — than the computer market as a whole.

The following paragraphs offer a sampling of the key data recently released by market researchers in the U.S. and Europe.

■ **The worldwide market.** According to Dataquest, the well-known market research firm, worldwide sales of systems with some version of the UNIX operating system will more than double between 1987 to 1992, from \$10.8 to \$24.2 billion. By contrast, sales of all computer systems worldwide will grow by just a third in the same period. As a result, sales of systems with a version of the UNIX operating system will grow from 13 percent to 20 percent of the overall market.

■ **The U.S. market.** Dataquest's figures for the U.S. show that computer systems incorporating a version of the UNIX operating system will jump from \$4.2 billion to \$8.9 billion between 1987 and 1991. Another respected market researcher, International Data Corporation (IDC), has looked out a year further and seen the same result: revenues from systems sold in the U.S. which use a version of the UNIX operating system will triple between 1987 and 1992, from \$4.4 billion to \$13.9 billion.

■ **The European market.** IDC's figures for Europe show a similar trend, with revenues from computer systems incorporating a derivative of the UNIX operating system tripling between 1987 and 1992, from \$2.4 billion to \$7.2 billion. Pamela Gray, president of Sphinx Ltd., a U.K. firm, said at the 1988 UNIX EXPO that the market for such systems in Europe is growing at more than 30 percent a year — much faster than the computer industry as a

whole, which she said was growing at about 10 percent a year.

■ **Market segments.** Gray also indicated that the majority of systems sold in Europe which include a version of the UNIX operating system fall in the \$15,000 to \$35,000 range. In the U.S., market researcher Infocorp estimates that sales of such systems costing \$12,000 to \$50,000 grew at nearly 100 percent a year from 1982 to 1986. Other firms believe that growth will continue. IDC sees strong growth from systems costing less than \$10,000; this segment will grow 45 percent a year, to revenues of \$6.1 billion in 1992. Systems costing \$10,000 to \$100,000, it says, will grow at nearly 40 percent, to \$4.5 billion in 1992.

The Buyers

So who's buying all those systems?

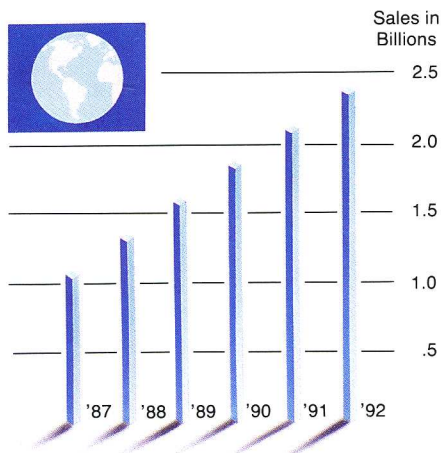
Large corporations are making the strongest collective impact. According to analysts, most corporate computer systems that include a version of the UNIX operating system are being bought at the departmental level rather than the corporate level. "The fastest growth in the commercial sector in Europe has been in mid-range systems," says Sphinx Ltd.'s Gray, "with a very large and fast-growing base of departmental systems." The U.S. commercial market is apparently following the same path. "Above the PC and below the mainframe," says Paul Cubbage, an Associate Director at Dataquest, "UNIX is no longer a movement — it's a stampede."

The U.S. Government is also an important customer for UNIX operating

systems, based on two factors. The first is preference: the Government is insisting more and more that its computer systems include a version of the UNIX operating system. The second factor is money: a single Federal procurement can amount to billions of dollars.

While big business and big government have been getting big attention, the academic, scientific, and technical customers who have always bought UNIX operating systems are also thriving. In 1987, for example, the technical and engineering workstation market doubled, due to more powerful workstations, more sophisticated applications programs, and more experienced users.

One of the most interesting segments of the market for UNIX operating systems consists of small businesses or workgroups in larger businesses that want the benefits of a multi-user, host/workstation system — without paying big money. AIX and the RT have been very successful in this market; AIX PS/2 is likely to be a big winner also. AIX PS/2 and AIX/RT can function as hosts, supporting up to 16 or 32 users, respectively, performing a variety of tasks concurrently. They also can be joined with other AIX systems to build



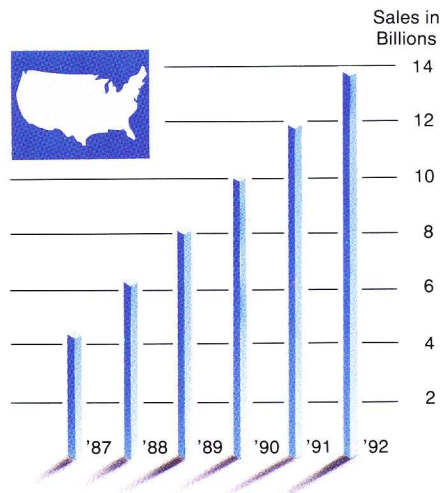
Worldwide sales of computer systems that include some form of the UNIX operating system are projected to more than double between 1987 and 1992 . . .

larger networks. (For an example of multi-user systems based on AIX PS/2 see Part Four, “Making TRACS™.”)

Beneath the Groundswell

Until recently, the UNIX operating system was a hard-to-use, research-oriented system that had been around for years without attracting much commercial attention. So what explains its rapid growth in the late 1980s?

To many industry observers, the explanation is simple: the universities and manufacturers that license UNIX software from AT&T have made major qualitative improvements in the system. IBM software engineers, for example, estimate that they fixed nearly 2,000 errors in the licensed source code before they would release AIX. But there are other reasons beneath the groundswell of interest.

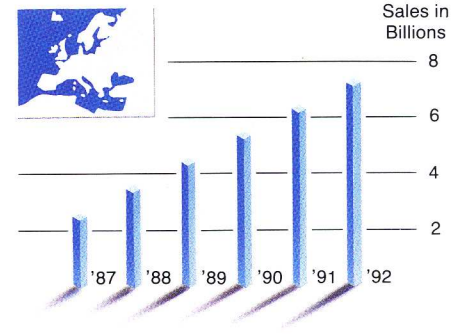


. . . based on a tripling of customer demand for such systems in the U.S. . . .

First of all, versions of the UNIX operating system are riding two strong trends that are already reshaping the computer industry. Networking is a term that has become almost synonymous with computing. Since virtually all large customers use different types of hardware from different vendors, and run a wide variety of applications programs, there is a growing

need for an operating system that can embrace all elements on the network and leverage their individual value. The best versions of the UNIX operating system, such as AIX, meet this need.

Closely allied with the rise of networking is today’s focus on “open systems.” At their best, open systems offer users more options for expanding their networks and more ways to preserve the



. . . and comparable growth in the European Community.

data and applications they have already invested in. Although open systems can be achieved using any operating system and set of standards, there is general agreement among computer companies that versions of the UNIX operating system such as AIX offer the fastest path toward the open systems benefits that customers want. (See “Portability, Scalability, and Interoperability.”)

Not surprisingly, technological breakthroughs have also contributed to the clamor for versions of the UNIX operating system. When start-up companies come out with a new computer these days, they often adapt some form of the UNIX operating system as their own operating system. This decision saves time and money and also ensures that customers will have applications that can run on the new machine. Similarly, a growing number of software developers are optimizing their programs for UNIX operating systems. The more applications that are available under it, the more users

will buy systems with a version of the UNIX operating system as part of their overall business solution.

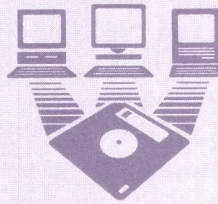
Finally, industry at large is at last acquiring a critical mass of programmers and users familiar with the UNIX operating system. The richest source is the

nation's universities, where most programmers first learn the system. But the universities don't just train students in using the UNIX operating system. They also teach their students how to program for it and network with it. The result is that the government and commercial sec-

tors are fast acquiring their own resident experts in UNIX software. With their education and their companies behind them, these new users are ready, willing, and able to buy top-quality derivatives of the UNIX operating system — such as AIX. ■

Portability, Scalability, and Interoperability

Much of the recent interest in UNIX operating systems is part of a larger interest in open systems. Computer users want to preserve their applications and their data as their computer networks grow and they take on components from different manufacturers. Users want to be independent of a single vendor, to choose hardware and software from many different vendors with the assurance that everything will work together. The concepts most important to open systems are portability, scalability, and interoperability.



Portability, or “applications portability,” refers to a user's freedom to run the same application program on computers from different

vendors, without rewriting the program's code. UNIX operating systems help provide this portability, because they are written in a high-level language that permits them to run on more than one kind of computer. If an application can run under a UNIX operating system, then it is portable to more than one computer — at least theoretically. Applications portability is often given as an important reason for people's interest in UNIX operating systems.

AIX offers the highest achievable level of applications portability between different computer platforms, because AIX is the same operating system on three different lines of computers: the PS/2, the RT, and the System/370 mainframe processors. This makes it easy to move applications from platform to platform.



Scalability refers to a user's ability to move applications and data among larger and smaller computer systems to meet changing needs. Many small companies, for example, face scalability issues when they outgrow the processing or storage power of the systems they started business with.

Large companies face scalability issues when they replicate application solutions in user locations with very different hardware requirements. All companies can save significant time and money in employee training if they do not have to change applications and user interfaces when they change to a larger or smaller system.

The AIX Family offers a built-in scalability that no other vendor can match. Customers can move applications among stand-alone PS/2s, multi-user RT systems, and powerful mainframes — without changing their operating system, their applications, or their user interface.

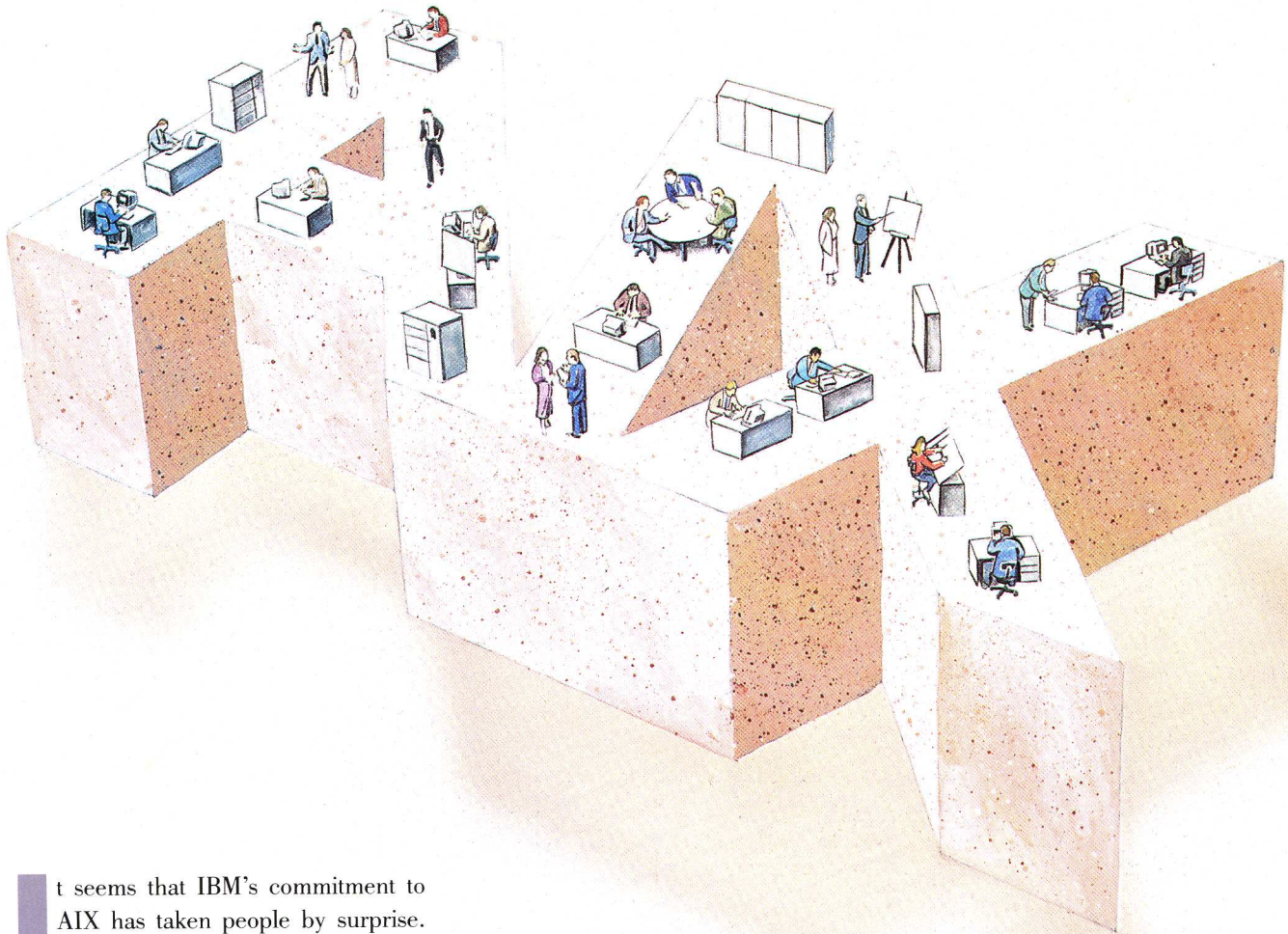


Interoperability refers to the ability to run applications programs on networks built up of different kinds of machines manufactured by different vendors. Once again, AIX offers interoperability that other vendors will find tough to meet. Why? Since AIX is compatible with other versions of the UNIX operating system, IBM systems can work with hardware built by other vendors. But AIX will also offer the easiest and broadest access to IBM's widespread and well-founded Systems Network Architecture (SNA) and SAA.

From the standpoint of portability, scalability, and interoperability, AIX offers advantages other systems just can't match. For customers seeking open systems, AIX is truly in a class by itself. ■

Is IBM Serious About AIX? Absolutely.

The evidence is clear: IBM's commitment to AIX is good news for eager customers.



It seems that IBM's commitment to AIX has taken people by surprise. "When the Open Software Foundation (OSF) announced its formation... one of its most startling revelations was that it had settled on an IBM UNIX version, AIX, as the base of its efforts," began a 1988 article in UNIXWORLD. "For [OSF] to pick any kind of UNIX as a common ground was amazing enough — for it to be IBM's UNIX was stunning." A few pages later, the same article used the adjectives "remarkable" and "astounding" to describe IBM's AIX effort.

Perhaps some surprise is understandable. After all, IBM has been generally considered the world's largest and most successful computer company for years, without making the UNIX operating system a cornerstone of its strategy. Some industry analysts have even suggested that it was the phenomenal success of the IBM PC that kept the UNIX operating system off small computers until recently.

Today, however, IBM is offering a leading-edge, industrial-strength version of the UNIX operating system of its own, called AIX, and backing it with the company's considerable resources and reputation.

A Growing Opportunity

Industry analysts are beginning to understand the depth of IBM's commitment, and changing their surprise to careful evaluation. "Users and vendors who think that IBM Corporation [wants to] sabotage UNIX should examine the facts more closely," wrote Wendy Rauch-Hindin, President of Emerging Technologies Group, Inc. in MINI-MICRO SYSTEMS® magazine recently. "People who think this way are generally looking at IBM's product history and thinking that, in the past, IBM was not associated with UNIX. But if they want to understand what IBM will do vis-a-vis UNIX, they must realize that IBM has a history of following growth markets."

"When IBM develops a new product, it does so with the intention of making that product the best of its kind . . . and that includes AIX."

Does AIX represent a "growth market" for IBM? "AIX is a **tremendous** opportunity for IBM," says Irving Wladawsky-Berger, Vice President, IBM Data Systems Division. "Many of our customers have asked us to provide a version of the UNIX operating system for their IBM computers. Through AIX/370, we can now bring the performance and function of our S/370 products to new users, new applications, and new environments. Given this, we believe the growth potential for AIX is enormous. Of course the best way to encourage that growth is to make AIX a world-class operating system, and that's our goal."

As a leading version of the UNIX operating system, AIX stands to perform well in a growing market. Overall, the market for computer systems incorporating a version of the UNIX operating system is projected by analysts to grow by a factor of five by 1992 in the Fortune 500 alone. In that year, say analysts, fully 60 percent of all office automation systems sold will be written to run under versions of the UNIX operating system. Figures like these indicate the presence of a major opportunity for IBM. But figures alone don't tell the story.

Internal Energy

First of all, there is the internal commitment of money and talent IBM has made to AIX. No one doubts, for example, IBM's commitment to the PS/2 computer and its IBM Operating System/2™ (OS/2™) operating system. In fact, IBM is putting as many development dollars into AIX as it has into OS/2 — and has said so publicly. And talent? "There's no shortage of talent working on AIX," says Larry Loucks, Director of Software Architecture, IBM Entry Systems Division. "We've got good people working as hard on AIX as on our other strategic operating systems."

Then there are the public statements of commitment to AIX. These have been made by IBM executives from Chairman John Akers on down. A typical remark comes from Pete Schneider, IBM Director of Systems and Programming, who says: "When IBM develops a new product, it does so with the intention of making that product the best of its kind. Our goal is to provide our customers with the best solutions they can find anywhere, and that includes our AIX solutions."

Proof of such statements is not hard to come by. For example, IBM describes AIX in terms formerly reserved only for Systems Application Architecture, an ambitious IBM strategy for forging complete links among its various computer

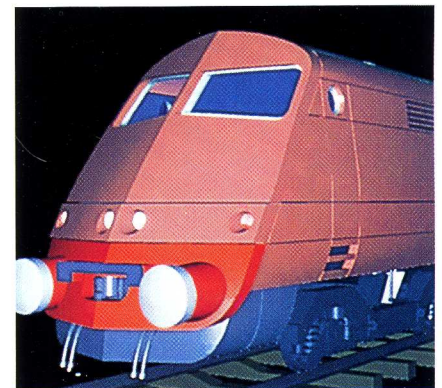
systems. "IBM is so serious about Unix that it has publicly stated that its AIX Family Definition will have equal status with its sacred Systems Application Architecture," writes Judith Hurwitz in *Unix in the Office*. "Now that's commitment!"

Standards and Applications

If people are still unconvinced about IBM's commitment to AIX, they should check on IBM's work with UNIX standards bodies and industry consortiums, and the company's effort to increase the number of AIX applications that are available to its customers.

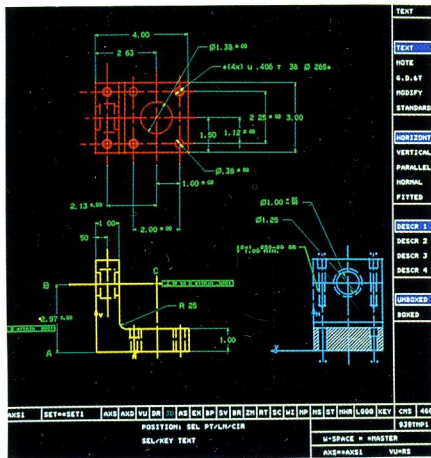
If people are still unconvinced about IBM's commitment to AIX, they should check on IBM's work with standards and applications.

In the standards arena, IBM is represented on every committee and subcommittee of the Institute of Electrical and Electronics Engineers' (IEEE's) effort to create an open systems definition called



Example of a CAEDS screen

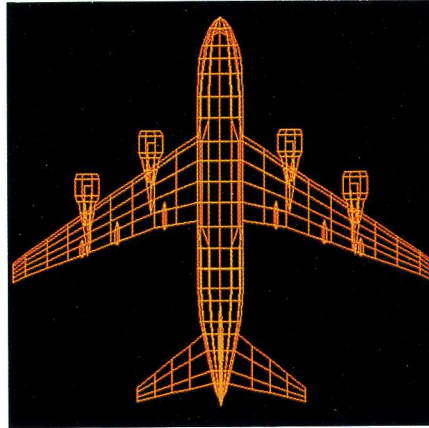
POSIX. The time and money spent on the POSIX effort alone is a major investment. IBM has also committed millions of dollars and countless hours of staff time as a founding sponsor of the Open Software Foundation. IBM is a corporate sponsor of X/Open™, an international consortium seeking to specify a common application environment for all versions of the UNIX operating system. Furthermore, IBM has been associated for years with such dyed-in-the-wool industry associations as /usr/grp® and USENIX. In many cases, IBM personnel play leadership roles in these organizations, including chairing key committees. (For more information on IBM's work in standards and consortium activities, see Part Three.)



Example of a CATIA screen

Meanwhile, IBM is moving quickly on a number of applications fronts, making its own software available on AIX platforms and encouraging independent software vendors to port their packages to AIX. IBM's engineering systems group, for example, was quick to make important offerings like CAEDS®, CATIA®, and

Professional CADAM™ available on the RT, resulting in important early customer acceptance of AIX. IBM has ensured that corporate customers wedded to database systems like ORACLE®, INGRES™, and



Example of a CAEDS screen

INFORMIX® will find them on AIX platforms. Through a series of business partnerships, IBM has helped bring a wide range of other programs and applications to the marketplace, and more are becoming available all the time.

"When the world's largest computer manufacturer has an aggressive and comprehensive AIX plan across three major hardware platforms, that's a fairly major statement . . ."

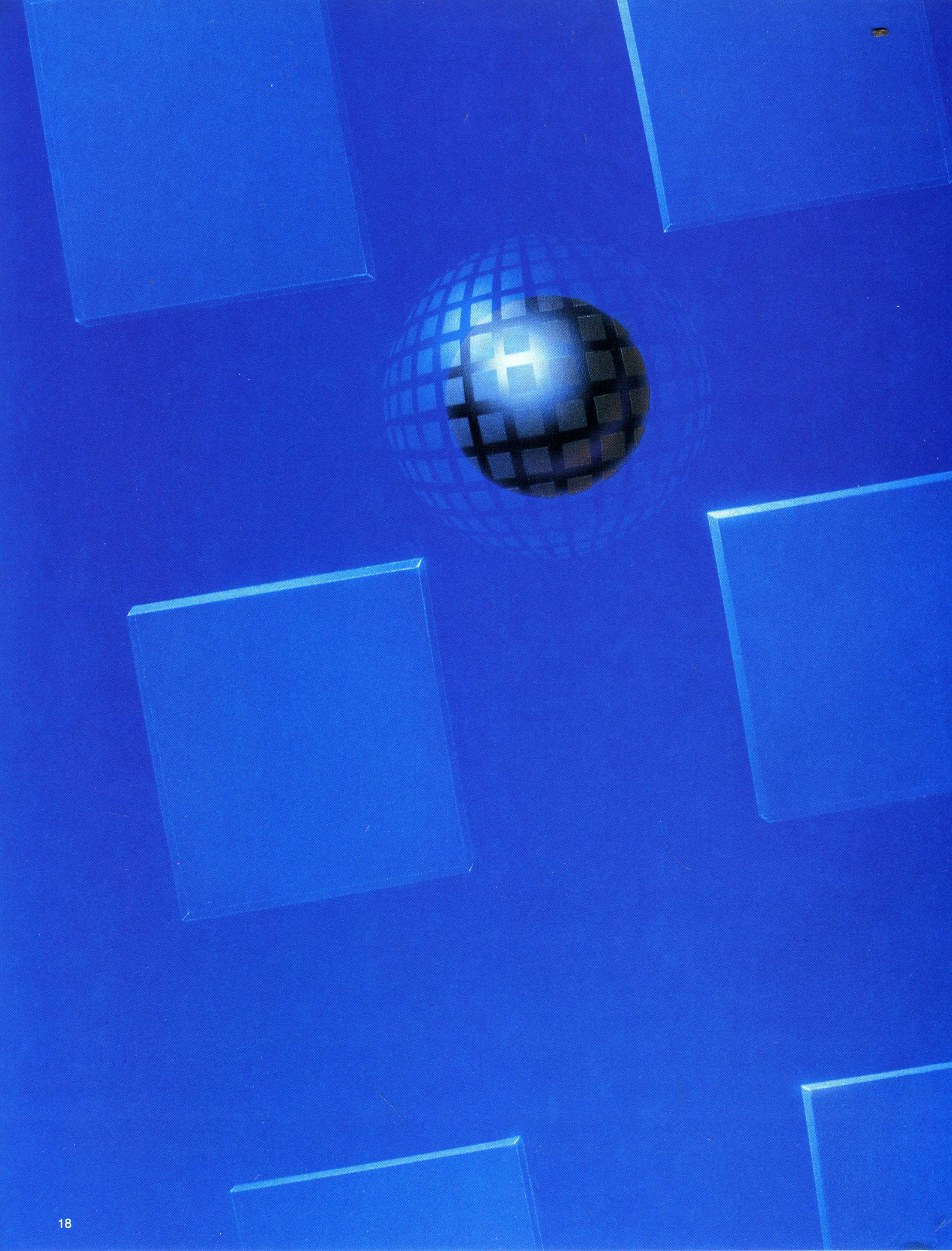
In addition, IBM has established a number of efforts to introduce AIX to customers who are unfamiliar with UNIX operating systems. At regionally distrib-

uted briefing centers, customers can gather with IBM personnel and find out about the advantages of AIX. At the Securities Briefing Center in New York City, for example, decision-makers from securities firms get basic training on and management-level advice about AIX. IBM has also set up "porting centers" around the country, to help make AIX more easily available to customers.

A Major Statement

Though there may be a few who doubt IBM's commitment, there are plenty who believe in it and see it as a positive development for IBM and the world of computing. AIX, according to Hurwitz, "sets IBM free . . . to explore a new frontier of cooperative and distributed network computing." AIX could also "attract a new set of users to Unix who will feel reassured that Unix has the IBM seal of approval."

IBM itself won't make such claims, preferring to let its products speak for themselves. "The UNIX operating system is legitimate with or without IBM," says Loucks. "But we are certainly a major player in this arena, and when the world's largest computer manufacturer has an aggressive and comprehensive AIX plan across three major hardware platforms, that's a fairly major statement, don't you think?"



PART TWO

IBM'S AIX Strategy

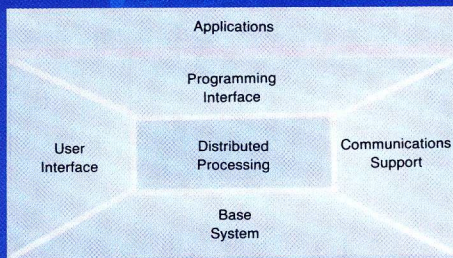
IBM has designed its Advanced Interactive Executive (AIX) operating system to meet the needs of its customers. AIX establishes a new, higher standard for derivatives of the UNIX operating system. It also embraces several major IBM hardware platforms — the PS/2, the RT system, and the System/370.

*Part Two of **AIX** presents prominent perspectives on AIX. "IBM's AIX Strategy" introduces the three AIX platforms, the synergy among them, and the AIX Family Definition that provides that synergy. "AIX: Extending the Power of the UNIX Operating System" sets out the key performance advantages offered by the AIX operating system itself. "The Evolution of AIX" offers a brief history of AIX's development, and "AIX Faces The Future" takes a customer-oriented look at how AIX will evolve in the next five to ten years.*



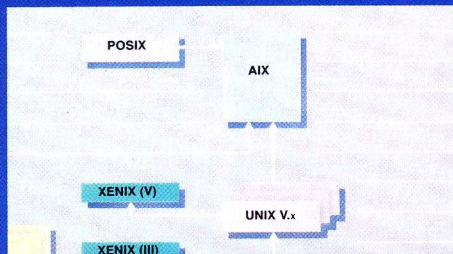
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AIX/370 provides a mid-range to high-end AIX environment for System/370 processors, up to and including the largest of IBM's ES/3090 mainframe systems.



26

The AIX Family Definition.



36

The AIX family tree.

IBM's AIX Strategy

IBM's AIX strategy is deceptively simple: to combine the benefits of the UNIX operating system with IBM's rich experience in operating system design, hardware architecture, and networking. The goal of this strategy: to make AIX the best available derivative of the UNIX operating system in the world.

The AIX operating system spans the industry's broadest range of single-vendor platforms. For personal workstations, powerful supercomputers, and the systems in between, AIX provides one integrated operating system environment.

With the introduction of AIX, IBM has taken derivatives of the UNIX operating system to new heights of performance and customer value. IBM has rewritten the source code to make AIX meet IBM's high standards for performance, reliability, and security. IBM has announced AIX on three strategic IBM platforms, creating a powerful family of compatible computing systems. And AIX has set new standards for distributed network computing.

"We understood, by listening to our customers, that it was important for IBM to offer a version of the UNIX operating system," says Clay Cipione, Director of AIX Systems, IBM Advanced Workstation Division. "We also knew that to succeed in that business we would have to combine the classic strengths of the UNIX operating system with the classic strengths of IBM." As most people know, IBM has a unique store of knowledge

about secure, high-performance operating systems; a broad range of computer hardware platforms; and various methods of combining them into networks.

"Putting those IBM assets together with the UNIX operating system makes for a very powerful concept," Cipione says, "and that's what we set out to achieve with AIX."

Meet The Family

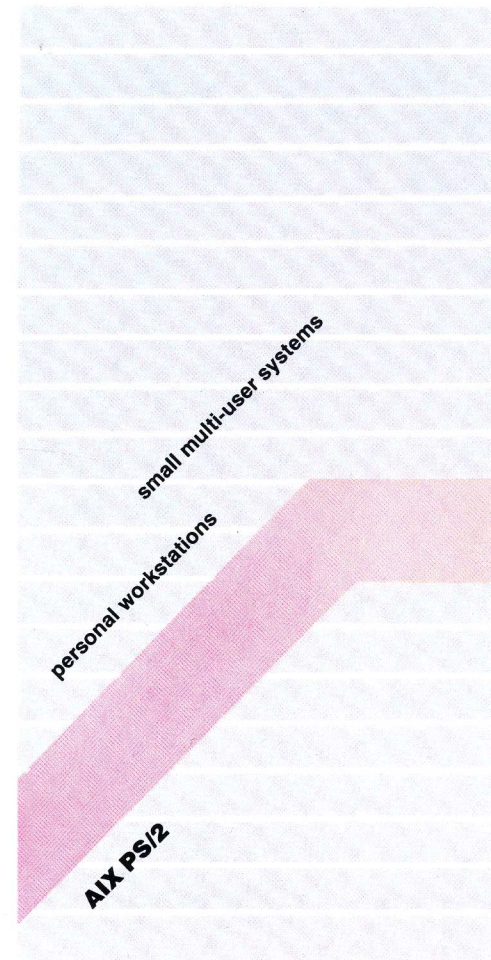
The AIX Family provides a compatible operating system environment for the 386 microprocessor models of the PS/2; the RT system, based on IBM's RISC technology; and the System/370 line of mainframe computers. The AIX operating system furnishes each AIX platform with compatible elements, ensuring applications portability and connectivity among the entire Family (see "The AIX Family Definition"). At the same time, AIX has been customized slightly for each individual AIX platform, to take

maximum advantage of the unique operating features of each platform.

As a key element in its AIX strategy, IBM has also made many significant improvements in the basic code it licenses from AT&T. IBM has focused on making the AIX file system more robust; created important advances in distributed network processing; added virtual memory management; increased security; developed installation and training modules that make the system easy to learn; and published the most complete and effective documentation of any derivative of the UNIX operating system. (For more information on the performance features of AIX, see "AIX: Extending the Power of the UNIX Operating System.")

Commonality and Connectivity

AIX PS/2 is the entry-level offering for the AIX environment. It provides the lowest-cost IBM solution for customers who want a stand-alone system or small



advanced workstations
departmental systems

corporate computing

super computing

AIX/RT

AIX/370

network to run a UNIX operating system. AIX PS/2 also supports migration from XENIX®, a popular PC-based UNIX operating system. Furthermore, AIX PS/2 offers a high degree of affinity with IBM DOS, preserving the huge volume of applications and data that customers have already assembled under

"AIX gives users an opportunity they've never had before. They can now develop applications without worrying about the processing power they'll need, because the AIX Family offers a 200-fold range of processing power under the same operating system."

DOS. Finally, AIX PS/2 is an ideal end-user terminal for AIX/370 processors

(see: "AIX PS/2").

AIX/RT addresses customer needs for mid-range, multi-user commercial UNIX operating systems and for high-function technical workstations. It supports high-performance graphics and has an extensive library of powerful applications for technical computing and for commercial multi-user environments. AIX/RT also provides an excellent front end for setting up or viewing the results of complex problems that must be executed on larger AIX computers, such as the ES/3090 system, IBM's largest processor (see "AIX/RT").

AIX/370 provides mid-range to high-end UNIX functions for System/370 processors, up to and including the largest of the 3090 mainframe systems. It supports the most powerful compute-intensive environments, including the ES/3090 Vector Facility. AIX/370 also offers particularly strong support for environments requiring centralized process-

ing and system administration, and large central data management (see "AIX/370").

All three AIX Family members contain common application, programming, and user interfaces built upon the same base system commands and libraries. Programming languages provide compatibility at the source code level, enabling users to easily port applications from one AIX platform to another.

AIX Family products support connectivity of systems and workstations, with a variety of communication protocols and physical attachment capabilities, including both local area network and wide area network support. In addition, they provide a rich set of distributed computing and resource sharing capabilities among AIX and other UNIX systems. IBM's AIX Distributed Services (DS), for example, provides AIX users with transparent access to files and devices on their AIX network. AIX's Transparent Computing

Facility (TCF) combines PS/2s and S/370 systems into “clusters” that give users a single-system image of all the computing resources available in the cluster.

With the choice of platforms, distributed processing capabilities, and network interfaces available with AIX, customers can choose the hardware architecture that best fits their environment and still enjoy unparalleled freedom to migrate applications and data to other systems as their business or computing needs change. “AIX gives users an opportunity they’ve never had before,” said James Cannavino at UNIX EXPO. “They can now develop applications without worrying about the processing power they’ll need, because the AIX Family offers a 200-fold range of processing power under the same operating system.” (For more information about UNIX EXPO, see Part One, “Exhibiting Commitment.”)

Synergy

This unique quality of the AIX Family is an important part of IBM’s AIX strategy, because the issues that are driving customers to embrace the UNIX operating system — portability, scalability, and interoperability — hinge on operating system similarities.

“AIX is truly a case where the whole is greater than the sum of the parts,” says Cipione. “When you buy one AIX platform, you’re buying a world of connectivity within the AIX Family, with other UNIX systems, and — because we’re IBM — with the whole world of SAA.” The AIX Family Definition, for example, specifies compatibility with the POSIX open systems standard, and with the 4.3 BSD and System V Release 2 versions of the UNIX operating system. It also specifies two programming languages (C and VS FORTRAN) that are included in IBM’s Systems Application Architecture (SAA).

“There’s a difference between three individual offerings that happen to have the same name, and a family of compatible operating systems,” Cipione points out. “With AIX, you have a **family** — the same blood runs in the veins of all three offerings. They all work in the same way, which means they work **together** better than anything else.”

It can truly be said of the AIX Family that the whole is greater than the sum of the parts.

Another realm in which AIX will outperform other UNIX operating systems is interoperability with the huge, ever-expanding world of SAA, which includes thousands of System/370 mainframes and trillions of bytes of data. IBM has an unparalleled ability to make AIX systems complementary with SAA systems, because IBM is a single company embracing both architectures. (For more information on the relationship between AIX and SAA, see Part Three, “AIX and IBM.”)

The Ultimate Strategy

Ultimately, IBM’s AIX strategy is part of IBM’s larger strategy: providing customers with the best possible solutions to their data processing needs. “People think there’s a special set of AIX customers that are different, somehow, from the people we’ve always worked for,” Cipione observes. “They’re not. It’s IBM customers who want AIX, and it’s IBM customers we’re aiming to serve.”

Most importantly, AIX shelters customer applications from dependence on one particular hardware platform, so customers can scale their applications up

as their business grows, or port applications to new computer systems as their operations change. The AIX operating system will remain the constant that keeps applications current despite evolving hardware strategies. Workers who are familiar with a set of user interfaces will not have to learn new interfaces when their computers change, because AIX will preserve the same command structure among its various Family members.

This is not to say that the AIX operating system itself will stand still — quite the contrary. IBM’s AIX strategy includes a continuous commitment to making AIX the best version of the UNIX operating system in the world. “The UNIX operating system itself has a long tradition of changing and improving almost constantly,” says Clay Cipione, “and we’re going to continue that tradition here at IBM with AIX.”

AIX PS/2 is the entry-level offering for the AIX environment, providing multi-user, multi-tasking capabilities for up to 16 users.



AIX PS/2

AIX PS/2 is a 32-bit multi-user, multi-tasking virtual memory operating system for the 386 microprocessor models of the PS/2, a powerful desktop computer that bridges the worlds of the PC and the workstation. AIX PS/2 can operate as a single-user system, or support up to 16 concurrent users sharing data and applications.

AIX PS/2 is, first and foremost, a full-function derivative of the UNIX operating system, offering basic compatibility with systems like UNIX System V Release 2 and 4.3 Berkeley Software Distribution (BSD). As such, AIX PS/2 includes a hierarchical file system; the Bourne and C shells; a variety of editors and program debuggers; and tools for programming, text processing, and document preparation. AIX PS/2 supports such popular programs as TCP/IP, NFS™, and the X Window System™. The system comes also with popular extensions such as INed® and INmail™, licensed from INTERACTIVE Systems Corporation. Last but not least, AIX PS/2 offers an easy migration path for users currently

working with XENIX, a popular PC-based version of the UNIX operating system.

In addition to these basic elements, AIX PS/2 features a number of IBM enhancements, including virtual memory support; enhanced file management; dynamic configuration; DOS support for multiple users; multiple virtual terminal support; and National Language Support. IBM support for AIX PS/2 includes education and extensive documentation designed specifically for users who are new to UNIX operating systems.

AIX PS/2 offers strong support for distributed network computing. AIX Distributed Services (DS) offers transparent access to files among AIX systems running DS, balanced by AIX's record-locking capabilities to ensure integrity of data and applications. The Transparent Computing Facility (TCF) provides a single-system image for users of AIX PS/2 and AIX/370 systems in clusters of up to 31 separate processors, giving users a single-system image of the storage, applications, and processing power of the

entire cluster from their own desktop. (Both DS and TCF are described in more detail in "AIX: Extending the Power of the UNIX Operating System.")

AIX PS/2 also offers a high degree of affinity with the DOS operating system and applications developed for it. DOS Server provides access to the AIX PS/2 file system for users of IBM DOS Version 3.3 applications on an appropriately attached IBM PC or IBM PS/2 running the AIX Access for DOS Users licensed program. DOS Merge allows multiple users, on ASCII terminals or the system console, to execute IBM DOS Version 3.3 and many DOS applications with AIX PS/2. (Both DOS Server and DOS Merge are described in more detail in "AIX: Extending the Power of the UNIX Operating System.")

(For an example of AIX PS/2 in a small business multi-user application, see Part Four, "Making TRACS: AIX At Work For Genuine Parts Company." For access to more technical information regarding AIX PS/2, see Part Five.)



AIX/RT is IBM's AIX offering for high-function technical workstations and for mid-range, departmental systems of up to 32 users.

AIX/RT

AIX/RT is a multi-user, multi-tasking virtual memory operating system for the RT system. The RT's 32-bit, Reduced Instruction Set Computer (RISC) architecture makes it a versatile microcomputer, and the AIX/RT operating system, with its 40-bit addressability, enables the RT to function either on its own as a high-function workstation, or as a multi-user system for up to 32 concurrent users (64 with a PRPQ) sharing data and applications. AIX/RT's rich set of programming languages and powerful graphics support makes the RT particularly useful for complex design and technology applications.

AIX/RT includes a full set of the features common to other major derivatives of the UNIX operating system, including System V.2 and 4.3 BSD. These features include a hierarchical file system, programming languages, shells, editors, debuggers, libraries, utilities, and other tools. Communication programs like TCP/IP, NFS, and the X Window System are fully supported by AIX/RT, which also comes with popular extensions like INed and INmail, licensed from INTERACTIVE Systems Corporation.

AIX/RT offers the additional advantages of numerous IBM enhancements not found in many other versions of UNIX operating systems. These IBM enhancements include virtual memory support; enhanced file management; real-time interrupts; dynamic configuration; DOS support for multiple users; multiple virtual terminal support; multiple interactive session management; and National Language Support.

AIX/RT offers important capabilities for file sharing, led by Distributed Services (DS). DS offers single-system-image access to files and programs among AIX systems running DS. AIX's record-locking capabilities ensure that DS does not compromise the integrity of data and applications. Another file-sharing option is DOS Server, which allows DOS users to access the AIX/RT file system with ease. These applications and users access DOS Server from appropriately attached IBM PCs or PS/2s running under IBM DOS Version 3.3 with the AIX Access for DOS Users licensed program. (Both DS and DOS Server are described in more detail in "AIX: Extending the Power of the UNIX Operating System.")

AIX/RT SNA Services allows AIX end users and application programs to communicate with traditional 3270, RJE, and peer applications within a Systems Network Architecture (SNA) network. SNA Services provides a documented application programming interface (API) to SNA LU1, 2, 3, and 6.2 Advanced Program-to-Program Communications (APPC). (The relationship between AIX and SAA environments is covered in more detail in Part Three, "AIX and IBM.")

Finally, IBM backs AIX/RT with education, extensive documentation, and assistance with installation and usage that complement the performance features already included in the AIX/RT system.

(For examples of AIX/RT in departmental and company-wide applications, see Part Four, "One Good Architecture Deserves Another: AIX at Skidmore, Owings & Merrill," and "Smooth Sailing for Technical Publications: AIX At Newport News Shipbuilding." For access to more technical information regarding AIX/RT, see Part Five.)

AIX/370 provides a mid-range to high-end AIX environment for System/370 processors, up to and including the largest of IBM's ES/3090 mainframe systems.



AIX/370

AIX/370 is a multi-user, multi-tasking virtual memory operating system for IBM's System/370 processors, providing a high-performance version of the UNIX operating system in an environment with large files and high-end computing capability.

AIX/370 draws on UNIX System V.2 for basic system functions, program development tools, text processing commands, and utilities. 4.3 BSD also supplies important basics, including the C shell, sockets, system calls, libraries, utilities, and signals, plus a subset of the BSD system management commands. Finally, AIX/370 shares with many other popular UNIX operating systems such popular programs as TCP/IP, NFS, and the X Window System.

AIX/370 is supported in both 24-bit and 31-bit addressing modes. In S/370 mode, 8 megabytes of process size are available to the user. In XA mode, approximately 770 megabytes are available for the user process. The ES/3090 Vector Facility is fully supported by AIX/370 on any VM system that supports the Vector hardware.

AIX/370 runs as a guest under VM/SP (with or without the High-Performance Option) or VM/XA™, and can coexist with CMS and other guest

operating systems such as MVS on the same processor. AIX/370 manages most of its own resources, such as I/O, paging, spooling, and scheduling, but uses the VM operating system for error logging and reporting, system printer support, and access to ES/3090 Expanded Storage.

A function called "onhost" (formerly "oncms") gives AIX/370 users convenient access to the large base of existing CMS programs, allowing users to submit commands such as those which start the execution of CMS programs like VS Pascal and SQL. Output of these programs may then be piped directly into an AIX program.

Local/remote file transfer support allows AIX/370 users to send files to and receive files from other users in a network accessed via the Network Job Entry (NJE) facility of the Remote Spooling Communications Subsystem (RSCS). In particular, this facility allows an AIX/370 user to receive files from or send files to a CMS user, an MVS/TSO user, or another AIX/370 user.

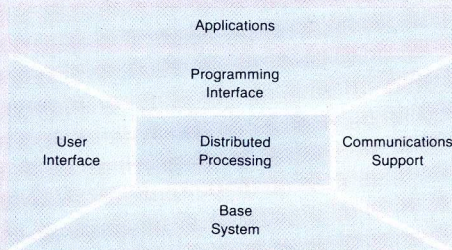
AIX/370 provides capabilities for communication between S/370 and other computer systems. The Transparent Computing Facility (TCF) provides a

single-system image for users of PS/2 and S/370 systems in clusters of up to 31 processors, giving users transparent access to the storage, applications, and processing power of the entire cluster. DOS Server provides access to AIX/370 from an IBM PC or IBM PS/2 running DOS Version 3.3 and the AIX Access for DOS Users licensed program. DOS output may be routed to an AIX/370 system printer, and users may access the AIX/370 file system as a local DOS resource. IBM intends to extend Distributed Services (DS), an IBM program for transparent file sharing, to AIX/370 at a later date. (TCF, DS, and DOS Server are described in more detail in "AIX: Extending the Power of the UNIX Operating System.")

IBM supports AIX/370 with extensive documentation (preformatted on-line documentation is available for all AIX/370 commands and system calls), education, and assistance with installation and usage.

(For an example of AIX/370 in a compute-intensive design application, see Part Four, "Meeting the Chip Design Challenge: AIX At Intel® Corporation." For access to more technical information regarding AIX/370, see Part Five.)

The AIX Family Definition



The AIX Family Definition establishes a common AIX operating system environment across the AIX Family of three different hardware architectures — 386-based PS/2s, RISC, and System/370. The AIX Family Definition consists of detailed specifications for six critical elements of the AIX environment: the Base System, User Interface, Programming Interface, Communications Support, Distributed Processing, and Applications. Each of these six elements is described below.

The AIX Base System definition ensures compatibility between AIX and other popular versions of the UNIX operating system.

Base System

The AIX Base System is the foundation of the AIX operating system; in industry parlance, it is equivalent to the "kernel," or interface to the hardware, of a UNIX operating system. As such, the Base System portion of the AIX Family Definition specifies interfaces between the kernel and other parts of the operating system; system calls and commands; libraries and utilities; and other services that are provided to the overall AIX operating system. (See the Glossary for a definition of "kernel" and an illustration of the UNIX operating system's structure.)

One of the key features of the AIX Base System definition is compatibility with other important versions of the UNIX operating system. Some versions, like the IEEE's POSIX standard, are important because they are emerging as official industry standards. Other versions are important because they are already in widespread use; two such versions include 4.3 BSD, and AT&T's System V Release 2. The AIX Family Definition provides Base System compatibility with these three systems, while also furnishing a foundation on which IBM can build performance enhancements to meet evolving customer needs.

The AIX Family Definition offers important language compatibility with SAA; both systems specify the C and VS FORTRAN programming languages.

User Interface

The AIX User Interface describes what users see and how they see it. The AIX Family Definition includes both character interfaces and all-points-addressable (APA) interfaces, so that both character and graphics interactions can be standardized across the PS/2, RT, and S/370 platforms. The User Interface definition also includes Version 11 of the widely popular X Window System developed at MIT, which provides important capabilities for developing distributed applications under AIX.

At this point, the AIX Family Definition does not specify a defined graphical user interface. IBM has licensed or sponsored the development of a number of innovative graphical interface technologies, including NeXT® Inc.'s NextStep™, OSF's Motif™, and Carnegie Mellon's Andrew. IBM has also indicated that it will provide the best available toolkits to give applications and user interface designers the support they need to create increasingly effective applications for users of tomorrow's sophisticated computer technology.

Programming Interface

The AIX Programming Interface defines interfaces, tools, and services that AIX makes available to systems programmers and applications developers. These include major programming languages, such as C and VS FORTRAN; programming tools, such as an advanced symbolic debugger and other utilities common to UNIX operating systems; and languages.

Application programs that use an AIX Family Definition language should be easily portable among AIX hardware platforms via simple

User Interface

Applications developed under the AIX Family Definition will transfer among AIX platforms, or to AIX platforms from other systems, with minimum difficulty.

Applications

Programming Interface

recompilation of the program. The AIX Family Definition also offers important language compatibility with SAA, which includes both C and VS FORTRAN. Where SAA extends beyond its current definitions for programming languages, IBM will evaluate those extensions for inclusion in the AIX Family Definition.

Distributed Processing

Distributed Processing

AIX Distributed Processing defines the protocols and functions that enable AIX systems to share available resources and processing power transparently with other systems (AIX, SAA, or OEM). AIX Distributed Processing strategies aim to give users access to all the resources contained in a computer network — including processing power, application programs, and data — from their own desktop. AIX should also release users from system administration duties, and make those duties easier for system administrators.

The AIX Family Definition specifies two major systems designed for transparent distributed processing: IBM's own AIX Distributed Services, and the Network File System (NFS) developed by SUN® Microsystems. NFS has become a de facto industry standard, and is included in the Distributed Processing strategy of the AIX Family Definition to make AIX systems compatible with the widest variety of existing and future customer systems.

Distributed Services (DS), on the other hand, was developed by IBM especially to raise AIX Distributed Processing to a new, higher level of performance and transparency than is available with other systems today. IBM's Transparent Computing Facility (TCF) is a candidate to join DS in the AIX Family Definition. (For more information on Distributed Services and the Transparent Computing Facility, see Part Two, "AIX: Extending the Power of the UNIX Operating System.")

Base System

Applications

AIX Applications is the portion of the AIX Family Definition that concerns customer application programs. Applications may be simple utilities or complex business software packages; they may reside on all AIX platforms simultaneously, or reside on one platform and be available to users of other platforms. Applications developed under the AIX Family Definition will transfer among AIX platforms, or to AIX platforms from other systems, with minimum difficulty, depending on the complexity of the application and any device-dependence written into it.

Within the AIX Family, for example, newly developed applications are portable to other AIX platforms with a simple program recompilation. Applications developed under 4.3 BSD or System V.2 can move easily to AIX platforms. Programs written for specific devices, on the other hand, may require new code to accommodate that built-in dependence.

Communications Support

In many customer data processing environments, high-performance data throughput — and thus the network communications systems that carry the data — is critical to the customer's business. AIX Communications Support specifies the protocols, services, and applications needed for high-performance information exchange among hardware systems.

The primary purpose of AIX Communications Support is to provide interoperability among connected homogeneous and heterogeneous systems, with a wide range of protocols over a wide range of connectivity options. The ultimate benefit of AIX Communications Support for customers is the ability to use and manage networks of mixed systems.

To achieve this result, the AIX Family Definition supports both official and de facto industry standards, including transmission protocols and programs. These include Transmission Control Protocol/Internet Protocol (TCP/IP), uucp ("UNIX-to-UNIX copy"), and the X Window System. Standard connections include IBM's Token-Ring and XEROX® Ethernet. Because standards for transmission and connection continue to evolve, the Communications Support element of the AIX Family Definition may be updated. IBM is currently participating in standards efforts such as Integrated Services Digital Network (ISDN) and the Open Systems Interconnect (OSI) model.

The ultimate benefit of AIX Communications Support for customers is the ability to use and manage networks of mixed systems.

Flexible for the Future

IBM is committed to enhancing the specifications that make up the Family Definition. As standards emerge, the AIX Family Definition will evolve in response. At the same time, IBM will continue to enhance the Family Definition on its own to satisfy customer requirements. In particular, IBM will continue to enhance the AIX Family Definition by extending and broadening interconnections with the SAA environment, which involves untold millions of bits of information in the enterprises of IBM customers worldwide.

■

AIX: Extending the Power of the UNIX Operating System

AIX introduces a wide range of new features, functions, and enhancements to existing UNIX operating systems, to establish an entirely new level of performance and customer value.

It would take many pages to describe all the ways that AIX sets new standards for derivatives of the UNIX operating system. This article highlights just a few major areas in which AIX excels, demonstrating IBM's commitment to AIX and to its customers who want the very best derivative of the UNIX operating system available today.

One of the key attractions of the UNIX operating system is its suitability to distributed networks of different kinds of computer processors. AIX offers two major new advances in distributed computing: AIX Distributed Services, and the Transparent Computing Facility. Each of these major efforts is discussed in detail in the following pages.

"I need mainframe computers for big jobs and desktop computers for small jobs — but I don't want users to think about which jobs run on which machines."

"AIX TCF combines up to 31 S/370s and PS/2s into a single system called a TCF cluster. Users can access all the resources of the cluster from their own desktops."



Transparent Computing Facility

The Transparent Computing Facility (TCF) was jointly developed by Locus Computing Corporation and IBM. As its name implies, the Transparent Computing Facility makes the physical boundaries between hardware systems transparent to users of PS/2 and System/370 computers. Up to 31 of these processors may be mixed and combined

The Transparent Computing Facility (TCF) makes the physical boundaries between hardware systems transparent to users of PS/2 and System/370 computers.

into a TCF "cluster" via Ethernet or Token-Ring (or, for some S/370 systems, via channel-to-channel connections). Users on the cluster "see" the equivalent of a single system — but one that possesses all the capabilities of the combined systems.

An accountant on a TCF cluster, for example, can run massive, complex calculations on an ES/3090 mainframe as well as small-business spreadsheets on a PS/2. Once the system has been

designed, TCF transparently selects the appropriate processor for each task. Individual workers use a single password to call for all the resources needed to complete a task, and the TCF cluster delivers them, regardless of where they may reside within the cluster.

TCF provides a number of important benefits for system administrators. All copies of a file, for example, are automatically updated throughout the cluster whenever a change is made, which eliminates the distinction between centralized and distributed applications. TCF also makes it easy to dynamically add or subtract processors from a cluster.

The benefits of the Transparent Computing Facility derive from two functional capabilities: a distributed file system, and remote tasking.

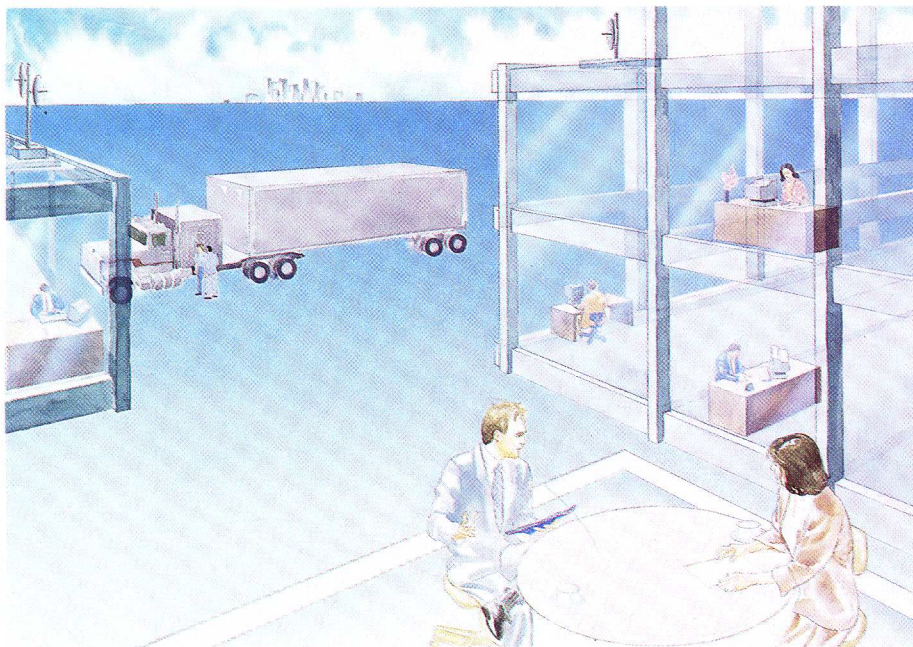
The TCF distributed file system provides all users on the cluster with a single hierarchical file system. Furthermore, file naming is independent of the file's physical location. Thus, users no longer need to know where a file is, and TCF administrators are free to locate files for most efficient access and processing.

TCF's remote tasking capability allows one process within the cluster to create additional processes on other computers, independent of where the code for the

original process resides. This allows the TCF cluster to use all available processing power within the cluster to complete jobs most efficiently. TCF remote tasking also allows a System/370 process to migrate from one computer to another of the same architecture — while the process itself keeps running. This in-flight "process migration" can be directed by the user, invoked by the process itself, or employed by system administrators for load-leveling.

TCF remote tasking allows S/370 processes to migrate from one computer to another of the same architecture while they are running. This in-flight "migration" can be directed by the user, invoked by the process itself, or employed by system administrators.

A TCF cluster can include as many as 31 separate processors. The number of users who can benefit from it, though, is much larger. For example, any ASCII terminal user connected to a PS/2 has full access to all facilities of the cluster, as do



"What if I want location-transparent access to files on all the computer systems within my company?"

"AIX DS extends the benefits of transparent file sharing to hundreds of systems on a Distributed Services network. DS also connects TCF clusters."

PC users supported by the AIX DOS Server. Best of all, an entire TCF cluster can be connected to other nodes or clusters via TCP/IP, NFS, or, in the future, IBM's Distributed Services.

Distributed Services

Another IBM advance in the field of distributed processing is AIX Distributed Services (DS), which extends the benefits of transparent file sharing to hundreds of systems on a network. Distributed Services allows users to create and access files on PS/2 and RT systems running AIX via TCP/IP on Ethernet or Token-Ring.

Distributed Services allows flexibility in the description of the way the systems participate in the distributed network. For example, a single-system image can be defined in which all systems share all resources. Multiple single-system images can be defined in the same network. A system can participate in more than one single-system image within the same network concurrently. Systems running DS can share some (or in some cases none) of their resources.

"While most other people have focused on one particular aspect of the full administrative model," says Dale Reed, a member of IBM's Senior Technical Staff, "we've worked hard to create a

system that covers the complete model, and that delivers a very high level of performance."

One of the fundamental benefits of Distributed Services is location-transparent access to all files within the DS environment. Users can request data files, program files, and directories without regard for where those resources reside.

AIX Distributed Services extends the benefits of transparent file sharing to hundreds of IBM systems on a network.

Unlike some other distributed versions of the UNIX operating system, AIX DS allows users to "remote mount" (i.e., logically attach) both files and directories. Furthermore, users need not limit their mounts to specially marked files or directories; under DS, users can mount any file or directory they can name (provided they are authorized to access it).

Another key benefit of Distributed Services is that workers can access all authorized directories, files, and other resources with equal ease from any DS-connected terminal, regardless of where it is physically located. An individual's

passwords, mail characteristics, and other user-specific elements remain unchanged from terminal to terminal, enabling workers to be equally productive at a number of sites within their DS environment.

AIX Distributed Services allows multiple users to process the same file concurrently, with minimal impact on processing performance and no inconsistencies in the file. File-sharing systems offered by other vendors, by contrast, have tended to create inconsistencies during multiple file access or exact significant performance penalties.

Distributed Services users can also initiate remotely located processes using TCP/IP, a set of communications protocols included with most UNIX operating systems. Users and applications running the DS program on one system can take advantage of the computing resources of remote systems running DS, using TCP/IP remote commands like rsh ("remote shell") and rexec ("remote execute").

Along with its high-performance file-sharing characteristics, DS offers enhanced security features compared to most other file-sharing systems. Advanced authentication programs in DS verify that users accessing remote

"What about all our DOS files and applications? Can I still use them under AIX?"

"Of course. AIX provides unsurpassed access to DOS and DOS applications from the AIX environment, and equally strong access to AIX from the DOS environment."



machines are actually connected to the machines they have specified. User identification translation functions built into DS provide a wide range of access levels; someone with a high level of access to the files on one system, for example, can be restricted to guest access to files on a second system.

A key feature of IBM's AIX Distributed Services is its compatibility with the Network File System (NFS) developed by SUN Microsystems and found in many UNIX operating system environments. AIX engineers have ensured that NFS systems can connect to DS for transparent file sharing. If necessary, system administrators can selectively use NFS to communicate with remote machines that are not running AIX Distributed Services; users, however, notice no difference.

AIX Distributed Services enables workers to be equally productive at multiple sites within their DS environment.

IBM is pressing on with future versions of DS, which will feature enhanced portability, so that DS will be able to support non-AIX operating systems. Distributed Services will also include virtual memory-mapping of both local and remote files, and new mechanisms for authorization and authentication, and more.

DOS Affinity

One of IBM's greatest legacies is the huge number of programs written for the DOS operating system. The AIX operating system features powerful affinity with DOS, for users who need a UNIX operating system but wish to preserve their DOS applications and data. Thus, AIX provides users with the best of both worlds.

AIX provides unsurpassed access to DOS and DOS applications from the AIX environment using the DOS Merge or IBM AIX/RT Personal Computer AT[®] Simulator programs, and equally strong access to AIX from the DOS environment

using the DOS Server and AIX Access for DOS Users programs. These programs are described below. In addition, the DOS shell included in AIX/RT enables users to direct AIX functions using familiar DOS commands.

DOS Merge enables multiple users to execute IBM DOS Version 3.3 and many DOS application programs concurrently with AIX PS/2. DOS programs can be invoked from AIX and vice versa, and the two operating systems can exchange data while in the process of running applications. DOS Merge can convert ASCII files between DOS and AIX, support graphics-based DOS applications under AIX implementations of X-Windows, and extend to DOS users such AIX features as password security and file protection.

The PC AT[®] Simulator provides the capability for many DOS applications to execute from the console on an AIX/RT system without requiring additional hardware. DOS applications run under the PC AT Simulator as if they were executing on a PC AT with 640 kilobytes of memory. AIX/RT utilities provide for file transfer between DOS applications and AIX, and enable DOS applications to share RT printers, plotters, and diskettes. The PC AT Simulator can be extended to multiple users via AIX X-Windows and TCP/IP.

DOS Server on the AIX host, in cooperation with a licensed program called IBM AIX Access for DOS Users running under DOS 3.3, allows DOS users access to AIX PS/2, AIX/RT, and AIX/370 systems. The AIX file system on each of these platforms appears to IBM DOS 3.3 as additional virtual files. Files may be transferred between the disk drives of the DOS workstation and AIX PS/2s or AIX/RTs, giving users of IBM DOS 3.3 access to storage facilities, data, and application programs maintained by AIX. DOS Server also provides utilities for converting DOS files to AIX files, and vice versa.

In addition to supporting DOS Server data sharing, AIX Access for DOS Users provides AIX printer access, terminal emulation, and a PC-based visual (vi) editor for use under DOS. DOS users con-

nected to AIX via AIX Access for DOS Users also enjoy AIX file security and record locking. DOS users can access AIX hosts via Ethernet, Token-Ring, or asynchronous connections.

User Interfaces

IBM has devoted special attention to making the full range of AIX user interfaces as friendly and as functional as they can be.

AIX provides unsurpassed access to DOS and DOS applications from the AIX environment, and equally strong access to AIX systems and resources from the DOS environment.

IBM has licensed or sponsored the development of a number of innovative graphical interface technologies, including NeXT, Inc.'s NextStep and Carnegie Mellon's Andrew. IBM has also licensed and has indicated that it will support OSF/Motif[™] (the graphical user interface selected by the Open Software Foundation). For windowing applications, AIX PS/2 and AIX/RT offer AIX X-Windows, an enhanced version of the system created (with IBM support) at MIT. Users can create multiple concurrent windows using AIX X-Windows, and switch back and forth between them with ease.

(For more information on IBM's AIX-related user interface research, see "IBM's AIX Partners" in Part Three.)

Base System Performance

One of AIX's original innovations on the RT system was the IBM RT Virtual Resource Manager (VRM). In AIX/RT, the VRM is a separate layer of the operating system that gives users transparent access to large memory spaces and all the freedom and flexibility that go with them. The VRM will become part of the "kernel," or base system, in AIX Version 3, a

future version of AIX selected by the Open Software Foundation for its core technology. Version 3 will also provide for flexible management of the physical disk space of the system, with features such as dynamic allocation of files. And by mapping the entire file system into virtual memory, Version 3 will enhance both I/O performance and recoverability in the event of a system failure.

System administrators will also appreciate AIX Version 3's capability for dynamic loading of AIX operating system modules. Individual system modules can be loaded as they are needed, rather than when the entire program is initialized. This will permit speedier, more efficient sharing of AIX resources, making it easier to replace or update modules, and permitting AIX to be run on smaller hardware systems.

Real-time enhancements in AIX Version 3 will include the ability to specify both absolute priorities for some applications, and relative priorities among a group of applications. This will allow real-time applications to use the resources of the AIX kernel the instant that they are needed, rather than waiting for preset interrupt points, as with other versions of the UNIX operating system. AIX Version 3 also will permit applications programs

to "pin" pages of storage into virtual memory in order to prevent delays in processing caused by going into main memory for files or data.

AIX Version 3 will provide enhanced virtual memory management, flexible disk storage management, dynamic program loading, and more.

The security of UNIX operating systems has recently been a vital issue. AIX Version 2 already meets the U.S. Government's C-2 level of security, and has remained largely free of invasions such as so-called computer "viruses." The Internet virus that shocked the computing community in the fall of 1988, for example, did not affect AIX or Distributed Services environments. "We had already fixed the problems that permitted that virus to spread through other versions of the UNIX operating system," says Dale Reed, a principal architect of AIX/RT.

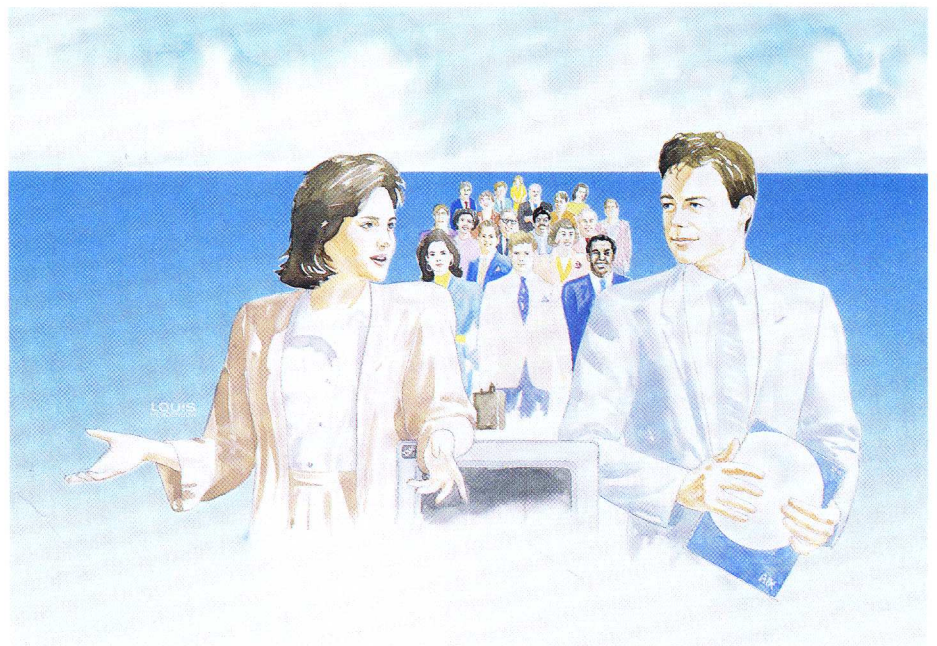
The Bottom Line

One of the most important things about the features of AIX described in this

article is that they are being provided by IBM. Customers who use AIX systems are assured of professional assistance in installing, using, and expanding their AIX systems. Because AIX is an IBM operating system, it will enjoy the advantages common to all IBM products: unmatched reliability; top-quality service and support; and on-going research and development to keep it at the cutting edge of cost-effective performance.

"IBM addresses new opportunities with the full intent of providing best-of-breed products," says Pete Schneider, IBM Director of Systems and Programming. "We feel that AIX represents a strong step forward for the UNIX operating system, and that feeling was confirmed for us when the Open Software Foundation took a very close look at the available versions of the UNIX operating system, and selected AIX as its core base system technology. It shows how quickly we've come in such a short time — from being new in the game to becoming a force to be reckoned with."

"Best of all, AIX comes with the quality, reliability, and support that IBM is known for worldwide."



Excerpts from: **TCF: A Distributed Model** by Judith S. Hurwitz

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UNIX in the Office, Vol 3 No. 4, April 1988.

Transparent Computing Facility (TCF) was jointly developed by IBM and Locus Computer. Locus has had several highly successful products in this arena, including DOS Merge, PC X-Windows, and PC Interface — all of which are available under AIX.

TCF has been under development for the past seven years, according to Locus President Jerry Popek. Popek began work on TCF while at [sic] he was a professor at UCLA. The product was prototyped in 1981. In 1982, Popek left UCLA to form Locus.

The philosophy behind all of Locus's products is transparency to the user. For example, with the PC Interface product, the user sitting at a Unix workstation can access the DOS filing structure as though he or she were at a DOS PC. The user does not have to be bothered knowing where different programs are stored or which environment he or she is working in — the software handles all that. While many vendors have selected Locus's DOS and Unix products, TCF is an IBM-only product. Why? Simply put, the amount of work required to create the sophisticated software for the IBM environment would make doing the same work for other vendors difficult.

The Underpinnings

The TCF function requires a LAN to operate. IBM will support either Token-Ring or Ethernet. TCF allows certain parts of programs, such as editing, to be run on the PS/2. In addition, the software is designed so that, if you wish, you can split different parts of programs among different CPUs. If the program is computer intensive, it may be appropriate to run it on a 3090 rather

than a 9370. Therefore, the system administrator will monitor the network to see where the available CPU cycles might reside. Once it has found the appropriate machine, the administrator can move the application in flight. In essence, it runs in parallel on the two machines until the second processor is in synch with the first processor. At this point, control is passed to the second processor, and the first processor is released. This is all transparent to the user. The system software causes the reads and writes to be effected on the physical terminals where the user assumes the process is running. For example, a stock broker on a local terminal running some "what if" scenarios might suddenly decide to calculate some complex, stock option processing. That stock option processing — which could be extremely CPU intensive — could automatically be run on a connected 3090. In a similar way, a program could be written to be automatically divided up among several different processors, depending on the CPU requirements. In essence, TCF allows users to make the best use of all CPUs.

Network Management. As programs and CPU cycles fly through the network, network management may seem nightmarish. Not so, according to Popek. Even if 30 machines are clustered together, the software treats all 30 systems as one logical machine. Therefore, administration and management are simplified. Since the TCF creates a single file structure, there is no need for something like SUN's Yellow Pages to keep track of files. Another advantage of TCF is that machines can be added and subtracted from the network without interfering with ongoing tasks. ■

UNIX is a registered trademark of AT&T for its operating system.

Looking for Compatibility?

The many advances and enhancements built into AIX in no way diminish its compatibility with UNIX System V Release 2; emerging standards such as POSIX; selected extensions of the Berkeley Software Distribution (4.3 BSD); and other elements common to UNIX operating system versions, including TCP/IP, NFS, and the X Window System. For information on AIX compatibility with these systems and functions, see **Part Three: New Roles, New Relationships.**

This is A Manual People Will Read



IBM's Bill Dickerson and Marilyn Payne: "We've become leaders in the field of user documentation, and we're going to keep working to maintain that leadership."

It may take a while for AIX to become an industry standard. IBM's AIX documentation, on the other hand, set a new standard for UNIX operating system documentation right from the start. "Based on customer demand for it and how rapidly our competitors are copying it, I'd have to say our documentation for AIX has become a benchmark in the industry," says Bill Dickerson, former Manager of Information Design and Development in IBM's Advanced Workstation Division.

Dickerson and his team in Austin, Texas began by performing a detailed analysis of the tasks that AIX users would perform, how they would interact with the system, and what they expected from its documentation. Based on that analysis, the AIX documentation team completely restructured and rewrote the existing documentation. Their efforts included separating installation and management information from basic user information; organizing a master index and bibliography; and pulling together separate, complete catalogs of system commands and messages. "We also created some new elements, such as quick references to important aspects of the AIX operating system," says Dickerson. A poster-sized

quick reference to the C programming language, for example, has proven highly popular.

Another important contribution involved standardizing terminology. The original UNIX documentation, for example, uses terms such as "flag," "parameter," and "option" interchangeably to mean the same thing. The AIX documentation team picked one term for each element and stuck with it.

"Based on customer demand for it and how rapidly [IBM's] competitors are copying it, I'd have to say our documentation for AIX has become a benchmark in the industry."

Clarity and Value

The documentation for AIX makes effective use of color, diagrams, and layout to clarify important issues for busy users. Instead of using densely bracketed synopsis statements to explain programming syntax, for example, the AIX documentation uses easy-to-read syntax diagrams.

Detailed explanations of various AIX operations are preceded by "fast-path" summaries that explain the operation at a glance, and show how the associated documentation is organized.

Recognizing that many AIX users will not have prior experience with the UNIX operating system, the AIX documentation designers added hundreds of examples, testing them so thoroughly that they were able to uncover errors buried in the original UNIX operating system code. The new examples were then built into a guide format that takes users through operations step by step.

Another Leap Forward

The resulting usefulness, completeness, and overall value of IBM's AIX documentation has won praise from the trade press, led industry competitors to emulate it, and, most importantly, made customers read it thoroughly and use it widely. "The questions we're getting from our customers show that they have really worked with the format and the information," Dickerson says. "That's been one of the most gratifying aspects of the whole project."

With solid success already assured for its early efforts, the AIX Information Design and Development team is preparing for another leap forward. At the 1988 UNIX EXPO, IBM demonstrated a prototype on-line AIX documentation system featuring hypertext retrieval. Hypertext allows users to find desired information at the touch of a button, to read that information just as readily, and to tailor the documentation to their own needs. When perfected, this type of documentation could very well change the way people learn to use computers. "We've worked hard to become leaders in the field of user documentation," Dickerson says, "and we're going to keep working to maintain that leadership." ■

The Evolution of AIX

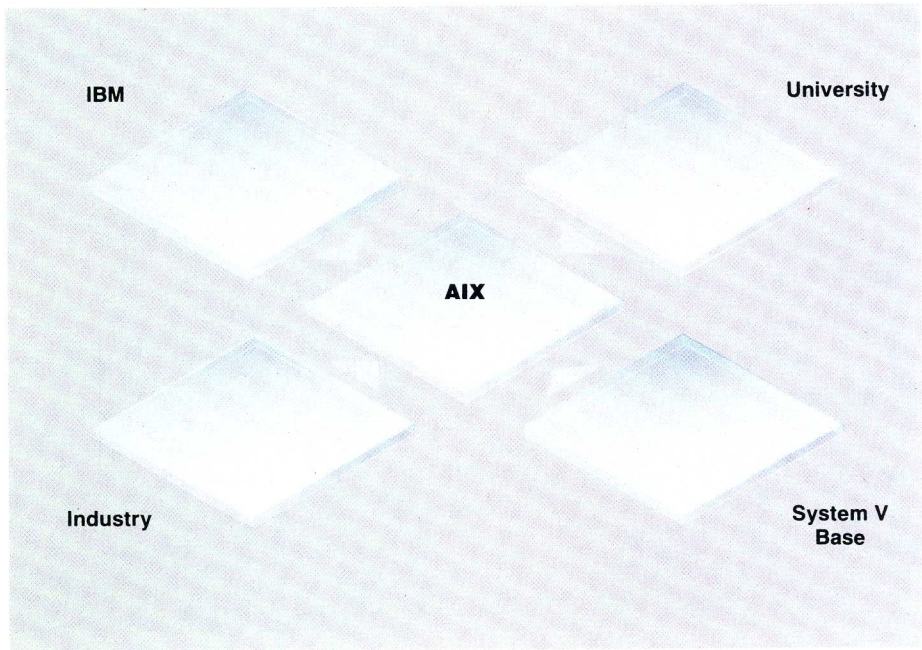
AIX represents the culmination of nearly two decades of evolution, starting with the original UNIX operating system almost 20 years ago.

Establishment of the AIX Family is a major milestone in IBM's work with derivatives of the UNIX operating system. It is also a major milestone in the evolution of the UNIX operating system itself, which is owned and licensed by AT&T. This article profiles the long, intricate pedigree of AIX — a system based on the UNIX operating system but also incorporating enhancements and extensions made by IBM and a host of other organizations.

Mythical Origins

A number of stories and myths surround the earliest origins of the UNIX operating system, but the basic outlines are clear. Computer engineers at AT&T's Bell Laboratories in the 1960s had run aground in the development of a new, time-sharing operating system called MULTICS. Ken Thompson and Dennis Ritchie, two contributors to the MULTICS effort, wanted to preserve some of the positive features of the system, and began to design a new operating system on their own, in 1968. This system included a number of features that remain central to AIX today, including a hierarchical file system, special files for devices and directories, a command interpreter called a "shell," and the capability of supporting more than one user at a time.

To distinguish it from MULTICS, the new system was referred to as "UNICS," which was soon shortened to "UNIX." With the addition of a few short subprograms that provided text, editing, and printing capabilities, the emerging system was offered in 1970 to the Bell Labs patent office, which needed a text-processing system. This early UNIX software had no memory protection, no documentation, and it was written entirely in machine language, but the patent office



AIX incorporates the best features of the UNIX, System V and 4.3 BSD operating systems, includes important industry extensions, and offers numerous IBM enhancements.

accepted it, giving Thompson and Ritchie a working system to develop and refine.

The first official users of the UNIX operating system were members of the Bell Labs patent office in 1970. Their system had no memory protection or documentation, and it was written entirely in machine language.

One of the most important advances came when they rewrote the kernel and shell of the UNIX operating system in a new, high-level programming language called "C." High-level language programs must be compiled, or interpreted, before they

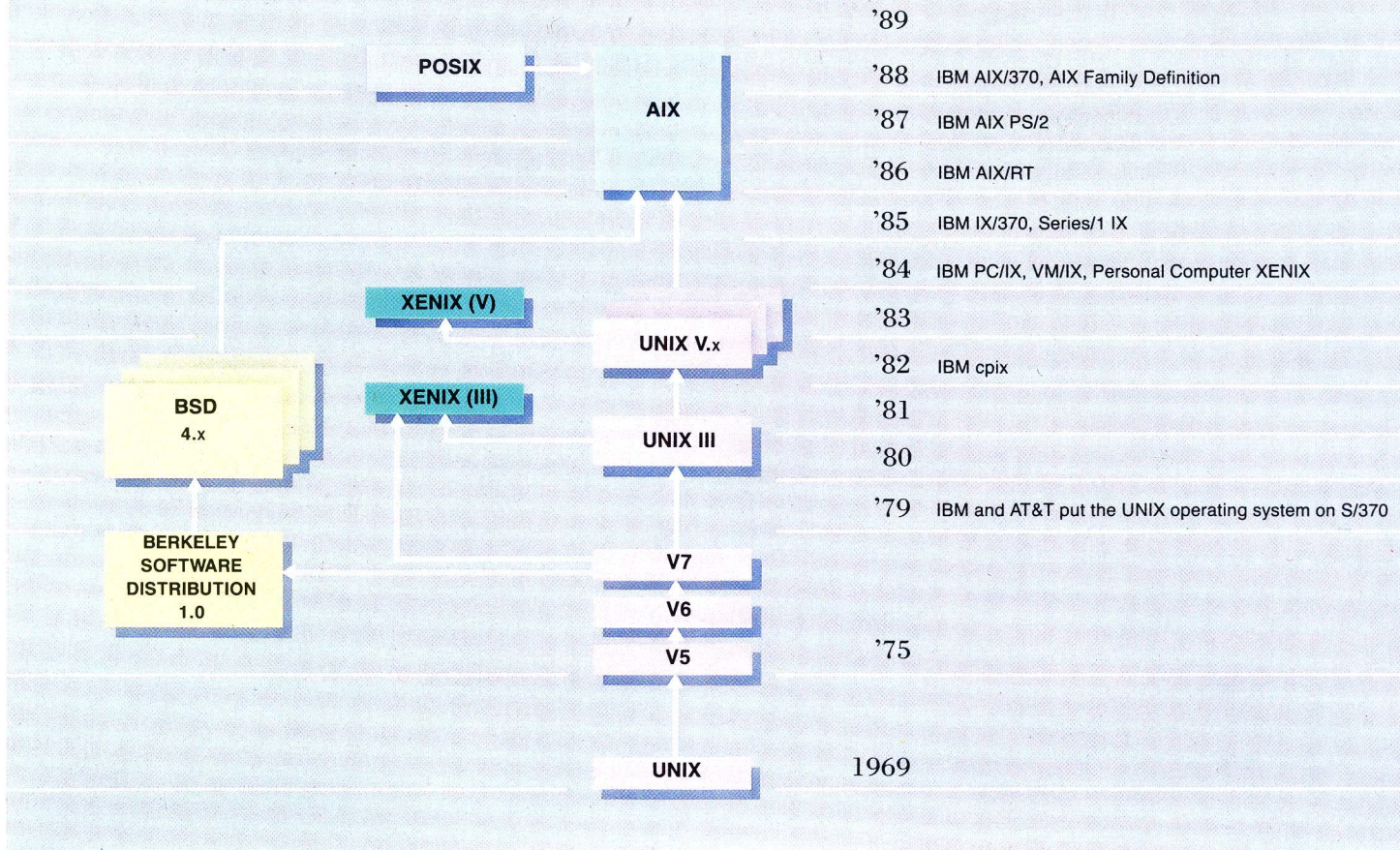
can run on physical hardware, but they are easier to write and remain independent of specific computer architectures. C had already been used to write utilities and applications for the UNIX operating system, so its advantages in terms of flexibility and debugging were well known. By 1973, the kernel, shell, and utilities of the UNIX operating system were all written in C, which set the stage for further, more rapid evolution.

Dissemination

In the early 1970s, other groups within Bell Labs heard about and acquired UNIX operating systems of their own. Then some computer engineers at Columbia University asked for the UNIX operating system source code. They signed an agreement not to disclose it to anyone else. Other than that, the

The AIX Family Tree - Taking the Best and Making it Better

The UNIX Operating System at IBM



The AIX family tree includes such notable forebears as AT&T System V, 4.3 Berkeley Software Distribution, and XENIX . . .

. . . as well as IBM's years of experience in implementing versions of the UNIX operating system on IBM hardware.

exchange was remarkably informal; Ken Thompson evidently made the tapes himself and didn't charge anything for them. When other universities asked for the UNIX operating system, they too got the rapidly expanding code for the cost of tapes and postage.

When universities asked for the UNIX operating system, they got the code for the cost of tapes and postage.

Meanwhile, a group within Bell Labs known as Programmer's Workbench was making refinements to the UNIX operating system, strengthening the source code in the kernel and enabling the system to support more users concurrently. Thompson and Ritchie also continued to work on the system, often working with ideas or questions from academic users

of UNIX operating systems. Version 6 (the Sixth Edition) of the UNIX operating system was released in 1975, and it went on to become so popular outside AT&T that the company began to license it more formally. Because of an earlier antitrust consent decree, however, AT&T was not allowed to make money from computer products, so the UNIX operating system remained essentially unsupported.

Largely because of this legal situation, the UNIX operating system became an open system by default. University users were quick to add features, write new applications, and test the potential of the system on their own. Professional programmers contributed ideas and fixed bugs. Everyone seemed to exchange their updated code with everyone else, either at "swap meets" or through electronic mail; during this time, the "uucp," or "UNIX-to-UNIX-copy," command came into its own. Whenever a sufficient

body of upgrades had accumulated, AT&T would issue a new version and print a new manual.

A Mid-1970s Watershed

Until about 1977 nearly everyone ran the UNIX operating system on a Digital™ Equipment Corporation PDP-11™ computer. In 1975, a programmer named Mike Lesk wrote a collection of input/output subroutines that would work for any computer running a C compiler (a program capable of translating C's high-level commands into instructions for the computer machinery). In effect, this set of routines made the C language — and programs written in it — portable to different computers. Two years later, the UNIX operating system was ported to three new machines, each of which was quite different from the PDP-11.

Ironically, the system's early years on PDP-11s had an important effect that has lasted to this day. Because of a physical limitation in the PDP-11 computer, programs were limited to 64 kilobits of instructions — a small size for operating system routines. Programmers had to write small, efficient routines that did one thing well, and use a process called “pipes” to pass the results of one routine on to the next. Thus programs written for the UNIX operating system really consisted of a series of linked routines; this style has become a hallmark of the system and has helped give it its own distinct personality. (See “More Than Just An Operating System.”)

Programs written for the UNIX operating system really consist of a series of linked routines; this style has become a hallmark of the system and has helped give it its own distinct personality.

The year 1977 was also important to the UNIX operating system because it marked the first time that a private, commercial company began reselling it to third parties and backing it up with installation and service. INTERACTIVE Systems Corporation was the company, and its entry into the marketplace made the UNIX operating system a supported product for the first time.

Finally, 1977 saw the first release of a derivative of the UNIX operating system by the University of California at Berkeley, where computer scientists had been experimenting with it for several years. Called “Berkeley Software Distribution 1” or “1 BSD,” this version offered an alternative shell (the C shell), a new editor for revising the contents of screens, and a variety of other enhancements. From this point on, BSD versions of the UNIX operating system became popular and widespread; new releases were quickly acquired, studied, and adopted by many

interested parties. (Other important sources of new ideas included Harvard University, Lawrence Berkeley Laboratory, and The Rand Corporation, but the entire list of contributors would be too long to include here.)

Turning the Corner

As of 1980, the UNIX operating system had not yet caught on outside research, government, and academic circles. IBM had ported the system to a System/370 mainframe for an application at AT&T in 1979, but did not yet offer a supported product. A couple of user groups had formed though, with names like USENIX and /usr/grp. Amdahl® Corporation, a mainframe manufacturer and major IBM rival, was talking about selling an internal version of the UNIX operating system to customers. Everything was in place for the system to turn the corner into the main street of commercial computing.

Then, in 1981, a version of the UNIX operating system for microcomputers, called XENIX, was developed by Microsoft Corporation and brought to market by The Santa Cruz Operation. XENIX enabled many more people to get their hands on a version of the UNIX operating system and try it out. Meanwhile the universities were starting to graduate significant numbers of programmers who wanted to keep using the UNIX operating system in their new jobs. The introduction of faster, smaller, more powerful microprocessor chips also made it possible to build high-performance workstations that took good advantage of the UNIX operating system.

UC Berkeley's versions of the UNIX operating system quickly became popular and widespread.

During 1982, Amdahl, Digital, and Tandy® Computer all offered versions of the UNIX operating system to their computer customers. AT&T had already

agreed to divest itself of its local telephone companies in 1983 in exchange for permission to return to the computer business; almost at once it began exerting more control over the licensing process by which everyone was allowed to use the UNIX operating system. In 1983, AT&T also introduced what it called “System V” (Roman numeral five); since then, all new versions of AT&T's UNIX operating system are called “System V” and given a release number (currently 3).

AIX's Predecessors at IBM

IBM ported the UNIX operating system to its Series/1™ computer in 1982, in a version called Series/1 Carrier Products Interactive Executive Program (cpix) that was made available on a per-request basis. IBM developed new implementations of its IX (Interactive Executive) system, including IBM Personal Computer Interactive Executive (PC/IX) for the IBM PC, and the IBM Virtual Machine Interactive Executive (VM/IX) for mainframes running the VM operating system.

“[The UNIX operating system] had some significant shortcomings, . . . but they were shortcomings that IBM has a history of being able to address.”

IBM also introduced a PC system called IBM Personal Computer XENIX. A year later, in 1985, IBM upgraded cpix to a commercially marketed and supported product called Series/1 IX. The company also introduced IBM IX/370 for its line of popular mainframes.

During the mid-1970s, however, the UNIX operating system was increasingly associated with the workstation — a mostly stand-alone, high-powered computer capable of effectively supporting skilled scientists, researchers, and designers working on complex tasks. IBM had its Reduced Instruction Set Computer (RISC) architecture set for the

workstation market, but lacked an available operating system. The UNIX operating system was well-suited to the workstation market and already available, so IBM made the unconventional choice to use another company's source code for one of its own, most innovative computers.

"IBM is famous for creating wonderful products from scratch and then developing applications for them," says Clay Cipione, Director of AIX Systems. "But we wanted to get in to the workstation business more quickly, and we saw that the UNIX operating system played a strong role in the workstation market. It had some significant shortcomings as an operating system, but they were shortcomings that IBM has a history of being able to address."

AIX is Born

A small team of less than 200 people was assembled in Austin, Texas to develop a derivative of the UNIX operating system for the RT. IBM also received important assistance from INTERACTIVE Systems Corporation, the company that had first offered a commercially supported ver-

sion of UNIX. While INTERACTIVE concentrated on porting the UNIX source code to the RT, IBM's engineers focused on developing a "Virtual Resource Manager" layer of the new operating system to give the RT virtual-memory capabilities. (See "AIX: Extending the Power of the UNIX Operating System.")

The Advanced Interactive Executive (AIX) was first implemented on the RT in 1986. It was built on a base of AT&T System V Release 1, and included extensions from 4.2 BSD and enhancements by INTERACTIVE. IBM engineers and managers quickly realized, however, that AIX could be extended to other IBM computers, giving the company a significant advantage in the rapidly expanding marketplace for systems incorporating UNIX operating systems. "Other computer companies don't generally deal with our range of processors," observes Larry Loucks, Director of Software Architecture, IBM Entry Systems Division, and the author with Charlie Sauer of the Virtual Resource Manager.

Recognizing its unique opportunity, IBM quickly formed teams to implement AIX on the emerging PS/2 architecture

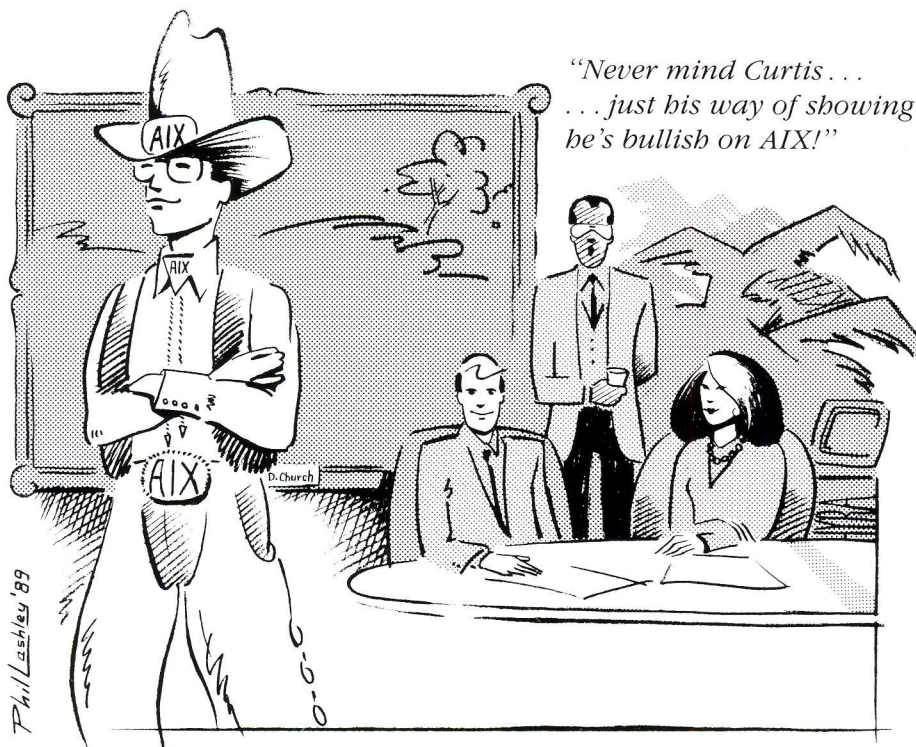
and on System/370 machines. IBM announced AIX PS/2 in the fall of 1987; in March of 1988, IBM announced AIX/370 and the AIX Family Definition, officially establishing AIX across a range of platforms from a line of desk-top computers to one of the industry's largest commercially available processors, the ES/3090 600E.

Recognizing a unique opportunity, IBM decided to implement AIX on the RT system, the emerging PS/2 architecture, and on System/370 machines.

IBM's AIX designers worked hard to minimize all but the advantageous differences among the AIX implementations on the PS/2, RT, and S/370 computers. They also concentrated on adding core value to the system, by making the file system more robust, creating more effective documentation, and adding new capabilities for distributed network computing. This hard work was recognized in 1988 when the Open Software Foundation, founded by a group of major computer makers (including IBM) and supported by members from many vital industries, chose Version 3 of AIX as its "core technology" for producing a new, open systems version of the UNIX operating system.

(For examples of IBM's efforts to enhance AIX see "AIX: Extending the Power of the UNIX Operating System.")

Confident of their hard-won experience and ability with the UNIX operating system, IBM's own AIX engineers are hard at work improving AIX for future releases. "We built our original AIX systems with a lot of help from the outside, which is very much in the spirit of the UNIX operating system community," says Clay Cipione. "Over the past few years, though, we have become an equal player in the game. The other people outside IBM are no less smart than they used to be. But now we're just as smart."



More Than Just An Operating System

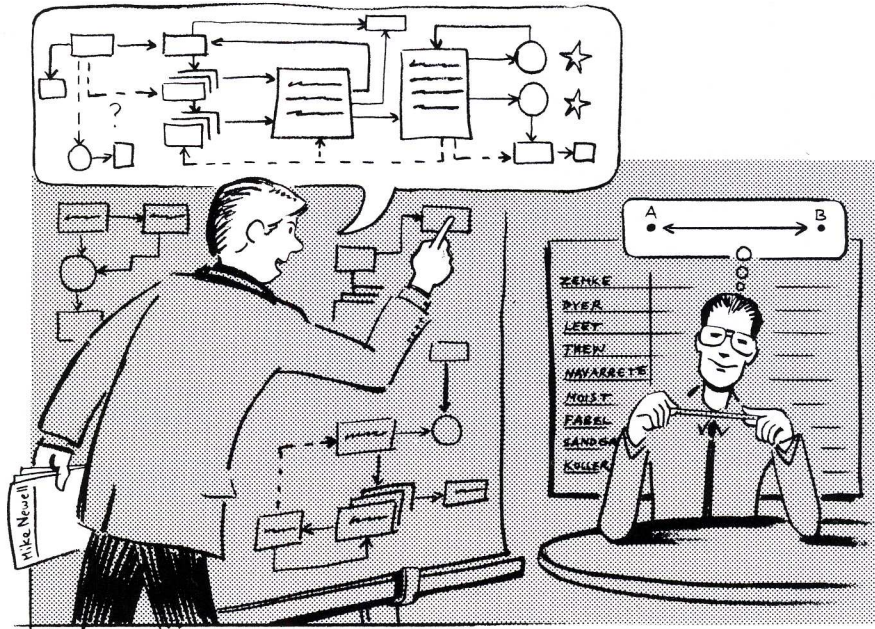
From the point of view of copyright, the term “UNIX” refers to an operating system owned and licensed by AT&T. In conversation, though, many people use the term to refer also to a community of interest, a shared approach to programming, perhaps even a state of mind.

The basic philosophy associated with the UNIX operating system derives from the way the program itself is built. Because of addressable memory limitations in the machines the UNIX operating system was developed on, subroutines for tasks like file management and screen paging had to be kept small. It was essential to write small programs for small parts of the operating system program, and then link the programs together.

This necessity becomes a virtue in the first tenet of UNIX operating system philosophy: **Small is beautiful.** The original designers of the system included a number of simple routines, called pipes, that take the standard output of a process and make it the standard input of other processes. Another kind of simple routine, called a filter, sorts through the output of one process and delivers selected results as the input of other processes. Using pipes and filters, it is possible to connect small, precise programs/activities into one large, complex program/activity very effectively.

This “tools” approach to programming is very attractive to programmers, as it gives them a large number of small, reusable chunks that can be combined and recombined in endless ways. Another tenet of the UNIX operating system philosophy says that **A tool should do one thing well.** According to this tenet, it is best to pull a complex activity apart into its constituent parts and write a program, or tool, for each part. That way you never have to solve the same problem again in later programs.

A third major tenet of UNIX operating system programming is **Keep it simple.**



Since the output of any one program is likely to become the input of another, it is important that programs themselves stay simple and direct in their functions. This tenet aids greatly in cutting down special cases and complicated solutions that slow overall program performance and limit what other programmers can do with the code later.

Since doing the simplest thing isn't always going to enable programmers to solve every problem, devotees of the UNIX operating system have created a fourth unwritten tenet to resolve the dilemma: **One-tenth of the work solves nine-tenths of the problems.** In other words, the UNIX operating system does not attempt to be all things to all programmers and all programs. Instead it provides a number of extremely useful tools, with the understanding that some of those tools are going to be used much more often than others. To a dyed-in-the-wool UNIX operating systems programmer, if you can't do something simply and directly using the tools you have, you probably shouldn't be doing it at all.

Perhaps the most interesting thing about the unwritten tenets of UNIX oper-

ating systems programming is that they are broad, open-ended descriptions rather than rigid laws of logic. “Notice that none of these guidelines are technical in nature,” write Don Libes and Sandy Ressler in *Life With UNIX*. “What these guidelines do is spell out a sense of style. In a way, they implicitly decide the technical aspects of a program. Any program which follows them is a program that would live well in a UNIX system.”

Another interesting thing about the philosophy associated with UNIX operating systems is that a UNIX system seems to take on importance beyond its original function. “The thing about UNIX,” says a Silicon Valley programmer who has worked with the operating system for over a dozen years, “is that it gets into your life in ways you never expected. You start to see that it really is better to keep things simple, do one thing at a time, and solve problems once and for all instead of bumping into them again and again. And if everyone communicated as well as the processes do in the UNIX operating system, we'd have a lot more understanding in the world.”



Future versions of AIX will provide even greater capabilities for IBM customers.

AIX Faces The Future

NOTE: Larry Loucks, Director of Software Architecture, IBM Entry Systems Division, has been called “the father of AIX” for his early work in establishing a leading-edge version of the UNIX operating system on an IBM hardware platform. In a recent interview, Loucks discussed the major trends that he sees in the development of AIX and its uses in an expanding range of applications.

AIX: AIX has gotten a lot of attention for its technological quality and the features that it introduced to UNIX operating systems. Obviously, though, IBM won't stand still. How do you see AIX developing from here?

Loucks: The UNIX operating system is being shaped by the desire on the part of a number of companies, including IBM, to take the system into areas where it hasn't been before. Some of that is driven by new applications, and some of it is driven by technology. Let's look at technology first.

There has been a dramatic increase lately in companies developing interesting new technology and then saying “I'm going to run the UNIX operating system.” IBM's RISC technology is a good example of this. With the RT we had a really innovative hardware architecture. But we didn't want to work for five years to create a brand new operating system and an entire set of applications. Instead we got a big headstart by licensing that million lines of code known as the UNIX operating system. We had to do some work on it, of course, but it got us started.

Now this same process is going on in distributed processing, parallel computing, high-performance graphics, in supercomputers — just an explosion in new technology. You're going to see versions of the UNIX operating system in all those areas, for the same reasons that we chose the system for the RT.

“The UNIX operating system is being shaped by the desire on the part of a number of companies, including IBM, to take the system into areas where it hasn't been before.”

AIX: The only difference is, now people can say “I'm going to run AIX.”

Loucks: The other thing that's driving changes in the UNIX operating system is applications. One of the main things we've done with AIX Version 3 is modernize the base code to enable AIX to handle new and interesting application areas, like real-time processing, dynamic program management, and mission-critical applications.

AIX: Can we talk about those three issues a moment, starting with real-time processing?

Loucks: Real-time doesn't necessarily mean running machine tools and things that people traditionally call real-time. Here's an example: a guy on Wall Street is sitting at a workstation, doing long-term analysis. At the same time he's got a program in there to calculate arbitrage decisions, and at the instant that

some price somewhere goes up or down, he's got to jump on it in less than a millisecond or he loses the buy.

AIX: You've got to have real-time facilities in your operating system or you can't support that class of application.

Loucks: That's it. We put that in AIX Version 3. Now take dynamic binding. Basically, dynamic binding means you can change or add modules to a program without rebinding or relinking the whole thing. The obvious example of AIX and dynamic binding is a large program, like CATIA, an IBM mainframe program for solid modeling that has been ported to AIX. CATIA is something like a million lines of VS FORTRAN, 150 megabytes of object files — a big program. If you want to swap out a couple of modules to fix a bug out in the field, you don't want to stop and relink the whole program.

AIX: You want to plug in the new modules without affecting the entire program.

Loucks: Right, because it takes too long. Here's another example, involving a hot new area called object-oriented programming. Here you are, you're running a program or an editor and you stumble over a graphics object. Wouldn't it be nice to edit that object right there in that same editor? Well, you go get the code for that object, which is somewhere else, and you've got to load it. In this case, that code couldn't have been bound to the program in the traditional fashion . . .

The trend for the 1980s has been getting the kernel in shape for commercial applications. That's what IBM focused on in AIX Version 3.

AIX: . . . because you didn't even know it existed before you got to the point where you needed it.

Loucks: Exactly. You didn't even know you'd want to bind that code. And once you **do** know, once you've got it, you want to bind it on the fly. You want dynamic binding, so you can do dynamic program management. We put that in AIX Version 3, and it has profound implications for maintenance, for upgrading programs, all kinds of things.

AIX: Whereas the UNIX operating system was built as much for research and exploration as anything else, many of its implications go right to the heart of corporate computing, don't they?

Loucks: That's why applications are a big driver for changes in the UNIX operating system — the people running those applications have a lot of money riding on their computers.

AIX: Which brings us to mission-critical applications.

Loucks: Let's say they want to take advantage of the features of a UNIX operating system over at the *New York Times*. That's great — they'll get a lot of good stuff. But they've got to be sure that a glitch somewhere isn't going to keep them from putting out the paper tomorrow. That's a fairly mission-critical application.

We made the AIX file system more robust; we paid a lot more attention to reliability, security, and those aspects that maybe weren't so important before. In fact, that's essentially the trend for the 1980s: getting the kernel in shape for commercial applications. That's what we focused on in AIX Version 3.

AIX: So what are the AIX trends for the 1990s?

Loucks: Distributed processing will be a hot area in the 1990s, I think. There will be huge amounts of work all over, to link all computer systems and workstations together into networks. And once again it's technology that's behind the trend.

What drives people to change from a mainframe with hundreds of terminals to a distributed computing model? The most important thing is that now we have computers worth distributing. You can put a machine on your desk with 10 to 15 MIPS [millions of instructions per second], and do what only mainframes could do a few years ago. We also have very high-speed interconnect technologies now, 100 megabyte fiber pathways.

And then, of course, the software — think about the difficulty of this problem! We're used to having one operating system, with all the users hooked up in one computing environment. Now you have the distributed computing problem to deal with. And so one of our trends with AIX will be building on the tools we've already got to manage these distributed networks as a system.



AIX: AIX Distributed Services and the Transparent Computing Facility?

Loucks: Yes. The work in this area is immense, and we'll continue to play our part in it, working in the standards areas, maintaining compatibility with other people's efforts, and so forth.

Distributed processing will be a critical area in the 1990s... One of IBM's trends with AIX will be building on existing tools, like Distributed Services and the Transparent Computing Facility, to manage distributed networks as a single system.

AIX: We haven't talked about transaction processing yet.

Loucks: A classic application area, and a major trend. People are saying, "Oh boy, the UNIX operating system has got all these other characteristics, now let's get into transaction processing!"

What this means is, you're going to see a lot of transaction processing on databases. The traditional UNIX operating system model of time-sharing has each user connected to a collection of processes, but basically the terminal is associated with a single user: traditional, classic time-share. Transaction processing is much different: instead of the terminals being owned by each individual user, you end up with them being owned by a system. You end up with facilities like CICS and IMS, which are the IBM transaction processing systems. They have a lot to teach us as we go into this area with AIX.

AIX: Will the move into transaction processing grow out of the improved communications and improved networking capabilities, or is that going to be a parallel development?

Loucks: Well, I think the driving forces are all sort of interrelated. AIX has excellent communications, so it's not an unnatural step to go into transaction processing. We're getting driven into mission-critical fault-tolerance already, from another direction.

AIX: Those capabilities also play into transaction processing, because they cut the risk way down.

Loucks: Right. Now [with AIX] I've got a good file system, and I've got support for big commercial applications. I've always had good communications through the UNIX operating system. Now, if I get a transaction processor or two — wow!

AIX: You've opened up a brand new market for AIX.

Loucks: And this is a pattern that is absolutely always repeated. You have this great new technology for some special purpose, and it's used just for that special purpose for some amount of time, until the technology reaches a certain plateau. At that point someone says: "Aha! With just a little extra software I can take my AIX machine and make it into a transaction processor!"

AIX: So those are three major trends. What else can we look forward to with AIX in the 1990s?

Loucks: Number four is putting AIX on very large mainframes, running thousands and thousands of users. This will involve dealing with large, complex jobs, with endless printing

queues, with massive I/O, and huge DASD farms.

The big issues here are resource management and scheduling. These issues have traditionally been handled at IBM, probably better than anywhere else in the world, using MVS. But the UNIX operating system has not in the main dealt with scaling issues of this kind, so that's another whole set of interesting technical problems that affect the AIX operating system.

AIX: It seems that as computers get bigger and bigger sometimes the number of users gets smaller and smaller.

Loucks: Yes. That's because the problems are so massive that it only takes one or two to use all the cycles of the machine. You get another issue when you have lots of users, because there's a set of scheduling things you have to do. In general, though, large multiprocessors, with large numbers of users or with very large problems, are giving UNIX operating systems issues to deal with that they have never dealt with before.

"Large multiprocessors, with large numbers of users or with very large problems, are giving UNIX operating systems issues to deal with that they have never dealt with before."

AIX: How about user interfaces?

Loucks: There's a lot going on there. As far as trends go, the area that I think is going to make major strides is high-performance graphics. The technology is such that capabilities that used to reside only in a few graphic supercomputers are now going to be available on regular old-fashioned RISC machines that sit on your desk. I think we're going to see major explosions in high-performance graphics, including

high-speed, integrated 3D graphics of surfaces, solids, those kinds of things — just lots more integration.

High-performance CAD/CAM programs that used to run on mainframes and dedicated terminals are now moving to workstations because of this capability. Innovative new window environments deliver your mail in one part of your window and your data in another window of the same machine. So high-performance graphics is another major area of investment and direction.

AIX: When do you think high-performance 3D graphics might be available to a critical mass of users?

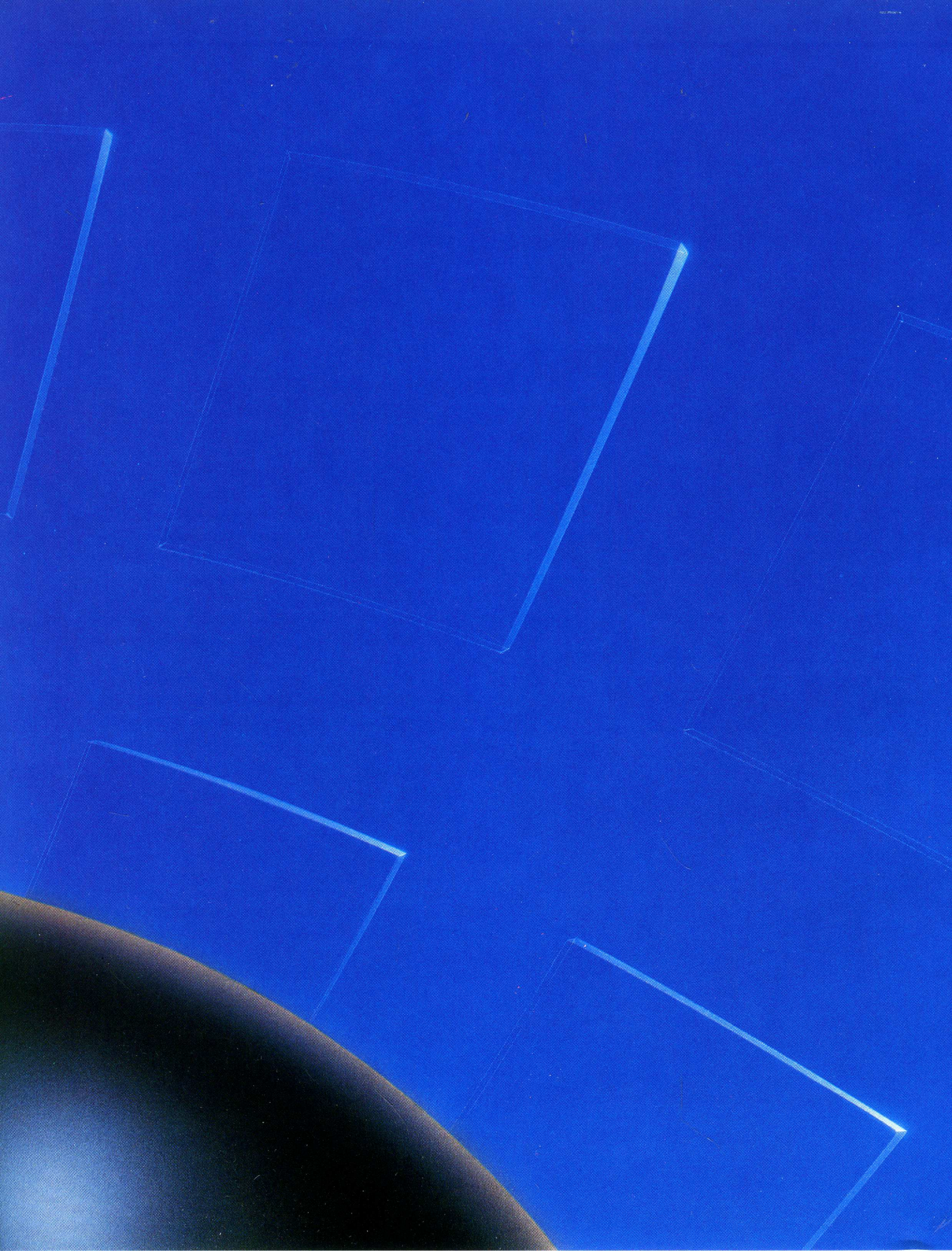
Loucks: I don't consider myself a good soothsayer, but I would say that in the middle 1990s, 3D will have reached down into the top end of the PC area. The most advanced companies will be coming around with displays that allow you to have high-performance 3D applications on your desktop. At that point the top end of the business will be going wild with full-blown 3D animation and other stuff like that.

AIX: We have a lot to look forward to with AIX, it seems.

Loucks: We really do. Of course, all this work we're doing on AIX doesn't mean we're not enhancing MVS and SAA — we're working very hard on them.

AIX: But at the same time, AIX is a strategic effort for IBM.

Loucks: That's it. I mean, AIX is not some sort of intellectual, esoteric ideal around here. We're working hard on AIX because it takes us into a number of areas that are extremely profitable, extremely important for our future. ■

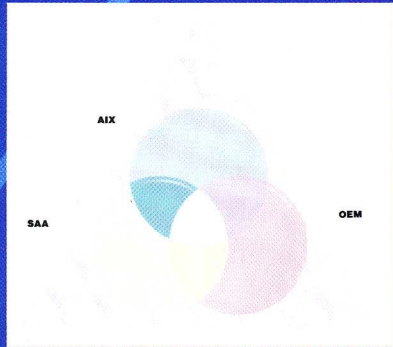


PART THREE

New Roles, New Relationships

IBM's development of AIX presents intriguing possibilities for the company and its customers. IBM has also sought new and important relationships with other organizations in its quest to make AIX an industry leader.

*This section of **AIX** describes IBM's new roles and relationships in three separate articles. "AIX and IBM" focuses on the relationship between AIX and Systems Application Architecture (SAA), and between AIX PS/2 and OS/2, the operating system designed especially for the PS/2 line of desktop computers. "AIX and Open Systems" focuses on IBM's work with standards bodies and industry consortiums devoted to defining and developing open systems. "IBM's AIX Partners" describes IBM's work with major universities, software specialists, and other companies, toward the goal of developing AIX into the premier version of the UNIX operating system available today.*



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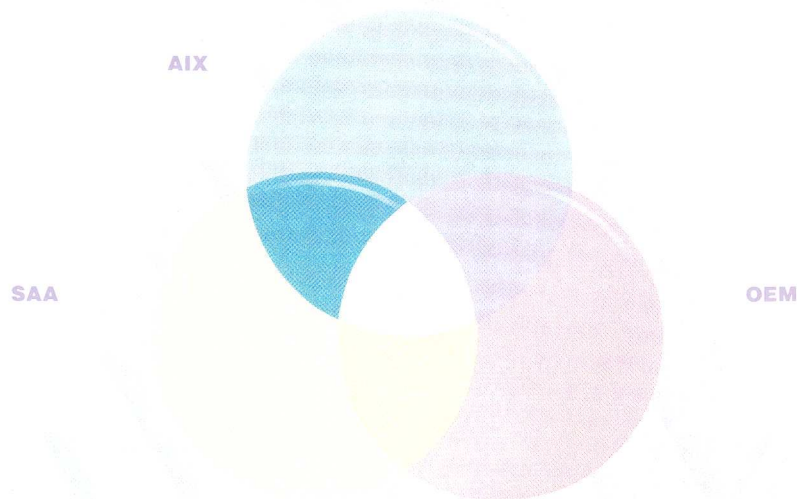
"If it's good to be interoperable with **UNIX** operating systems, it's got to be better to be interoperable with **all** systems."



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"When we started in on AIX we were still fairly new to the UNIX operating system, . . . we knew we had to get our feet wet quickly."

AIX and IBM



AIX joins Systems Application Architecture (SAA) as a strategic computer operating environment within IBM. In today's world of heterogeneous customer networks, these complementary architectures will work together to enable IBM to meet customer needs more effectively than ever before.

Systems Application Architecture has been called "one of the most ambitious software projects ever undertaken." Briefly stated, the purpose of SAA is to provide a framework for applications portability and interoperability among different operating systems. SAA will achieve this result by providing a common set of programming interfaces, user interfaces, and interconnection interfaces across IBM operating systems. As this description suggests, the consequences of SAA for IBM and its customers are far-reaching. Thus many people are naturally curious about how AIX and SAA will coexist,

both within IBM and within customers' data processing environments.

Essentially, both SAA and AIX address the same objectives: providing a structure for consistency and connectivity between computer system environments, and allowing for greater applications portability. The difference between the two architectures lies in how they approach these objectives.

Systems Application Architecture was defined to provide applications portability across the IBM MVS, VM, OS/400, and OS/2 Extended Edition operating systems. SAA is based on industry stand-

ards and has a published interface architecture. SAA enables customers using these operating systems to protect their investments as they take advantage of new IBM hardware and software technology.

AIX provides a UNIX operating system environment with a rich set of industry-standard and widely accepted interfaces and functions, both for applications portability, and compatibility with other UNIX operating systems. For customers who have or desire a UNIX operating system environment, AIX embraces not only IBM's System/370, RT system,

and PS/2 platforms, but also provides strong compatibility with a wide range of UNIX operating systems from other vendors.

SAA and AIX, then, are complementary strategies. "In IBM, we are meeting the goal of cooperative processing by establishing two strategic operating system environments — the AIX Family and SAA," says Mike Saranga, Assistant General Manager of Development Operations, IBM Personal Systems. "Each environment has its advantages, and we are committed to both. We are equally committed to providing the closest links between the two, so that customers can use both environments, and exchange data between them. Where practical, we will provide common languages, databases, and communication facilities. At the same time, AIX will not deviate from industry standards or interfaces, because those standards are critical for customers."

Interoperability With All Systems

IBM is devoting considerable attention to providing common languages and expanding the interconnect capabilities of the AIX and SAA environments. "Our customers have told us that they want to do some things with UNIX operating systems," says Mike Saranga, "and some things with their existing SAA systems. So part of our success will be defined by how we integrate AIX solutions into the existing environment."

OSF/Motif, the graphical user interface that will be supported by AIX, will be consistent with the OS/2 Presentation Manager user interface style.

In terms of programming languages, IBM has included both the C and VS FORTRAN languages in the AIX Family Definition. Both are SAA standard languages, so programs written to conform to SAA will function under AIX as well. IBM is also making sure there will be

abundant means of interconnection between SAA and AIX environments. IBM's LU6.2 protocol, for example, provides access to the SAA environment from AIX/RT systems, while IBM TCP/IP for VM and IBM TCP/IP for MVS offer AIX systems access to SAA System/370 environments.

Furthermore, IBM is looking beyond the relationship between AIX and SAA toward integrated solutions that involve hardware and software from many vendors. This will become increasingly important as the trend toward multi-vendor networks grows and expands. "People like to talk today about interoperability of UNIX operating systems," Saranga says. "At IBM we talk about interoperability of **all** systems within the customer's enterprise. If it's good to be interoperable with UNIX operating systems, then it's got to be better to be interoperable with **all** systems."

*"If it's good to be interoperable with UNIX operating systems, then it's got to be better to be interoperable with **all** systems."*

AIX PS/2 and OS/2

Many of the questions about AIX and SAA are also being asked about AIX PS/2 and OS/2, the operating system developed by IBM and Microsoft® for the Personal System/2 line of computers. The basic answer is that OS/2 and AIX PS/2 are complementary operating systems that, together, allow customers to address a wide range of computing needs.

OS/2 Extended Edition is an SAA operating system, so it is ideal for enterprises incorporating the PS/2 into their SAA environments. Users might also

select OS/2 to support specific applications written for the operating system, or because they are seeking high personal productivity for individual users. Maintaining consistency with an existing DOS environment is another reason for preferring the OS/2 operating system for the PS/2.

AIX PS/2 is an outstanding choice for users in a mixed-vendor environment or who require a multi-user operating system, especially when there are other versions of the UNIX operating system in use. As with OS/2, users might select AIX PS/2 to support a particular application. AIX PS/2 is also an excellent choice when the PS/2 is to be used as a technical workstation, for high-quality graphics, or when compute-intensive price-performance is required.

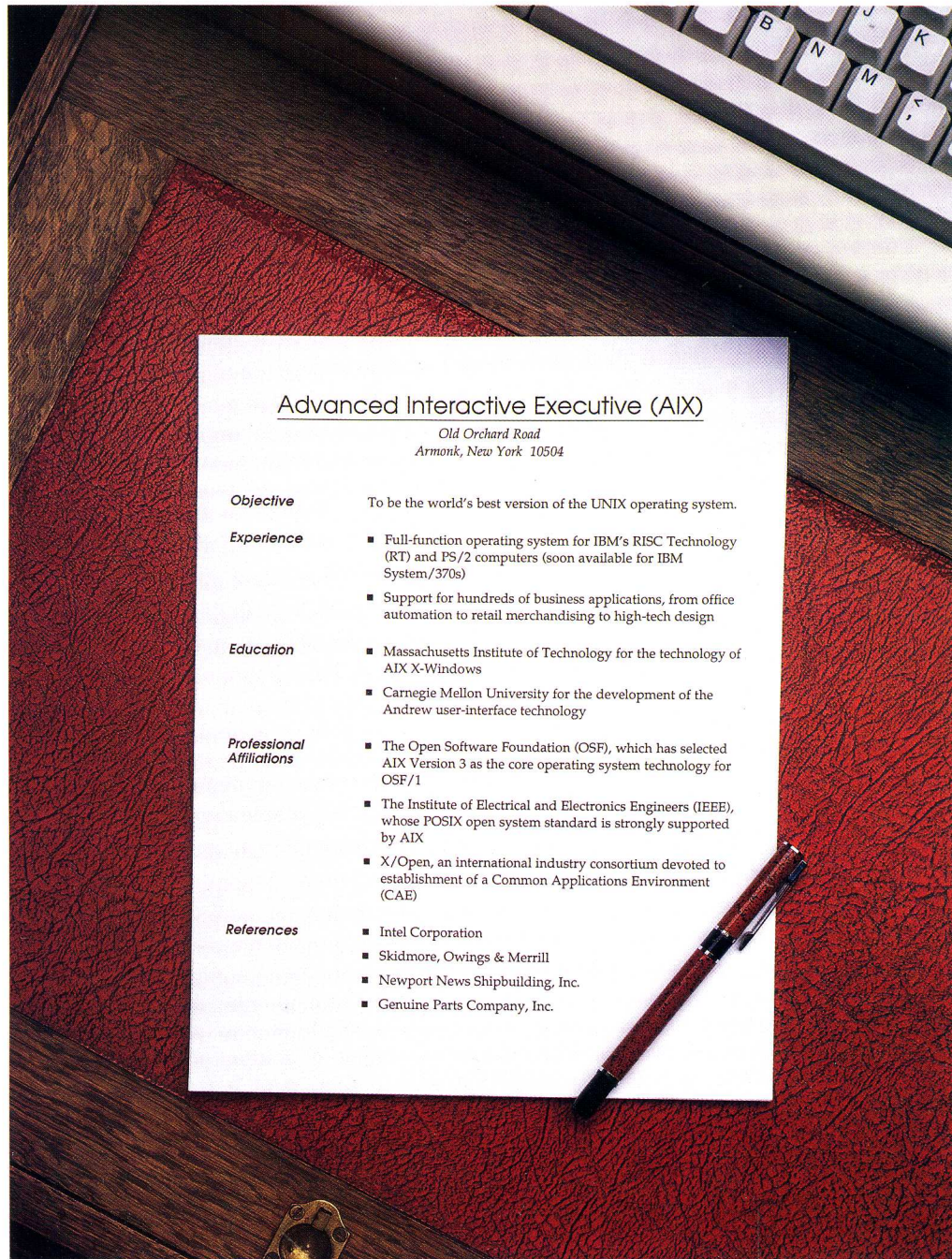
Of course, some customers may have a mixture of requirements, in which case OS/2 and AIX can serve together: DOS and OS/2 for personal productivity applications; and AIX PS/2 for multi-user, mixed-vendor connectivity and technical applications. As with SAA, IBM will continue to develop a range of interconnection options between OS/2 and AIX environments, to allow smooth interchange of data and application functions.

OS/2 and AIX PS/2 are complementary operating systems that, together, allow customers to address a wide range of computing needs.

"It's not strong enough to say we're 'building bridges' or 'providing linkage' between AIX and our other operating system strategies," concludes Mike Saranga. "We're really making the differences transparent to the users, so they can do their work without thinking about the technology."

AIX and Open Systems

IBM's participation in efforts like the IEEE's POSIX, the Open Software Foundation, and X/Open demonstrates its commitment to AIX as a leading derivative of the UNIX operating system.



Advanced Interactive Executive (AIX)
*Old Orchard Road
Armonk, New York 10504*

Objective To be the world's best version of the UNIX operating system.

Experience

- Full-function operating system for IBM's RISC Technology (RT) and PS/2 computers (soon available for IBM System/370s)
- Support for hundreds of business applications, from office automation to retail merchandising to high-tech design

Education

- Massachusetts Institute of Technology for the technology of AIX X-Windows
- Carnegie Mellon University for the development of the Andrew user-interface technology

Professional Affiliations

- The Open Software Foundation (OSF), which has selected AIX Version 3 as the core operating system technology for OSF/1
- The Institute of Electrical and Electronics Engineers (IEEE), whose POSIX open system standard is strongly supported by AIX
- X/Open, an international industry consortium devoted to establishment of a Common Applications Environment (CAE)

References

- Intel Corporation
- Skidmore, Owings & Merrill
- Newport News Shipbuilding, Inc.
- Genuine Parts Company, Inc.

AIX is uniquely qualified to provide customers with the benefits of "open systems."

The late 1980s may be remembered in the computer industry as the time when customers began insisting on open systems. Broadly speaking, open systems allow customers to keep their applications and user interfaces the same, even though their computer networks might combine different kinds of hardware from a number of vendors.

AIX provides the key open systems benefits associated with UNIX operating systems. IBM has also participated fully in industry efforts to forge clearer standards and a more open environment for the UNIX operating system.

AIX is an Enhanced Version of the UNIX Operating System

IBM has been implementing versions of the UNIX operating system on various hardware platforms since 1979. Still, AIX is by far IBM's most comprehensive involvement with UNIX operating systems to date. IBM has made it clear that AIX is, and will continue to be, part of the worldwide effort to evolve and develop the UNIX operating system.

"First and foremost, AIX is an enhanced version of the UNIX operating system," says Larry Loucks, Director of Software Architecture, IBM Entry Systems Division. "We're participating in industry standards, we're getting all of the public-domain software, and we're working with the colleges to create things like the X Window System and Andrew. We're keeping up with all the developments and we're intimately involved in a lot of them."

Perhaps the strongest proof of this statement is IBM's showing in the standards arena. Throughout the history of UNIX operating systems, there have been groups of one kind or another attempting to preserve consistency as the system grew and evolved rapidly at a number of sites worldwide. The oldest such group is known by its original designation on the system: /usr/grp. IBM has

been a member of /usr/grp since 1981, and a sponsor since 1984.

In recent times, however, the number of UNIX operating system variants has grown into the hundreds, making standards essential to meet market demands for increased applications portability. Several vital, well-funded, and well-attended efforts have been launched in the past few years to address this need. Some involve industry professional bodies, such as the Institute of Electrical and Electronics Engineers (IEEE), that have a long history of sponsoring standards efforts. Others involve organizations like the Open Software Foundation and X/Open, that strive to develop a consensus version of the UNIX operating system based on existing elements.

Broadly speaking, the activities of all these groups have the same aim: a unification of the many versions of the UNIX operating system now available. Their approaches differ, however, as does the nature of IBM's participation in them. In the following paragraphs are descriptions of IBM's relationship with IEEE (and its open systems standard, known as POSIX); with the Open Software Foundation; and with X/Open.

AIX and POSIX

IBM has been actively involved for a number of years in IEEE's development of an open operating system standard called POSIX (Portable Operating System for Computer Environments). As is normal in an IEEE standards effort, there are a number of committees, each working on a different facet of the problem; IBM is represented on all POSIX committees and subcommittees. POSIX standard 1003.1, the operating system interface standard, was adopted by IEEE in 1988.

IBM has also agreed to provide test cases for POSIX compliance to the National Institute of Standards and Technology (formerly the National Bureau of Standards). Because so many govern-

ment and industry procurement contracts now specify "POSIX compliance," such test cases have become an integral part of applying standards once they are created.

What is unusual about POSIX is that it is the first operating system interface standard that has ever been developed, and it may well have a powerful impact on the UNIX operating system. Much of this potential impact stems from the fact that POSIX is not a proprietary interface. In fact, it is in the public domain, equally available to everyone. So far, nearly 300 companies and organizations — including major end users — are participating in the POSIX effort.

POSIX is the first operating system interface standard that has ever been developed.

It is important to recognize that the POSIX committees are not creating a new operating system, but an interface standard that software developers can use in writing new applications. Thus the POSIX interface will not be restricted to UNIX operating systems. In fact, there may be a number of non UNIX operating systems that can meet the POSIX interface definition. One example is the Mach operating system jointly developed by Carnegie Mellon and Brown Universities. Another is OS/2, which Microsoft Chairman William Gates has said will comply with the POSIX interface.

AIX itself is closely associated with POSIX. IBM has made it clear through its participation in the IEEE and its own work with AIX that POSIX and AIX will exhibit a high degree of compatibility, even as they continue to develop. AIX's official development direction is toward meeting the POSIX standards, to provide IBM customers with maximum applications portability.

POSIX Committees

1003.0	Guide to POSIX Open System Environment.
1003.1	Base System (kernel), including system calls and system utilities.
1003.2	Shell and Application Utilities (user interfaces).
1003.3	POSIX Test Methods.
1003.4	Real Time Extensions.
1003.5	Ada (a U.S. Department of Defense programming language) Bindings to the POSIX Base System.
1003.6	POSIX Security.
1003.7	System Administration.
1003.8	POSIX Networking.
1003.9	FORTTRAN Bindings.
1201	POSIX Windowing.

IBM and OSF

The POSIX committees are conducting an open process, and their open systems standard will be available to everyone, but they will not actually create a new version of the UNIX operating system. Last year, an international group of computer companies founded the Open Software Foundation (OSF) to do just that.

“OSF has the potential to change the nature of the computer industry for many years to come.”

OSF was jointly announced on May 17, 1988 by founding sponsors Apollo® Computer, Digital Equipment Corporation, Groupe Bull, Hewlett-Packard™, IBM, Nixdorf® Computer, Philips®, and Siemens®. These original eight sponsors have since been joined by others. All sponsors, including IBM, hold a seat on the OSF board of directors. OSF's membership is comprised of nearly 100 organizations, including academic institutions; user organizations and research foundations; and private companies from a broad range of industries.

OSF is an international, non-profit, industry-supported organization dedi-

cated to the open development of a complete, POSIX-compatible version of the UNIX operating system, including extensions and subsystems. OSF is based in Cambridge, Massachusetts and will ultimately be staffed by over 200 employees. OSF was initiated with over \$100 million in sponsor funding, receives substantial amounts from membership fees, and possesses a charter granting its officers the freedom to run it as an independent enterprise.

OSF is not starting from scratch. Instead it has invited all interested parties — including non-members — to nominate elements of their own operating systems, such as basic source code, user interfaces, and so forth, for inclusion in “OSF/1™,” OSF's own POSIX-compliant operating system. “OSF will evaluate all the products it is offered with a fair and

open process, and it will choose the best to endorse,” says an OSF spokesman.

One of OSF's first technology decisions was to select AIX as its base system. This decision remains in force, despite challenges from some non-members. “OSF recently undertook an extensive reevaluation of our original decision to use AIX as the basis for our core operating system,” said then OSF President Henry Crouse at the end of 1988. “We concluded once again that it is technically superior.” At the same time, Crouse affirmed that OSF/1 would remain compatible with such major versions of the UNIX operating system as AT&T System V and 4.3 BSD.

OSF's charter gives its officers, through OSF's open process, technological independence from its sponsors. This freedom has convinced many industry observers that OSF can be a leader in promoting an open standard for the UNIX operating system.

IBM has also indicated that it will support OSF/1 and its recently announced user interface, OSF/Motif, recognizing that this new version of the UNIX operating system may become widely popular.

OSF's Guiding Principles

- Offerings based on relevant industry standards.
- Open process to solicit inputs and technology actively.
- Timely, vendor-neutral decision process.
- Early and equal access to specifications and continuing development.
- Hardware-independent implementations.
- Reasonable, stable licensing terms.
- Technical innovation through university/research participation.

Along with all OSF members, IBM will receive the source code for OSF/1 as it becomes available.

IBM has ported OSF/Motif to AIX on the RT and PS/2, and demonstrated it in February, 1989 at UniForum in San Francisco.

OSF's charter gives its officers, through OSF's open process, technological independence from its sponsors. This freedom has convinced many industry observers that OSF can be a leader in promoting an open standard for the UNIX operating system. OSF has already established a formal, open process for evaluating available UNIX based technologies and identifying both their technical excellence and industry acceptance. The selection of Motif has demonstrated that OSF's open process can provide superior products in a timely way. OSF's own Research Institute is sponsoring experimentation at universities and technical institutions. "Standards bodies will look to us to move the standards ahead," says Ira Goldstein, OSF's Vice President of Research.

In the end, OSF may be as important for the open process it is pursuing as for the product it delivers. "OSF has the potential to change the nature of the computer industry for many years to come," writes Judith Hurwitz, Editor-in-Chief of *Unix in the Office*. "In an age of complexity and competition, one vendor alone cannot rule the world — or set the standards. The only way individual companies can survive and thrive is to work together... and allow teamwork and technology to flourish."

IBM and X/Open

In contrast to OSF, which will produce its own version of the UNIX operating system, X/Open is an industry consortium devoted to specifying what it calls a Common Applications Environment. In a 1988 report, The Yankee Group market

research firm said:

*"Because applications have become much more ambitious since UNIX was first developed, the focus of the debate [about applications portability] has shifted from an **operating system** to an **application environment**. An application environment goes beyond the operating system to address: the related services and systems calls; interfaces to application and system-level software; and the end-user interface."*

Founded in Europe in 1984 and incorporated as a non-profit organization in 1987, X/Open is an independent group of international computer systems vendors who are investing significant resources in the development of an open, multi-vendor, common applications environment based on de facto and official international standards. X/Open is supported by numerous corporate sponsors (including IBM) and members. X/Open has also formed advisory councils composed of end users and software vendors.

X/Open is an independent consortium of international computer systems vendors who are investing significant resources in the development of a common application environment.

X/Open's primary product is a multi-volume document called the "X/Open Portability Guide," which spells out all the technological specifications that computer systems and software must meet in order to comply with X/Open's Common Applications Environment (CAE). The Portability Guide specifies such critical elements as operating system services; programming languages; data manage-

ment; networking; window management; and security. X/Open has also released an "X/Open Security Guide," which may be the first of a number of special-issue guides.

The basic benefit offered by X/Open is simple but powerful: all software that follows the Portability Guide will run on all hardware that complies with CAE. X/Open works formally with international standards bodies; for example, X/Open submitted CAE to POSIX committee 1003.0. X/Open, though, also includes de facto industry standards in its application environment — a move designed to speed the achievement of working standards. The X Window System developed at MIT, for example, is so widely accepted among users of the UNIX operating system that X/Open has specified it as part of its Common Applications Environment.

IBM is centrally involved in X/Open's work toward application commonality. IBM became one of X/Open's corporate sponsors in July of 1988. On that date, IBM Chairman John Akers said that joining X/Open "is further evidence of IBM's commitment to provide open systems to customers who desire them, and to our AIX operating system family of products. X/Open is an important international forum for defining open software and hardware. IBM's AIX systems represent a key strategy that is consistent with X/Open's goals and directions."

IBM's AIX Partners

IBM has pursued a bold course in developing and extending the capabilities of AIX, forging ground-breaking alliances with industry-leading technology companies and major universities.

One of the key strategic decisions behind IBM's rapid and successful development of AIX was a willingness to create vital partnerships with other organizations, including technology start-ups, established companies, and major universities. In each case, these partnerships have helped IBM advance rapidly to the forefront of UNIX operating systems technology. "When we started in on AIX we were still fairly new to the UNIX operating system, but many of our competitors had been selling versions of the system for years," notes Gary Snyder, Programming Center Manager in IBM's Advanced Workstation Division. "We knew we had to get our feet wet quickly."

Early Alliances

IBM immediately began developing its own staff of UNIX software engineers. Meanwhile, however, IBM sought out private companies that had extensive background with UNIX software. One of the most important was INTERACTIVE Systems Corporation, the company that in 1977 provided the first commercially supported version of the UNIX operating system (called IS/1™). INTERACTIVE had already assisted IBM with IX/370, a mid-1980s version of the UNIX operating system for IBM's mid-range processors. That made INTERACTIVE a logical choice to help "port" the necessary code to the RT system (then known as the "RT PC"). IBM has since licensed a number

of utilities and tools from INTERACTIVE and made them available with AIX systems.

INTERACTIVE
A Kodak Company

"We got two very good things out of our relationship with INTERACTIVE," Snyder says. "First, we had the advantage of their expertise in porting the UNIX operating system to new hardware platforms, which is what we were doing with the RT. Second, we had the benefit of working closely with a group that was steeped in the technical and philosophical aspects of UNIX software programming, which go hand in hand and which we needed to learn about."

"When we started in on AIX we were still fairly new to the UNIX operating system, ... we knew we had to get our feet wet quickly."

Another company that IBM has worked closely with in developing AIX is Locus Computing Corporation. In fact, to many in the industry Locus is best known

for its on-going work with IBM, especially regarding the Transparent Computing Facility (TCF), a distributed processing function jointly implemented by Locus and IBM. TCF has been praised by a number of industry observers, one of whom called it "a wonderful product." (See Part Two, "AIX: Extending the Power of the UNIX Operating System.")

Locus' founders left the University of California at Los Angeles (UCLA) in the early 1980s to commercialize their innovative work in distributed processing. Today Locus offers a number of products designed to integrate the UNIX and DOS operating system environments, such as DOS Merge, PC X-Windows, and PC-Interface™; each of these is also available under AIX (as DOS Merge, X-Windows for IBM DOS, and AIX Access for DOS Users). "Our relationship with Locus has been a good one, and it continues to be good for both companies," Snyder says. "In their case, they brought



an understanding of the UNIX operating system from the academic world, which has been a particularly rich source of experimentation and development."

In addition to INTERACTIVE and Locus, IBM has also made agreements with companies like Silicon Graphics®, Inc. and Apollo Computer Inc. IBM has licensed Silicon Graphics' IRIS® 3D graphics technology and Apollo's Network Computing System™ (NCS) for dis-

tributed network computing.

The Academic Connection

Working with academic institutions has paid off handsomely for IBM and the entire community of UNIX operating system users. Consider the X Window System, also known as "X." X is a very popular network-transparent windowing system for computer systems running a version of the UNIX operating system.



IBM was a co-sponsor, with Digital Equipment Corporation, of Project Athena at Massachusetts Institute of Technology (MIT) that produced X. The system is now in the public domain, where it has quickly become a de facto standard. (See "Everybody Agrees On X.")

IBM has also sponsored the development of the "Andrew" system at Carne-

gie Mellon University. Andrew permits users of the system to edit and combine simple graphics objects without having to deal with the complex software code that underlies them. "Andrew is used by hundreds of students at Carnegie Mellon —



including a lot of English majors and drama majors and music majors," says Mike Conner, an IBM senior programmer. "These students may not know how to program a graphics object, but they know how to draw a picture in the middle of a paper to illustrate the point they're trying to make. Andrew lets them do that in a straightforward way."

IBM would like to offer the Andrew technology in AIX. "The number of potential applications for the Andrew

technology is really exciting," Conner says. "There is a growing understanding that we must make our user interfaces more accessible to people, and the use of technologies like OSF/Motif and Andrew will accelerate that process tremendously."

The Process Works

If licensing other people's technology, developing systems for the public domain, and seeking fundamental technical assistance for a whole new architecture all seem like unusual activities for IBM, that's because they are, Snyder says. "We're not the first group in IBM to do these kinds of things," he says, "but we're probably the first group that had so much riding on our work with people outside IBM. We've proved that the process can work, and work very well."

Everybody Agrees On X

When users of the UNIX operating system talk about a "de facto standard," chances are they're talking about the X Window System. "X," as the system is commonly known, makes all applications in a multi-processor network look as if they are running on the user's own computer, even if they are actually simultaneously hosted — or running — on other processors in the network. In other words, X invisibly opens "windows" between applications and users, independent of computer hardware, operating systems, or network configurations.

X was developed jointly by MIT, IBM, and Digital Equipment Corporation in an effort known as Project Athena. It has since won the support of nearly all other major computer companies. It has also been adopted by the Open Software Foundation as part of its version of the UNIX operating system, OSF/1, and its graphical user interface, OSF/Motif. And

it is part of the Common Applications Environment under development by the X/Open consortium.



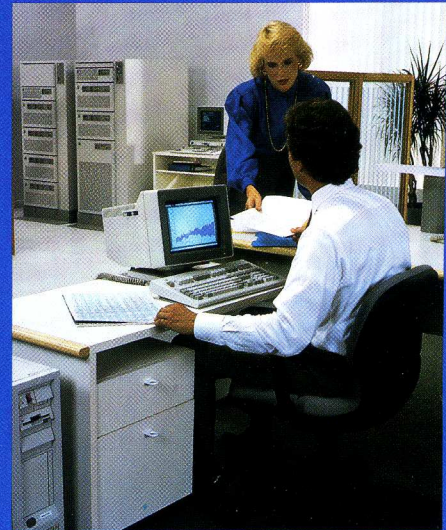
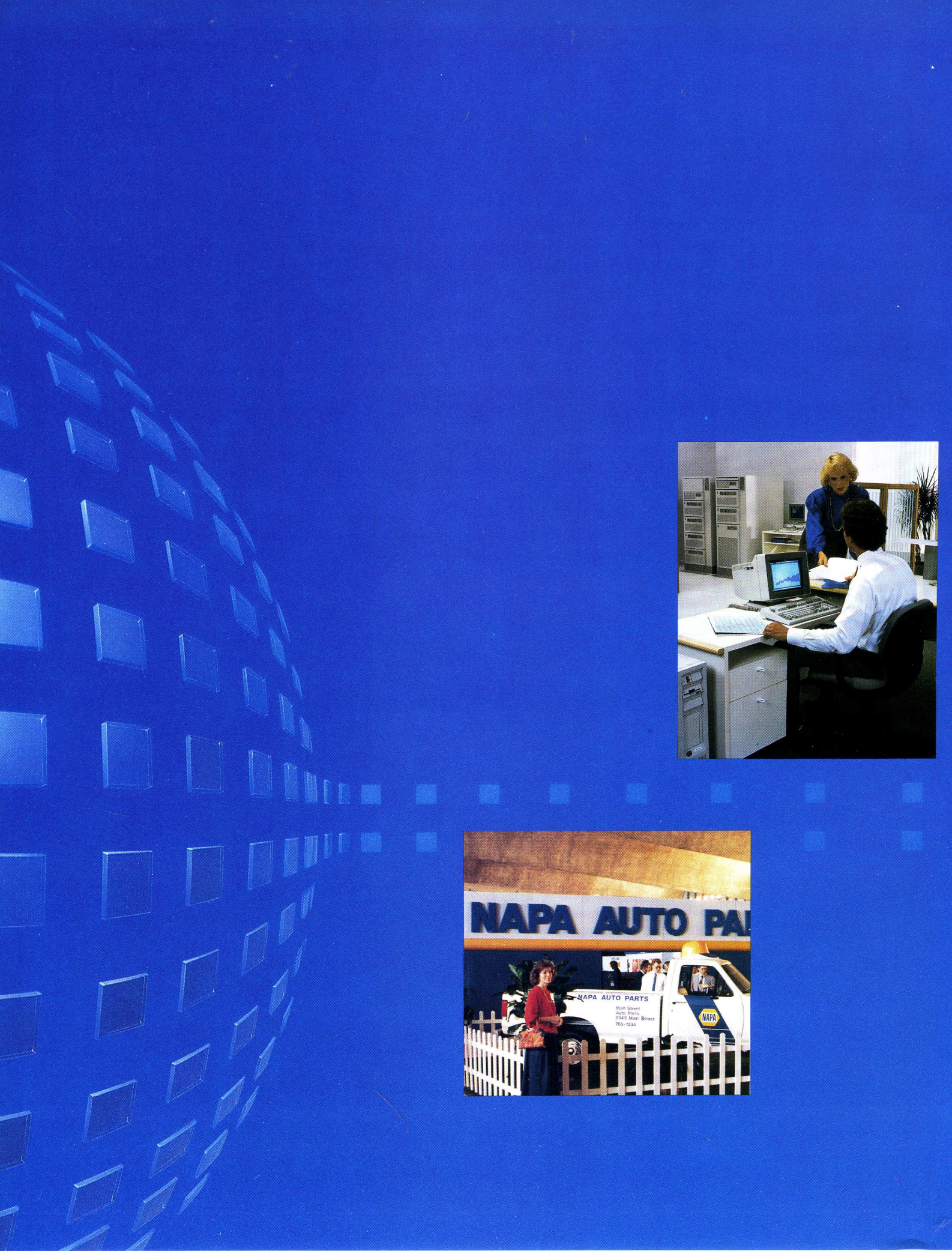
IBM was one of the original sponsors of the X Window System developed at MIT. AIX includes a full-featured version of the system, called X-Windows.

X's popularity starts with the fact that it is in the public domain, and thus available for all vendors to use and develop in their own way. Also important is the fact that X represents an important breakthrough in distributed computing (com-

monly referred to as "networking"). X is particularly useful in environments where PCs, workstations, and minicomputers from different vendors need to run the same application.

For these reasons, the system in the last year has been implemented on nearly every computer that runs a version of the UNIX operating system. IBM plans to use AIX X-Windows, its implementation of X, as the base system for providing AIX users with windows to their applications.

As more companies have developed enhancements and new applications for X, the call for standardization has grown more persistent. One key issue is the need for a standard user interface, or "look and feel," for the system, that will further erase differences and incompatibilities between hardware architectures and applications. Agreement on standard communications protocols within X would also cut down barriers to wider use of the system.

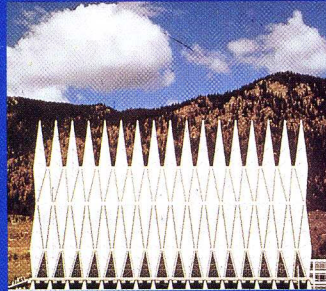
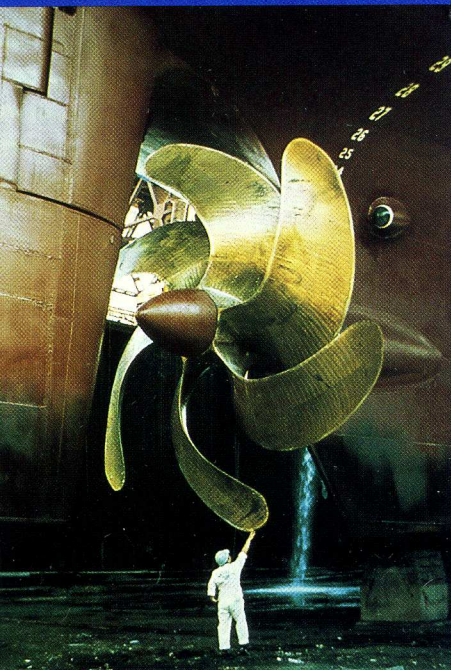


P A R T F O U R

AIX At Work

All the characteristics, features, and benefits of a computer operating system should add up to one result: strong support for applications. IBM's Advanced Interactive Executive (AIX) operating system provides exceptional support for applications that cover industries of all kinds and companies of all sizes.

***AIX Goes to the Office — and the Laboratory, the Publications Department, the Repair Shop . . .** introduces profiles of four different AIX applications, including small-business management, major manufacturing, high-tech design, and professional services support. “**Meeting the Chip Design Challenge: AIX at Intel Corporation**” describes how the well-known microprocessor maker is using AIX/370 to design a follow-on to the 386 microprocessor chip. “**One Good Architecture Deserves Another: AIX at Skidmore, Owings & Merrill**” and “**Smooth Sailing for Technical Publications: AIX at Newport News Shipbuilding**” present examples of AIX/RT in architectural design and technical publishing applications, respectively. Finally, “**Making TRACS: AIX At Work For Genuine Parts Company**” makes the case for AIX on the PS/2 as an ideal low-cost, multi-user computer system.*



AIX Goes to the Office — and the Laboratory, the Publications Department, the Repair Shop...

AIX is going to work in hundreds of applications, from the executive suite to the garage down the street.



According to a popular computer industry maxim, “People don’t buy operating systems, they buy solutions to their business problems.” It is also true, however, that no computer solution is complete without an operating system. And in some cases, the operating system itself makes a big difference to the overall effectiveness of the solution.

Take the case of a small business in which four or five different people need constant access to the same data and application software. The best way to keep system costs low and operation simple is with a multi-user, multi-tasking operating system like AIX PS/2. (For an example of AIX PS/2 in a small-business environment, see “Making TRACS: AIX At Work for Genuine Parts Company” later in this section.)

Toward the other end of the spectrum, consider a manufacturing company in which departmental computer systems are running some version of the UNIX operating system. If the company wants to integrate all its data on a corporate mainframe, AIX/370 may be the common denominator that ties everything together. (For an example of AIX/370 in a high-tech environment, see “Meeting the Chip Design Challenge: AIX at Intel Corporation” later in this section.)

In between, there is a vast range of applications where AIX — with its multi-

user, multi-tasking, and communications capabilities — plays a key role in computer solutions. Professional firms, for example, often deploy their computer resources flexibly to meet the needs of different projects. AIX on the RT provides departmental computing power, a rich set of communication options between systems, and the freedom to scale individual systems up or down to accommodate changes in the number of users. (For an example of AIX/RT in a professional design environment, see “One Good Architecture Deserves Another: AIX at Skidmore, Owings & Merrill” later in this section.)

It would require a thick book to describe the hundreds of other AIX applications already in place in a wide range of industries, including accounting, application development, communication, distribution, education, engineering, finance, insurance, manufacturing, medicine, office automation, process technology, transportation, and utilities. AIX is going to work in hundreds of applications, from the executive suite to the garage down the street. In the following pages, you’ll find profiles of representative, industry-leading companies that are using or remarketing AIX today. In each case, they have chosen AIX because it is the operating system that makes their computer solution work.

(For access to information on additional AIX application solutions, including those offered by IBM Business Partners, see Part Five.)

Meeting the Chip Design Challenge: AIX at Intel Corporation

Intel Corporation is deep into the design of its next industry-leading desktop computer chip. AIX is helping to speed and simplify the complex process.

Throughout the 1980s, Intel Corporation has been a leading provider of microprocessors for desktop computers. In 1981, IBM chose Intel's 8086/8088 chip to power the new IBM PC. A few years later, Intel's 286™ microprocessor chip became the driver of IBM's popular PC/AT (and its many clones), making the 286 a de facto standard for desktop computing. Then, in 1987, Intel brought out its most powerful microprocessor ever: the 386™ microprocessor. By 1988, nearly all desktop computer vendors had announced or introduced products that included the new chip. In industry jargon, such computers became known simply as "386 machines."

Despite the still-growing success of the 386 microprocessor, Intel is already moving on. Today the company is hard at work on the design and manufacture of its newest microprocessor, the 486™ — and IBM's AIX is playing a key role in the chip design process.

Smaller, Better, and Faster

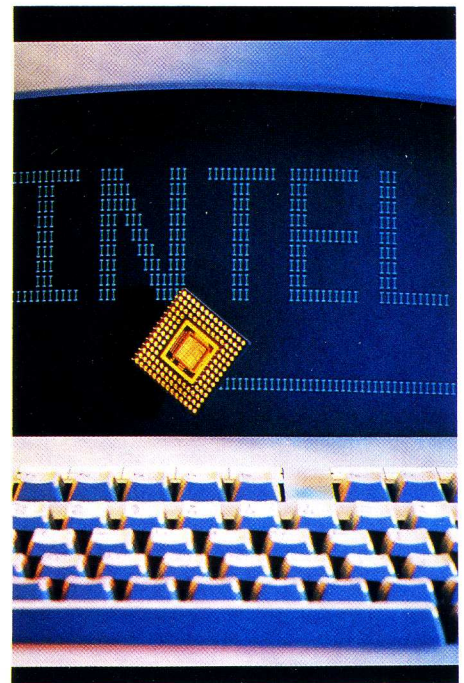
Designing a new microprocessor is an exceedingly complex job, as manufacturers try to pack more processing power and increased functionality into smaller spaces. To make it even more difficult, chip makers are under intense competitive pressures to produce new designs faster each time around. "In this industry, companies want to be able to design a more complex chip in less time than it took to design the last one, while still

improving the quality," comments Joe Glynn, IBM's Account Development Manager responsible for Intel. "It's quite a challenge to do accurate designs of such powerful chips in the time frames involved."

"We could not have completed the 486 design on schedule without the ES/3090 AIX system."

To meet these challenges, Intel's 486 microprocessor design team decided to establish a UNIX operating system environment, teaming high-function workstations (for interactive design work) with a powerful mainframe (for sharing data and chip design applications). The function of a mainframe computer in this arrangement is to perform compute-intensive tasks such as simulating and verifying the performance of circuits, microcode, and chip layout; checking design rules; and generating the master design data for the new chip's physical layout — a process known as "taping out." The mainframe can also provide enhanced security for data and designs, while at the same time making it easier for dozens of designers to share information.

"A typical job may require tens of megabytes of memory, several gigabytes of data requiring multiple CPUs for multiple days," says Pat Gelsinger, the 486



Microprocessor Design Manager at Intel. “I could not fathom doing that kind of job on a minicomputer or a workstation.”

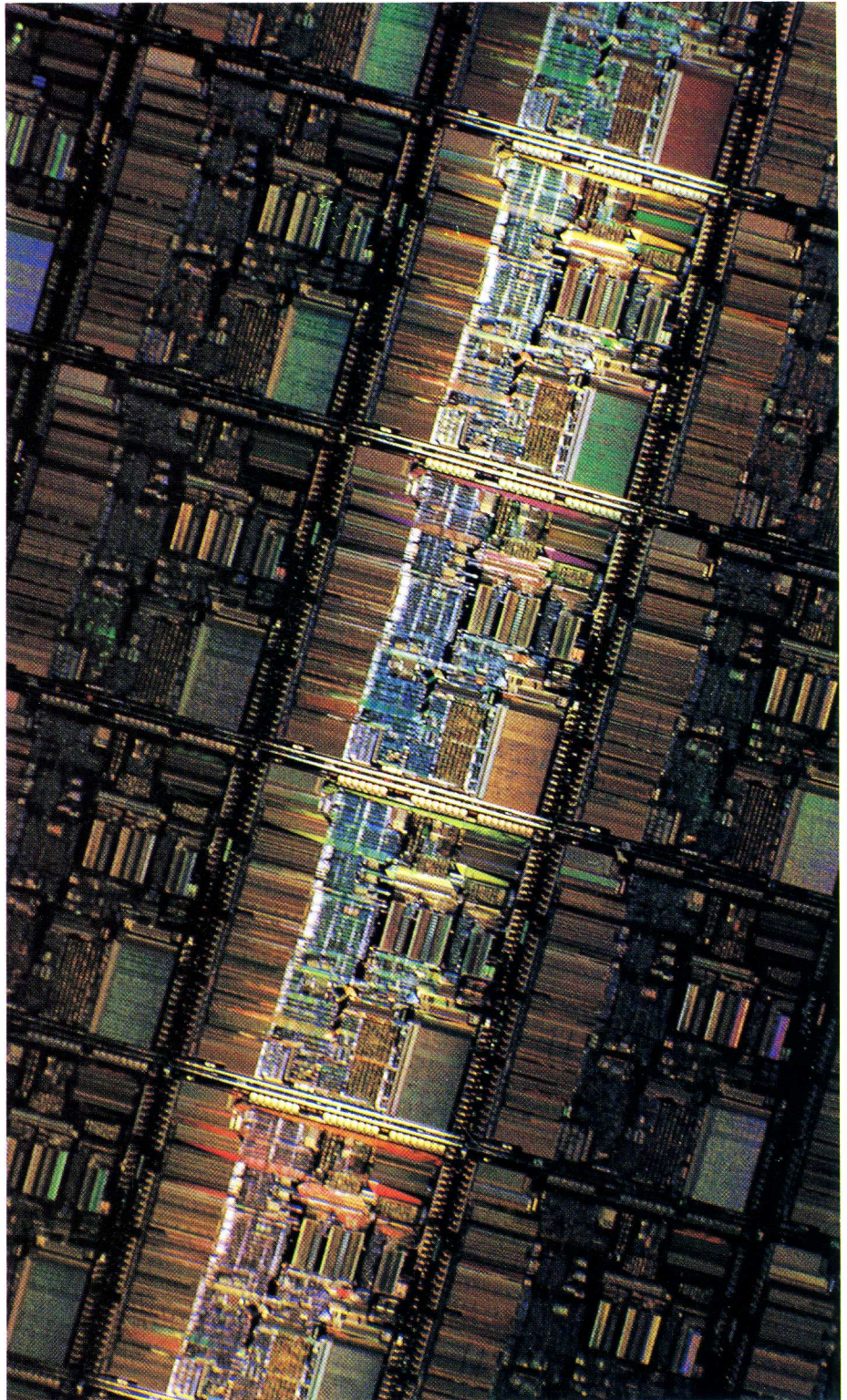
AIX on the ES/3090

For the mainframe element of its 486 microprocessor chip design effort, Intel chose IBM’s AIX operating system on an IBM ES/3090 600E, one of the industry’s largest commercial processors. “We could not have completed the 486 design on schedule without the ES/3090 AIX system,” says Gene Hill, Microprocessor Design Manager.

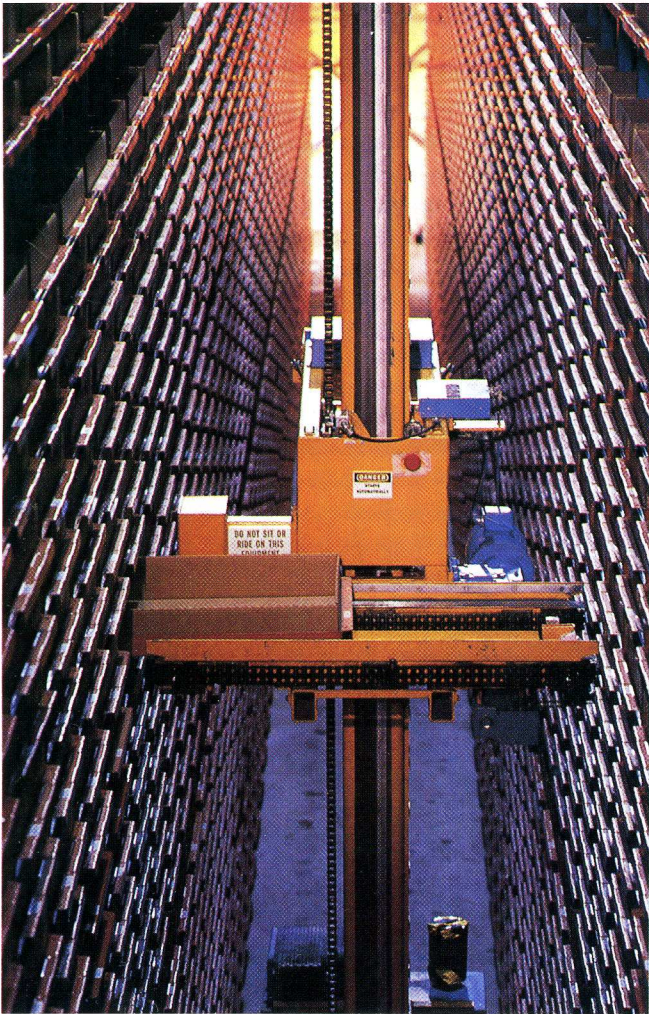
“AIX/370 provided extended memory beyond what was available on other UNIX systems — and that capability was required to complete the 486 microprocessor,” adds Hill.

“AIX gave us the ability to use the same CAD tools across multiple platforms, which allowed us to move any job or database to the most appropriate computing platform.”

Besides providing critical storage and processing capacity, AIX also provided a common operating system environment for the range of platforms, including workstations from SUN Microsystems, based on the 386 microprocessor, and minicomputers from Digital Equipment Corporation. “AIX gave us the ability to use the same CAD tools across multiple platforms,” Gelsinger explains, “which allowed us to move any job or database to the most appropriate computing platform at any point in the design process.”



Intel's 80386 chip, with 275,000 transistors, can run the AIX PS/2 and DOS operating systems simultaneously.



Intel's use of AIX on the IBM ES/3090 demonstrates the tremendous potential of AIX/370 on mainframe computers.

AIX X-Windows enabled Intel's chip designers to "look into" the ES/3090 from their workstation consoles, and also to input data or instructions to the ES/3090 for large-scale, interactive simulation jobs. And to fully exploit the computing and storage capabilities of the ES/3090, Intel took advantage of the Transparent Computing Facility (TCF) offered exclusively in AIX.

Manifest Benefits

The benefits to Intel of running AIX on the ES/3090 quickly became apparent. On the productivity front, Intel engineers are enjoying the effects of less data duplication and easier access to centralized applications. Even more importantly, the ES/3090's processing power and high speed have dramatically increased Intel's ability to test its evolving chip designs.

With such gains in speed come gains in quality. "Some of the Intel engineers

have told us that they have higher confidence in their chip designs, because they're able to test them a lot more thoroughly," says Wendy Koba, an IBM Systems Engineer who worked closely with the Intel 486 microprocessor design team. "It appears that people are submitting more design tests and running them more thoroughly, because they have a level of computing capacity and performance they didn't have before."

This early success has prompted Intel to consider implementing AIX/370 for other functions in its design and engineering environments. The XA capability of AIX/370, for example, will enable Intel to perform such tasks as multiple simultaneous chip simulation. AIX could also make use of the ES/3090 as a host for all data shared among Intel's workstations using NFS. "In the future, AIX will be deployed throughout Intel," says Rich Martin, Manager, CIS Engineering Sup-

port at Intel. "We tried it on the 486 microprocessor design job, and it worked. We are now in the process of moving remaining users onto the AIX/370 systems."

Exploring the Ramifications

IBM worked hard to make AIX on the ES/3090 ready in time for Intel's 486 microprocessor design effort. Now that its hard work is paying off, IBM is exploring the ramifications for other customers and industries. "We have a number of companies in the semiconductor business who are eager to see what AIX/370 can do in their environments," IBM's Joe Glynn observes. "If you step back and consider the semiconductor industry, you can see that there is tremendous potential for AIX on mainframe computers."

One Good Architecture Deserves Another: AIX at Skidmore, Owings & Merrill

*Why did an internationally known
architectural design firm choose AIX?
To leverage the value of its investment
in information technology.*

The Sears Tower in Chicago, Illinois.

If you enjoy gazing at the skylines of New York, Chicago, or San Francisco, then you're familiar with the work of Skidmore, Owings & Merrill (SOM), the widely respected 53-year-old architectural firm. SOM has offices in all three cities, as well as in Washington, D.C., Los Angeles, and London. Perhaps its best-known building is the Sears Tower in Chicago, SOM's headquarters city.

It's easy to identify an architectural firm with the buildings it designs, but Doug Stoker, an SOM partner and the firm's Director of Computer Services, takes a different view. "We are really in the information business," he says. "The product we deliver is not made of bricks or glass. It's composed entirely of information. That's why information technology is so important to us." In the past few years, Skidmore, Owings & Merrill has met its need for information technology with AIX on the RT system.

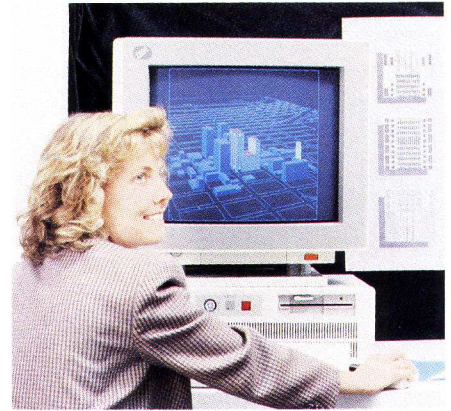
Power and Productivity

Skidmore, Owings & Merrill is a multidisciplinary architectural design firm, which means it also provides construction and mechanical engineering, interior design, and other services as part of an integrated design package. One of the firm's basic reasons for selecting AIX was its power on the RT to handle large amounts of information generated by a multiplicity of workers. "In order to leverage the advantage we have as a multidisciplinary firm, we have to coordinate different kinds of information into a coherent package," Stoker says. "We needed a powerful multi-user system to facilitate that coordination, and we chose AIX on the RT."

There are 250 or so AIX/RT systems scattered throughout SOM's offices worldwide, usually connected via IBM's Token-Ring. The RTs are used individually and in groups for design and development work, for engineering analysis, for office automation, and other purposes. Perhaps the premier application running under AIX at SOM is the Architecture and Engineering Series (AES), an integrated design program that SOM wrote itself (and which IBM markets to other design firms). "AES is a large, complex program, and AIX runs it at a very high level," Stoker says.

Skidmore, Owings & Merrill recommends AIX to clients who use SOM design databases to manage their buildings after construction.

Stoker emphasizes also that as a partnership, SOM pays keen attention to maximizing the productivity of both human and technological capital. Workers at SOM, for example, are organized into "design studios" that pursue individual projects from beginning to end. These design studios change size or location depending on the firm's workload, so that the firm's talent is always where it can be the most productive. In the same way, SOM shifts, connects, and reconnects its RTs to match current computing needs. "The networking capabilities of AIX are essential to our operation," says Stoker. "They enable us to work our RT hardware at near capacity almost all the time,



Skidmore, Owings & Merrill uses its network of AIX/RT systems for architectural design, engineering analysis, office automation, and more.

so we get the maximum return on our hardware investment."

AIX also helps SOM increase its productivity by leveraging information. In many cases, for example, the owners of a new building require access to original design data to manage the building most efficiently over its long life. SOM gathers its design information into a database and offers it to clients after construction of their building is complete. The key is that AIX supports IBM's Structured Query Language (SQL), which SOM uses to link geometric, spatial information, and more traditional, non-geometric data into a single database. Building owners with IBM computer systems can use SQL to access

both kinds of information without going through an expensive or cumbersome translation process.

AIX and the "Appropriate Hammer"

After several years of using AIX on the RT throughout its office network, SOM is pleased with both the hardware platform and the operating system. "We probably know as much about AIX on the RT as anybody around, and we're very pleased with it," Stoker says. "The hardware is solid, for one thing. It has a kind of solid, tactile feel about it that we all like as architects."

SOM professionals also appreciate the advances that AIX offers compared to other UNIX operating systems they have studied. "We see AIX as a kinder, gentler implementation of UNIX, and I can tell you without qualification that we're very happy with it," Stoker says. Skidmore, Owings & Merrill recommends AIX to clients who use SOM design databases to manage their buildings after construction. "It solves enormous headaches for me to be able to say, 'Call IBM, they've got an AIX system that will work for you,'" Stoker points out.

Finally, SOM has long-term reasons for selecting AIX as its operating system. As AIX becomes available for the PS/2 and System/370, the firm will have even more options to distribute the required computing power in the right place at the right time. For complex design processes like finite element analysis, for example, the firm anticipates running AIX on IBM mainframes. SOM is already testing the IBM PS/2 for inclusion in its office networks, giving the firm a range of hardware platforms running under a single operating system. "AIX enables us to select the right tool for the job," says Doug Stoker. "We won't have to use a million-dollar hammer to pound a half-penny nail."



SOM provides construction and mechanical engineering, interior design, and other services as part of an integrated design package.

The Metrodome sports facility near Minneapolis-St. Paul, Minnesota.



Smooth Sailing For Technical Publications: AIX at Newport News Shipbuilding



Building ships for the U.S. Navy demands innovative technology and efficient operations. Newport News Shipbuilding uses AIX, the RT, and Interleaf® software.

Newport News Shipbuilding, the largest privately owned shipyard in the U.S., has been building ships for the U.S. Navy and merchant marine for over 100 years. At the turn of the century, the company designed and built battleships for Theodore Roosevelt's "Great White Fleet." During the World War II era, Newport News produced the famed aircraft carriers Essex, Hornet, and Yorktown. After the war, Newport News designed and built the world's first nuclear-powered carrier, the Enterprise.

Today Newport News is turning out the largest mobile structures made by man: Nimitz-class aircraft carriers. Each of these huge vessels amounts to a small floating city — with its own airport. Newport News is also building the Los Angeles-class attack submarines and is

currently designing the sophisticated Seawolf-class submarine for the Navy, as well as providing maintenance, repair, and rebuilding services for a wide range of commercial and naval vessels.

To boost productivity, and to meet the growing demand in the armed services and transportation industries for more sophisticated technology, Newport News is expanding its use of computer technology by nearly 40 percent a year. The giant shipbuilder, a division of Tenneco, is paying particular attention to integrating computer technology throughout its 550 acres of offices, design centers, ships, and dry docks in its shipyard at the mouth of the James River in Virginia.

Hundreds of Thousands of Pages a Year

Newport News' work for the U.S. Navy involves more than designing, building, and delivering ships. The company must also provide complete technical documentation and maintenance specifications for ships that can last 30 to 40 years in active service. At Newport News, this technical publishing task involves 200 writers, editors, designers, and production specialists, who turn out hundreds of thousands of polished technical documents each year.

To help streamline this effort, and to take advantage of a huge existing database of design information, Newport News last year installed a local area network of IBM AIX/RT systems running



Interleaf software as well as Newport News-developed proprietary software. Interleaf is a full-function technical publication package optimized for use with AIX/RT systems.

“We want to increase our competitiveness by lowering costs, and the new system is an important step in that direction.”

“The combination of AIX, the RT, and Interleaf met our requirements better than the other systems we looked at,” says Bill Georges, Manager of Technical Information Systems at Newport News Shipbuilding. “We like Interleaf because of its flexibility, its range of capabilities, and its user friendliness. It also runs very well under AIX on the RT.”

Newport News was interested in implementing AIX in part because the UNIX operating system on which it is based was originally designed for multi-user technical environments — much like that at Newport News. “We have quite a large amount of data to store and work with on our technical publishing network,” says Sean Loberg, a CAD/CAM

Systems Analyst at Newport News. “We felt that AIX would allow us to handle that data efficiently and also integrate it with some of the other systems we have here at the shipyard.” Newport News is also interested in open systems — another reason for implementing AIX.

More Productivity, Less Paper

Newport News found that getting its RT network up and running was surprisingly straightforward. “We were into production with the new system in about six weeks,” Georges recalls. “Installation and training have gone smoothly, and we got fine support from the local office of IBM.” The 22 RTs and other peripheral equipment were originally networked via Ethernet, but Newport News is migrating the network over to IBM’s Token-Ring. In addition, IBM PS/2s are currently being connected to the network to boost the productivity of writers and editors performing keystroke-intensive jobs such as technical writing and editing.

“Productivity and integration were really the driving forces in our decision to implement the RT network and AIX,” Georges says. “We want to increase our competitiveness by lowering costs, and the new system is an important step in that direction.”



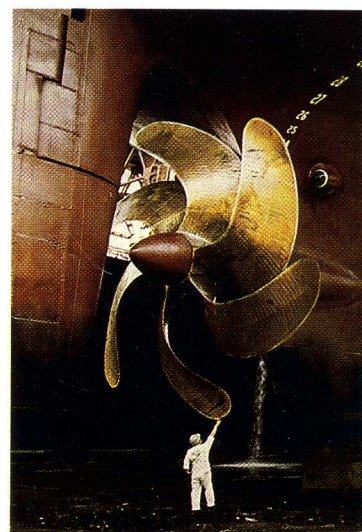
The new system will also help Newport News keep up with the demands of its key customer: the U.S. Navy. If current trends continue, new classes of naval vessels will soon be designed as “paperless ships.” Like the “paperless office” that has been predicted for major corporations in the 1990s, a paperless ship would store most data (including its own maintenance records and specifications) in digital rather than printed form. The difference between offices and ships is that ships — and submarines in particular — have much less space in which to store shelves of printed books.

“We expect that by 1990 any new class of vessel will include the paperless ship concept,” says Dennis Frink, Manager of Integrated Logistics Support at

Newport News. “The RT publications network is a key step in positioning Newport News to meet that requirement.”

Putting the Tools In Place

As the technical publications staff at Newport News becomes more familiar with AIX, the RT, and Interleaf, the group will log solid productivity gains and increase their technical publications business, Georges predicts. “We have the tools in place now,” he says. “We are already beginning to use them to work more efficiently, and therefore strengthening our lead position in the shipbuilding industry.”





Making TRACS: AIX at Work for Genuine Parts Company



AIX plays a key role in the creation of a cost-effective, multi-user business management system for automotive repair shops.

Genuine Parts Company, the largest distributor to the U.S. automotive aftermarket, began 1988 with a corporate goal of doubling its \$2.5 billion business by 1993. Achieving that ambitious goal depends on the continued good health of Genuine Parts' customers: auto repair shops that buy aftermarket auto parts from NAPA stores supplied by Genuine Parts. To help its customers compete, Genuine Parts Company (GPC) is now offering them an innovative business-management system based on the IBM PS/2 and AIX.

An Integrated Auto Repair System

The new system is called NAPA TRACS™, for "Total Repair Automotive Computer System." TRACS includes modules for generating estimates and repair orders, inventory control, accounts receivable, file management, and sales analysis. A sixth module provides dial-up access to the repair shop's nearest NAPA store, both for on-demand ordering of necessary parts, and for automatic restocking of inventory. Additional modules for financial analysis and other activities are also available.

"NAPA" refers to the National Automotive Parts Association, of which GPC is a member; there were roughly 6,000 NAPA stores in the U.S. at the end of 1988.

"We designed TRACS as a low-cost, multi-user system that will help the repair shop owner manage every important aspect of the business," says Craig Bierman, Manager of Dealer Systems at Genuine Parts Company. "It has to be low-cost, because in most cases it's a new investment for a small business. It also has to be multi-user, because the typical repair shop involves a number of different activities under one roof."

TRACS will make it nearly effortless for auto shops to order parts from NAPA stores.

According to Bierman, a typical TRACS installation will include an IBM PS/2 in the auto shop office, with optional IBM 3164 color terminals for the manager, bookkeeper, and service writers. In time, as repair shops become more familiar with the part ordering and inventory control features of TRACS, they may run additional terminals into their automotive service bays. IBM Proprinters™ and tape back-up units complete the system.

Innovative Inventory Control

TRACS keeps track of a myriad of details while smoothing the flow of information from the order desk to service bays to the bookkeeper's ledger. In addition to daily



tasks such as printing estimates and repairs orders, the system will generate productivity reports, perform sales analyses, and monitor inventory. TRACS will also remember to create service reminders, thank-you notes, and other customer correspondence that helps build repeat business.

From Genuine Parts Company's point of view, TRACS will make it nearly effortless for auto shops to order parts from NAPA stores. "In the process of creating a repair order, all a person has to do is touch a function key to hook up with the nearest NAPA store," Bierman says. TRACS logs on to the NAPA store computer, sends the necessary vehicle information down the line, and requests parts information. The NAPA system then sends back price and availability data and asks if the repair shop wants to place an order. If the repair shop agrees, invoices are printed and the parts are

Genuine Parts Company unveiled its TRACS system, based on the IBM PS/2 and AIX, at NAPA's 1989 National Business Conference in New Orleans.

delivered, often within a half-hour. "Service is the name of the game in the repair business," Bierman points out.

In the distribution business, the name of the game is inventory control, and GPC has built numerous inventory features into TRACS. One feature allows the repair shop to set minimum and maximum parameters for selected part numbers. As orders are written against the inventories of these parts, the system monitors current levels. When a minimum level is reached for a particular part, the system will automatically create a purchase order to replenish the supply; the repair shop needs only to approve the order.



TRACS will help independent auto repair shops operate more efficiently. It should also boost sales of NAPA auto parts nationwide.

AIX To the Rescue

Genuine Parts Company was eager to select IBM hardware and peripherals for its TRACS system, to take advantage of IBM's reputation for quality products and reliable service. During the early development of TRACS, however, IBM had not yet announced AIX on the PS/2, which left GPC with a difficult choice. The RT offered a multi-user operating system, but it was considered too expensive for an entry-level system. A network of PS/2s would provide multi-user functionality, but it was considered too complicated for small auto repair shops to manage.

"We had pretty much come to the conclusion that we **had** to have a multi-user operating system to meet our price and performance targets," Bierman recalls. "When IBM announced AIX on the PS/2, it was a life-saver." Genuine Parts quickly obtained early releases of AIX PS/2, and was happy to discover that AIX produced maximum performance from the SQL relational database system GPC had already licensed for TRACS.

TRACS was officially unveiled in March, at NAPA's National Business Conference in New Orleans. "The auto repair industry recognizes that it needs to computerize to compete in the 1990s, so there's definitely a demand out there," Craig Bierman says. In fact, there are well over 300,000 auto repair shops in

*"We **had** to have a multi-user operating system to meet our price and performance targets."*

the U.S. Most of them are independently owned, small or mid-sized businesses, for which TRACS should be ideal. "We knew all along that we had to provide a low-cost, multi-user system to be successful," Bierman concludes. "For our purposes, and for the purposes of our customers, that means AIX on the PS/2."

P A R T F I V E

Additional Information

*This section of **AIX** offers access to information about AIX applications; an AIX Resource Guide that lists classes and other materials available from IBM; a Glossary of terms, and an Index.*



National Solution Center

IBM's National Solution Center is a reservoir of reference tools, containing thousands of product applications and solutions, customer references, and IBM Business Partner Resources. All IBM branch office sales and systems personnel can access this data via the internal Hands On Network (HONE).

AIX Resource Guide

Publications

Brochures:

AIX Overview	G580-0917
AIX/370 Fact Sheet	G580-0931
AIX/RT Fact Sheet	G580-0932
AIX PS/2 Fact Sheet	G580-0933

Manuals:

AIX Family Definition Overview	GC32-2002
AIX PS/2 General Information	GC23-2055
AIX/370 General Information	GC23-2062
AIX/RT General Information	GC23-2129
Architecture and Engineering Series General Information	GC33-8157

IBM Systems Journal Reprints*

AIX Operating System Overview	G321-5300
AIX Program Development Environment	G321-5302
AIX Usability Enhancements and Human Factors	G321-5303

*IBM Systems Journal Volume 26,
No. 4, 1988

G321-0088

Self-Study Programs

UNIX Operating System: Fundamentals Series

32408

Introduction	32401
Editing and Printing	32402
Files and Directories	32403

UNIX Operating System: Applications Series

32409

Text Formatting	32404
System Administration	32405
Shell Programming	32406
Program Development Tools	32407

C Language Series

32356

Introduction to C Language	32351
Coding in C Language	32352
Advanced C Language Coding	32354

Classes

IBM Internal Education

AIX Marketing	20185
AIX/RT Quick Start	76983
AIX LAN Communications	77486

AIX Application Education

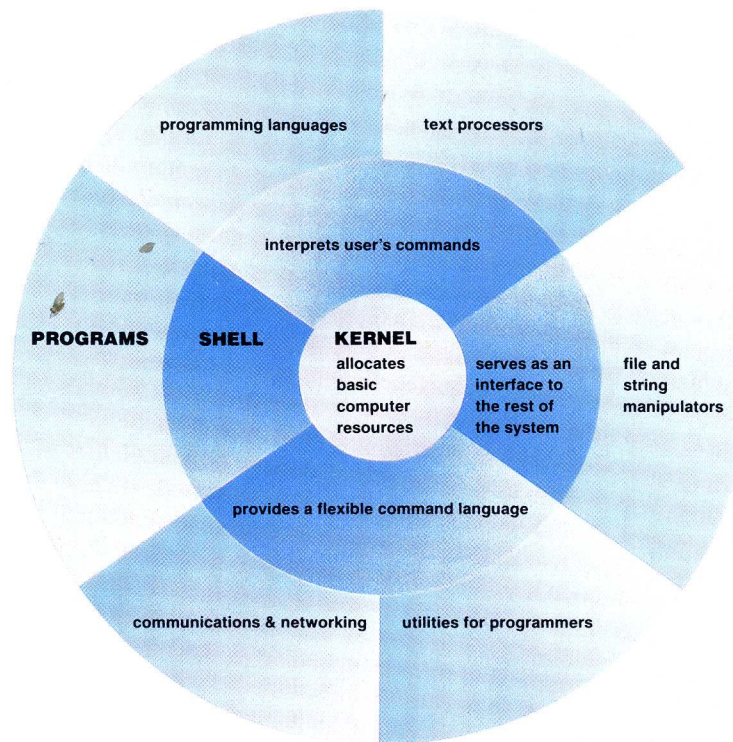
RT CAEDS Basic Operations	N1057
RT CAEDS Basic Dimensioning	N1060
RT CAEDS Basic System Modeling	N1066
RT CAEDS Basic Finite Element Solver	N1065
RT CAEDS Basic Solids Modeling	N1062
RT CATIA System Installation	E3692
RT CATIA Basic 3D Design	N1056
RT CATIA Basic Drafting	N1061
RT CBDS Basic Operations	N1058

AIX Customer Education

Getting Started With AIX	Q1004
AIX/RT Installation and Implementation	Q1001
AIX PS/2 Installation and Implementation	Q1005
AIX Communications on the RT System	Q1003
AIX TCP/IP and NFS Installation and Implementation	Q1007
AIX Distributed Services Installation and Implementation	Q1008
I/S Showcase Program: Programmer Productivity	Y6707



UNIX Operating System Structure



UNIX operating systems are interactive computer programs designed to support multiple users in multi-tasking operations. Essential components of all UNIX operating systems include a kernel, a shell, and a number of other elements including (at a minimum) a hierarchical file system; programming tools and languages; communications functions; libraries of existing subroutines; and various editors.

The kernel interacts directly with computer system hardware, and responds to requests for hardware services, such as I/O, from other parts of the operating system. The kernel also manages memory, monitors the multi-user environment, and enforces security. All kernels must be tailored to the particular computer platforms they are running on. In the case of AIX, for example, the kernels are slightly different for the PS/2, the RT, and S/370 computers.

The shell provides a flexible interface between users and the rest of the UNIX operating system. When a UNIX command is entered, the shell interprets it and calls upon the right program or utility to perform the desired task. Shell commands can be combined into a "shell script" that links a number of UNIX routines into a working program that passes the results of one routine on to the next until its task is completed.

The file system consists of individual files and directories of files. Files are defined as strings of characters with no further structure (that is, the UNIX file system knows nothing about record sizes), while directories consist of a number of files organized in hierarchies, like the roots or branches of a tree. For security, all files can be defined in two dimensions:

(1) whether a file can be read, written, or executed, and (2) whether those permissions apply to the user, the group(s) of which the user is a member, or all other users on the system. For example, users may define program files that they and members of their group may read, write, and execute, but that other users may execute only.

Programming tools are an integral part of the UNIX operating system, because it was originally created to support application developers. The C and VS FORTRAN programming languages are offered with most UNIX operating system versions, including AIX. Highly developed libraries of precompiled code include routines for system interfacing, message queuing, sorting and searching, mathematics, etc. Other development tools assist programmers with source code version control, "pretty printing," symbolic debugging, parsing, execution profiling and other functions.

User tools provided with UNIX operating systems include useful subroutines for fast and sophisticated searching (grep, awk); for editing text (ed, sed, vi); for formatting text (nroff for traditional printers and troff for typesetters); and for spell checking. System administration tools include utilities for updating the operating system, system and user accounting, performance monitoring, etc. All these tools can be combined with shell scripts into complete application programs.

Communications round out the functions provided by typical UNIX operating systems. Programs for terminal emulation and file transfer are included at a minimum. At a maximum, a UNIX operating system may provide systems for distributed and cooperative processing and other communication functions.



Glossary

- AIX™** Advanced Interactive Executive. IBM's implementation of the UNIX operating system, announced for three strategic hardware platforms: the 386 microprocessor-based models of the Personal System/2 (AIX PS/2), the RT system (AIX/RT), and the System/370 line of mainframe processors (AIX/370). AIX is based on UNIX System V and 4.3 BSD, and includes popular industry extensions as well as numerous enhancements from IBM.
- AIX Family Definition** IBM's definition for the common operating system environment for all members of the AIX Family. The AIX Family Definition includes specifications for the AIX Base System, User Interface, Programming Interface, Communications Support, Distributed Processing, and Applications.
- Andrew** A system developed at Carnegie Mellon University for versions of the UNIX operating system. The Andrew Toolkit provides an object-oriented application development system. The Andrew File System is a distributed network file system for very large scale networking. **See** Object-oriented programming.
- ANSI** American National Standards Institute. A standards organization. The United States' liaison to the International Standards Organization (ISO).
- Applications** Computer software that provides a specific user function, such as spreadsheet, word processing, database management, etc.
- Also** the component of the AIX Family Definition that describes common application interfaces for the AIX PS/2, AIX/RT, and AIX/370 operating systems.
- ASCII** American Standard Code for Information Interchange. A collection of public-domain character sets considered standard throughout the computer industry.
- awk** An interpreter, included in most UNIX operating systems, that performs sophisticated text pattern matching. In combination with shell scripts, awk can be used to prototype or implement applications far more quickly than traditional programming methods.
- Base System** The component of the AIX Family Definition that describes common functions for the "kernel," or hardware-interface layer, of the AIX PS/2, AIX/RT, and AIX/370 operating systems.
- Berkeley Software Distribution** Disseminating arm of the UNIX operating system community at the University of California at Berkeley; commonly abbreviated "BSD." Complete versions of the UNIX operating system have been released by BSD for a number of years; the latest is numbered 4.3. The phrase "Berkeley extensions" refers to features and functions, such as the C shell, that originated or were refined at UC Berkeley and that are now considered a necessary part of any fully configured version of the UNIX operating system.

Bourne shell (sh) UNIX shell written in the early days of the system by Steven Bourne. Considered the simplest of many available shells, the Bourne shell (sh) is widely popular for its simple variables and inclusion of a rudimentary programming language; it is included with virtually every UNIX system.

BSD See Berkeley Software Distribution.

C The programming language in which the UNIX operating system and most UNIX application programs are written. The portability attributed to UNIX operating systems is largely due to the fact that C, unlike other higher level languages, permits programmers to write systems-level code that will work on any computer with a standard C compiler.

C shell (csh) UNIX operating system shell developed at UC Berkeley to employ programming constructs similar to those used by C, the high-level programming language in which the UNIX operating system is written. The C shell (csh) provides features such as job control and command histories, and is considered superior to the Bourne shell for interactive applications. See Berkeley Software Distribution, Shell.

CAD Computer Assisted Design.

CAE See Common Applications Environment.

CAM Computer Aided Manufacturing.

CASE Computer-Aided Software Engineering.

CIM Computer Integrated Manufacturing.

Client User of a network service. In the client/server model, network elements are defined as either using (client) or providing (server) network resources. See Server.

Cluster Term used to describe a group of System/370 and PS/2 processors connected by the AIX Transparent Computing Facility (TCF). See Transparent Computing Facility.

CMS Conversational Monitor System. IBM's system for interactive use of a VM/370 machine.

Common Applications Environment (CAE) Goal of X/Open consortium, of which IBM is a member. The Common Applications Environment (CAE) is believed to be achievable earlier than complete UNIX operating system standards; X/Open has already published more than one release of its multi-volume "Application Portability Guide" as well as an "X/Open Security Guide." See X/Open.

Communications Support The component of the AIX Family Definition that describes common communications programs and interfaces for the AIX PS/2, AIX/RT, and AIX/370 operating systems.

DASD Direct Access Storage Device. IBM's term for a hard disk.

DBMS Database management system; superset of relational database management systems.

Distributed Processing The component of the AIX Family Definition that describes distributed processing functions, such as AIX Distributed Services and the Transparent Computing Facility, for the AIX PS/2, AIX/RT, and AIX/370 operating systems.

Distributed Services (DS)	Capability of IBM's AIX operating system. Distributed Services permits transparent sharing of files and other system resources between AIX systems, on Ethernet or Token-Ring local area networks via TCP/IP (or, on AIX/RT, via SDLC).
DOS	Disk Operating System. In the UNIX operating system context, this normally means PC DOS.
DOS Merge	An optional program for AIX PS/2 which allows the execution of DOS 3.3 (and most DOS applications) under control of AIX PS/2.
DOS Server	In cooperation with a licensed program called IBM AIX Access for DOS Users, which runs on an IBM PC or PS/2, DOS Server (in AIX PS/2, AIX/RT, or AIX/370) allows DOS users to access and use AIX storage, file systems, and printers and simulates an asynchronous terminal running programs on the AIX host.
DS	See Distributed Services.
ed	A simple line editor included with most versions of the UNIX operating system.
Ethernet	A baseband protocol, invented by the XEROX Corporation, in common use as the local area network for UNIX operating systems interconnected via TCP/IP.
Filters	Data-manipulation commands (which, in UNIX operating systems, amount to small programs) that take input from one process and perform an operation yielding new output. Filters include editors, pattern-searchers, and commands that sort or differentiate files, among others.
FORTRAN	Formula Translator. A high-level programming language invented by John Backus of IBM. After C, FORTRAN is the most commonly used language with UNIX operating systems; both C and VS FORTRAN are part of the AIX Family Definition and Systems Applications Architecture.
Gateway	A device that acts as a connector between two physically separate networks. It has interfaces to more than one network and can translate the packets of one network to another, possibly dissimilar, network.
grep	Utility included with most UNIX operating systems that "gets repeating" patterns in a file (or files) and lists them for analysis.
GSL	Graphics Subroutine Library. The IBM support provided on AIX workstations for the device independent manipulation of two-dimensional graphical data.
Heterogeneous	Descriptor applied to networks composed of products from multiple vendors.
Homogeneous	Descriptor applied to networks composed of products from a single vendor.
Hypertext	Term for on-line interactive documentation of computer software; to be included with AIX.
IEEE	Institute of Electrical and Electronics Engineers. A professional society active in standards work, the IEEE is the official body for work on the POSIX (Portable Operating System for Computer Environments) open system interface definition.
INGRES™	A database management system available for UNIX operating systems, currently marketed and supported by Relational Technology. IBM has announced INGRES for AIX PS/2 and AIX/RT.

INTERACTIVE INTERACTIVE Systems Corporation, which assisted IBM with its first implementation of the UNIX operating system for the RT system. INTERACTIVE continues to develop tools for UNIX and DOS operating systems.

Interleaf® Company providing powerful integrated software (of the same name) for publishing applications. Interleaf is available under AIX/RT.

Interoperability The ability of different kinds of computers to work well together.

IP Internet Protocol. **See** TCP/IP.

ISDN Integrated Services Digital Network. An emerging standard for providing a wide range of data and voice applications on the same digital communication networks.

ISO International Standards Organization. A United Nations agency that provides for the creation and administration of worldwide standards. **See** OSI.

IX/370 Interactive Executive/370. An IBM version of the UNIX operating system available for System/370 processors.

Kernel The layer of a UNIX operating system that interacts with the computer hardware, provides services for the other parts of the operating system, and insulates other parts from hardware dependency.

LAN **See** Local Area Network.

Library In UNIX operating systems, a collection of existing subroutines that allows programmers to make use of work already done by other programmers. UNIX operating systems often include separate libraries for communications, window management, string handling, math, etc.

LISP A list-processing language popular in artificial intelligence work, noted for its ability to process procedures in the way other languages pass data. The RT system is ideally suited to LISP, because its inverted page table memory management unit provides for the efficient management of large virtual memories, which are required by many LISP applications.

Local Area Network (LAN) A facility, usually a combination of wiring, transducers, adapter boards, and software protocols, which interconnects workstations and other computers located within a department, building, or neighborhood. Token-Ring and Ethernet are local area network products.

LU6.2 IBM SNA communications protocol supported by AIX/RT, designed for communication between processes which may be executing on different systems.

Mach A version of the UNIX operating system developed at Carnegie Mellon University and Brown University, specifically for multiprocessing and parallel processing in computer networks. Mach has been ported to the RT and other computers.

make Programming tool included in most UNIX operating systems that helps “make” a new program out of a collection of existing subroutines and utilities, by controlling the order in which those programs are linked, compiled, and executed.

Minidisk A portion of a physical disk, configured by software to appear as a miniature model of that physical disk, having fewer cylinders, tracks, or blocks, but otherwise architecturally equivalent.

Motif™	The graphical user interface for OSF, incorporating the X Window System. Behavior of this interface is compatible with the IBM/Microsoft Presentation Manager user interface for OS/2. Also called OSF/Motif.
Mount	A logical (i.e., not physical) attachment of one file directory to another. “Remote mounting” allows files and directories that reside on physically separate computer systems to be attached to a local system.
Multi-tasking	Capability of performing two or more computing tasks, such as interactive editing and complex numeric calculations, at the same time. AIX and OS/2 are multi-tasking operating systems; DOS, in contrast, is a single-tasking system.
Network File System (NFS™)	A program developed by SUN Microsystems, Inc. for sharing files among systems connected via TCP/IP. IBM’s AIX, VM, and MVS operating systems support NFS.
NextStep™	The object-oriented graphical user interface (GUI) from NeXT, Inc. which has been licensed by IBM for use in developing an advanced GUI for AIX.
NFS™	See Network File System.
NIST	National Institute of Science and Technology (formerly the National Bureau of Standards).
NJE	Network Job Entry. An SNA-based protocol for the submission of jobs to a host computer from a workstation. AIX provides facilities for the submission of jobs via NJE.
Object-oriented programming	Method of programming in which sections of program code and data are represented, used, and edited in the form of “objects,” such as graphical elements, window components, etc., rather than as strict computer code. Through object-oriented programming techniques, toolkits can be designed that make programming much easier. Examples of object-oriented programming languages include Parcplace Systems, Inc.’s Smalltalk-80™, AT&T’s C++™, and Stepstone Inc.’s Objective-C®.
OEM	Original Equipment Manufacturer. In the context of AIX, OEM systems refer to the processors of a heterogeneous computer network that are not made or provided by IBM.
onhost	Formerly “oncms,” for “execute the following command on VM/CMS.” An AIX command designed to pass its argument to a coupled CMS session, so that the requested command line can be executed in that environment, with results being returned back for use in the AIX environment.
Open Software Foundation™ (OSF)	A non-profit consortium of private companies, universities, and research institutions formed to conduct open technological evaluations of available components of UNIX operating systems, for the purpose of assembling selected elements into a complete version of the UNIX operating system available to those who wish to license it. IBM is a founding sponsor and member of OSF, which has selected a future release of AIX for its base system technology.
ORACLE®	A relational database management system for various operating environments, including the UNIX operating system. Developed and marketed by Oracle Corporation, ORACLE has been announced by IBM for AIX/RT and AIX PS/2.

OSF™	See Open Software Foundation.
OS/2™	Operating System/2 for the Personal System/2 line of computers. OS/2 Extended Edition was the first IBM operating system to be released that participates in IBM's Systems Application Architecture. OS/2 provides multi-tasking, memory addressability to 16 megabytes, and the use of graphics and windowing. OS/2 Extended Edition also provides common communications interfaces, plus integrated relational database and query functions.
OSI	Open Systems Interconnect. A layered collection of standards developed under the aegis of the International Standards Organization (ISO) for interconnection of heterogeneous computer and communication networks. See ISO.
Packet switching	The transmission of data in small, discrete switching "packets" rather than in streams, for the purpose of making more efficient use of physical data channels. Employed in some UNIX system communications.
Parallel processing	A computing strategy in which a single large task is separated into parts, each of which then runs in parallel on separate processors.
Pipes	UNIX operating system routines that connect the standard output of one process with the standard input of another process. Pipes are central to the function of UNIX operating systems, which generally consist of numerous small programs linked together into larger routines by pipes.
Portability	Desirable feature of computer systems and applications, referring to users' freedom to run application programs on computers from many vendors without rewriting the program's code. Also known as "applications portability," "machine-independence," and "hardware-independence"; often cited as a cause of the recent surge in popularity of UNIX operating systems. See C.
POSIX	"Portable Operating Systems for Computer Environments." A set of open standards for an operating system environment being developed under the aegis of the IEEE. See IEEE.
Programming Interface	The component of the AIX Family Definition that describes common programming interface functions for the AIX PS/2, AIX/RT, and AIX/370 operating systems.
PS/2®	Personal System/2. IBM's current line of microcomputers. AIX is supported on 386-based models of the PS/2.
RDBMS	Relational Database Management System. A database in which relationships between data items are explicitly specified as equally accessible.
RISC	Reduced Instruction Set Computer. A class of computer architectures, pioneered by IBM's John Cocke, that improves price-performance by minimizing the number and complexity of the operations required in the instruction set of a computer. In this class of architecture, advanced compiler technology is used to provide operations, such as multiplication, that are infrequently used in practice. The RT is a high-function workstation featuring the RISC architecture. See RT.
RJE	Remote Job Entry. Submission of jobs through an input unit that has access to a computer through a data link.
RT PC AT Simulator	A licensed program for IBM's AIX/RT that provides the capability for many DOS applications to execute from an RT console without additional hardware, as if they were executing on a PC AT with 640 KB of memory.

RT[®] system	RISC Technology system. It runs the AIX/RT operating system. The RT is a multi-tasking, multi-user computer capable of supporting up to 32 users (64 users with a PRPQ) and offering high-function graphics among many other performance features. See RISC.
SAA	Systems Application Architecture. IBM architecture for providing a consistent set of programming, user, and interconnection interfaces across IBM MVS, VM, OS/400, and OS/2 operating systems.
Scalability	Desirable feature of computer systems and applications. Refers to the capability to use the same software environment on many classes of computers, from personal computers to supercomputers, to accommodate growth or divergent environments, without rewriting code or losing functionality.
sed	Non-interactive (stream) editor used to do “batch” editing. Often used as a tool within shell scripts.
Server	A provider of a service in a computer network; for example, a mainframe computer with large storage capacity may play the role of database server for interactive terminals. See Client.
Shell	The outermost (user interface) layer of UNIX operating systems. Shell commands start and control other programs and processes, such as editors and compilers; shells can be textual or visual. A series of system commands can be collected together into a “shell script” that executes like a batch (.BAT) file in DOS. See Bourne shell, C shell.
SNA	Systems Network Architecture. A set of IBM standards for communication and networking.
Sockets	Destination points for communication in many versions of the UNIX operating system, much as electrical sockets are destination points for electrical plugs. Sockets, associated primarily with 4.3 BSD, can be customized to facilitate communication between separate processes or between separate UNIX operating systems.
SQL	Structured Query Language. An IBM standard for database access.
Streams	Similar to sockets, streams are destination points for communications in UNIX operating systems. Associated primarily with UNIX System V, streams are considered by some to be more elegant than sockets, particularly for interprocess communication.
SVID	System V Interface Definition. An AT&T document defining the standard interfaces to be used by UNIX System V application programmers and users.
Symbolic debugger	Program for debugging other programs at the source code level. Common symbolic debuggers include sdb, dbx, and xdbx.
System V	AT&T’s recent releases of its UNIX operating system are numbered as releases of “UNIX System V.”
TCF	See Transparent Computing Facility.
TCP	Transmission Control Protocol. A facility for the creation of reliable bytestreams (byte-by-byte, end-to-end transmission) on top of unreliable datagrams. The transmission layer of TCP/IP. TCP is used to interconnect applications, such as FTP, so that issues of retransmission and blocking can be subordinated in a standard way. See TCP/IP.

TCP/IP

Transmission Control Protocol/Internet Protocol. Pair of communications protocols considered de facto standard in UNIX operating system environments. IBM TCP/IP for VM and IBM TCP/IP for MVS are licensed programs that provide VM and MVS users with the capability of participating in networks using the TCP/IP protocol suite.

Transparent Computing Facility (TCF)

A facility, available on AIX/370 and AIX PS/2, which permits a collection of AIX systems to appear to the user as a single system possessing all the power and resources of all the collected components.

UNIX® Operating System

A multi-user, multi-tasking interactive operating system created at AT&T Bell Laboratories that has been widely used and developed by universities, and that now is becoming increasingly popular in a wide range of commercial applications. **See** Kernel, Shell, Library, Pipes, Filters. **See also** the illustration “UNIX Operating System Structure.”

User Interface

The component of the AIX Family Definition that describes common user interface functions for the AIX PS/2, AIX/RT, and AIX/370 operating systems.

/usr/grp®

One of the oldest, and still active, user groups for UNIX operating systems. IBM is a member of /usr/grp.

vi

Visual editor. A character editor with a very powerful collection of editing commands optimized for ASCII terminals; associated with BSD versions of the UNIX operating system.

Virtual Resource Manager (VRM)

In AIX/RT, a layer beneath the kernel that provides virtual memory and related resources, such as support of I/O devices, disk storage management, and hardware initialization.

X.25

A commercial packet network access protocol that specifies three levels of connections. The X.25 physical level, link level, and packet level correspond to the first three layers of the ISO/OSI model.

XA

Extended Architecture. A facility on System/370 which provides, among other things, a 31-bit virtual address space.

XENIX®

A version of the UNIX operating system for personal computers developed by Microsoft and brought to market by The Santa Cruz Operation.

X/Open™

An international consortium, including many suppliers of computer systems, concerned with the selection and adoption of open system standards for computing applications. IBM is a corporate sponsor of X/Open. **See** Common Applications Environment.

X-Windows

IBM's implementation of the X Window System developed at the Massachusetts Institute of Technology with the support of IBM and DEC™, that gives users “windows” into applications and processes not located only or specifically on their own console or computer system. X-Windows is a powerful vehicle for distributing applications among users on heterogeneous networks.



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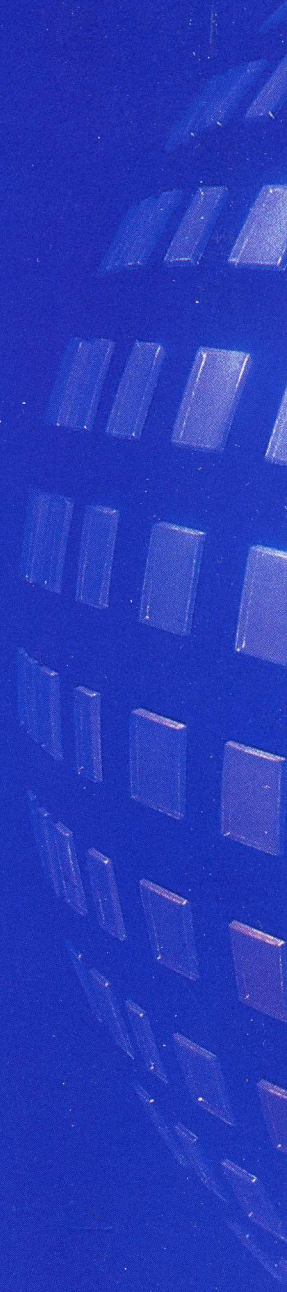
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