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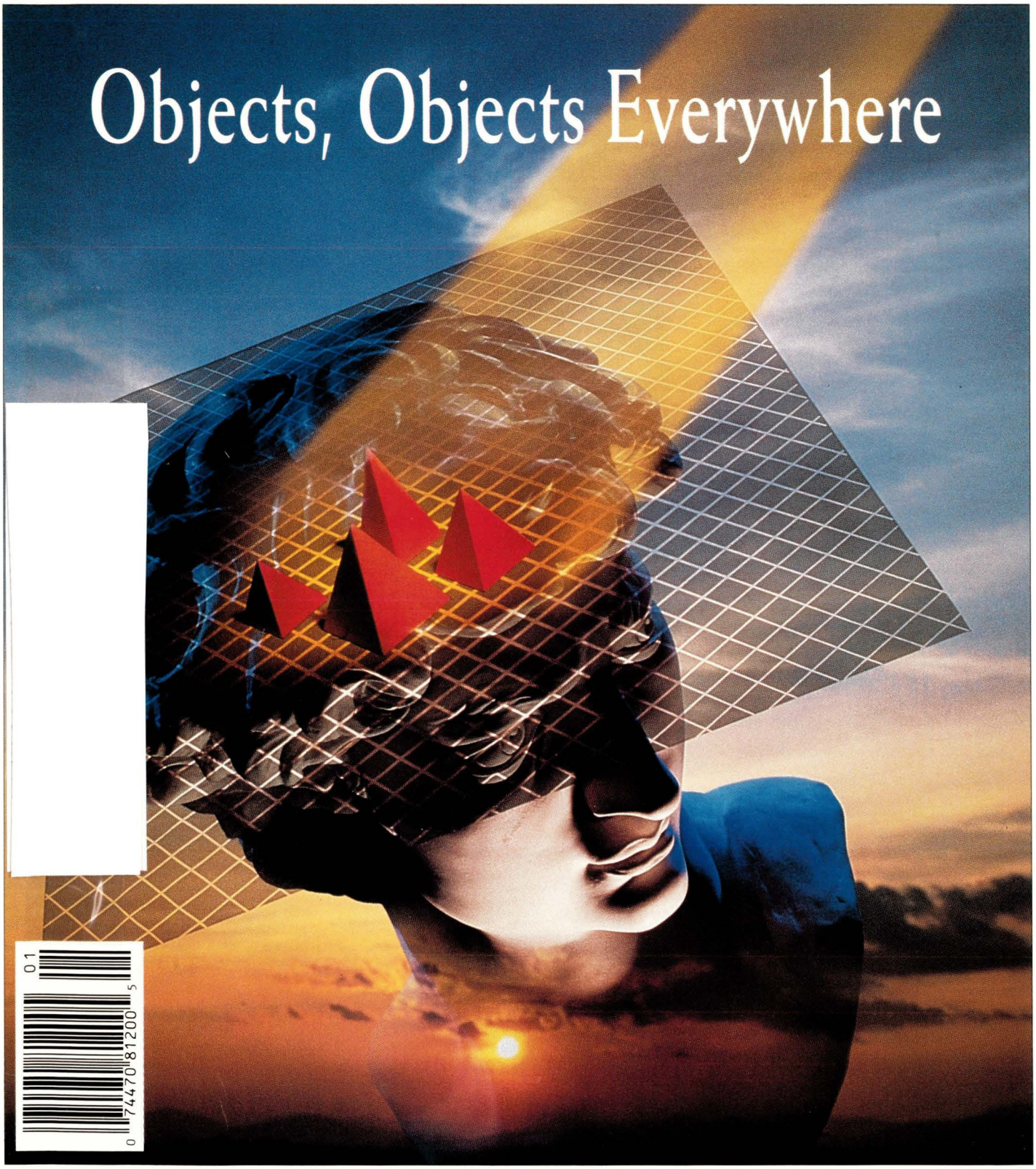

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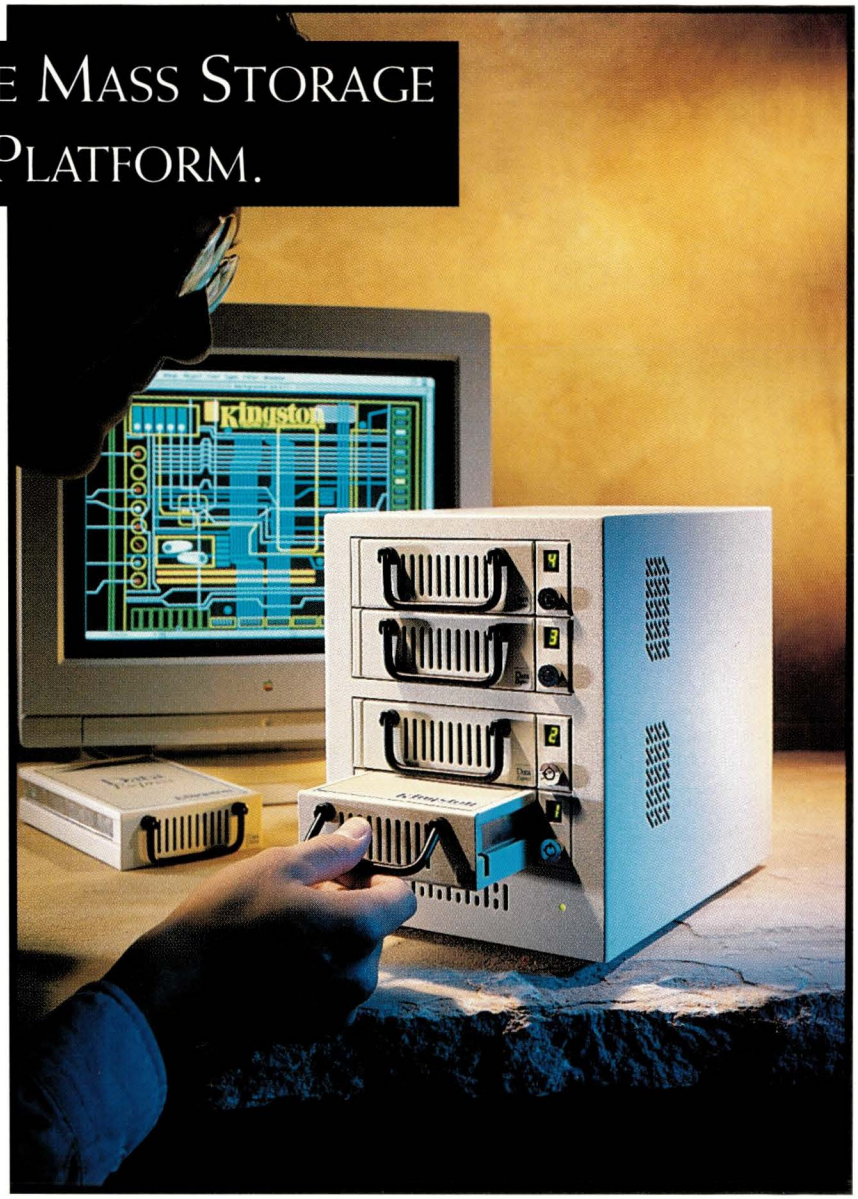

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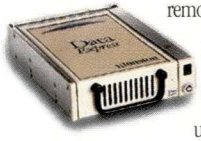

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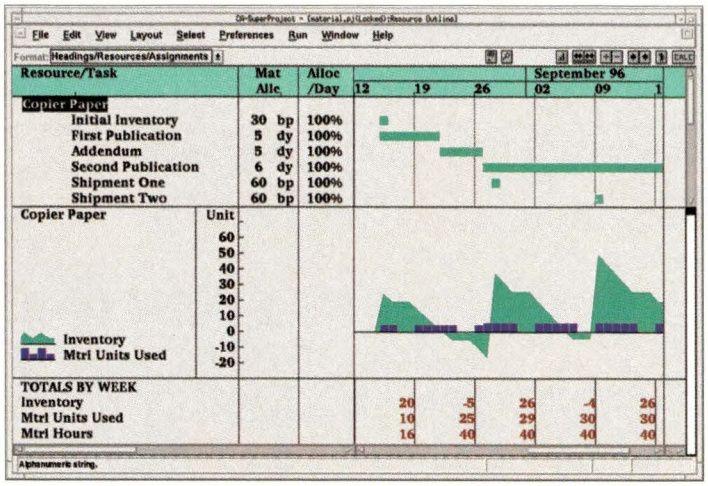

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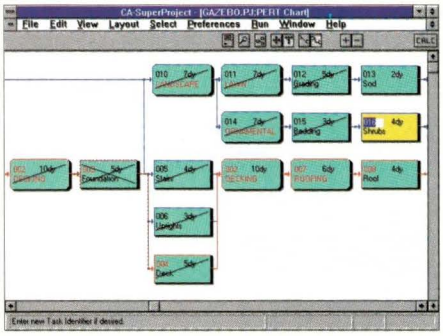

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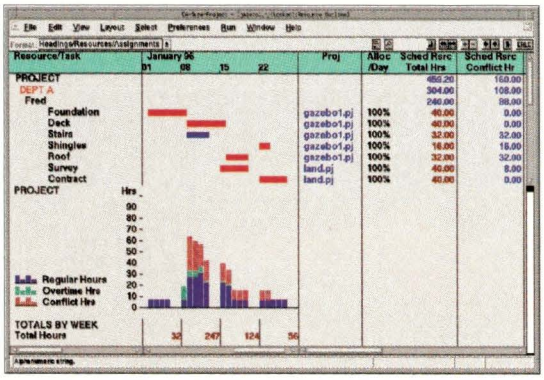

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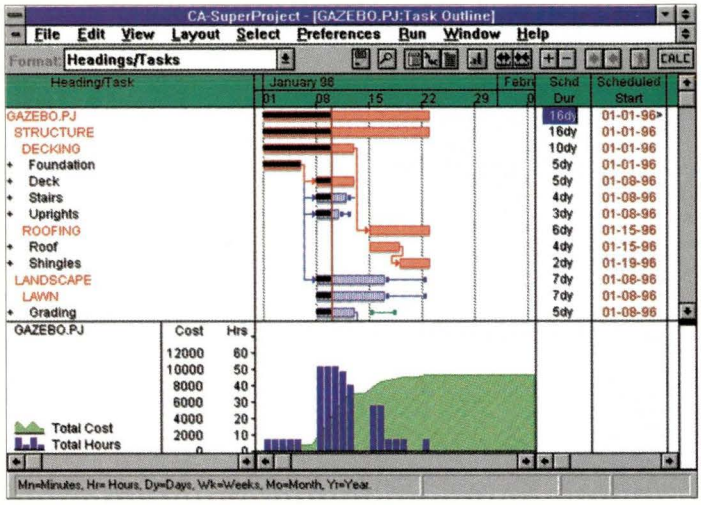

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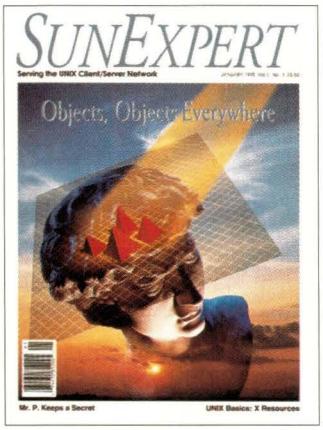
CONTENTS

JANUARY 1995 VOL. 6 NO. 1



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by M. Tcherevkoff, The Image Bank

Visual Thought; microCOMPstation p. 64

FEATURES

SPECIAL SECTION: OBJECT-ORIENTED SYSTEMS

38 Living in an Object World – The cultural issues of adopting object-oriented programming may be more complex than the technical ones. Michael Jay Tucker

50 Object-Oriented Comes of Age – IBM's VisualAge object-oriented development environment is a harbinger of the future of custom application development, including the acceptance of object-oriented languages other than C++. Simson L. Garfinkel

54 Object-Oriented Training Providers – A listing of 40 object-oriented training providers for beginners to advanced users. Maureen McKeon

64 **Product Reviews –** A gutsy technical drawing package and an attractively priced SPARCstation 5 clone. Simson L. Garfinkel

NEWS

6 Includes: **Sun Shows HyperSPARC System; PC RISC Systems Vie for Workstation User; Richard Pick: 1938-1994; Sybase Buys Powersoft.**

COLUMNS

16 **Ask Mr. Protocol – Mr. Protocol Keeps a Secret –** When data securty and personal security are the same thing, it's time to investigate Net services that protect both. Michael O'Brien

24 **UNIX Basics – X Resources –** Tips on tailoring your X system. Peter Collinson

30 **I/Opener – Grow, Little GROW Worm –** A portable, multitasking "Virtual OS," with built-in support for communications and GUI building. Richard Morin

34 **Systems Administration – Out with the Old, In with Solaris –** Introducing Solaris and your environment to each other. S. Lee Henry

DEPARTMENTS

4 Editorial
36 Reader Feedback
68 New Products
73 The SunExpert Market

SUNEXPERT
serves the UNIX workstation environment, emphasizing Sun, SPARC and Sun-compatible systems.

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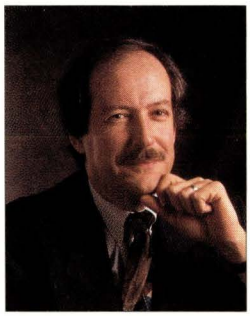
Editorial

Objects Everywhere

The keys to client/server success require new ways of looking at organizational structures in general and new technologies such as data warehousing, database replication and electronic software distribution in particular. However, all these systems come to naught without developers to keep them fed. Today's corporate software shops face considerable challenges that can only be addressed by fundamental changes in the way tasks are done. Capable rapid application development tools, efficient communications pipes and software reuse philosophies will play increasingly important roles in enterprise client/server environments. That's why *SunExpert* decided to devote so much space in this month's issue to object-oriented technologies and methods.



In our cover story, "Living in an Object World," Executive Editor Michael Jay Tucker gets the lowdown from the user trenches. Based on dozens of user interviews with object-oriented pioneers, his article can serve as a road map for devising strategies to bring your organization up to speed with its object projects.

If you need more help finding resources, take a look at the object training table compiled by Research Editor Maureen McKeon. Maureen has found a number of companies that provide vital object training in technical courses ranging from the fundamental to the advanced. If your boss needs a few lessons, send him or her to a class like "Executive Overview of Object-Oriented Methodology" or "Management Overview and General Introduction to Object-Oriented Technology."

The third ingredient in this month's object mix is "Object-Oriented Comes of Age" by Senior Editor Simson L. Garfinkel. Simson takes a look at the latest developments in object technology, especially the debate over Smalltalk, C++, NextStep, Sun's DOE and VisualAge, IBM's latest unified visual programming tool for OS/2, which may be a harbinger of things to come in object programming.

Doug Pryor

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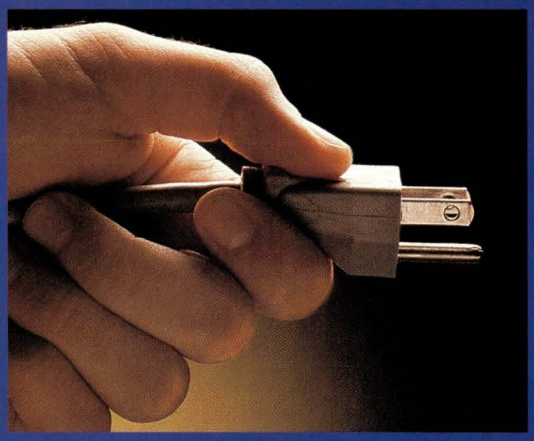

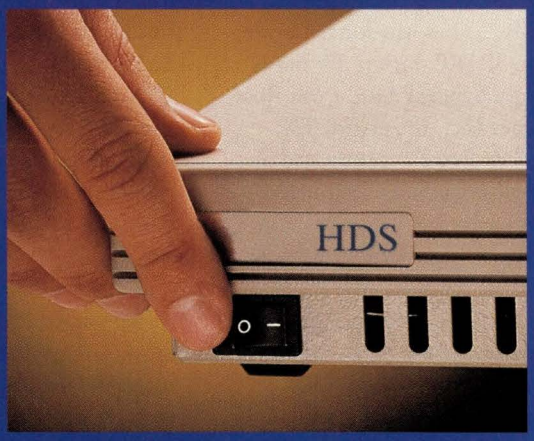

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NEWS

Sun Shows HyperSPARC System

Sun Microsystems Computer Corp. (SMCC) has introduced a version of the SPARCstation 20 that is based on the hyperSPARC from Ross Technologies Inc., in Austin, TX. Think of it as flowers, candy and a sincere apology to Sun's technical users everywhere.

"We are getting a strong message from a market segment that is important to us that they were not getting the performance they need," acknowledges James Enns, manager of the SMCC technical systems market.

Enns' comment is perhaps one of the understatements of the decade. When SMCC began its push into the commercial markets, it was widely perceived as neglecting its traditional engineering and scientific markets. Technical buyers reported they couldn't even get Sun representatives to return their phone calls (see "Sun 1994: The State of the Company," *SunExpert*, December 1994, Page 42).

Even those technical users who got Sun's attention reported that the performance of the SuperSPARC was short of what they needed. While the SuperSPARC might have been superb at running large customer databases, it did not have the floating performance or caching that engineers and designers wanted.

Meanwhile, Solaris 2 left a foul taste in the engineers' mouths. It wasn't the Berkeley UNIX they had gotten in SunOS, a k a Solaris 1.

In late 1994, however, SMCC apparently noticed that it was alienating its customer base. It announced that it would rebuild some bridges. Among the first of these is the SPARCstation 20 Model HS11. "It is intended to complement the [SuperSPARC-based] SPARCstations," says Chris Scheuele, product manager at SMCC. "We position it for the technical customer who can appreciate things like high floating-point performance."

The new SPARCstation 20 is based on the 100-MHz hyperSPARC. "The hyper-SPARC has a very efficient cache design," says Enns. "We are seeing performance improvements [of cache-dependent applications] of 30% to 50%."

The company insists, however, that this does not represent a departure from its SuperSPARC-based product line, merely an addition to it. "These are complementary," says Enns. "We are bringing out hyperSPARC systems not to replace SuperSPARC but because there are specific users who can use them."

Still, the adoption of hyperSPARC at any point in Sun's product line could be confusing for some observers. Sun has already performed several dramatic flip-flops in its processor strategy. In the mid-1980s, when SPARC first appeared, Sun said the processor was to be licensed to any silicon foundry that wished to produce it. Further, so long as their versions of the CPU met certain interface definitions, the foundries were free to improve and redesign it as much as their hearts desired and their R&D budgets allowed.

The idea was that, in this fashion, SPARC would become an industry standard and would rapidly improve as the silicon foundries competed to produce the best product. The strategy was partly based on Intel Corp.'s experiences, and partly on the MIPS processor, from the former MIPS Computer Inc., which was designed by MIPS employees but fabricated by licensees.

By the 1990s, it became clear that the strategy wasn't working. The silicon foundries were not performing much R&D–with one or two dramatic exceptions, such as Ross Technologies. Finally, in 1992-93, Sun more or less abandoned the idea that SPARC was to be an industry standard. Instead, the processor would be designed chiefly by Sun's own SPARC Technology Business (STB) group and fabricated by Austin-based Texas Instruments Inc.

But now Sun is going back to the model in which they buy SPARCs from someone else–to wit, Ross Technologies. SMCC, however, says that nothing has really changed. "We have always been willing to shop around for processors," says Enns. "HyperSPARC just didn't meet our needs until recently. It was the 100-MHz version that we needed."

Besides, he says, Sun has never relied exclusively on TI for its CPUs. "We also have Fujitsu for a foundry for the microSPARC," he says. Fujitsu is Ross' parent company.

Further, the HS11 is being sold only into the technical markets, and not even into all of those. "It is clear that a large percentage of our technical

Sun's new SPARCstation 20 is based on the 100-MHz hyperSPARC from Ross Technologies.

Rack & Roll

Rackmounting an off-the-shelf desktop SPARC 5, 10, or 20 preserves the Sun warranty, service, and price.

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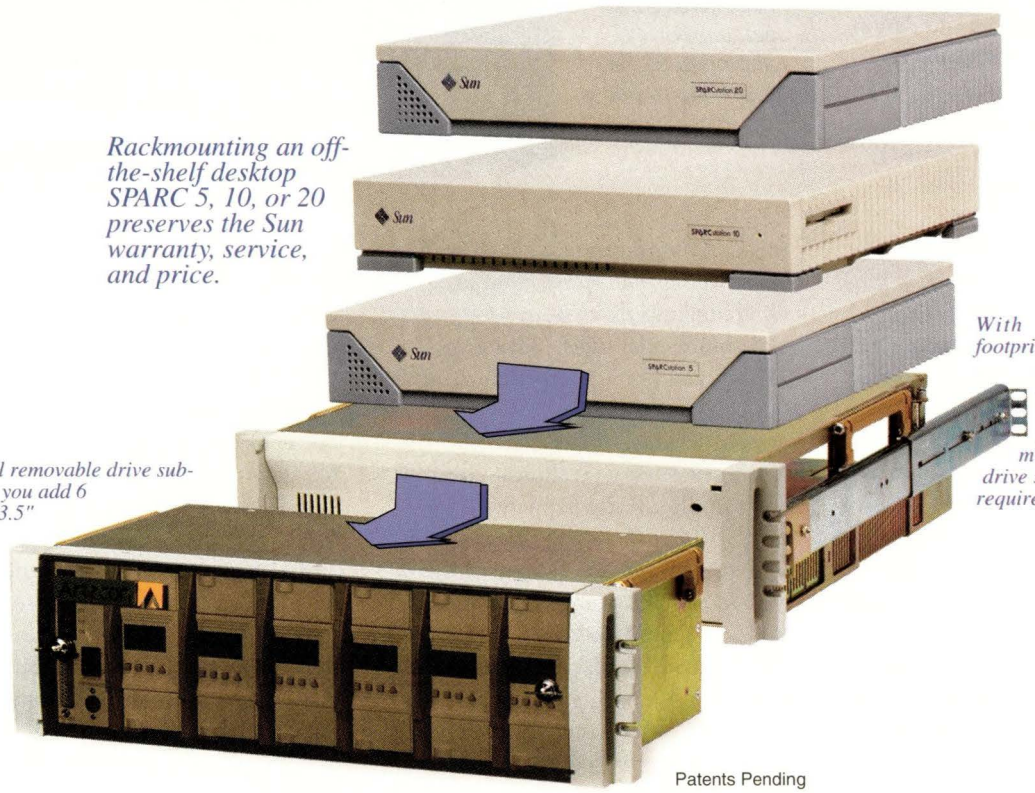

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users are perfectly served by the SuperSPARC. We don't expect to cannibalize [SPARCstation] 20 Model 61 sales," says Enns. Where Enns does expect to see the HS11 play a role is in the design markets. "HS11 is more for ECAD, design and simulation," he says. "It's not for, say, 3D graphics."

But ECAD, design and simulation applications are mostly running on SunOS/Solaris 1, not Solaris 2. And that leads to yet another change. "There is a new version of Solaris 1, called Solaris 1.1.2," says Enns. "It supports the hyperSPARC."

Again, SMCC is eager to say that nothing's really changed. There will be no return to Berkeley UNIX within the confines of SMCC. "[Solaris 1.1.2] has no additional features beyond that it now supports the hyperSPARC and incorporates various bug fixes," says Enns.

However, Enns does acknowledge that Solaris 1.1.2 represents a change in Sun's strategy. "That is somewhat of a change in our focus," he says. "In the past, we were doing whatever it took to get customers off [Solaris] 1 and onto 2. But we realize now that people are going to do both–and that what we are really going to do is support the coexistence of Solaris 1 and 2."

But surely the biggest change in Sun's strategy is its new awareness of its technical roots. "We want to make it clear that when we say 'enterprise computing' we are talking about both technical and commercial users," says Enns. "When you hear 'enterprise,' we mean both."

PowerPC-based devices, like these systems from FirePower Systems, are an alternative to traditional workstations. The FirePower boxes can support NT and other 32-bit operating systems.

Enns claims, in fact, that Sun never neglected its technical users. "I don't think it really happened," he says. "I think there was a perception of that, perhaps. But it wasn't because we had stopped doing anything that we had been doing before. It was just that our commercial focus became so dominant."

On the other hand, there are still a few customers who don't seem welcome at Sun. The company's installed base has long included small shops–the buyers of one or two systems. Selling to these installations was one of the ways Sun got its start. But that's not who Sun says it's selling to now.

Says Enns, "The one-man shop is not our target user." And who is? "The global company–that's our focus."

PC RISC Systems Vie for Workstation User

Where do you buy a workstation if you aren't the "global company" that Sun Microsystems Computer Corp. claims as its target market? Who can you turn to if you are the "one-man shop" that wants only a few systems?

SMCC would like to send you to one of its distributors and resellers. But, like dating in the '90s, this is harder than it sounds. And there is no equivalent to a personals column.

Certainly, SMCC hasn't gone out of its way to pair buyers with sellers. The industry is rife with stories of small business buyers who cannot get Sun even to respond to their questions, much less refer them to a VAR or reseller who might actually sell them a system.

So some small business buyers are starting to turn to other systems. Many, for instance, have gone to SPARCalikes (see "Rumors of Their Death...," *SunExpert*, November 1994, Page 38). Others might now turn to RISC processor-based PCs and PC-like systems.

In recent months, several new devices have appeared that are based on other RISC processors or the Intel Pentium, and running the Microsoft Corp. NT operating system. Many of these processors seem designed expressly to do battle with workstations.

Consider NetPower Inc., in Sunnyvale, CA, founded by such industry luminaries as Robert Miller, formerly CEO of MIPS Computer Inc., and Edward Frank, considered to be the co-designer of the Sun SPARCstation 10. NetPower is a company with a mission: to sell MIPS processor-based NT machines.

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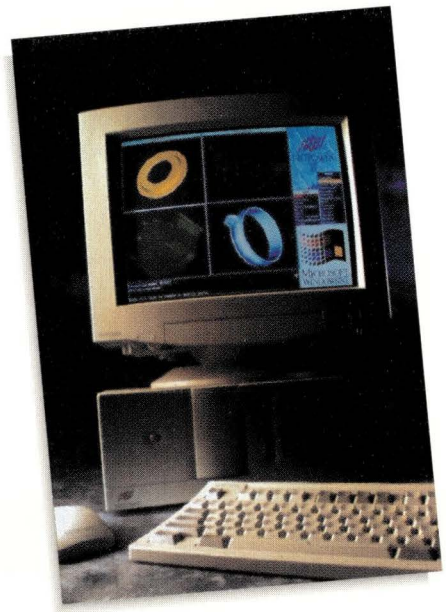

NetPower's Fastseries line of workstation-like personal systems is one option for buyers who can't seem to get their needs met by resellers. The system combines the MIPS processor with the NT operating system.

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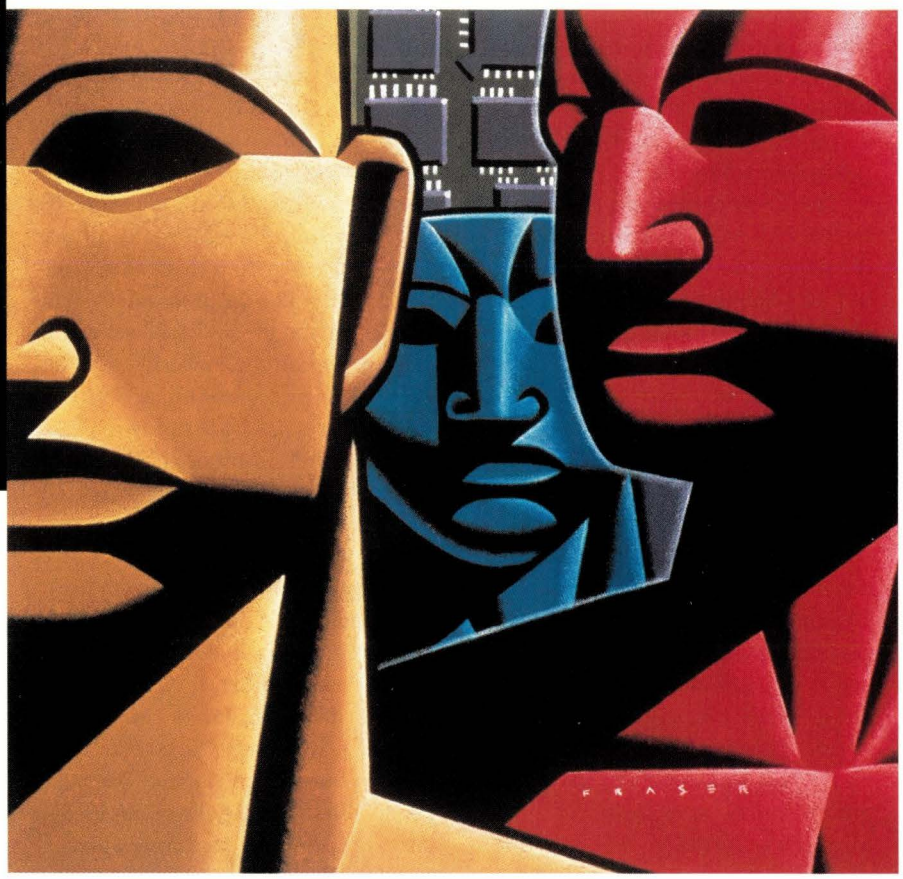

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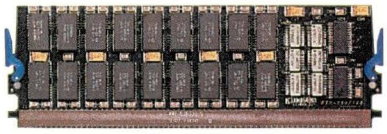

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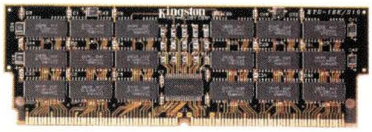

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Silicon Graphics Inc. (the parent company of MIPS) and an ongoing alliance with Microsoft. In November 1994, it introduced two personal workstations called the Fastseries: the uniprocessor Fastseries SP and a multiprocessor Fastseries MP.

The SP machines have a single R4600 133-MHz processor, 512 KB of cache, 32 to 384 MB of memory and 525 MB to 12 GB of disk. SP pricing begins at $3,995. The MPs, meanwhile, have up to two $4,400 processors, 1 MB of of cache per processor, 64 to 385 MB of memory and one to 12 GB of disk. MP pricing begins at $15,995.

And NetPower has already won fans. A recent report from market research firm the Aberdeen Group Inc., in Boston, MA, said the company "has combined market-leading performance and price/performance with network and graphics enhancements to build an advanced system specifically designed for the next-generation applications that are now being deployed on Microsoft's...Windows NT operating system."

But MIPS isn't alone–there are PowerPC machines out there as well. Apple Computer Inc. and IBM already have PowerPC desktops. A less famous but more aggressive company, FirePower Systems Inc., in Menlo Park, CA, has come into business expressly to provide "PowerPC Reference Platform-compliant systems to OEM suppliers."

To this end, FirePower has introduced the Powerized MX product line. The line, with a starting price of $6,000, is based on dual PowerPC 604 processors for multiprocessing servers and desktop systems. Each 604 is rated at 160 SPECint and 185 SPECfp, and the resulting combination yields a system that can deliver 320 MIPS. For uniprocessor systems, the company offers the Powerized ES line, based on the PowerPC 603 and 604, with prices starting at $3,000. Both lines support Windows NT, as well as other 32-bit operating systems, including (potentially) Solaris.

But perhaps the biggest challenge to the workstation turf has come from Intergraph Corp., a former workstation vendor in Huntsville, AL.

Intergraph is an old-timer in the workstation market. It is one of a small, charmed group of companies founded at the beginning of the workstation industry in the late '70s and early '80s–when Apollo Computer was the company everyone chased, and Sun faced stiff competition from the likes of MassComp.

Intergraph was and still is a specialist in design, particularly MCAD. Early on, it staked out the federal systems market for its own, and many tanks, planes and submarines were designed at least in part on an Intergraph workstation. The company was also early into RISC, building its systems around the Clipper processor when that chip set was still being manufactured by Fairchild Semiconductor, and ultimately purchasing Fairchild's Clipper division when that company was folded into National Semiconductor.

For a time, it seemed that Intergraph would become a SPARC box builder. It ported much of its software to SPARC and was working with Sun on a port of NT to SPARC. Then, in 1994, the relationship between Sun and Intergraph suddenly fell apart. For reasons that are still unclear, Sun ceased to fund Intergraph's port of NT, and Intergraph stopped work on SPARC.

Intergraph's next move was a surprise–the Pentium, running under NT. Specifically, the company produced a pair of workstations, the TD-4 and TD-5, which each used dual Pentiums, NT and the company's own proprietary graphics acceleration hardware. The resulting system, says the company, is a workstation in everything but price.

"We learned early that it is the applications, stupid," says Chandler Hall, senior manager of systems product marketing at Intergraph. "You see, to users, openness means volume. They don't care that Microsoft controls the operating system. They do care that NT is supported."

Pentium-based systems, like this TD-5 from Intergraph, are yet another option for workstation buyers. The Intergraph systems provide dual Pentiums, NT and the company's own graphics accelerators.

Richard Pick: 1938-1994

The industry has been saddened to learn of the death of Richard (Dick) Pick, the founder of Pick Systems, in Irvine, CA, and developer of the PICK operating environment. Dick Pick was known as a colorful and outspoken man who, in the early 1980s, was the terror of the UNIX community. His well-reasoned attacks on UNIX's shortcomings as a business operating system earned him the grudging admiration of many of his opponents.

Instead of UNIX, Pick offered operating system of his own design, PICK OS, which was based on work he had originally done as a government contractor. PICK was one of the first of the cross-

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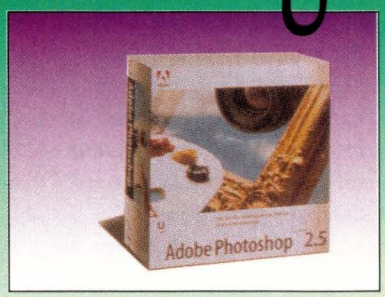

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platform operating systems. Long before DOS offered a shrink-wrapped standard to PCs, PICK was on thousands of minicomputers. It was, in fact, the basis of PRIMOS, the famed OS and database that ran on the former Prime Computer Corp.'s business systems.

With the decline of the minicomputer, PICK suffered a brief reversal of fortune. However, Dick Pick and his company were quick to adapt. Despite his long history of UNIX-bashing, as UNIX moved increasingly into the mainstream, Pick ported his software to UNIX as a guest OS and a database application.

Hardly a month before his death, Dick Pick undertook a press tour that included a stop at the offices of *SunExpert* and *RS/Magazine*, both UNIX magazines pure and simple. This reporter–who began his career writing about minicomputers that ran PICK–mentioned what an odd thing it was that, after a decade, Dick Pick, once the scourge of the UNIX community, should now be so at home there.

Pick laughed and said simply, "In the end, it all comes around, doesn't it?"

Richard Pick died October 17, 1994. He was 56.

Sybase Buys Powersoft

Relational database giant Sybase Inc., in Emeryville, CA, has purchased database development environment maker Powersoft Corp., in Concord, MA. Under the terms of the merger agreement, Powersoft shareholders will receive 1.6 Sybase shares for each share of Powersoft stock.

Powersoft will be an independent subsidiary of Sybase. Powersoft's current president, David Litwack, will report to Dave Peterschmidt, Sybase's chief operating officer. Meanwhile, Powersoft's chief executive officer, Mitchell Kertzman, will report to Mark Hoffman, Sybase's chairman of the board.

The deal has its critics. "I hope we will be able to continue doing business with Sybase," says Anu Shukla, vice president of worldwide marketing for the Uniface division of Compuware. Uniface markets the Uniface development environment and 4GL. Among the RDBMSs that Uniface supports is Sybase. "I know of no reason why we can't," says Shukla. "But will Powersoft be able to continue to work as well with Oracle? That I don't know."

Uniface and other tool vendors have always competed with Powersoft, but now they face a situation in which Powersoft has the advantages of Sybase's backing and blessing. Shukla, however, says that in the long run, this could cause trouble for Powersoft. Her own company doesn't compete with any of the RDBMS vendors, and therefore is regarded as a valuable ally by all of them. "I think that means we have better access to their technology," Shukla says.

That isn't true now for Powersoft. "If you look at history, there is no database vendor who can provide tools for another database vendor's product."

On the other hand, Powersoft may not need to care whether it alienates other RDBMS vendors. According to market research firm The Meta Group, the company has nearly 40% of the market for client/server tools in its class.

Solbourne's Strict Structure

Solbourne Computer Inc., in Longmont, CO, has completed its restructuring plan. Solbourne is known to the Sun community as one of the first vendors of non-Sun SPARC-based systems. In fact, the company had multiprocessing SPARC-based servers long before Sun itself.

However, the once-promising company ran into hard times. An attempt to enter the workstation market proved unsatisfactory, and Sun itself introduced multiprocessor systems. By 1994, the situation had become so dire that Solbourne abandoned its own line of hardware and became a reseller of Sun hardware.

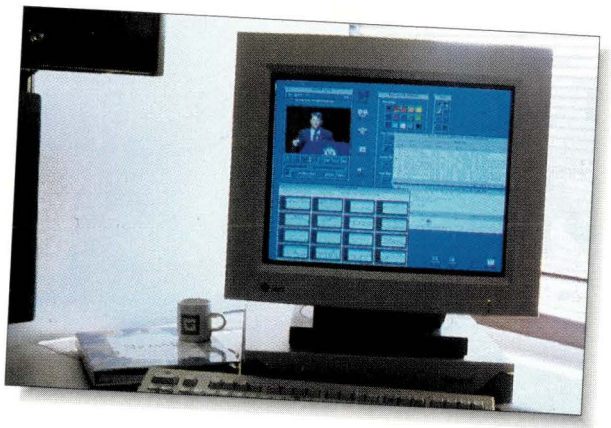
The new Solbourne will also have a new president. The role of CEO had been Carl Herrmann's, but it will now be filled by Walter Pounds, the company's former chief financial officer.

Meanwhile, Solbourne will sell Sun systems running Oracle Corp.'s Financials applications and describe itself as a "consulting services company."

ShowMe TV

Multimedia strikes again. This time, Sun Microsystems Computer Corp. brings video broadcasting to the desktop, with software named ShowMe TV. Jon Haas, networked digital media products manager at SMCC, explains why there's a need for ShowMe TV in the business world. "In the financial services industry, for example," Haas says, "traders need time-critical information so they can make effective trade recommendations. With ShowMe TV, individuals can monitor news shows or other live broadcasts that might affect their business decisions."

Designed for Sun SPARC computers running Solaris and standard TCP/IP networks, ShowMe TV consists of two primary components. The



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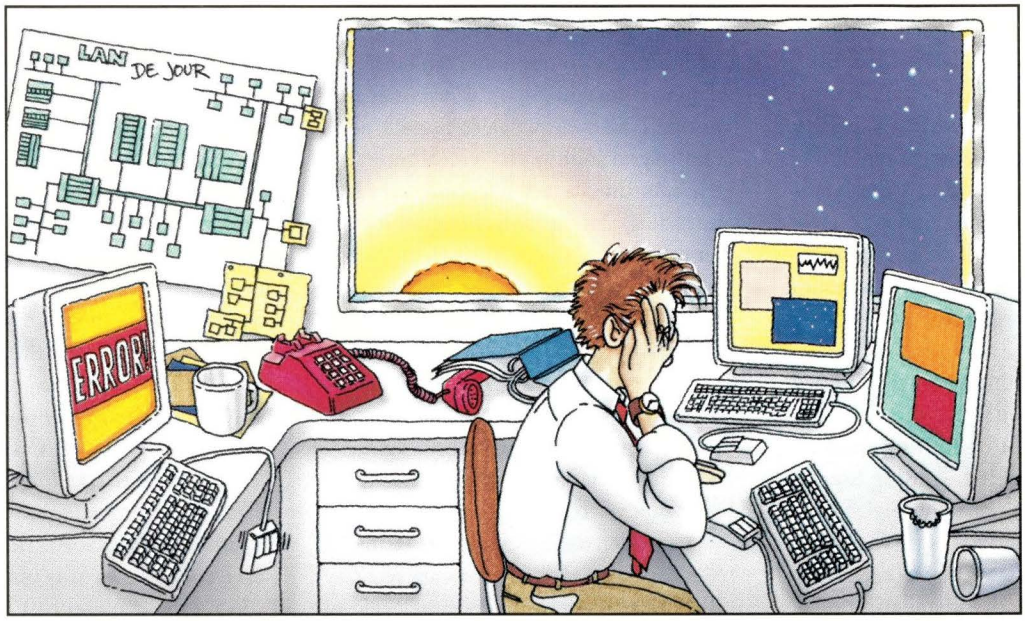

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ShowMe TV Receiver allows the user to display, control and record program material that is broadcast over the existing local-area network. The recorded program is stored on local or remote disks for archiving or editing.

The second component, the ShowMe TV Transmitter, broadcasts video and audio source material over the network to any workstation running Solaris and ShowMe TV Receiver software. Multiple video and audio channels can be broadcast simultaneously to everyone on a network or to individuals. A broadcast scheduler is used to enter program and scheduling information in a Net-accessible program guide.

Efficient compression techniques are used to broadcast over the existing network without disrupting its normal data flow or use. Adding users to an existing broadcast channel does not affect the network's performance.

Any SPARCstation can receive broadcasts with the installation of ShowMe TV Receiver software, or can become a broadcast node by adding a SunVideo board, ShowMe TV Transmitter Software and a video source such as a VCR, camera or tuner. The Transmitter requires Solaris 2.3, while the receiver works on both Solaris 2.2 or later versions and Solaris 1.x.

Licenses for ShowMe TV Receivers start at $100 per user, for 100 users. Transmitter licenses are priced based on configuration.–*mm*

Turnkey Multimedia Solution

Siemens Nixdorf Information Systems Inc., based in Burlington, MA, has formed a global alliance to deliver end-to-end multimedia network solutions for service providers. Siemens will bring key products and technologies to the alliance from its Public Networks Group. Other alliance partners include Scientific-Atlanta Inc., a leading supplier of broadband products and expertise, and Sun Microsystems Inc. as networking and server provider.

The alliance, called IMMXpress, will be a global turnkey offering. The IMMXpress network strategy will deliver a complete multimedia network with Siemens as the systems integrator.

The alliance says modularity will be IMMXpress' secret for success. Network providers with legacy systems or other existing equipment can select the IMMXpress components that best suit their network evolution plans, while protecting their initial investments. In addition, the components can be deployed incrementally as revenues are justified. Siemens will also provide an end-to-end solution for video, interactive multimedia and telephony service, including a full systems integration series.–*mm*

'Speech Recognition Coming Right Up'

If Sun is to play a role in multimedia and cable television, it will need to keep up with those technologies, which are changing almost as rapidly as computer technology.

Consider voice recognition. Time Warner Cable recently announced that BBN Hark Systems has been selected to design a system to integrate speech recognition into the Full Service Network (FSN). The Full Service Network is a prototype being developed by Time Warner Cable for future interactive cable services, and will provide home shopping, video-on-demand and interactive games. The Orlando project already involves companies such as Scientific-Atlanta Inc., Silicon Graphics Inc. and AT&T.

BBN Hark will begin work on the development of a detailed plan for speech integration and the demonstration of a number of speech-enabled applications. "Speech recognition is a natural choice as an interface because it provides customers with an intuitive nonthreatening means of interacting with a multimedia environment," says James Chiddix, Time Warner Cable's senior vice president of engineering and technology.

FSN's field trial will involve 4,000 customers and will eventually be offered to Time Warner Cable's full 7.3 million customer base. The Orlando FSN will be deployed prior to the introduction of speech recognition. However, upon completion of the rollout, speech interfaces will be test-marketed in a number of households.–*mm*

This Just In...

• A new computer company, ***Maple Computer Systems Inc.***, in St. John's, Newfoundland, Canada, is looking to pick up some disaffected workstation customers. The firm, which builds NT PCs running on Pentium or MIPS processors, believes there is money to be made in providing systems integration and close support for technical users.

• Sun Microsystems Computer Corp. scored a standards win in November when ***IBM*** and ***Apple Computer Inc.*** endorsed the company's OpenBoot specification. OpenBoot is a specification for firmware that controls the system boot operation. Apple and IBM have announced their intention to use OpenBoot in PowerPC systems.

• ***Auspex Systems Inc.***, in Santa Clara, CA, has been granted a patent on aspects of its Network File System services. The patent is number 5,355,453, "Parallel I/O NetworkFile Server Architecture."

• ***Cray Research Inc.***, in Eagan, MN, has announced a joint effort with ***Informix Software Inc.***, in Menlo Park, CA, to develop the technologies necessary to support very large databases on such systems as the Cray Superserver 6400.

• ***Object/FX Corp.*** has been formed in St. Paul, MN. The company will develop object-oriented technology for geographic visualization.

• ***Sense8 Corp.***, in Sausalito, CA, a vendor of virtual reality software, has teamed up with ***MicroFocus***, in Palo Alto, CA, to develop a version of Sense8's core product, WorldToolKit, tailored for the MicroFocus COBOL compiler. The two companies think that virtual reality has a place in business settings for such applications as stock market analysis, training and design.

• ***Software Development '95 West***, in a shift of focus, will target UNIX developers. According to Miller-Freeman Inc., the show's sponsor, Sun, DEC, IBM and Novell will be featured in the CDE Pavilion, sponsored by the OSF. The show will be held Feb. 14-16 at the Moscone Center in San Francisco. ⊸

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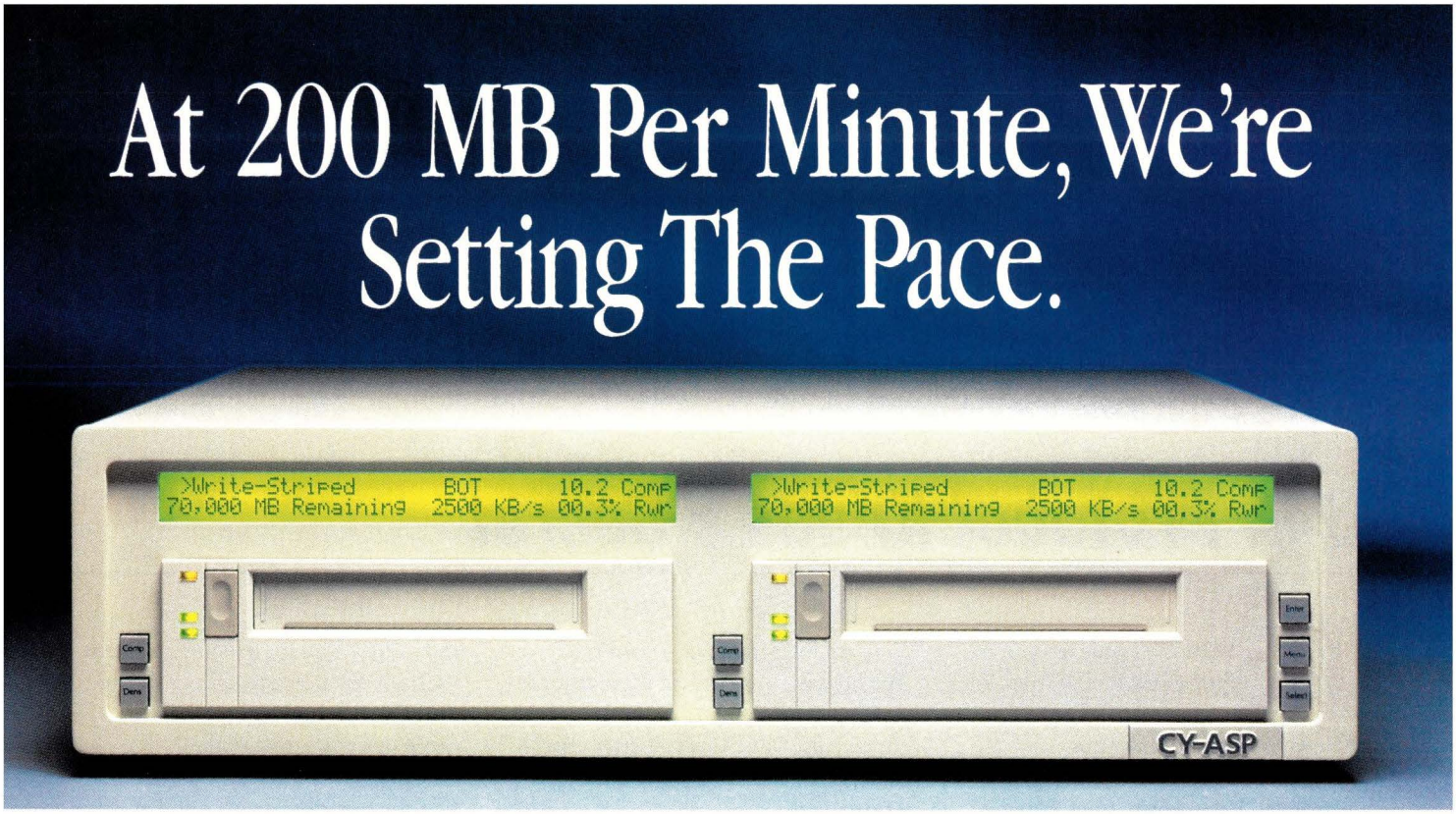

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by MICHAEL O'BRIEN

"Who dat say who dat?"
–Anon.

"Quo Vadis?"
–Someone a long time ago,
with the same problem

"Whatever you do will be insignificant, but it is very important that you do it."
–Mahatma Gandhi

Mr. Protocol Keeps a Secret

Q: I think it's time for you to find a new line of work, old mangel-wurtzel old thing. How far do you think your professional reputation is going to carry you when you're stuck playing translator and hack for a guy who sneaks around the house all day wearing a Halloween mask?

A: Pay no attention to the man behind the curtain. You wouldn't be able to understand him anyway. You're merely suffering from the effects of watching a man whose on-line and off-line lives are virtually indistinguishable, which should come as no surprise, seeing as how the man's entire existence is virtual to begin with. I will admit, however, that if he doesn't quit playing the Mole Man Music track from the Sam & Max CD-ROM on infinite repeat, I'm going to sentence him to a term of hard labor in a locked IRC channel. He just thinks it's music for sneaking by. A pox on him.

Mr. Protocol's main problem seems to be that it has only taken him about 25 years on-line to discover that there are people on the Net who don't think exactly the same way he does. I can only attribute this to a massive lack of concern on his part, since it's a mystery to me how anyone else can even begin to comprehend how Mr. P. thinks. Personally, I think he's a better candidate to see a xenobiologist than a psychoanalyst.

Be that as it may, Mr. P. received a considerable shock when someone on the Net told him they didn't particularly like him. Now, to Mr. Protocol, data security and personal security are the same thing. `/bin/rm` holds the same terrors for Mr. P. that a loaded Uzi does for us. The entire notion of Unpleasant People on the Net, therefore, threw him for a loop so severe it took a week and several cases of Big Stuf Ding-Dongs before he'd even come out of the bedroom.

Mr. Protocol has always believed that the best defense is a good attack of blind panic. Once that was over with, he settled down and began to do some research on his options. They were limited.

One, he could leave the Net. As a solution, this might seem extreme to us. To Mr. Protocol, it's equivalent to searching out The Jackal and calling him a doo-doo head. It's an option that precludes all other options.

Two, he could keep a low profile. Being as how his Net profile is his only profile, this amounts to rearranging his personal profile with a table saw. Also unattractive, also messy.

Three, he could enter a psychosis so severe as to be unaware of any unpleasant repercussions. He actually tried this one. In fact, he tries it about twice a month. Unfortunately, like everything else about him, his psychosis is virtual. Eventually he forgets about it and it goes away, usually at an unpleasant moment, like at the family gathering when he was talking quite

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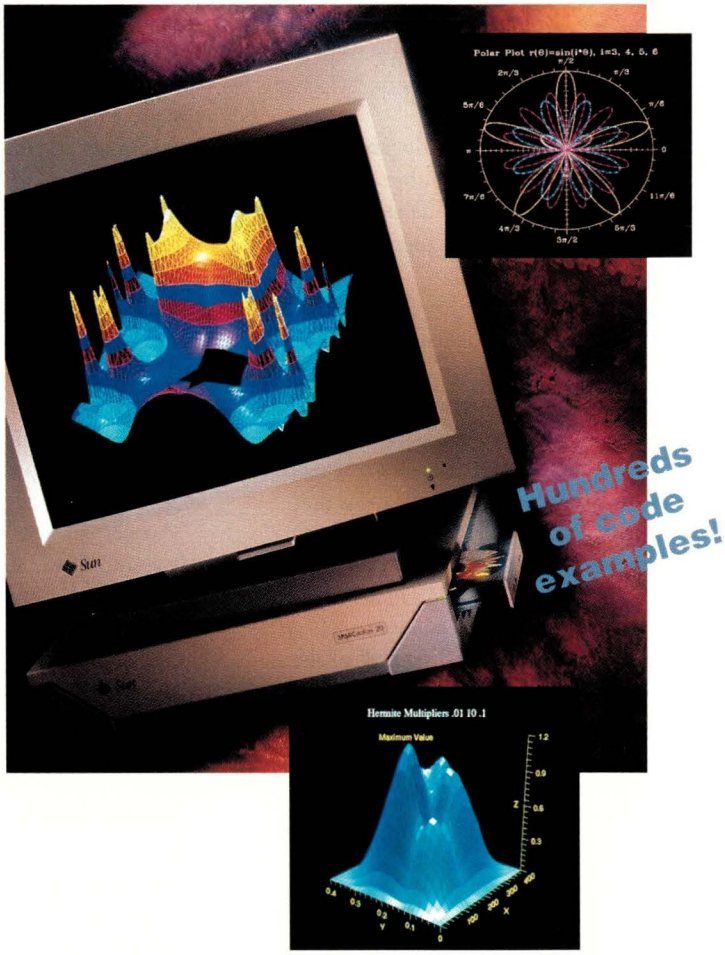

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pleasantly to Aunt Martha, whom just last week he'd called a...well, never mind, but it wasn't pleasant, and when he suddenly woke up and realized who he was talking to, it would have been really unpleasant, except that she never understands a word he says anyway. There are blessings in obscurity.

Four, he could make use of Net services that ensure protection of both one's person and one's data. Let's consider those.

On the Net, the only part of our person at risk is our public identity: who we are, our friends and our reputations. Any or all of these can come under serious attack.

We grow up and become socialized through face-to-face interactions. Current thinking is that certain elements of these interactions–the human face, for example–are wired into our brains. Certainly, there is a huge set of nonverbal checks and balances that operate when we talk to another person–from an impersonal transaction at the bank, to a mugging in an alley, to the chemistry between lovers. All of these cues, and I do mean all of them, are missing in an on-line interaction. Only text exists. Even the most basic of nonverbal cues exist only as "smiley faces," which serve to suppress the serious interpretation of nonserious text.

This is at once liberating and extremely dangerous. It is liberating because those whose socialization has served only to silence their voices can finally communicate freely, without the self-suppression that cripples them in "outside" society–and there are a lot of these people, far more than one would think. It is merely that in the ordinary world, we never hear from them.

However, it is also dangerous because the suppression of face-to-face society works both ways. It serves to suppress aggression. In on-line society, people behave in a way that would be thought either neurotic or psychotic at a cocktail party. Slight disagreements, instead of being passed off, escalate instantly into raging ad hominem screaming matches. People who are prepared for this can pass it off with effort, but those without innately strong personalities, strong interpersonal skills or both, can quickly come to feel that they're in a meat-grinder. The amount of sheer personal upset and agony that can arise from even the most elementary on-line disagreement is, or should be, truly terrifying. This is a problem that is still in its infancy. Mr. Protocol sadly believes that as on-line interactions become more common, we'll be seeing an upsurge in emotional problems caused by on-line disagreements.

Beyond the circle of our own personalities, we have our reputations. Outright slander and libel play the same role on-line as they do in face-to-face society, with the proviso that on-line slander and libel are far more common due to the previously noted lack of restraint.

A more serious problem is that of forgery. We'll consider two forms of forgery: Usenet postings and electronic mail.

Forgeries of both sorts are trifling to produce if the security of one's account has been compromised. Basically, if someone else gets hold of your account, your entire on-line life is toast. For all intents and purposes, the interloper is you. They have your files, they can produce mail and postings that are indistinguishable from your own. They own you. You don't want this.

The best advice for prevention is the same as it has always been: Don't do dumb stuff. Don't give your password to your secretary. Don't write down your password. Don't hire an idiot to be your systems administrator. Don't hire the systems guy in *Jurassic Park*. And for god's sake don't give the password to your MUD character to a friend for the weekend. Boy howdy, was that one an unholy mess. You don't want to know what unbelievable schmucks your beer buddies really are–trust me on this one.

Usenet forgeries can come about because Usenet, at base, has no authentication. In fact, the number of misfeatures in Usenet's architecture would be startling in any commercially designed system. Usenet, of course, started in academia and just sort of grew up. Consequently, Usenet articles can be created to look like anything from anybody, and then injected into the stream of news wherever they'll fit.

The only ineradicable feature of a Usenet article is the `Path:` component, which is incrementally constructed by every system through which the message passes. Forgeries are created with previously existing `Path:` components, of course, misdirecting the reader as to the system of origin. The point of injection will always appear, however, along with all other systems the article passes through after that. Often, this is enough to identify the true point of injection. The point of injection, however, may have nothing to do with the true originator of the message, who may indeed merely have fooled some other system's Internet NNTP server into accepting the message.

In general, however, the perpetrator will not be able to construct a `Path:` component identical to that of a message really originated by you. Although the perpetrator can create quite a ruckus until the forgeries are detected, you will generally be able to point out to your readers what to watch for in the `Path:` line.

Mail forgery is a much more serious business but is even harder to carry off. It is painfully easy to lie to an SMTP server. Even the headers in your message come from whatever the SMTP server was told: They're included in the text of the message, not the SMTP "envelope," which in any case can be forged along with the rest.

Except for one thing. And what is that? Mr. Protocol is glad you asked.

SMTP mail is passed by Internet connection. That means that the SMTP server can determine the Internet IP address of the system from which it is receiving mail. The server will add that information to a mail message as a `Received-From:` header component. Because mail servers are complicated beasties these days, one often has more of these components in a mail header than anything else. The most recent header will have been put there by your own mail system, and indicates who the mailer really got the message from. Impersonation of an IP

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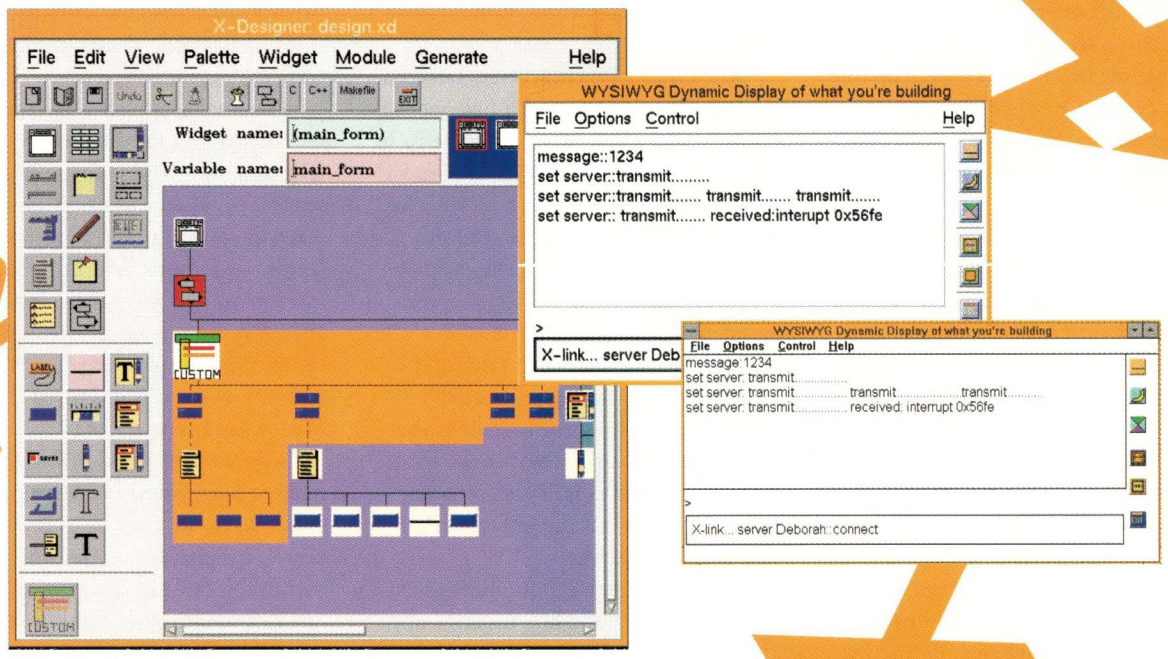

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address is possible, if difficult, on a local net, but unless the impostor is on the same physical net as the person he is impersonating, he will also have to fiddle with routers along the way to make two-way communication possible with your own system. This is a difficult business.

Today, for most interactions on the Net, there is security in obscurity. Most people live lives so unremarkable that they never need worry about impersonation. For those whose messages carry more weight, there are weightier remedies.

The easiest current remedy, at least for those inside the United States, is the digital signature. This is a scheme whereby the mail, or the article, is signed in such a way that the originator of the message can be known with a high degree of confidence, as can the integrity of the signed message. The most common form of digital signature uses public-key cryptography.

Cryptography is more closely related to mathematics than most other areas of computer science. Public-key cryptography, in particular, depends on the fact that it is very difficult to find the prime factors of a sufficiently large number. This leads to the creation of a form of cryptography where two keys may be used instead of the normal one key. A public key, which is widely known, may be used to encrypt a message. The corresponding private key is the only one that may be used to decrypt it. Digital signatures are carried out by first calculating a hash function of the message to be signed. This function is sufficiently broad that any change in the message will cause a change in the calculated hash. This hash is then encrypted using the originator's private key, and the resultant ciphertext is placed at the bottom of the message.

A recipient who wishes to determine the authenticity of the message (or Usenet article) need only take the purported originator's public key and use it to decrypt the signature block. The resultant hash is then compared with the hash calculated by the recipient. Since only the true originator has access to the secret key, and only the secret key could have produced the text decrypted by the public key, a matching hash guarantees that the message was indeed produced by the originator. In this way, both Usenet articles and private mail can be authenticated, without depending upon any characteristics of the transport service.

Mr. Protocol is completely satisfied with this argument, which just goes to show what an unrealistic poop he is. In the real world, there remains the most pressing of all cryptographic problems: key dissemination. The originator's public key must arrive to the recipient in a way guaranteed not to have been tampered with or substituted. Ultimately, the best way of doing this is to talk to the originator over the phone, establish that this really is the person you thought it was, read his public key back to him and verify its correctness. This is the only ironclad guarantee you have.

The final attack mountable against an individual on the Net involves not the individual, nor his reputation, but his data. These days, real data security means encryption, and strong encryption at that. Mr. Protocol has already given his views on the usefulness of the U.S. government's proposed solution, in the form of the Skipjack algorithm. (In case you missed them, they aren't favorable.) Technically, Skipjack promises to be a strong algorithm; politically, it's a disaster.

The best readily available encryption is PGP, which stands for Pretty Good Privacy. This is not a military-grade cipher, but it promises to be reasonably strong against any credible attack mounted by civilians. It uses public key encryption, and may be used not only for encryption, but for digital signatures. Inside the United States, it is available for non-commercial use from the public FTP archive at `mit-dist.mit.edu`. People outside the United States are, as usual, on their own, for the usual reasons.

It should be noted here, by the way, that the exmh mail handler has hooks in it to enable the automatic use of PGP for encrypting and signing messages, as well as decrypting and checking the signatures of incoming messages. exmh is a graphical front end to the MH mail system. It runs under X Windows, and is written using the Tcl/Tk package. Mr. Protocol recommends that those with industrial-strength mail loads, security needs or privacy concerns take a look at it. exmh is available via anonymous ftp from `beta.xerox.com`.

The final group who wish to protect themselves on the Net are those who dare not express themselves fully for fear of repercussions. Many people want to conceal their identities for legitimate reasons. Mr. Protocol does not intend to discuss these individuals at length–no one could possibly fail to recognize that singular personality no matter how he was disguised. Halloween mask, indeed.

In general, though, posting and mailing anonymously is often a high-stakes affair. In the case of cryptography and digital signatures, the trust involved is trust in the algorithm and its implementors. For all but students of cryptography, this must be a blind trust; for any nonpublic code (Skipjack, for example), all trust, even that of cryptographers, must reside in the agency promoting its use.

This is not the case with anonymous posting and mailing, where the service is provided by a remailer, whose actions are obvious: The message headers are stripped of all identifying information and remailed with an anonymous "tag" replacing the original address in the `From:` line. This tag is tied, via a database at the remailer, to the true originator of the message. In all current services of which Mr. Protocol is aware, replies to the anonymous tag are themselves anonymized before being forwarded back to the originator. Anonymity is a two-way street, unless an interactor chooses to identify himself in the body of the message.

A remailer's integrity is, therefore, paramount in ensuring the true anonymity of any users of the service. This being the real world, Mr. P. decided to do some digging and talked with Professor Jeff Elman, chairman of the Cognitive Sciences

department at the University of California at San Diego. Elman runs a remailing service at UCSD. Aside from the personal integrity of the remailer, which will quickly become obvious (be most wary of new services, says Mr. P.), Elman says the greatest danger to the shield of anonymity comes from outside pressure, presumably created by offended readers with enough clout to cause real trouble. Therefore, the usefulness of any anonymous remailer service depends upon the service provider's immunity to external pressures. In a university setting, the two most likely sources of pressure are administration and law enforcement. What this means, Elman says, is that any pressure from a dean will not take the form of a demand that anonymity be broken, but that the service, as too great a generator of headaches, be shut down altogether. The flame of academic freedom may flicker occasionally, but it does still burn.

The problem of law enforcement is finessed in the statement issued to users of the service. The service may not be used to harass others, and it may not be used for illegal activities. Therefore, anyone who causes enough of a nuisance to merit attention from law enforcement will presumably already have violated the terms of the service and forfeited his or her shield of anonymity.

Mr. Protocol feels strongly that while guarantees of privacy and anonymity are not explicitly guaranteed by the U.S. Constitution, the advent of technology represented by the Internet is so invasive that the American system of checks and balances demands that refuge be granted not just to those who need it, but to anyone who desires it. Need is not a precondition for any of our other civil rights, and it should not be a requirement for this one.

Mr. Protocol believes that the use of privacy and of anonymity should be investigated, and essayed, by all. Unexercised rights disappear. New rights are granted by their universal exercise. On the Internet, if you want to be yourself, you should prevent others from doing it for you. ⊸

Mike O'Brien has been noodling around the UNIX world for far too long a time. He knows he started out with UNIX Research Version 5 (not System V, he hastens to point out), but forgets the year. He thinks it was around 1975 or so.

He founded and ran the first nationwide UNIX Users Group Software Distribution Center. He worked at Rand during the glory days of the Rand editor and the MH mail system, helped build CSNET (first at Rand and later at BBN Labs Inc.) and is now at an aerospace research corporation.

Mr. Protocol refuses to divulge his qualifications and may, in fact, have none whatsoever. His email address is `amp@cpg.com`.

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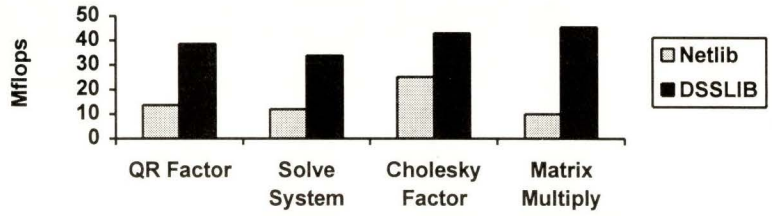

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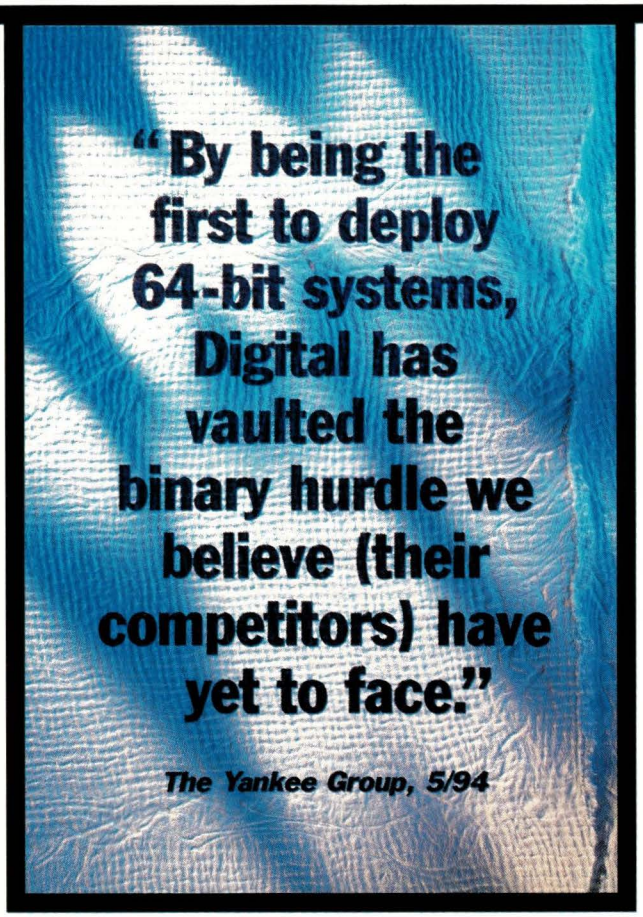

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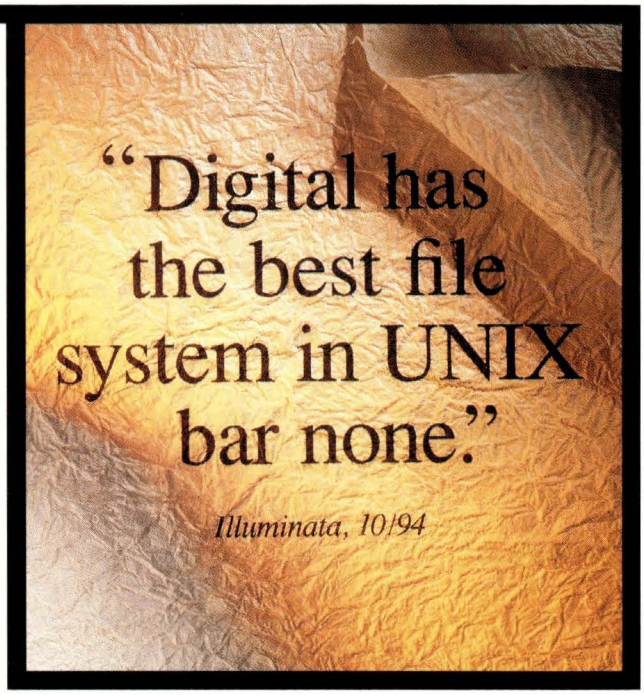

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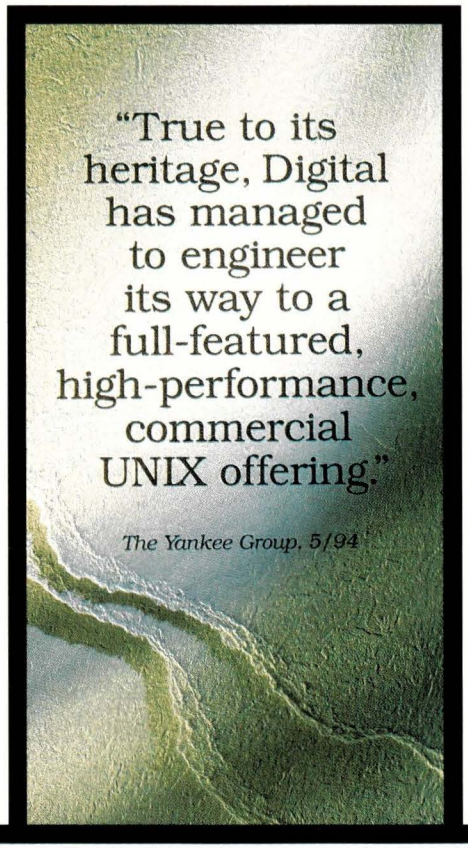

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by PETER COLLINSON, Hillside Systems

X Resources

For good or ill, the X Window System allows considerable user tailoring of its applications. You can change many aspects of your interaction with your system. This approach differs greatly from other commercial windowing systems where the "look and feel" is cast in stone. The designers of X wished to create "mechanism not policy." They wanted to design a way of interacting with a computer system without forcing the use of specific methods.

I guess that this aim started as a self-defense mechanism. X's designers figured that they would get less hate mail from the early academic developers if they did not impose any particular set of actions on the end user. (Like religion, user interfaces are a topic not to be discussed in polite company at meal times.) It certainly allowed experimentation with interfaces that would not have been possible otherwise. Later, when commercial organizations became interested in X, the approach was attractive because a particular vendor could create a visual look that identified its product.

This independence has its downside. Every system using X is not the same; you must learn new keystrokes and perhaps new methods every time you transfer from system to system. The same applications on different systems can work in different ways. What happens when you use the mouse or keyboard is not always immediately predictable.

Some X interactions are hidden from the user. For example, to get the control menus in `xterm`, you hold down the Control key on the keyboard and press one of the mouse buttons. Once learned, this information is not forgotten, but you must read the manual page rather than just using the application. X is riddled with such examples, the fault of application developers and not the designers of X. I notice that commercial offerings like OpenWindows have worked hard at avoiding making hidden keys be a feature of their interfaces.

Most X applications allow some form of user tailoring. You can supply configuration information on the command line or set up the tailoring for "all time" in the resource database (a set of keyword and value pairs that are stored in text files).

You can have a "per application" file, where each application may have its own file used for configuration. You can also store values that affect applications in a private file. You can load values into the X server, so that configuration options that relate to that server on that particular machine can be specified.

A good X application will have been written to obtain most of its configuration information from the database. The key thing here is that if the application insists on a value, then this will take precedence. However, it's usual to export much of the configuration information into a resource file and let the user decide how things should look.

For example, text strings are often exported into resource files so the user can choose the strings they wish to see. This

GREG HALLY

really helps users whose first language is not English to move an application into their own language.

You can change things around in X, but that doesn't mean you should. Some people go overboard with tailoring, and thus the application that they use is very different from the "standard" default settings. I don't mind this too much for output, but caution against doing it too much for input. Over-customizing makes it hard for other people to use your screen and makes it difficult for you to move to a new system without taking your default settings with you.

Widgets

To understand how the resource database is used and specified, you must know a little about how X works. Most X programs are written using a *toolkit*. A toolkit provides the programmer with a set of high-level objects that each provide some functionality on the screen. These may include a scrollbar, a window supporting text editing or a geometry management window that controls the placement of other objects within its screen area. These high-level objects are known as *widgets*.

Widgets are constructed from other widgets through object-oriented programs. Let's look at how we might create a push-button widget, a screen rectangle that contains some text. The user "presses" a "button" by moving the cursor inside the box and clicking with the mouse button. The text will change color to indicate that the button has been pressed. A routine in the application program will be called to handle the semantics of pressing the button.

To make our push-button widget, we can start with the widget that displays a single text line in a box on the screen. This is already quite a complex object. The text to be displayed will be rendered in a particular font and will be displayed in one color, while the background of the rectangle will be in another color. The box may have a border around it, and the width of that border will be controllable. The spacing between the edge of the box and the text is also settable. The rectangle holding the text can be shown with rounded corners or right angles. The box holding the text will behave in a prescribed manner when the window holding it is resized. Perhaps the box will spread to fill the available space; maybe it will stay the same size, with the left-hand side of the box staying in the same relative position. There are many configurable options.

We don't want to have to recode all this functionality when we create our new push button. We make the new widget from an existing one by adding new actions. We specify that our new widget is *derived* from an old one, and it will inherit actions from the original. So when we make our new push-button widget, we only concern ourselves with the new functionality that we require. We will need to add some code that deals with changing the color of the text box when the mouse button is clicked in the window. This means that we must be able to obtain and set the color. We will need to add some code that calls the user's application

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when the button is clicked. This will interface to the standard mechanism that allows the application to register routines that are called during certain events.

Most, but not all, X toolkits are constructed in this manner. The C++ Interviews toolkit, for example, stands on its own, as does the XView toolkit, which supports many applications in your OpenWindows system. However, XView does use the resource database to derive variable values and fits in with the naming scheme described below.

Other toolkits, like the original set (the Athena widgets) or Motif, build on pieces of code that have been written to perform some action. This building is very formal and ensures that things fit together dynamically. Our new push-button widget might form the basis for someone else's new widget later on.

Part of this formality is a naming scheme for widgets. This naming scheme allows us to direct information into a particular widget from the resource database.

Each widget has an *instance* and a *class* name. The instance name refers to a particular invocation of that widget. For example, we can specify the text that is to be placed in a particular push button in the application. The class name allows us to address all the instances of a particular widget in an application. This can reduce the setup that we need to do; for example, we can make all the push-button widgets have a red background by using the class name.

Specifying Resources

When an X application runs, it is composed of a hierarchy of widgets. Widgets contain other widgets–an application is a tree structure of widgets. The tree structure mirrors the appearance of the application. When basic elements are grouped together, they are contained in a widget that manages their placement on the screen. The basic widgets are the leaves of the tree; the management widget is one "level" below them. In turn, these groupings may be contained within other widgets, creating larger screen areas. The geometry management widgets are an important part of X. They permit combinations of widgets to be controlled, building up complex screen areas.

At each level in the tree, each widget will have an instance name and so can be uniquely addressed. The tree is addressed like the UNIX file system, with a string like a pathname except that the period character is used as a separator, so

```
hello.push.label: Hello world
```

will set the string "Hello world" in the label resource of the widget called `push`, which we assume is some form of push-button. I've called the value of the label a *resource* because these lines are part of the resource database, and each line has an address and a value.

The `push` widget is running in an application called `hello`. We can set other attributes of the `push` widget

```
hello.push.foreground: red
hello.push.background: white
```

which sets the background and foreground colors.

When we don't know the names of the intermediate levels in the trees of widgets or we simply don't want to have to type them, there is a wildcard using the star character:

```
hello*foreground: red
hello*background: white
```

This sets the colors on all the widgets in the `hello` application that recognize `foreground` and `background` as resources.

Another alternative is to use the widget's class name to set values. You can set the color of all the push buttons in an application (using the Athena widget set) by:

```
hello*Command.foreground: red
```

The `Command` string is the class name for the button widget from the Athena set. We do need to know the class name of the object that we are trying to set, and this may not be easily available to us. It's hard to get a class name from a binary; we need the person who wrote the manual page to be sure to tell us.

In fact, resources have class names too, and saying something like

```
hello*Foreground: pink
```

will set all the `Foreground` resources to pink. The class name of the resource is usually the same as its instance name, but with a capitalized first letter.

By the way, applications also have instance and class names. Their instance name is usually the name of the program, which on UNIX is name of the file that contains the binary for the program. The class name is set by the programmer in the program when the toolkit is initialized.

You can see that the right-hand side of the resource/value pair is a text string, for example `red` or `Hello World`. Other text strings are possible, like `true` for Boolean values or a string that specifies a particular font. The resource manager provides a number of "converters" that recognize the string on the right-hand side and translate it into a value that is used internally by the widget code. This is a numeric value giving the color value to a color; for text, this will be a pointer to a stored text string.

This conversion happens automatically. Sometimes you will get an error message that says something like, "I haven't got a converter for that." This usually means that you have entered something incorrectly.

Resources are not limited to describing widgets and can also be used to supply parameters to the application. We had an example of this in my article about HTML (see "HyperText Markup Language," *SunExpert*, October 1994, Page 28), where we gave the Mosaic application a new default home page:

```
Mosaic.homeDocument: http:// etc...
```

Mosaic has other arguments. For example

```
Mosaic.confirmExit: False
```

inhibits that annoying dialog box that asks if you really want to exit Mosaic.

Using the resource database to contain program settings allows a particular application to be tailored to make it always behave differently from the standard release. It avoids having to specify arguments on the command line and makes it easier to launch the application from a menu.

Setting Resources

Well, we've seen how to specify resources, let's look at where we do that. The first step, a seemingly retrograde one, is to realize that most commands allow you to specify some resource settings from command line options. X provides a standard set of program options that interface directly to the toolkit, setting colors or sizes, for example.

```
xterm -bg black -fg white -name rlogin
```

sets the background color to black, the foreground color to white and also sets the application instance name to `rlogin`. This allows us to have different instances of the `xterm` terminal emulator that have different names. A full list of the options appears on the X11 manual page. The command is:

```
% man X11
```

There is also one "catchall" program option that allows you to set resources directly: the `-xrm` option. This option is followed by a resource specification, like the ones described above. For example:

```
xclock -xrm '*foreground:blue'
```

will set the the application's foreground color to blue. It's a good idea to use single quotes around the argument to prevent the shell from messing with the star. You can use this technique to check the resource settings that you are going to put in a file. I generally put the name of the application in the resource:

```
'xclock*foreground:blue'
```

because that's what I am going to put in my resource file. Also, you will find that some programs have their application class name in their default setup file, which we need to override by giving an application instance name.

A problem with setting resources is that things often don't work as you would expect and give you no hint why nothing seems to be changing when you supply the `-xrm` option. The application is probably not "broken." You are doing something, just not the right something. Sadly, we've all been there.

Resource settings can be taken from a number of different files. Normally, the resources are loaded from a file into

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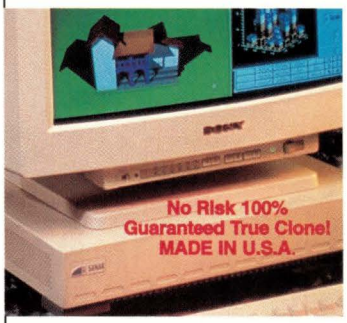

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the server. This way, they are available to all applications using your display, irrespective of where they are running. X has the notion of "window properties," where you can store data along with any window on the screen.

All applications can see that the *root* window and resource data is stored in two of its variables called SCREEN_RESOURCES and RESOURCE_MANAGER. The SCREEN_RESOURCES property is assumed to contain resources that are specific to a given screen. RESOURCE_MANAGER contains other general properties. This is true if you are running the X11R5 server. For OpenWindows, only the RESOURCE_MANAGER string seems to be defined.

You can see the contents of all the stored variables by typing:

```
% xprop -root
```

Loading the server is done using the xrdb program, generally in the X start-up sequence. I use

```
% xrdb -load $HOME/.Xdefaults
```

where the argument file contains my private settings. This call is made for you from a standard setup file if you are using vanilla OpenWindows.

The source file .Xdefaults is passed into the C pre-processor with some definitions about the display environment already made. For example, the variable COLOR is defined for a color rather than a monochrome display. The size of the display in pixels is given by the WIDTH and HEIGHT definitions. The display's resolution is given by the X_RESOLUTION variable. See the manual page for xrdb for other definitions.

You can use these variables to set different defaults for different screens:

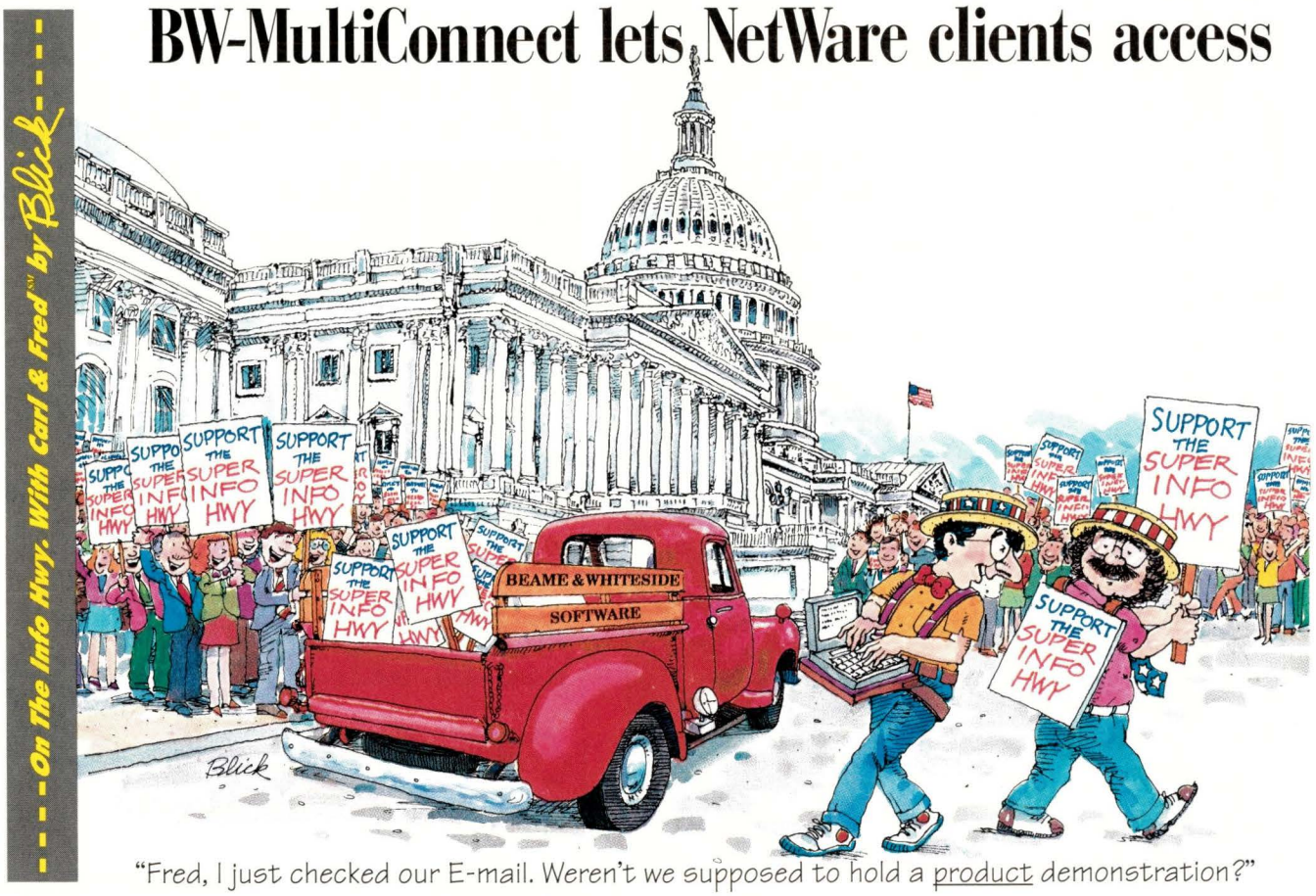
```
#ifdef COLOR
    stuff for color
    screens
#else
    stuff for mono-
    chrome screens
#endif
```

You can also use the C pre-processors' numeric ability to do tests on the resolution definition:

```
#if X_RESOLUTION > 3600
..
#endif
```

It's useful to know that a comment in the .Xdefaults file is introduced by an exclamation mark at the start of the line.

The xrdb program has several other arguments. For example, you can add definitions using the -merge option. I rarely bother; I have a shell alias that loads the database, and that's it.



It's also possible to have an application-specific resource file. This file contains the system defaults for the settings of a class of applications and is usually set up when the application is installed. If you are putting up a new application and it isn't behaving as promised, the problem is often that you haven't installed the resource file.

The name of the file is the application class name. It is usually to be found in a directory called `app-defaults` stored in the X library directory. The class name for the `xterm` program is `XTerm`, so on my Sun system, the toolkit looks for the file `XTerm` in `$OPENWIN/lib/app-defaults`. Perusing the class file is a good source of inspiration for what is tailorable in an application.

You can also specify your own private application class file. The toolkit code in the application will look for a file called by the class name that is stored on your home directory. The application will look for your private files before loading them from the system.

Setting the shell variable `$XAPPLRESDIR` will allow you to move the files from your home directory to some other place. This avoids littering your home directory with visible setup files.

Finally, there is a set of files that permits you to set up values specific to a machine. The idea is to permit you to make settings that depend on the machine running an application, not the server displaying the windows for the application. You can use this to color-code your windows, so that windows from different machines are different colors.

There are a couple of options to set this up. First, the application looks for the `XENVIRONMENT` variable. If the variable is defined, it is interpreted as a path name to a file. The application looks for the file `$HOME/.Xdefaults-` *hostname* if `XENVIRONMENT` is not defined.

I have already described the files in the order that an application scans them. First, it looks in the resource database, then the application resource file, then any of your private files.

Further Reading

For a good overall view on X, X applications and programming, get *The Joy of X*, by Niall Mansfield, published by Addison-Wesley Publishing Co., ISBN 0-201-56512-9. Niall's other book on X is *The X Window System: A User's Guide*. It's also published by Addison-Wesley, ISBN 0-201-51341-2.

The X programming bibles are the series of books on X from O'Reilly and Associates Inc. These are several volumes that are either written or edited by Adrian Nye. ⊸

Peter Collinson runs his own UNIX consultancy, dedicated to earning enough money to allow him to pursue his own interests: doing whatever, whenever, wherever... He writes, teaches, consults and programs using SunOS running on a SPARCstation 2. Email: `pc@cpg.com`. WWW: `http://www.hillside.co.uk/`.

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by RICHARD MORIN, Technical Editor

Grow, Little GROW Worm...

Every so often, I have the privilege of hearing inspired technologists talk about where things are–or at least should be–going. Their predictions aren't always accurate, but they tend to be thought-provoking.

Several years ago, Bill Joy gave a talk about language futures. He said, in essence, that life is too short to spend programming in compiled languages like C. Most tasks aren't all that time-critical, and machines get faster all the time. Use C for problems that need real speed, but code the remainder in languages that are better suited to the task(s) at hand.

The popularity of languages like awk, Emacs, Lisp, Perl and Tcl/Tk indicates that Joy's opinion has become widespread in UNIX circles. The explosive growth of Visual BASIC in the Windows community tells me that this isn't an isolated phenomenon. C isn't dead, or even dying, but it is no longer considered the only serious programming language for application development.

Unfortunately, the competition is badly fragmented; no single interpreted language has achieved any kind of dominance across the entire range of modern computer systems. This severely limits the market for any given program and hampers the free exchange of programming techniques.

David Rosenthal has also talked about the "strong" and "weak" models of window systems. He has said that the "strong" model assumes that programs can and should know all necessary details about the display server. The advantage of the strong model is that programs can take very good advantage of the server's capabilities.

ROBIN JAREAUX

The "strong" model's disadvantage, unfortunately, is that a given programmer is unlikely to have all possible servers on hand during development and/or testing. More to the point, the programmer may not want to spend the time needed to tune the program to every possible server. So the program remains unoptimized at best, and broken at worst, on most of the servers it will encounter.

Worse, in my opinion, is the fact that the limitations of the "strong" model encourage a mode of programming that caters to the lowest common denominator. If you can't depend on servers having a particular feature, don't use it. This facilitates portability, but only at great cost to freedom and flexibility.

The "weak" model, in contrast, demands very little specific knowledge about the nature of the server. It glosses over this lack by assuming that the server can be trusted to make appropriate mappings from requested to available features. This also, incidentally, allows the user to exert some control over the appearance and/or interface of the program. (What a concept!)

Most window system programmers

will recognize that the "strong" model is exemplified by the X Window System. Despite the advent of extensions like Display PostScript, many X applications are all too eager to define the user's experience down to the last pixel.

Students of lost causes will recognize Sun's abandoned (nay, murdered) NeWS product as a recent example of the "weak" model. NeWS aficionados also speak of the flexibility and power that was lost with NeWS' demise. NeWS programs could, for instance, dynamically accept and execute arbitrary bits of code. A new user interface feature (e.g., pie menus) or communication protocol could be grafted in at runtime, invisibly meshing with the server's code.

The X design has no extension language equivalent to NeWS' extended version of PostScript. Consequently, the protocol can only be enhanced in awkward ways. A single vendor can add features, but there is no guarantee that any other vendor's server will accept them. Formal standards can be developed, but the process takes time and effort. Lacking changes to the protocol, developers are forced to make all changes at the client side of the link–not an ideal environment for experimentation and growth.

GROWth Resumes...

Recently, I had a chance to speak with Tom Lord, of Cygnus Support, a provider of commercial support for free software, about his proposed GROW project. Initially envisioned as an extensible replacement for Mosaic, GROW is actually a portable, multitasking "virtual OS" with built-in support for communications and GUI building.

GROW contains some of the more interesting elements of NeWS and other recent systems. More importantly, it appears to have a chance to gain the sort of real popularity that the systems I mentioned earlier never achieved. Let's look at why.

GROW is designed to be implemented on a wide range of computer systems. It should be possible to run a fully capable GROW session on any system with a bit-mapped screen, regardless of native multitasking or other capabilities. This is crucial, for obvious reasons.

Both NeWS and GROW (and, for that matter, Tk) can import and execute code fragments, but GROW does so in a controlled manner. Imported code can be checked for authenticity, using cryptographic techniques. This tells us who wrote the code and whether we have a clean copy. The code can then be executed within a controlled environment. These techniques greatly reduce the danger of Trojan Horses, even to my paranoid eyes.

GROW offers built-in support for HTTP, HTML and other WWW standards. This is a felicitous spin-off of GROW's initial goal as a replacement for Mosaic, but it could well prove useful in other contexts. There are many networked GUI applications waiting to be written; GROW could well lie at the heart of some of them.

Like NeWS, GROW allows code to

Circle No. 19 on Inquiry Card

be transmitted in a precompiled format. Along with reducing overhead, this offers commercial developers some protection from random snooping of source code.

Extension Languages

NeWS uses PostScript as its extension language. This is a big win from the standpoint of graphics models, but a big loss vis à vis programmer acceptance. Most programmers are not fans of Reverse Polish Notation (RPN), and their reluctance to code in PostScript reflects this.

GROW, in somewhat dubious contrast, uses a variant of Scheme as its extension language. I suspect that there are far more Lisp and Scheme programmers than PostScript programmers, but none of these languages is really "mainstream."

On the other hand, Scheme is an extraordinarily versatile language, and it is nowhere near as baroque as, say, Common Lisp. (For a stunning tour of Scheme's capabilities, see Abelman and Sussman's classic work, *Structure and Interpretation of Computer Programs*, MIT Press, 1985, ISBN 0-262-01077-1.)

And, lest die-hard fans of algebraic languages feel irate, GROW offers a C-like programming language that will be translated into Scheme. Tom promises that this language will have more capability than Perl, with far less syntactic soup ("tastes great/less filling?").

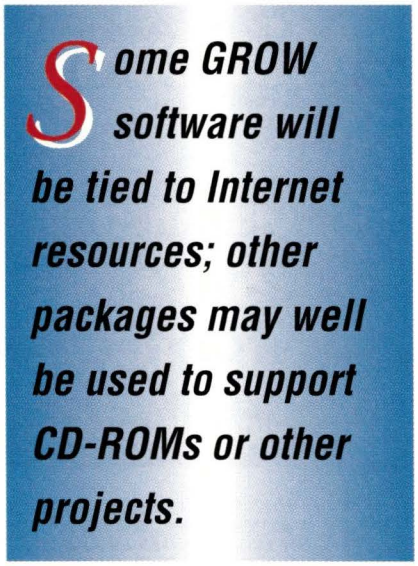
I'll reserve judgment until I've seen the new language in practice, but I'm prepared to believe that a careful language design could accomplish all that Tom says.

Implications

Even the initial goal of GROW is pretty radical–to revolutionize the way the Internet is used. Forget this tedious business of hitting buttons, following links and downloading images, let alone wasting your eyesight on the tired syntax of FTP sessions.

GROW users can receive whole new user interfaces over the wire, supported by custom-tailored protocols and data structures. A GROW application can present any desired appearance to the user, utilizing the network bandwidth to its best advantage. With built-in multitasking, GROW can support background activities, caching and other features that will effectively increase the available bandwidth.

Both commercial and freeware developers can coexist in the GROW community. Tom expects to see both kinds of GROW servers, as well as client software of all descriptions. Some GROW software will be tied to Internet resources; other packages may well be used to support CD-ROMs or other projects. (My own company, for instance, could really use a powerful, portable way of building browsing software.)



In summary, GROW provides a well-defined, open (albeit de facto) standard for building extensible, OS-independent, GUI-based applications. It will leverage off both the mistakes and successes of the last decade, providing flexibility, security, openness *and* commercial opportunities. Obviously, I'm pretty excited about the prospects.

Project Status

GROW is still in the initial planning stages, and there is no guarantee that it will ever come to fruition. For GROW to succeed, Tom will have to marshal help from a plethora of language designers, graphics geeks and other knowledgeable techies.

GROW will also have to interest the commercial side of the Internet with its possibilities of offering a *really* flexible set of protocols. Commercial vendors should also be excited by the possibilities inherent in GROW's design. Furthermore, they should also be relieved to learn that no Copyleft (GPL) is planned for the GROW project. Instead, licensing and distribution are expected to follow the model used by the X Consortium and similar organizations.

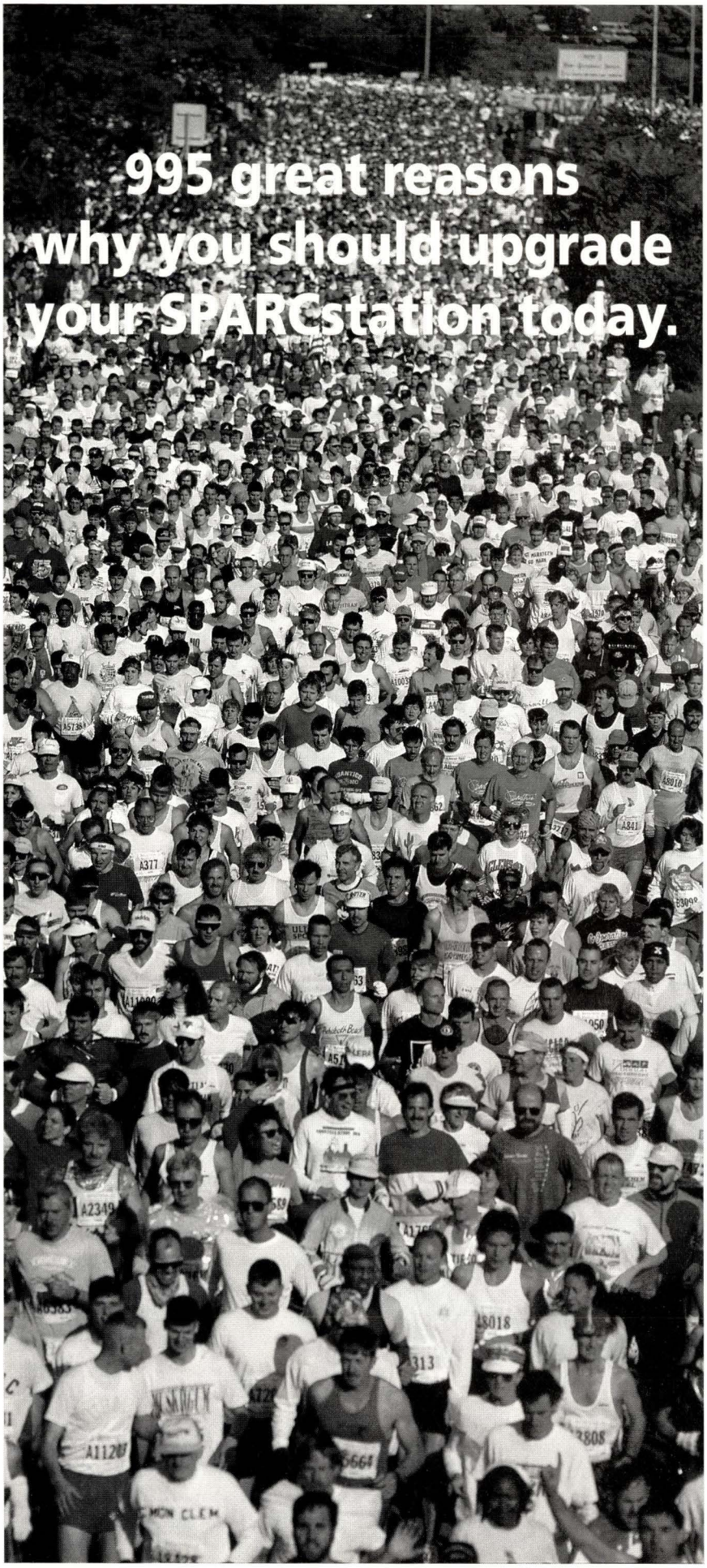
Finally, the GROW project will have to produce solid implementations for MacOS, Windows and assorted flavors of UNIX. Not impossible, but not trivial, either. Fortunately, Tom is not alone.

His company, Cygnus, is well known among GNU users as the official maintainers of several key pieces of GNU software. Cygnus is backing Tom in this project and will provide support from other members of its staff. Other notable freeware authors have also volunteered their efforts.

Various members of the Scheme community are looking on and will act as advisers in the development of the GROW implementation. The Free Software Foundation has already announced its goal of developing a Scheme-based extension language. FSF and Cygnus will work together closely to ensure that GROW is compatible with the FSF base language. In short, GROW has an all-star cast, and its prospects look good.

If GROW can provide the solid, extensible GUI development platform it promises, hackers should leap at the chance to add nifty frobs and twiddles. Commercial vendors, already panting at the prospects offered by Mosaic, should be entranced with the freedom offered by the GROW design. Should be interesting... ⊸

Richard Morin operates Prime Time Freeware (ptf@cfcl.com), which publishes mixed-media (book/CD-ROM) freeware collections. He also consults and writes on UNIX-related topics. He may be reached at Canta Forda Computer Laboratory, P.O. Box 1488, Pacifica, CA 94044 or by email at rdm@cfcl.com..



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Circle No. 31 on Inquiry Card

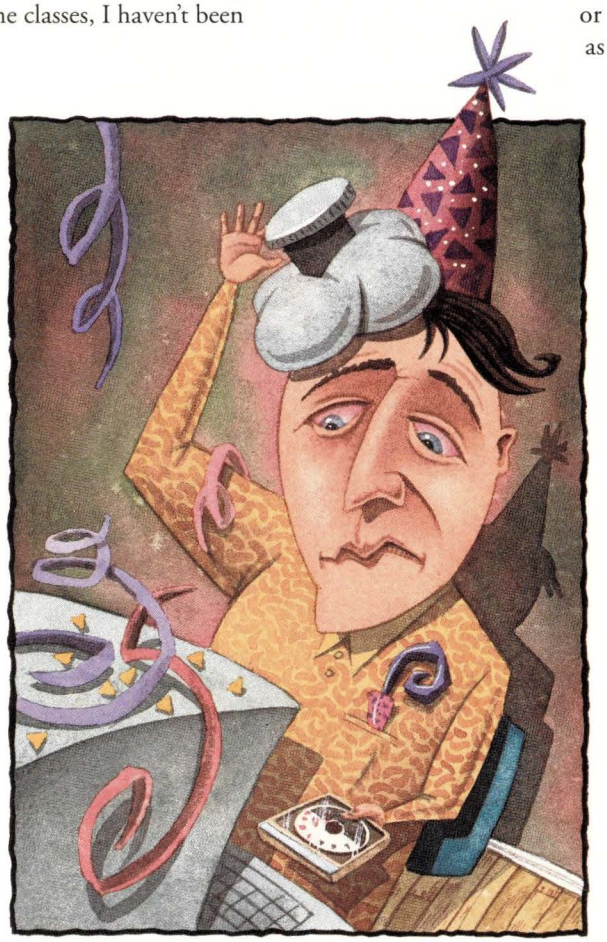
by S. LEE HENRY

Out with the Old, In with Solaris

Happy New Year, all you clever folks out there! I am sure that you, like me, have your good-intentioned new year's resolutions all polished up and ready to guide you through the coming months. One of mine is to pay more attention to Solaris 2.x in my columns. Although I've written a book and taught some classes, I haven't been using Solaris 2.x on a daily basis for a while. And, consequently, I haven't been giving it enough coverage in my columns. This is now all going to change. With many of us beginning to work in the mixed SunOS 4.1.3/-Solaris 2.x world, knowing how to manage this mixed OS environment is becoming ever more important.

To get us off to a good start for 1995, I'm going to talk about introducing Solaris into your environment. If you don't yet have at least one system running Solaris and you have more than a handful of Suns, now's a good time to get started. Solaris 2.4 is considerably more stable and bug-free than its predecessors.

For those of you who are confused by the naming convention here, most of us choose to ignore the fact that Sun elected to give SunOS 4.1.3 the Solaris label. This was undoubtedly a marketing ploy of some kind, but it seems to serve only to confuse newbies to the Sun world when they hear talk about the big "migration" to Solaris. Most of us call Solaris anything based on BSD, SunOS and the SVR4-based versions of SunOS.



RUSS WILLMS

Step by Step

When you usher in your first Solaris server, there are a number of issues that immediately begin to occupy your mind. One of these is the question of whether you will begin to use NIS+ or simply set up the Solaris system as a client of your existing NIS domain. Another is the training of your users in the differences between the "old" UNIX and the "new" UNIX. And, of course, we cannot overlook the question of what software will need to be recompiled or repurchased for the new operating system.

The best advice that I can give you about introducing your first Solaris 2.x system is to take it slowly. Incorporate Solaris in stages and master each before you move on to the next.

The first step is to install the system and get it up on your network. Installing Solaris is quite easy. The `suninstall` tool provides the familiar options (host name and address, zone, etc.). It also allows you to specify remote mounts during installation–and to test them on the spot. This ensures that the appropriate access has been provided on the hosts exporting the file systems.

Software selection within `suninstall` Solaris 2.x is very different. The introduction of software "packages" provides features you will quickly learn to appreciate. It's extremely useful to be able to deinstall software later or check an

installed package against its original state in order to find files that have changed size or altered permissions.

Try first to set up your Solaris system as an NIS client of your existing domain and to make it a master of its own NIS+ domain when you have mastered the new environment and when a move to the distributed functionality of NIS+ will benefit your organization. Solaris 2.x systems work fine as NIS clients but cannot run as NIS masters. Setup of NIS+ is considerably easier than when Solaris was first introduced. Several powerful scripts now replace the many commands that used to be required to configure and populate the NIS+ tables. NIS+ is certainly more complicated than NIS, but this is a direct result of its being more functional and engineered for better performance.

File Systems: Coming and Going

Once your Solaris system is up and running, try exporting file systems. The commands and files for exporting file systems in Solaris are different than, but very similar to, SunOS. The `/etc/fstab` file has been changed to `/etc/dfs/dfstab` and has a column for determining whether or not to mount the file system on reboot. This is very handy for file systems you want to mount occasionally without having to use the full mount command, including source and mount point. The `shareall` command is like `exportfs -a` and the `mountall` like `mount -a`, but Solaris adds the option of mounting by file system type.

The easiest way to add printers to your new Solaris system is to use admintool's Print Manager. Keep in mind that there is no more `/etc/printcap` file. Print Manager allows you to enter the printer name and the print host and to select the type of printer and whether it is running on a BSD (e.g., SunOS 4.1.3) or System V (e.g., Solaris) host. Print Manager includes a menu of printer types and is, for the most part, much easier than setting up a printcap entry.

NIS+ is certainly more complicated than NIS, but this is a direct result of its being more functional and engineered for better performance.

Don't worry if you only have a terminal on your new server. You can use the (C shell) `setenv DISPLAY sunos_host:0.0` and the `xhost + solaris_host` commands to send the GUI-based tool to another host on your network.

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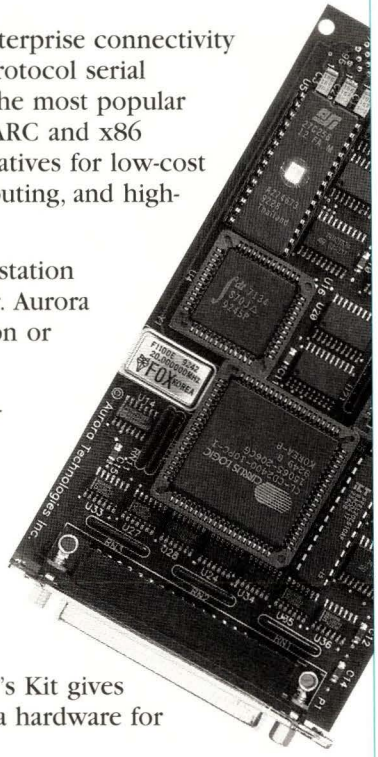

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You should also exercise the automounter. When running NIS, your new Solaris system will access the same maps. Make sure you've shared file systems on the Solaris system and included its hostname in the `/etc/exports` file of your SunOS systems. The automounter should work just as it does on your SunOS hosts.

Setting Users Loose

To fully ring out the changes that are going to impact you before you finish your move to Solaris, consider setting some of your more aggressive users loose on the system as soon as you can. Give them free accounts or lots of disk space, whatever it takes to entice them into giving the new system a workout. Let them know that many familiar commands–like `lpq`, `hostname` and `whoami`–that are replaced or missing in Solaris can be found in the directory `/usr/ucb`. Have them document any problems they run into. Their experiences might be very helpful in deciding how much introduction other users will need to quickly become productive in their new OS.

One problem my users noted right away was that their `.login` files included a now invalid `-n` parameter to `tset` that caused the TERM variable to be set to null. Well, actually they didn't notice this. Rocket scientists though they are, they complained about `vi` not working properly. I needed to track the problem down to their `.login` files.

Why Doesn't This Work?

One thing that I miss already from the old OS is the "fast find" option of the BSD `find` command. This option searches a file containing a "snapshot" of the file system contents (ordinarily re-created each night with an updated `b` command through cron). Fast find greatly reduces the time it takes to find files as well as simplifying the syntax of the `find` command. If there isn't a fast find tool out there in the public domain, I suspect that there will be soon.

Other sites have run into a problem with the two `rsh` commands–one being the remote shell and the other the restricted Bourne shell. The commands are, of course, in different locations–`/usr/bin/rsh` and `/usr/lib/rsh`, respectively. If you run into any problems here, have your users make changes to their PATHs to include the `/usr/bin` before `/usr/lib`.

There will be growing pains in your move to Solaris no matter how slowly and carefully you proceed. But, just like learning UNIX in the first place, you can get used to this new "flavor" in measured doses. ➸

S. Lee Henry is on the board of directors of the Sun User Group and manages computer and networking services for the Physics and Astronomy Department at Johns Hopkins University. Send mail to `slee@cpg.com`.

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Product Reviews	176	177	178
Columns:			
Ask Mr. Protocol–Mr. P. Keeps a Secret	179	180	181
UNIX Basics–X Resources	182	183	184
I/Opener–Grow, Little GROW Worm…	185	186	187
Systems Administration–Out with the Old, In with Solaris	188	189	190

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Circle No. 16 on Inquiry Card

Living in an Object World

by MICHAEL JAY TUCKER, Executive Editor

SunSoft, Sun Microsystems Inc.'s software planet, officially displayed Solaris 2.4 at this past fall's Uniforum. The new version of the operating system includes features designed to support multithreaded and multiprocessor technologies, and object-oriented programming techniques. Also in October 1994, SunSoft introduced its enhanced version of Workshop, its software development environment. It too reflected an awareness of the new world of programming– where object-oriented is the norm, multithreaded is a given and multiprocessor is a must.

The Sun community now understands object-oriented programming's technology. But the cultural issues of adopting OOP are far less understood, and may be even more complex.

Quite simply, the Sun and UNIX communities are adopting these new programming methodologies in a great and fearsome rush. Fortunately, the technology of these innovations is increasingly understood by programmers and their managers.

But what cultural changes must organizations undergo to take advantage of these new technologies? To find out, *SunExpert* contacted three users in transition. The word coming back is that, above all else, the new organization must learn patience and the art of planning ahead.

M. TCHEREVKOFF, THE IMAGE BANK

'The Developers Just Kicked and Screamed'

Nancy A. Lanning is a senior systems analyst at Harris Electronic Systems (HES), in Palm Bay, FL, a division of Harris Corp. "Our little sector supports the whole internal organization of Harris," she explains. "We do accounting, payroll, support–everything."

Less than a year ago, Lanning was a conventional MIS officer. "I came from the mainframe world and then I got thrown in UNIX and Suns," she jokes. "I was working for another [division of Harris] and then came over here. My boss said, 'Well, you're new anyway, let's give you the most controversial assignment we can find.'"

Specifically, HES is beginning a series of transitions that will move it from conventional programming methodologies to more modern ones. Already, it is moving to a client/server architecture, with the Suns as servers and PCs as desktop clients. It is also starting to position itself for object-oriented programming.

As one of the first moves to this end, HES has brought in a configuration management tool for its developers: PCMS from SQL Software Inc., in Vienna, VA. With a CM tool, HES felt it could tell more easily what software was being written, where it was in the process of development and (eventually) if it might be used again. "We just had to have a handle on development," says Lanning. "With CM, it is sort of like putting in process management controls."

This seems like a minor innovation. But Lanning discovered that any change in the development process could be fraught with perils. "Any time you take people who have had no structure and try to put structure into their life, you have problems," she says.

Lanning had already seen this in mainframe MIS, where she'd watched configuration management introduced some time before. "The developers just kicked and screamed," she remembers. Now, she is introducing CM for the UNIX people. "I expect the kicking and screaming to start any time now," she says. "But I'm used to it."

All joking aside, Lanning has developed techniques to facilitate adoption of the new technology. First, she says, she "got the developers involved, totally, from the beginning. They gave me their requirements. Then I explained what I could buy for them."

In other words, the developers had every possible chance to explain what they wanted and to object to what was offered. This has cut back hugely on Monday morning quarterbacking.

What advice would Lanning offer anyone in a similar position? "Make sure you control your own resources," she says.

Lanning was a lone individual tasked with the implementation of a new technology in a large organization with no staff to help her. "My biggest problems weren't technical. Those I could overcome," she says. "It was people problems. I wasn't given a group of people to help me install the product."

That meant she had to rely on staff borrowed from other managers. "But they get their direction from their own bosses," she says. "And for them, CM wasn't exactly a top priority."

Communications is the key, says Nancy A. Lanning, senior systems analyst at Harris Electronic Systems. Lanning found that involving users was a requirement in bringing innovative technologies into existing organizations.

A Sponsor with Muscle

Lanning thus finds herself in a position that is all too common for those charged with innovation in large organizations: They must make changes but aren't given the tools to make them.

"You have to have a corporate sponsor," says Ed Swanstrom, domain specialist in object-oriented technology at Trecom Business Systems Inc., in Edison, NJ. "You absolutely have to."

Currently, Swanstrom is a consultant to companies that want to move to object-oriented programming. His expertise, though, was won as a user who made that transition while he was in the telecommunications industry. "I have had about eight years of this," he says.

One of the things Swanstrom has learned in those eight years is that no matter how ideal the OOP technology or any other technical innovation–no matter how talented and intelligent the innovator–nothing will happen unless someone in upper management is behind it. "You have to have a corporate sponsor and make certain you have that person's 100% support," he says.

Moreover, that support has to be active. "You need someone to be the champion of getting it through," Swanstrom says. "It could be a group or an individual, but it has to be someone with the muscle to just go ahead and make it happen–to get people's schedules clear for the orientation meetings if nothing else."

Given that kind of backing, the innovator can expect clear sailing–until "you get to the project management level." Here, says Swanstrom, the innovator may discover strong opposition, since OOP requires a lot of up-front planning before any code actually gets written. "Project management gets scared," he notes, "because nothing seems to be happening for two or three weeks. Or more."

However, he says, during those two or three weeks, the developers are in fact planning what sort of software they will write and how they are going to reuse it afterwards. "It seems like you're standing still," Swanstrom says. "But then, the project seems to miraculously

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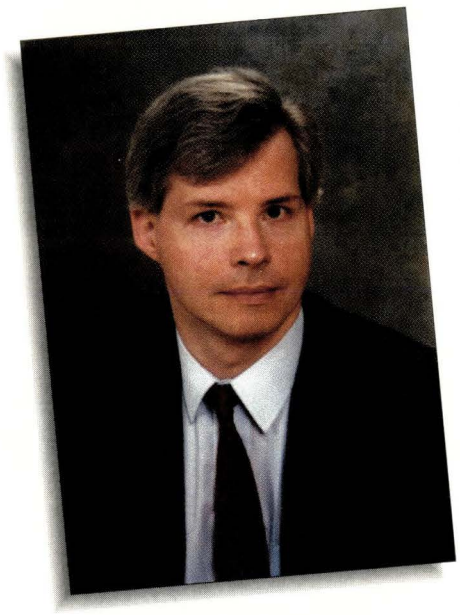


Patience is a virtue, says consultant Ed Swanstrom, of Trecom Business Systems. Program managers must learn that during OOP projects, there seems to be little motion during the vital planning phases, and then the projects "miraculously surge forward."

surge forward."

But the miracle depends on software reuse, which in turn depends on an organization knowing what software is available, and where it is and who wrote it. Swanstrom says that the result is, in effect, the creation of a new profession. "I find one individual and I assign that person to be reuse manager," he says. The reuse manager is then responsible for not only keeping track of reusable objects but also for "finding out which are the most stable objects in the system. Business objects, for instance, ought to be very stable."

Swanstrom defines "business objects" as those that may affect almost anything that a company does. A company's basic business rules, for instance, could be encoded in a single business object.

Obviously, though, such a business object would be vital to the long-term health of the company. Its creators therefore must be very trusted indeed. And trust is the one thing that most organizations lack.

'That Confidence is Hard Won'

Mercer Technologies, in Deerfield, IL, is a division of William M. Mercer, "the world's largest benefits consulting firm," says Terry B. McLane, the company's head of technology. "What we have done for the last 20 years is consult with our clients about their employee benefit compensation plans."

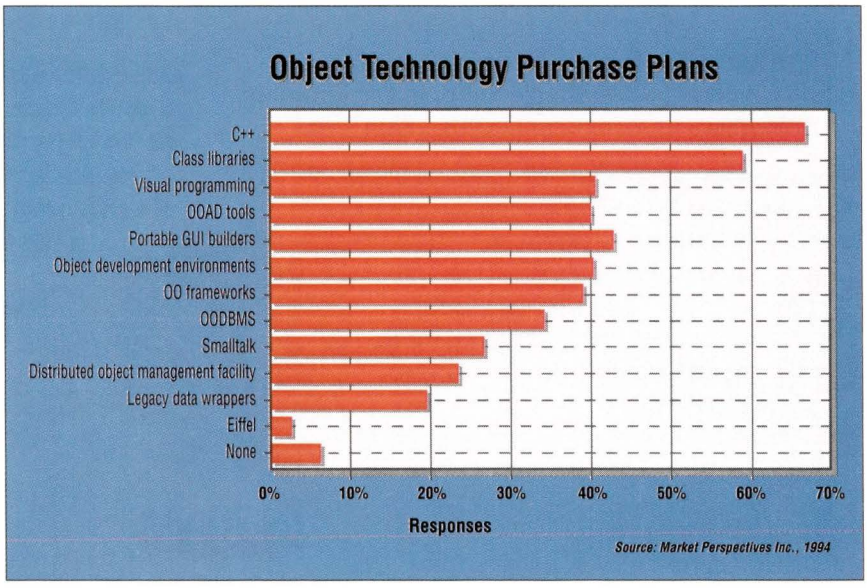
Mercer's investment in computing was unplanned. Individual offices put together systems to address their own needs. In time, the company found itself with several systems that could not even communicate with one another. "So, some time ago, we decided to create a centralized system, with centralized standards," says McLane. "And when we started to do that, we starting looking at object-oriented programming, too."

Mercer developed a system based on desktop PCs and UNIX server systems. The company then needed software that would allow it to deal with the various benefits plans offered by its clients. This would seem like a good old-fashioned application requiring nothing more sophisticated than good old-fashioned COBOL. But Mercer was committed to an object-oriented approach. "The problem with [using] COBOL is that everyone's benefit plan is different," says McLane. "Everyone's 401K is similar, but different. Everything is the same, except for one or two things. So, with that variety of plans and instructions and types, it is very difficult to do up a single piece of software."

So, instead, the company went with C++, the ObjectCenter from CenterLine Software Inc., in Cambridge, MA, object modeling tools from Interactive Development Environments Inc., in San Francisco and the ClearCase configuration manager from Atria Software Inc., in Natick, MA. "We did all this in one shot," says McLane. "We went from a PC system with some mainframe applications to UNIX."

One of the first things that McLane worked on was a series of front ends for the applications. "We have a variety of front ends," he says. "The first is an operator workstation for benefit service representatives." This workstation is used by a Mercer employee whose job it is to sit at a phone and answer questions about benefit plans from employees of the various clients. "Then there is voice response, where people can dial in and get information from an automated system, since we obviously can't have millions of operators standing by to deal with everyone." Another version of the operator workstation is designed for an employee who is doing more than just answering questions about a plan

Market Perspectives, a market research firm based in Framingham, MA, conducts interactive surveys at high-tech trade shows to gather market information for decision makers. Here, the company surveyed 500 attendees at Object World, held in Boston in January 1994, to track OT purchase plans for 1994 through 1996.



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and may be actually developing or modifying one–"It is a little more user-friendly and not so transaction-oriented." And finally, "there is a kiosk system. It might be in an employee cafeteria, for instance."

McLane says he was fortunate that Mercer didn't have a large population of programmers to retrain. "In a way, we had a different culture to begin with," he says. Even so, he encountered some difficulties, not the least of which was the issue of trust. "A big cultural issue is that with C++, you are much more dependent on the people who work around you. That results in two things. First, you have smaller teams–and second, you have to be really, really confident of other people's objects."

This may be the biggest problem innovators face. "That confidence is hard won," says McLane. "Programmers tend to believe that each of them is unique on the planet. Culturally, they are just not set up to share things."

Changing those attitudes comes partly by simple training, which goes hand in hand with the whole business of training your staff in C++ in the first place. "The biggest issue for C++," McLane says, "is that people are simply unprepared for the amount of time that it takes to turn a pretty good programmer into a pretty good C++ programmer. It will be months before he produces anything that is really good–I mean, objects that are really reusable."

The other issue is C++'s complexity. Not everyone you train will turn into a C++ programmer, regardless of how long you, and they, try. "I believe if you take 100 programmers, 20 could become good object-oriented programmers," he says. "And 10 will become good C++ programmers. I think that is a comment on C++."

The good news, though, is that those 10 will be much more productive. "People come to me and say, 'What are we going to do with a million C++ programmers?'" says McLane. "But the fact of it is, you only need 100,000 of them, because they will be literally 10 times as productive."

Which brings up another interesting cultural question. What is to be done with the 900,000 programmers left over?

'I Don't Know If That's Possible'

"BCTel is a traditional [telephone company] of the type that, I think, you would refer to in the States as a Baby Bell," says Bruce Campbell. Campbell is project manager with BCTel System

What Are Objects Anyway?

Before the widespread use of higher level programming languages, the only data types were collections of bits and whatever else was directly implemented in the hardware of a computer. Typically these would be integers, floating-point numbers and some sort of packed field representing characters. Even fundamental ideas such as strings or arrays were only in the programmer's mind–a contiguous block of characters or other items in memory.

Early programming languages reflected little more than these data types. Their main purpose was to allow you to program in a more natural and formulaic style, and to simplify and standardize management of looping, subroutines and other control primitives.

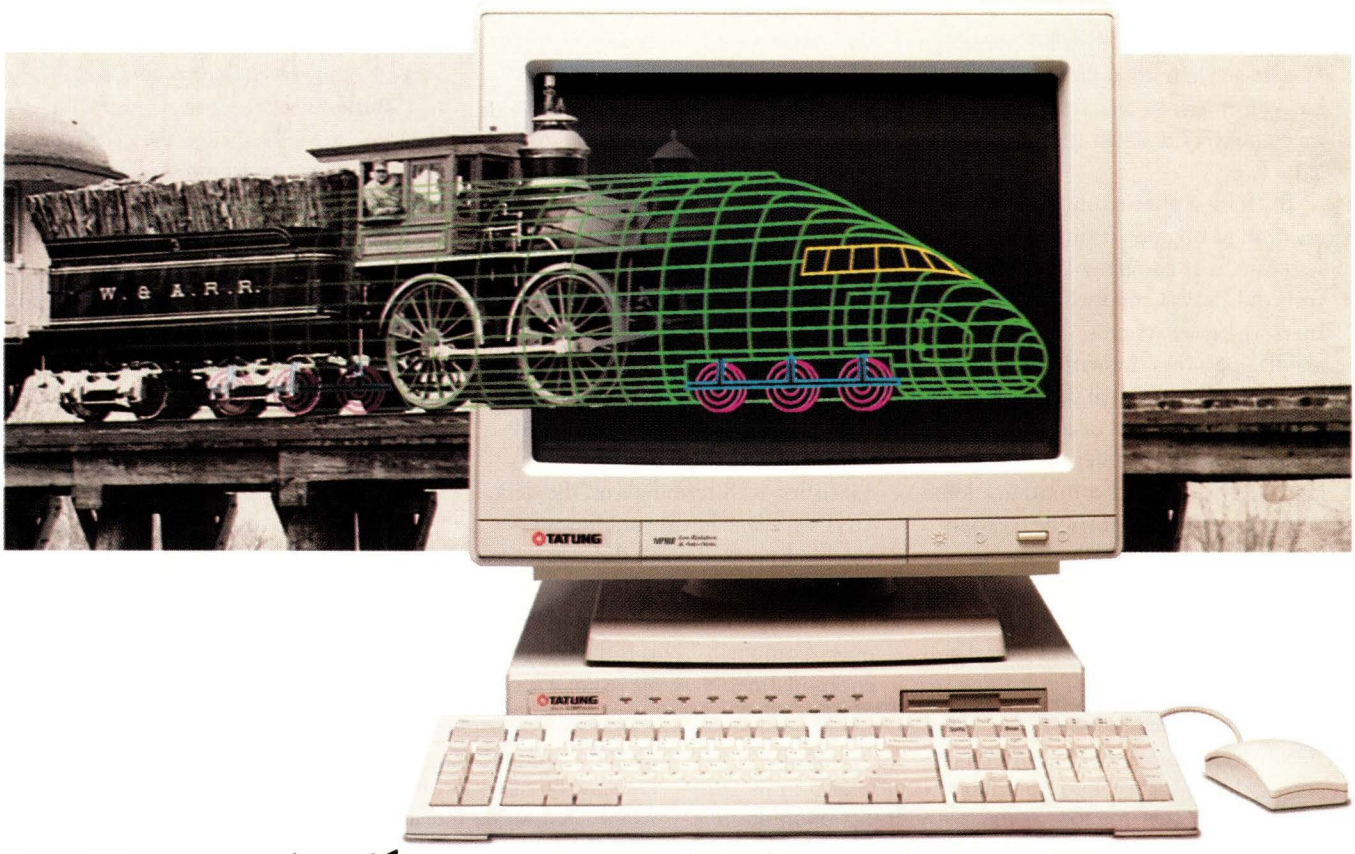
As programming languages evolved, so did abstractions of data into data types. One particularly important development was the record or structure, which was little more than a data type consisting of one or more other data items, which could, in turn, be of mixed types. You could create a record that contained a character string for a name field, a number to hold salary information, another string for address and a field of bits in which to store various yes and no information. Typically, programming languages had ways to at least move, copy, create and initialize these aggregate data types. The rest was done more or less manually by selecting out a field such as a salary, which was then recognizable to the language as an integer, and then performing native integer operations on that number, such as addition or subtraction.

Even a fundamental operation such as printing out a record involved selecting each field in turn and formatting it for printing. You generally could not tell the language to just print the record and get satisfactory results.

Synthetic or artificial data types were another important development. Early on, these were little more than aliases; names you could give to other basic types in the language for mnemonic value. So you could define a type PostalAddress that was really an 80-character string and then declare new variables and routines using the word PostalAddress as if it were a built-in data type. This left something to be desired. If you wanted to perform any operations on this new data type other than those that needed the same amount of memory or happened to coincide exactly with built-in operations on the underlying data type, about all you could do was write a library of subroutines and remember to call them at the appropriate time–*printPostal(thisAddress)*, for example.

The next logical step in this progression was to extend programming languages and other applications systems so that completely new data types with their own specialized set of operators could be defined. Perhaps the most fundamental concept is the ability to print an item of a new data type. Suppose your language already understands how to print fundamental data types such as integers, floating-point and simple character strings by calling a routine *print(item)*. In an extensible type system, you should be able to extend the definition of the built-in *print()* routine so that calling *print(newtype)* will do something sensible. For example, if we defined a new type money, the *print()* routine would print it with the appropriate currency symbol and digits to the right of the decimal point or other separator. In many cases, it would be useful to be able to explain to the language what to do when it encounters other basic operations with this new type such as adding two values meant to express hours and minutes. For example, 06:30+00:45 should yield 07:15 and 23:15+01:00 should yield 00:15.

If we can bundle the data and the operations that represent and manipulate a new type, then we call that an object. This allows new jargon in thinking about programming, such as "tell it to print itself," or "create a new instance of yourself." We think in terms of telling the object what we basically want (its contents printed, a



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Solutions, BCTel's information systems division, in Burnaby, British Columbia. "We have two million lines and a million customers. By Bell standards, we're small, but by Canadian standards we're quite large."

BCTel is a phone company with a mission: to upgrade its information systems. "The company is over 100 years old," says Campbell. "Its systems are truly legacy systems. They run on mainframes, they are written in COBOL, their original designers have long ago quit, retired or expired."

BCTel needed modern computing–"GUIs, standard communications between systems, client/server, expert systems," says Campbell. "How do you go to a board of governors and tell them they ought to spend x million dollars to transition to all of this? The reality is, that's a very difficult thing to do." But it was what Campbell *had* to do. "That was the environment into which I was thrown."

Campbell's particular project was to re-engineer the way the company took orders. "We had a bunch of folk sitting in front of 3270 terminals. It processed an incredible amount of data, but it was not user-friendly, was difficult to maintain, almost impossible to change and it took a long time to learn."

After several attempts to somehow salvage the old system, or to mate it with new ones, the company finally went with a entirely new approach consisting of X terminals on the desk, UNIX systems in the middle and batch jobs passed on to the company mainframe. "We are starting to get into concepts of object orientation," notes Campbell. "This is the notion of encapsulating. Now, we've got a server interacting with the mainframe system and doing so in a way that is effective as far as the work floor is concerned."

But, to get this done, Campbell needed tools–he picked the TeleUse development environment from San Diego, CA-based Alsys Inc.–and programmers. "Basically, I gathered up every single person in the company who knew anything about UNIX," he says. Campbell reenforced this group with "three new grads who had no business experience, a fellow who had 15 years of experience on the old system and had gotten tired of it and a couple of consultants."

This crew put together the new system, which was first deployed in 1991 and has been rereleased each year since. The system has been, Campbell says, a roaring success. "Of the 700 employees who switched to this system from the

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fresh copy to work with), and it is the responsibility of the object to perform these operations customized to its own design. For this reason, some early object-oriented languages referred to message-passing as their fundamental operation.

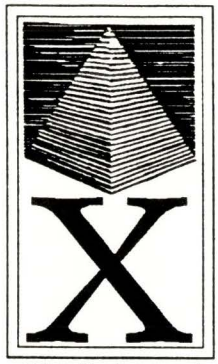
There is no need for an object and its operations to be as simple as described thus far. They can be very complex, sophisticated and, most important, self-contained data types. As an example, imagine that I am managing a fleet of ships. I create objects representing each type of ship in my fleet. At some early point, I assign each of these objects data such as heading, weight and speed. Then I tell one to change its speed and some time later ask it where it is right now (latitude and longitude). It would be up to the object to update its own coordinates based upon its internal settings for heading, speed, initial position, any changes in these settings, and the amount of time that had passed. It has become an expert on being a representation of a ship and frees the user from the messy details of navigational calculations. One expert can code all this information into the object once, and everyone else can just use that knowledge.

Objects naturally lend themselves to object hierarchies. I might create a general notion of a ship with location, heading, speed and how to calculate various questions I might ask later, such as its coordinates. From this I can specialize new subclasses of ships that might also know about fuel consumption for various types of engines. Now I can ask each for its location and the amount of fuel it has left. The new class inherits all the properties of its parent class heading, location, etc.), plus adds some new data and/or operations. Or it might replace some of the operations of its parent class (a new and customized *print()* routine, for example).

Generally, such object or class hierarchies have a fundamental root class, which consists of little more than the operators to create a new instance of itself, destroy an existing instance (i.e., free up its memory) and print itself. One lively issue in object programming revolves around what is known as multiple inheritance: the ability to create new classes from more than one existing class. Although a natural and compelling idea (what is an amphibious vehicle other than a mixture of a boat and a car?), it presents various complexities into otherwise simple hierarchical systems. For one thing, you can no longer represent your entire object system as a simple branching tree.

Object-oriented systems accomplish two goals: expressivity and manageability. You can express new data types such as ships or forms to be filled out in new and powerful ways. Because each object is self-contained, the management of the information and operations the object represents can generally be updated without affecting other parts of the system. For example, imagine a collection of objects, each representing a form to be filled out at tax time. There are a few pieces of information you must give each object to calculate the tax, but otherwise its machinations remain a black box to you. Should the tax laws change in some small way, someone can modify the internal operations of each object to reflect the new laws, but otherwise its behavior is opaque to the person using the object. This approach helps in the management of large, complex information systems.

One exciting development in object-oriented technologies is the introduction of objects into databases and network applications. Being able to store operations along with an object or record in a database, such as rules for deciding whether a new value being entered is plausible or not, promises to greatly enhance database management. On networks, it is natural to think of passing objects between machines on the network as a way of coordinating distributed processing. All of programming can be reduced to three basic concepts: data, operators and control flow. Object-oriented programming captures two out of those three concepts in one neat package.–*bzs*



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Whose Future?

In some ways, the new methodologies of software development–in which objects are written and reused, and in which the programmer is far less autonomous–conflict with the software developer's worldview. "Today, we have a world in which software is built from raw materials by craftsmen," says Peter Winston, president of the software tools provider Integrated Computer Solutions, in Cambridge, MA. "You turn to the craftsman and say, 'When will it be done?' And then Michelangelo turns back and says 'It will be done when it's done.'"

This contrasts sharply with a future in which "you are manufacturing software where you worry about suppliers, not about craftsmen," Winston says.

Could it be, then, that the COBOL programmers of traditional MIS, who are far more familiar with such disciplines as a mandated company style and corporate policies, are actually better fitted for the world of the software factory? Could it be that the traditional UNIX programmers, accustomed to a certain prima donna status, are the group that really faces the most difficult future?

3270s, we had less than a dozen have any difficulty learning it. The rest absolutely adopted it with open arms."

But, meanwhile, the bulk of the company's programmers still work with COBOL. "We are seeing a transition of the staff, but it is slow," he says. "The vast majority of the staff is still working on the mainframe."

And that vast majority may never make the transition. "There is a cultural difference between mainframe people and UNIX people," says Campbell. "It stems from the environment. A UNIX person is close to the system. They learn very quickly how the system manages files, how to write shell scripts and so on. But a mainframe person–he may not be allowed to interact with the system space. He is told how to name files. His programming style must conform to a corporate style."

The result, Campbell concludes, is two different and perhaps irreconcilable perspectives. "The UNIX people look at an assignment and say, 'Yeah, I can do that.' The mainframe person says, 'Let me check and see if that's possible.'"

It may be, then, that there are some cultural problems that simply cannot be solved. Some programmers, some staffs, some entire companies will simply never successfully make the move to OOP, or even to client/server. According to Campbell, most of the programming staff at BCTel is still working in the traditional MIS operation. "Sad to say," he says, "the vast majority are still working on the mainframe." But that mainframe may not be around forever. It's a problem that software professionals will face in the very near future, and not just at BCTel. They may have to choose between an uncomfortable period of rapid adoption, or an even more uncomfortable early retirement.

'But It's More Fun'

Some of the characteristics of a successful innovation program are already fairly clear. The innovator must have excellent communication with the users and must rely on their input. But that person also needs the support of a strongly committed corporate HQ. That corporate HQ, in turn, must have the patience, and foresight, to let OOP generate its rewards in full time. During that time, the programmers must learn new ways of interacting, and perhaps be reorganized into tiny and dedicated bands that can reuse code.

And finally, perhaps grimly, everyone involved must be prepared for at least some of the participants not to make the crossing.

Mercer's McLane jokes that the whole crossover process is at least improbable, and maybe impossible, even though he's done it successfully. "I think you really ought to start with a pilot project. Except no one ever really does a pilot project because no one can afford to. So, in that case, you really ought to start with a project that isn't mission-critical. Except, of course, that no one ever funds a job unless it is really mission-critical. So, when you get picked to perform a large-scale, mission-critical project, you ought to allow yourself lots of time–except, of course, that nobody is blessed with adequate deadlines."

But all the users agree that, in the end, converting to the new technologies is worth it. "It's not going to solve all your problems," says BCTel's Campbell. "But, in my personal opinion, it's a lot more fun than doing it the old way." ⊸

Companies Mentioned in this Article

Alsys Inc.
10251 Vista Sorrento Pkwy.
San Diego, CA 92121
Circle 140

Atria Software Inc.
24 Prime Park Way
Natick, MA 01760
Circle 141

CenterLine Software Inc.
10 Fawcett St.
Cambridge, MA 02138-1110
Circle 142

Integrated Computer Solutions Inc.
201 Broadway
Cambridge, MA 02139
Circle 143

Interactive Development Environments Inc.
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Vienna, VA 22182
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Object-Oriented Comes of Age

by SIMSON L. GARFINKEL, Senior Editor

Last spring, IBM Corp. shook the programming world when it released its VisualAge object-oriented development environment for its OS/2 operating system. VisualAge represents a new generation of application development environments. It combines sophisticated development tools, object-oriented programming and the elegant object-oriented language, Smalltalk, into a unified environment designed to speed both application development and deployment.

ERIC MEOLA, THE IMAGE BANK

"Smalltalk and VisualAge are turning the market upside-down," says Paul White, vice president of marketing for The Object People, a training and consulting group in Ottawa, Ontario. VisualAge is visual programming that works, says White. On the screen, programmers can build fully featured applications simply by connecting prefabricated program components. Unlike other visual programming environments, VisualAge is rich and expressive. And, most importantly, White says, VisualAge makes it easy to get at Smalltalk, the system's own development language, for programmers with special needs not covered by VisualAge's current generation of visual objects.

New Trends Mean New Opportunities

VisualAge is now available on IBM's OS/2 operating system. Versions for SunOS and Solaris are scheduled for introduction sometime in 1995. The product is a harbinger of two important gains for custom application development in the second half of this decade: the mainstreaming of object-oriented development environments, and the market acceptance of object-oriented languages other than C++, the language invented by Bell Laboratories Inc. and popular on most UNIX platforms.

"It's been accepted for a long time that C++ isn't the best language for many applications," says White. "It was originally conceived for the telecommunications world," where the demands of real-time processing put execution speed at a premium. In the business world, an application program's runtime is often far less important than how long it takes to develop the program itself. Many programmers conversant in both Smalltalk and C++ readily admit that application development under Smalltalk can take significantly less time than under C++ because of faster development tools, better debugging facilities and richer object libraries.

IBM isn't the only company pushing Smalltalk. This spring, Quasar Knowledge Systems Inc., a five-year-old software development company in Bethesda, MD, will be releasing its Smalltalk Agents development environment. The system is a multiplatform object-oriented development environment that will allow developers to create a single application with a graphical user interface and deploy it on a variety of different computers. Smalltalk Agents now runs on the Macintosh and Power Macintosh platforms. QKS plans to ship Smalltalk Agents for Microsoft Corp. Windows, Sun Solaris, Silicon Graphics Inc. Irix and other UNIX platforms during the first half of 1995.

At SunSoft, work continues on Project Distributed Object Environment (DOE) and OpenStep, SunSoft's collaboration with NeXT Computer Inc. An alpha release of the system, which brings NeXT's object-oriented application development environment to Solaris, has been available to select NextStep developers since last October. OpenStep is based on Objective-C, a language that combines the C programming language with the Smalltalk object model, giving it, supporters say, the best of both worlds: speedy program development *and* program execution.

It's been accepted for a long time that C++ isn't the best language for many applications.

There is a growing number of new free software object-oriented systems as well. A version of Smalltalk distributed by the Free Software Foundation is slowly maturing, joining the ranks of the FSF's G++, a C++ compiler developed by Michael Tiemann, president of Cygnus Support and perhaps the most widely used implementation of C++ in the academic world. A number of Project GNU volunteers are also working on a freely available version of the OpenStep system called GNU Step, although the system is far from compilation.

Tcl/Tk is a freely available system for building applications with graphical user interfaces. The system is based on Tcl, a scripting language developed by University of California at Berkeley professor John K. Ousterhout, who created Tcl as a scripting language to control small interactive tools. Tcl runs on most UNIX computers and is freely distributed over the Internet at `ftp://ftp.cs.berkeley.edu/ucb/tcl`. You might also check out *Tcl and the Tk Toolkit*, by Professor Ousterhout, published by Addison-Wesley Publishing Co. Inc. (ISBN 0-201-63337-X).

Tcl isn't without its problems. Some programmers think the language's syntax is idiosyncratic and difficult to understand. Tcl is slow, perhaps 100 to 200 times slower than languages like Forth, and a thousand times slower than C. For this reason, versions of Tk are being developed that are based on Scheme, a Lisp-like language, and Perl, a scripting and systems administration language developed by Larry Wall. Perl itself underwent an object-oriented transformation in 1994, with the release of Perl5, a new version of Perl that adds objects and object-oriented features.

Object-Oriented Databases

Once you've made the transition to an object-oriented development environment, you'll be faced with another question: How do I store the data that my application generates?

Increasingly, programmers are turning to object-oriented databases as an answer. These systems, which have been on the market for years, reinvent the computer's database, turning it from a system that stores tables of data into a system that's fine-tuned for storing the same sorts of objects that programs use to build their applications.

One of the advantages of using an object-oriented database is that data sets created with one program are easily read by another, says William Blundon,

vice president of marketing at Object Design Inc., in Burlington, MA, one of the two leading vendors of object-oriented database management systems (OODBMS). "Most of the people using object-oriented tools are using them not just to develop form-based presentation of information, but are using more complex tools because they have additional data-types that are not table-oriented, or they've gotten to the point where creating the table and forms results in so many joins in a relational database that they can't get the performance out of it," Blundon says.

For example, the Whitehead Institute for Biomedical Research at the Massachusetts Institute of Technology uses an object-oriented database to store information as part of the U.S. Human Genome Project. The institute's data management system, called MapBase, tracks the progress of laboratory experiments. "The data objects we deal with are extremely complex," says Nathan Goodman, a senior research scientist at the Whitehead, who has led the MapBase development team. The system, based on Object Design's Object Store, stores DNA sequences, genetic map information and nearly 200 kinds of custom objects.

Currently, Object Design's ObjectStore supports objects created in C or C++. A new version of the product, ObjectStore for Smalltalk, is in beta testing and due to be released early this year. ObjectStore Version 4.0, due for release sometime this year, will allow programmers to move objects easily between C++ and Smalltalk, Blundon says. The system also has an SQL interface, allowing it to work with traditional report-writing tools. ODI's principal competitor, Versant Object Technology, already supports Smalltalk and C++ with its OODBMS.

During the next two years, the industry is likely to standardize a system for connecting application programs with each other and with object-oriented databases. That "glue" will be CORBA 2.0, the Common Object Request Broker Architecture, a standard being developed by the Object Management Group. CORBA allows objects to communicate with each other over a network, using a system similar to Sun's Remote Procedure Call system. It's likely to be a fundamental ingredient in Sun's initial DOE offering.

New design tools may even eliminate the need for programmers using C++ to actually type C++ code.

C++: Still Going Strong

Despite the interest in new technology, C++ is likely to be a strong player in the object-oriented arena for some time to come. This is due to a large installed base, its perceived need by MIS directors and the increasing number of companies that are now delivering high-quality C++ tools.

Many people attribute C++'s early success to its backing by Bell Laboratories. Developed by the same research lab as the UNIX operating system, C++ gained instant credibility in the minds of many developers, despite the fact that it followed Smalltalk by several years.

Liant Software Corp. is a development firm in Framingham, MA, whose main product is C++/Views, an object-oriented development environment that allows programmers to write an application with a uniform API and field it on a variety of platforms, including Solaris, Motif, Macintosh and even Microsoft Windows. The system was originally developed in Smalltalk, says Neil Goldman, Liant's director of marketing, and then rewritten in C++ for speed and portability.

"One of the things we have done in our library is try to incorporate the things in Smalltalk that are really good," explains Goldman. "Our architecture is a model-view architecture. Our representations of views are separated from the data representation, and we have one notifying representation that handles message passing between views and models. That separation of views from data is something that Smalltalk does that C++ does not do. What we found are a number of people who have used Smalltalk and like that architecture, but have come to C++ and C++/Views because Smalltalk's performance wasn't acceptable."

Real-time systems is another area where C++ is likely to remain on top. That's because dynamic languages like Objective-C and Smalltalk perform message resolution at runtime, instead of at compile time, as is the case with C++. Smalltalk also has the overhead of automatic garbage collection, which programmers widely believe is slower than C++'s. On the other hand, a 1992 technical report paper from the University of Colorado at Boulder, *The Measured Cost of Conservative Garbage Collection*, by B. Zorn (Technical Report CU-CS-573-92), indicates that automatic garbage collection may be faster than manual systems in many circumstances.

New design tools may even eliminate the need for programmers using C++ to actually type C++ code. "The user never has to edit the derived C++," says Garth Gullekson, vice president of marketing for ObjecTime Ltd., in Kanata, Ontario, which sells an object-oriented development tool for real-time applications. ObjecTime's system is based on the concept of an *executable model*, explains Gullekson. Users edit a graphical representation of their program, which then can be animated while it runs under simulation or in real time. "You see the communication links highlighted, you see the [program] move to various states as the program is executing," says Gullekson. Using any language other than C++, he adds, would simply be too slow.

Where to Go from Here

Moving to object-oriented programming requires a mental shift from conventional programming. If you've already embarked on the transition, stay the course: Programmers seldom

become proficient at OOP until they have been practicing the craft for a year or more.

If you haven't yet committed to a particular object-oriented strategy but are strongly considering going with C++, you may wish to hold off on a final decision until Sun releases DOE Version 1.0. Although DOE will support C++, it will also give people the flexibility of using Objective-C, which many programmers seem to prefer because of its simpler syntax.

Meanwhile, the number of Smalltalk offerings for SPARC systems is likely to skyrocket in 1995. IBM, for example, plans to move its Smalltalk system to UNIX sometime in 1995, according to a company insider; the company's VisualAge should follow in late 1995 or early 1996. Meanwhile, numerous other Smalltalks will be appearing on the market within the next 12 months.

All in all, there was never a better time to think objectively. ⊸

Companies Mentioned in this Article

Liant Software Corp.
959 Concord St.
Framingham, MA 01701-4613
Circle 146

Object Design Inc.
25 Mall Road
Burlington, MA 01803
Circle 147

ObjecTime Ltd.
340 March Road, Ste. 200
Kanata, Ontario K2K 2E4
Circle 148

Quasar Knowledge Systems Inc.
9818 Parkwood Drive
Bethesda, MD 20814
Circle 149

Versant Object Technology
1380 Willow Road
Menlo Park, CA 94025
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Training: The Key to Object Transition

by MAUREEN MCKEON

The benefits of object-oriented technology are plenty–but the transition can be tricky. The technology is there. The hardware is there. The software is there. Even management–which as little as two years ago thought it impossible to implement and maintain object use–has come to recognize the benefits of object-oriented technology.

What's missing is training.

These days, it's widely recognized that when properly used, object technology yields increased productivity, easier maintenance, higher reuse and shorter development times. The next step is to get to work and implement this technology. But for the programmers and engineers assigned to make the transition into objects, understanding the concepts is fundamental.

That understanding can be both expensive and hard-won. Just learning the syntax of C++ isn't enough. Courses must be specifically designed to teach the underlying concepts of object-oriented development, not the mechanics of a particular language or tool.

"Prior to starting a pilot project, selecting tools or choosing a methodology, a development group should receive fundamental retraining and fully understand the principles of object-oriented development," says Madison Cloutier, vice president of marketing at Tower Technology, a provider of high-performance and open tools for developing Eiffel-based systems. Cloutier adds, "Software developers must understand the object-oriented concepts before they can successfully utilize and implement reusable class libraries to achieve the full benefits they provide."

Object-oriented development has the best chance of improving the software development process because it's not merely a new methodology, language or tool. It's a new way of thinking about systems. Just as today there is an overwhelming preference for open systems, object-oriented technology may soon be the preferred method of programming. But, unless programmers are trained to think in objects, those advantages might as well have never existed.

The following table takes a closer look at some of the companies that provide some of that vital training. Their courses range from from fundamental, technical courses, like "Introduction to Object-Oriented Technology," to advanced technical courses, such as "Advanced System Construction with Smalltalk." Also featured are executive-targeted classes like "Executive Overview of Object-Oriented Methodology" and "Management Overview and General Introduction to Object-Oriented Technology." Use them to jump-start your move to the object-oriented world. ⊸

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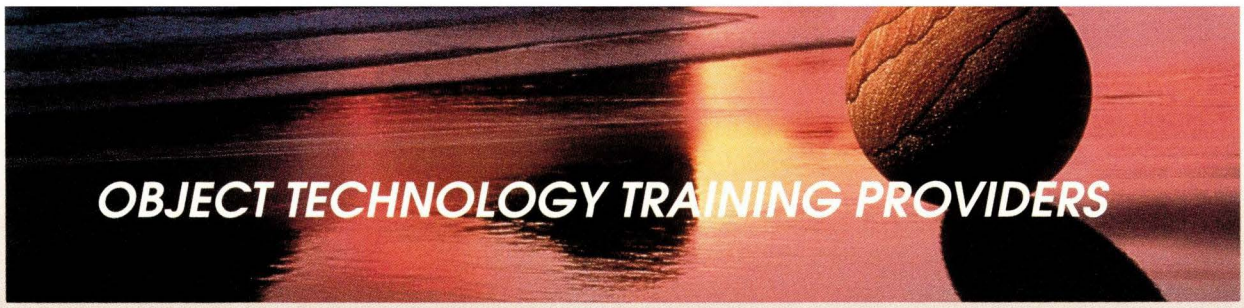

OBJECT TECHNOLOGY TRAINING PROVIDERS

compiled by MAUREEN MCKEON

Company Courses	Duration	Price ($)
AMS Training Services (formerly DBMI), 300 Chapel Road, Manchester, CT 06040. Circle 200		
Object-Oriented Business Perspective	1 day	435
Object-Oriented Technology Overview	1 day	435
Comparison of Object-Oriented Methodologies	2 days	900
Managing Object-Oriented Software Development	2 days	900
Object-Oriented Analysis and Design	5 days	1,485
Object-Oriented Analysis	3 days	1,135
Object-Oriented Design	2 days	785
C++ and Object-Oriented Design for Non-C Programmers	10 days	2,980
Introduction to C++ and Object-Oriented Design	5 days	1,685
Intermediate C++ and Object-Oriented Design	5 days	1,685
Advanced C++ and Object-Oriented Design	5 days	1,685
Introduction to Object-Oriented Programming in Smalltalk	5 days	2,485
Advanced Programming in Smalltalk	5 days	2,485
Smalltalk Immersion Program	30 days	9,885
Building Distributed Systems Using CORBA	5 days	1,885
Integrating Applications Using CORBA	1 day	595
Batky-Howell, 6061 S. Willow Drive, Ste. 101, Englewood, CO 80111. Circle 201		
Object-Oriented Programming in C++	5 days	1,495
Bluestone Inc., 1000 Briggs Road, Mt. Laurel, NJ 08054. Circle 202		
Technology Overview: Introduction to Object-Oriented Technology	1 day	3,000
Object-Oriented Analysis and Design	4 days	1,895*/2,200†
C++ Object-Oriented Programming	5 days	1,695 per seat*/1,900 per day†
C++ Programming for non-C Programmers	3-4 days	2,200 per day†
Introduction to Client/Server Technology	1-2 days	2,200†
UIM/X Object-Oriented GUI Development	3 days	1,495 per seat/2,200 per day†
db-UIM/X Development of Database GUIs	2 days	995 per seat/2,200 day†
CORBA Programming Using Orbix	5 days	1,750 per seat/2,700 per day†
Computer Skills Corp., 5305 Lookout Trail, Arlington, TX 76017. Circle 203		
Programming in C++	5 days	4,495
Object-Oriented Programming Overview	1 day	1,495
C++ in a UNIX Environment	5 days	Contact vendor
Courseware Technologies Inc., 11300 Sorrento Valley Road, Ste. 105, San Diego, CA 92121. Circle 204		
Introduction to Object-Oriented Technology	4-6 hours	1,474+
Object-Oriented Analysis and Design	12-14 hours	1,270+
C++ Programming Workshop	16-18 hours	1,270+
Object-Oriented Technology Library	Contact vendor	Contact vendor
Digital Consulting Inc., 204 Andover St., Andover, MA 01810. Circle 205		
Ed Yourdon on Object-Oriented Analysis and Design	2 days	995
Ed Yourdon's Workshop on Object-Oriented Analysis and Design	5 days	1,895
Object-Oriented Database Technology/Relational Remodeled	2 days	1,095
C++ Programming	4 days	1,595

* Public – course offered to general public as well as corporate participants
† On site – course offered on purchasing company's premises

Company Courses	Duration	Price ($)
Digitalk Inc., 7585 S.W. Mohawk St., Tualatin, OR 97062. Circle 206		
Building Applications: Foundation Course 1	4 days	1,650 public*/17,450 on site†
Development Components: Foundation Course 2	4 days	1,650 public*/17,450 on site†
Designing Object-Oriented Software: Foundation Course 3	3 days	1,350 public*/16,250 on site†
Object Design Workshop	1 day	3,000 on site†
Advanced Smalltalk/V Techniques	4 days	1,650 public*/17,450 on site†
Building Effective GUIs	3 days	Contact vendor
Building Applications using the PARTS Wrapper for ADW	4 days	17,450 on site†
Client/Server Systems for Large Enterprises	3 days	17,950 on site†
Business Engineering with Object Technology	2 days	16,500 on site†
Elite Systems, P.O. Box 2205, Beaverton, OR 97075. Circle 207		
Analysis and Beyond: Leading to Object-Oriented Programs	4½ days	Contact vendor
Object-Oriented Design: A Professional Approach	4½ days	Contact vendor
Transition to Object-Oriented Technologies: A Manager's Role for Success	1-2 days	Contact vendor
The Power of Patterns: Capturing Acquired Wisdom	2-3 days	Contact vendor
Genesis Development Corp., 1512 West Chester Pike, Ste. 333, West Chester, PA 19382. Circle 208		
Object-Oriented Programming with C++	5 days	1,495
Developing with Objects: A Case Study	90-120 minutes	Contact vendor
Managing Change: A Business Case for Object Technology	60-90 minutes	Contact vendor
GHG Corp., 1300 Hercules, Ste. 111, Houston, TX 77058. Circle 209		
Programming with C++	5 days	1,305 (group disc. available)
Introduction to Object Engineering	3 days	720 (group disc. available)
Hewlett-Packard Co., 100 Mayfield Ave., Mountain View, CA 94043. Circle 210		
Object-Oriented Technology Seminar (HP3319S)	1 days	445
Object-Oriented Analysis and Design: Survey (HP50790S+054)	3 days	1,145
Object-Oriented Analysis and Design: Fusion (H5851S)	4 days	1,645
C++/Object-Oriented Programming	5 days	1,625
Odapter/OpenODB	5 days	1,995
ICON Computing Inc., 12343 Hymeadow Drive, Ste. 3C, Austin, TX 78750. Circle 211		
Object-Oriented Technology: An Executive Overview	1 day	Contact vendor
Managing Object-Oriented Software	1 day	Contact vendor
The Object-Oriented Paradigm: An Overview	1 day	Contact vendor
Object-Oriented Analysis: Modeling and Conceptual Design	5 days	Contact vendor
Object-Oriented Development: The FUSION Method	5 days	Contact vendor
In-Depth Comparison of Object-Oriented Methods	1 day	Contact vendor
Object-Oriented Design: Idioms and Architectures	5 days	Contact vendor
Advanced Object-Oriented Design Patterns	3 days	Contact vendor
Objects with OLE	3 days	Contact vendor
Object-Oriented Design Using C++	5 days	Contact vendor
Advanced Object-Oriented Techniques in C++	4 days	Contact vendor
Optimizing C++ Programs	1 day	Contact vendor
Object-Oriented Design Using Smalltalk	5 days	Contact vendor
Advanced Object-Oriented Techniques in Smalltalk	3 days	Contact vendor
Real-Time Object-Oriented Design	1 day	Contact vendor
Distributed Object Computing: Principles and Pragmatics	5 days	Contact vendor
Object-Oriented Databases	2 days	Contact vendor
Integrated Computer Solutions Inc., 201 Broadway, Cambridge, MA 02139. Circle 212		
Advanced X and Motif Programming and Widget Writing	5 days	1,995
C++ Programming for Motif Developers	5 days	1,995
ICONIX Software Engineering Inc., 2800 Twenty-Eighth St., Ste. 320, Santa Monica, CA 90405. Circle 213		
An Overview of Object-Oriented Analysis and Design Methods	2 hours	995
JumpStart Training Courses in Object-Oriented Development	1-3 days	2,000/day

* Public – course offered to general public as well as corporate participants
† On site – course offered on purchasing company's premises

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Company Courses	Duration	Price ($)
Instruction Set, Natick Office Park, 209 West Central St., Ste. 312, Natick, MA 01760. Circle 214		
Introduction to Object-Oriented Design	1 day	550
A Comparison of Object-Oriented Design Methodologies	1 day	Contact vendor
Object Management Architecture Overview	1 day	Contact vendor
Understanding Object-Oriented Design	2 days	Contact vendor
Object-Oriented Programming in Smalltalk Fundamentals	4 days	Contact vendor
Object-Oriented Analysis	5 days	Contact vendor
Object-Oriented Analysis and Design Workshop	5 days	1,495
Object-Oriented Programming and C++ Primer	5 days	Contact vendor
C++ Programming Workshop	5 days	Contact vendor
Advanced C++ Programming Workshop	5 days	Contact vendor
Introduction to Smalltalk GUI Development: Visual Works	1 day	Contact vendor
Introduction to Smalltalk GUI Development: Native API	1 day	Contact vendor
Introduction to Smalltalk GUI Development: Window Builder	1 day	Contact vendor
Introduction to Smalltalk GUI Development: PARTS	1 day	Contact vendor
Interactive Software Engineering Inc., 270 Storke Road, Ste. 7, Goleta, CA 93117. Circle 215		
Object Technology and Management	1 day	395
Object-Oriented Software Construction	2 days	695
Object-Oriented Software Construction	Video-based	800
Object-Oriented Technology: A Management Overview	1 day	250+
Managing Large Object-Oriented Projects	1 day	250+
Designing Object-Oriented Libraries: The Art and Science	1 day	395
Basics of Eiffel Programming	3 days	455+
Intermediate Eiffel Programming	2 days	375+
Intermediate Eiffel Programming: Using the Libraries	3 days	455+
Intermediate Eiffel Programming in Eiffel: Building Graphical Applications	2 days	375+
Building Professional Libraries of Reusable Software Components	2 days	375+
Advanced System Analysis and Design	3 days	455+
Techniques of Eiffel Compilation	Varies	Contact vendor
ITDC Open Systems Education, 4000 Executive Park Drive, Ste. 310, Cincinnati, OH 45241. Circle 216		
C Language for Programmers	Video-based	3,250
ANSI C Programming	Video-based	3,250
Advanced C Language	Video-based	750
Using C++	Video-based	5,500
Object-Oriented Design	Video-based	5,000
Grady Booch Object Technology	Video-based	400
Introduction to Object-Oriented Technology	Computer-based	Contact vendor
Object-Oriented Analysis and Design	Computer-based	Contact vendor
C++ Programming Workshop	Computer-based	Contact vendor
SunOS Fundamentals	3 days	Contact vendor
Solaris Fundamentals	3 days	Contact vendor
SunOS System Administration	5 days	Contact vendor
Solaris Systems Administration	5 days	Contact vendor
Bourne Shell Programming	5 days	Contact vendor
Koehler Consulting, 65 Rolling Meadow Drive, Holliston, MA 01746. Circle 217		
Object-Oriented Analysis and Design	4 days	8,995
Object-Oriented Technology: A Managerial Overview	6 hours	2,250
Learning Tree International, 1805 Library St., Reston, VA 22090. Circle 218		
C Programming Hands-On Workshop	4 days	Contact vendor
C Advanced Programming: Techniques and Data Structures	4 days	Contact vendor
C++ Hands-On Object-Oriented Programming	4 days	Contact vendor
C++ Libraries, Tools and Advanced Programming Techniques: Hands-On Workshop	4 days	Contact vendor
Hands-On Visual C++: A Windows Programming Workshop	4 days	Contact vendor
Software Systems Analysis and Design: Methods and Tools	4 days	Contact vendor
Object-Oriented Analysis and Design	4 days	Contact vendor
C Programming for Business Applications	4 days	Contact vendor
Object-Oriented Methods for Business Applications	4 days	Contact vendor
Application Development Workshop	4 days	Contact vendor
C++ Object-Oriented Programming Workshop for Business Applications	4 days	Contact vendor

* Public – course offered to general public as well as corporate participants
† On site – course offered on purchasing company's premises

Company Courses	Duration	Price ($)
Martin Marietta Advanced Concepts Center, 640 Freedom Business Center, King of Prussia, PA 19406. Circle 219		
Executive Overview of Object-Oriented Methodology	½-day to 2 days	Contact vendor
Overview of Object-Oriented Methodology	2 days	Contact vendor
Object-Oriented Analysis with OMT	4 days	Contact vendor
Object-Oriented Analysis–Booch Method	4 days	Contact vendor
Object-Oriented Analysis with StP/OMT	5 days	Contact vendor
Object-Oriented Design with OMT	4 days	Contact vendor
Object-Oriented Design–Booch Method	4 days	Contact vendor
Object-Oriented Design with C++–Booch Method	3 days	Contact vendor
Object-Oriented Analysis and Design with OMT	5 days	Contact vendor
Object-Oriented Analysis and Design–Booch Method	4 days	Contact vendor
Rational Rosefor Users	2 days	Contact vendor
StP/OMT for Users	2 days	Contact vendor
Object-Oriented Project Management	2 days	Contact vendor
Object-Oriented Distributed Systems Design	2 days	Contact vendor
C++ Programming	4 days	Contact vendor
Advanced C++ Programming	4 days	Contact vendor
C++ for Non-C Programmers	5 days	Contact vendor
C Programming	5 days	Contact vendor
Advanced C Programming	4 days	Contact vendor
Distributed C++ Programming for OO Ssytems	2 days	Contact vendor
McCabe & Associates, 5501 Twin Knolls Road, Ste. 111, Columbia, MD 21045. Circle 220		
Object-Oriented Analysis and Design	4 days	1,200
Morgan, Parker and Johnson Inc., 50 Broadway, 26th Floor, New York, NY 10004. Circle 221		
Object Technology Management Overview and General Introduction	1 day	Contact vendor
Object Technology and Object Environments–Executive Level	1 day	Contact vendor
Object Technology and Object Environments–Technologist Level	5 days	Contact vendor
Object Technology Management Perspective	3 days	Contact vendor
Methodology for Object-Oriented Development	6 days	Contact vendor
Analysis for Object-Oriented Programming	5 days	Contact vendor
Design for Object-Oriented Programming	5 days	Contact vendor
OT Team Building	5 days	Contact vendor
An Introduction to Object-Oriented Programming Concepts	2 days	Contact vendor
An Introduction to Object-Oriented Programming	6 days for each language	Contact vendor
Advanced Object-Oriented Programming	5 days	Contact vendor
National Education Training Group, 1751 West Diehl Road, Naperville, IL 60563-9099. Circle 222		
Object-Oriented Executive Series	7.5 hours	Contact vendor
Strategies for Migrating to Object Computing	4 hours	Contact vendor
Principles of Object-Oriented Systems	4.5 hours	Contact vendor
Principles of Object-Oriented Design	3 hours	Contact vendor
Object-Oriented Methodology Concepts	2.5 hours	Contact vendor
Object-Oriented Analysis and Design	4 hours	Contact vendor
Object-Oriented Design: Managing Change	1.5 hours	Contact vendor
The Object Technology Forum: A Decade of Change	2 hours	Contact vendor
Object-Oriented Programming in C++	3.5 hours	Contact vendor
Object-Oriented Analysis/Object-Oriented Design Series	50-72 hours	Contact vendor
NetLinks Technology Inc., P.O. Box 7437, Nashua, NH 03060-7437. Circle 223		
Introduction to Distributed Objects Using CORBA	1 day	Contact vendor
Introduction to Distributed Objects Using COM	1 day	Contact vendor
Developing Distributed Objects Using an ORB	3 days	Contact vendor
Developing Distributed Objects Using DEC ObjectBroker	3-5 days	Contact vendor
Developing Distributed Objects Using IBM SOMobjects	3-5 days	Contact vendor
Developing Distributed Objects Using IONA Orbix	3-5 days	Contact vendor
Developing Distributed Objects Using SunSoft DOE	3-5 days	Contact vendor

* Public – course offered to general public as well as corporate participants
† On site – course offered on purchasing company's premises

Company Courses	Duration	Price ($)
O2 Technology Inc., 2685 Marine Way, Ste. 1220, Mountain View, CA 94043. Circle 224		
Introduction to Object Technology	Contact vendor	Contact vendor
Introduction to the O2 ODBMS System	—	Contact vendor
Advanced Use of the O2 ODBMS System	—	Contact vendor
Object People, 885 Meadowlands Drive, Ste. #509, Ottawa, Ontario, K2C 3N2, Canada. Circle 225		
Introduction to Visual Age	5 days	Contact vendor
Introduction to Smalltalk/V	5 days	Contact vendor
Introduction to VisualWorks	5 days	Contact vendor
Object-Oriented Technology: A Management Overview	1 day	Contact vendor
Object-Oriented Concepts: Analysis and Design	5 days	Contact vendor
Building Applications Using Smalltalk	5 days	Contact vendor
Building Applications Using VisualAge and Smalltalk	5 days	Contact vendor
ENVY	2 days	Contact vendor
Immersion Programs	2-6 weeks	Contact vendor
Online Consulting Inc., 913 Market St., 6th Floor, Wilmington, DE 19801. Circle 226		
C++ and Object-Oriented Programming Introduction	3 days	885
C++ Advanced Programming	2 days	790
C++ for Non-C Programmers	5 days	1,495
PowerBuilder Introduction	3 days	1,185
PowerBuilder Advanced DataWindows	2 days	790
Visual Basic Programming Introduction	2 days	590
Visual Basic Programming Advanced	3 days	1,185
Open Systems Training, 4400 Computer Drive, Mail Stop G-153, Westboro, MA 01580. Circle 227		
C++ Object-Oriented Programming Workshop	3 days	Contact vendor
Introduction to C Programming	—	895
How To Write in ANSI C	5 days	Contact vendor
Palladio Software Corp., 16535 West Bluemound Road, Ste. 360, Brookfield, WI 53005. Circle 228		
Introduction to Object-Oriented Technology	1 day	2,550
Manager's Overview of Object Technology	1 day	2,550
Object-Oriented Analysis and Design Workshop	4 days	11,500
Object-Oriented Project Management	1 day	2,875
Project Kickstart	Custom	Contact vendor
Project Technology Inc., 5800 Campus Circle Drive, Ste. 214, Irving, TX 75063. Circle 229		
Fundamental Concepts of the Shlaer-Mellor Method	2 days	950 public*/1,200 on site†
Successful Deployment of a Software Development Process: The Shlaer-Mellor Method	1 day	5,500
Object-Oriented Analysis: Domains and Objects	5 days	1,800 public*/1,8000 on site†
Object-Oriented Analysis: States and Processes	5 days	1,800 public*/1,8000 on site†
Recursive Design: Implementation through Translation	5 days	2,000 public*/20,000 on site†
Quality Software Engineering, P.O. Box 303 Beaverton, OR 97075. Circle 230		
C++: Programming, Paradigms and Techniques	5 days	Contact vendor
Programming with Tools.h++	5 days	Contact vendor
R.S. Pressman & Associates Inc., 620 East Slope Drive, Orange, CT 06477. Circle 231		
Reengineering Strategies	Video-based	895
Object-Oriented Methods	Video-based	895
Rational, 2800 San Tomas Expressway, Santa Clara, CA 95051. Circle 232		
Executive Overview of Object Technology	½ day	Contact vendor
Introduction to Object-Oriented Methodology	4 days	Contact vendor
Object-Oriented Analysis	4 days	Contact vendor
Object-Oriented Analysis and Design	4 days	Contact vendor
Object-Oriented Design for Ada	4 days	Contact vendor
Object-Oriented Design for C++	3 days	Contact vendor

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Company Courses	Duration	Price ($)
Semaphore, 800 Turnpike St., North Andover, MA 01845. Circle 233		
MANAGEMENT COURSES		
Executive Overview of Object Technology	1 day	3,950
The Object-Oriented Paradigm for Technical Managers	1 day	3,950
The Object-Oriented Paradigm	1 day	3,950
The Object-Oriented Paradigm and Technology	2 days	6,950
Managing Object-Oriented Software Development	2 days	6,950
Object Database Technology for Technical Managers	1 day	3,950
ANALYSIS AND DESIGN COURSES		
Object-Oriented Analysis	3 days	9,850
Object-Oriented Design	3 days	9,850
Object-Oriented Analysis & Design	5 days	13,995
Object-Oriented Analysis & Design Using the Object Modeling Technique	5 days	14,995
Object-Oriented Analysis & Design for Real-Time Systems	5 days	13,995
Advanced Object-Oriented Analysis & Design Workshop	1-3 days	11,500
Comparison of Object-Oriented Methodologies	2 days	6,950
PROGRAMMING COURSES		
Introduction to Object-Oriented Programming in Smalltalk	5 days	12,995
Advanced Object-Oriented Programming in Smalltalk	5 days	12,995
The C++ Language	3 days	8,850
Introduction to C++ and Object-Oriented Design	5 days	12,995
Intermediate C++ and Object-Oriented Design	5 days	12,995
Advanced C++ and Object-Oriented Design	5 days	12,995
Efficient Implementation of Object-Oriented Design in C++	1 day	3,495
Developing Object-Oriented Software in C++	5 days	12,995
C++ and Object-Oriented Design for Non-C Programmers	7-10 days	22,950
An Introduction to Object-Oriented COBOL	5 days	12,995
APPLICATION COURSES		
An Overview of OMG's CORBA	½ day	1,995
Integrating Applications Using CORBA	1 day	4,495
Building Distributed Systems Using CORBA	5 days	14,995
The Microsoft Visual C++ Environment	5 days	14,995
An Overview of Borland's ObjectWindows Library	3 days	9,850
Introduction to Windows Using Borland's ObjectWindows Library	5 days	14,995
Developing Applications with Object Databases	3 days	8,850
Integrating Object Databases into Heterogeneous Environments	2 days	5,950
Sun Microsystems Computer Corp. Educational Services, UMIL02-34, 2550 Garcia Ave., Mountain View, CA 94043. Circle 234		
VW-210/Executive Introduction to Object-Oriented Technology	1 day	1,800
VW-235/Object-Oriented Design	4 days	4,900
VW-265/Using C++	5 days	5,500
VW-365/Advanced C++	2½ days	3,600
OO-220/Object-Oriented Analysis and Design Using C++	5 days	1,750
SL-290/Data Structures in C++	5 days	1,750
Syrinx Corp., 236 West 26th St., Ste. 7SW, New York, NY 10001. Circle 235		
Strategies and Tactics: Executive Program	1 day & customization	Contact vendor
Introducing Object Technology: A Manager's Planning Guide	1 day	2,500
Technical Mechanisms of Object Technology: A Developer's Introduction	1 day	2,500
Objects and Object Databases: An Introduction for Data and Database Professionals	1 day	2,500
Object Analysis, Design and CASE: An Introduction for Methodology and CASE Professionals	1 day	2,500
Comparative Analysis and Design: An Overview of the Currently Popular Techniques	1 day	2,500
Object-Oriented Requirements	2 days + 1 day exercise customization	Contact vendor
Object Analysis & Design Foundation	2 days + 1 day exercise customization	Contact vendor
Object System Design Using CRC	3 days + 1 day exercise customization	Contact vendor
Object-Oriented Software Engineering: A User Case-Driven Approach	5 days + 1 day exercise customization	Contact vendor
Programming Languages: C++, Smalltalk and Objective C	5 days + 1 day exercise customization	Contact vendor
Implementing the Object Model in Smalltalk	3 days + 1 day exercise customization	Contact vendor
Implementing Object Systems: From Design to Code	3 days + 1 day exercise customization	Contact vendor
Inspections of Object Development Materials	1½ days + ½ day exercise customization	Contact vendor
Managing Object Projects	2 days + 1 day exercise customization	Contact vendor
The Object Toolset	1 day + 1 day exercise customization	Contact vendor
Programming Language Courses	Customized	Contact vendor
Implementing Object Systems	Customized	Contact vendor
The Object Toolset	1 day	2,800
Inspections of Object-Oriented Systems	2 days	5,200
Testing Object Systems	Customized	Contact vendor
Managing Object Projects	Customized	Contact vendor

* Public – course offered to general public as well as corporate participants
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Company Courses	Duration	Price ($)
Technology Exchange Co., One Jacob Way, Reading, MA 01867. Circle 236		
Object-Oriented Software Engineering	4 days	1,500
Object-Oriented Analysis and Design	4 days	1,500
C++ Programming for Non-C Programmers: Concepts, Design and Implementation	4 days	1,600
C++ Programming: Concepts, Design and Implementation	4 days	1,600
Advanced C++ Programming and Techniques	4 days	1,600
Tower Technology Corp., Educational Services, 1501 West Koenig Lane, Austin, TX 78756. Circle 237		
Object-Oriented Concepts, Programming and Design	2 days	3,500
Eiffel: The Essentials	1 day	1,850
The Booch Method of Object-Oriented Analysis and Design and Eiffel in Action	1 day	2,500
Introduction to Object-Oriented Design and Programming with Eiffel	5 days	8,750
Advanced Design and Programming with Eiffel	5 days	9,500
Design Your Own Course	Contact vendor	2,250/day
University of California Extension, 740 Front St., Ste. 155, Santa Cruz, CA 95060. Circle 238		
Object-Oriented Programming	Approx. 4-month course	Contact vendor
Outline of Video Lectures/C++ and Object-Oriented Programming: An Overview	Video tape lecture series	56
Object Creation and Destruction	5-hour video training course	217
Parametric Polymorphism: Templates	5-hour video training course	217
UniWorx Inc., P.O. Box 910154, San Diego, CA 92191. Circle 239		
Overview of Object-Oriented Programming	4-5 days	Contact vendor
C++ Programming Workshop	4-5 days	Contact vendor
Advanced C++ Programming Workshop	4-5 days	Contact vendor
Object-Oriented Analysis	4-5 days	Contact vendor

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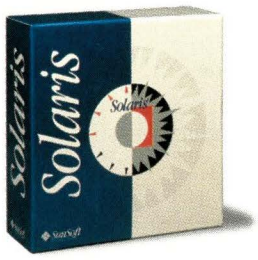
Run  on intel inside® now.

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Visual Thought 1.0 and microCOMPstation II

by SIMSON L. GARFINKEL, Senior Editor

This month we review a sophisticated and easy-to-use technical drawing package and a SPARCstation 5 clone with a bargain-basement price.

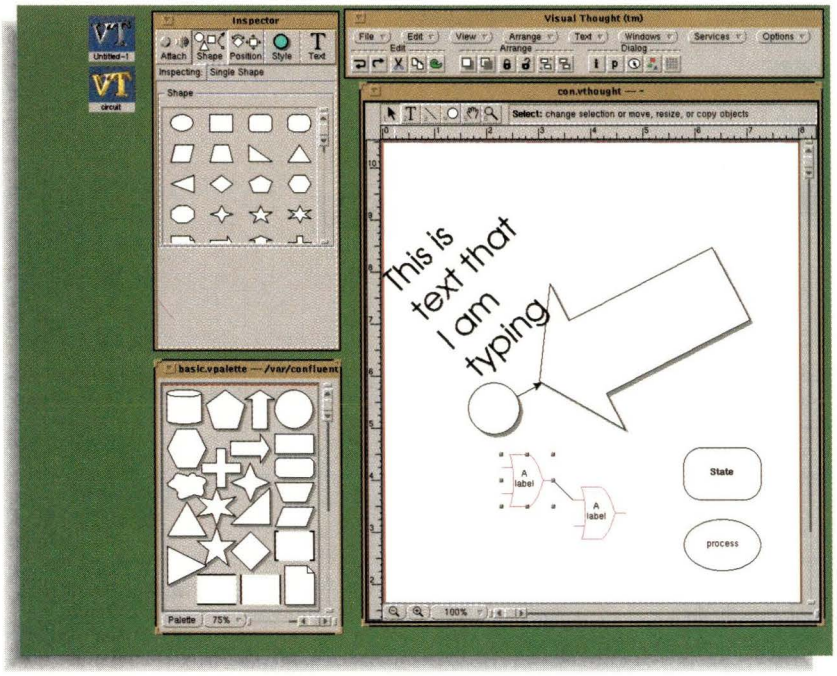
Visual Thought 1.0

If you ever have to make a sign, prepare a presentation or create some technical drawings, you can't go wrong with Visual Thought 1.0, by Confluent Inc.

Visual Thought could be the most sophisticated technical drawing package available for SPARC systems today. Indeed, it may be the most sophisticated technical drawing package on any platform–something of a rarity in this day when most Macintosh and Windows "productivity applications" can run circles around similar UNIX programs.

What gives Visual Thought its gusto is a simple philosophy: When you make a change, you see it instantly on the screen. Click a mouse on an object to drag it, and the object–not a wire frame–moves with your cursor, hiding and exposing other objects as it moves along. Click the mouse in the drawing window and start to drag, and "handles" will appear around objects as they fall within the selection rectangle. Click on a handle to resize an arrow, and you'll see the arrow get bigger or smaller as you move the mouse, exposing or hiding objects underneath. Change the width of a box containing text, and you'll see the paragraph automatically wrap to fit the current width.

Even if Visual Thought's features stopped right there, it would still be one of my favorite drawing tools. Instantaneous feedback is a godsend when trying to draw a complex diagram. It lets you spend your time thinking about the drawing at hand, rather than trying to second-guess what your drawing program is going to do when you let go of the wire frame.



Visual Thought is something of a rarity: a sophisticated UNIX-based technical drawing package.

With Visual Thought, you really do think on your workstation's screen.

Instantaneous feedback is great, but it's also only the start of Visual Thought's impressive feature list. Simply put, Visual Thought is a drawing program with a vengeance. When you start up Visual Thought, the program displays a drawing canvas, a palette of building blocks and a feature called the Inspector. Want a square in the middle of canvas? Drag it off the palette. Once the square appears on the canvas, you can drag it around or grab it by one of its handles to resize it. If you've ever used MacDraw, you'll have no problem.

Now let's say you want to title the square with some text. No problem. Just double-click in the square's center. A label appears, ready to be filled.

Once you drag a few objects onto your canvas, you can connect them with a curve or a line. Lines can attach to the center of objects or to specified attachment points. Once connected, the line sticks to the objects, even if one or both of the objects are moved. It's the simplest way on the planet to build an organizational chart.

To make things really interesting, explore Visual Thought's Inspector, the panel in the upper-left-hand corner of the screen. With the Inspector, you can change the object's shape (there are 81 objects to choose from); change its position, size and rotation (in case you want the arrow to be exactly 3 inches by 4 inches and at a 47-degree angle); change its style (stroked, filled, line type, shadowed and so forth); and change the font of any text that the object might contain. You can attach files to objects, allowing you to have Visual Thought play sounds or open other applications when the objects are clicked.

The Inspector changes depending on what you've got selected. Draw a line between two objects, for example, and you'll have a choice of 14 different arrowheads, including white, black, hooked, single, double and so on. Want to undo something you've changed? Don't worry: There are 100 levels of undo/redo. You can even tell Visual Thought to select every instance of a particular kind of object (like all of the circles).

If you get tired of Visual Thought's built-in shapes, you can group objects together to build compound, hierarchical objects. If you like your objects a lot, you can put them on your own palettes and then share them with other people. Overwhelmed? Don't worry. Confluent provides 11 palettes; four are specialized for object-oriented design.

With Visual Thought, you can make a drawing that is as big as you want. You then print the drawing as a number of pages and tape them together. With the Page Layout panel, you can also set your paper size, the scale for the printout and the margins to use. Files can be exported in EPS or GIF format, in addition to the program's internal format. A "Services" menu allows you to do screen captures–either the selection, the window or your entire screen. There's even a Suggestion Box, which lets you compose a little note to Confluent and send it to the company via email.

In case you haven't gotten the idea yet, I like this product.

If Visual Thought's gusto comes from its design philosophy, its power comes from two other sources. The user interface, application and object-based approach to technical drawing all come from the Visix Software Inc. Galaxy object-oriented application development environment. With it, Visual Thought's programmers were able to build a 1.0 product that has an amazing amount of features *and* is incredibly reliable: I could find only a few minor bugs with the program. (Other users might not find any in day-to-day activities.)

The other source for Visual Thought's power is Diagram!, a similar technical drawing program written for the NextStep operating system by Lighthouse Design, in San Mateo, CA. To be blunt, Visual Thought seems to be a direct clone of Diagram!. While imitation may be the most sincere form of flattery, I was surprised that I found no mention of Diagram! or Lighthouse Design in Visual Thought's documentation.

I have used Diagram! for more than three years, and the program has been an invaluable aid to me during that time. Although Lighthouse Design will probably port Diagram! to Solaris once Sun's OpenStep partnership with NeXT bears fruit, OpenStep won't run on SunOS and OpenStep is at least six months away. For that reason, I can recommend Visual Thought without reservation.

Visual Thought 1.0

Company
Confluent Inc.

Address
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Phone
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microCOMPstation II

Tatung's microCOMPstation is a SPARCstation 5 clone that is competitively priced with Sun Microsystems Inc. hardware. For those with absolute budget limits, Tatung's bottom-of-the-line price of $3,550 beats out Sun's ($3,995) by $445. (To be fair, Sun's bottom-line configuration also features a better 15-inch monitor, a higher-resolution graphics card and a bundled license for Solaris 2.4.)

For those who want more features,

Configurations Menu

microCOMPstation 85 MHz (microSPARC II)	$3,490
GX graphics card	$655
17-inch Sony Trinitron monitor	$1,455
3½-inch 1-GB Fujitsu hard disk	$950
16 MB extra RAM	$860
Solaris 2.3	$195
Floppy disk drive	$80
Stand-alone CD-ROM drive	$995
Total reviewed configuration price	**$8,680**

Tatung has a bundled system that includes an 85-MHz microSPARC II, 16 MB of RAM, Turbo GX Graphics Card, 1-GB hard disk and a 20-inch color display for $6,645, or $7,505 with 32 MB of RAM. Sun's loaded SS5 includes a 17-inch TGX card, 32 MB of RAM and a 1.05-GB hard disk for $9,595.

The microCOMPstation comes in a traditional "pizza-box" configuration with Tatung's attractive styling and a 3½-inch floppy disk drive on the front. Inside are three disk drive bays (one for the floppy, one for the hard disk and one spare), a fairly clean system board, three SBus slots and a powersupply (manufactured by Sony). There is space for eight memory SIMMs, and jumpers to select between RS-232 and RS-423 on the serial port. The back of the system features a SCSI-II connector, a DB15 AUI Ethernet interface connector, a single 25-pin serial connector for both serial ports (accessing serial port B requires a special Y-Cable), a parallel port adapter and Mini-Din8 connectors for keyboard/mouse and audio. The system does not have a hard-disk activity light.

We tried two monitors from Tatung. The first was the standard 17-inch color video monitor ($935), manufactured by the company itself, and the second was a 17-inch Sony Trinitron monitor ($1,455), which provided trouble-free operation. (Beware of manufacturer measurements: Even though Sony calls this a 17-inch monitor, we measured it across the diagonal and found only 16 inches of the monitor's glass shows through the plastic bezel; the usable screen area was 14.5 inches across the diagonal.)

Tatung's CD-ROM drive (a Sony CDU-8012) comes in Tatung's "shoe-box," a 12-inch high minitower with places for four half-height devices and a four-gang SCSI setting switch on the back. We can't figure out why Tatung is still shipping a single-speed CD-ROM drive and case for $995 when PC vendors now are selling multimedia 486 systems with double-speed CD-ROM drives, 4 MB of RAM, sound cards and 200-MB hard disks for roughly the same price.

Be forewarned the first time you turn on this system: The micro-COMPstation doesn't start sending video to the monitor until 62 seconds after you turn on the power switch. This can be downright disconcerting, especially since there is no mention made of this "heart attack" feature in Tatung's documentation.

Tatung's microCOMPstation II series can offer savings of nearly $2,000 off Sun's list price.

Once the system starts up, it's hard to tell it apart from SMCC's own hardware. Tatung ships stock Sun operating systems without any modifications. The SPARC binaries run problem-free.

The microCOMP scored 63,224 dhrystones when the benchmark was compiled with GCC Version 2.5.7–performance that one would expect for this machine. In user testing, programs like Frame Technology Corp. Framemaker, WordPerfect Corp. WordPerfect and CAD applications performed well, although the CPU was clearly bottlenecked by the feeble graphics controller. Performance with Apple Computer Inc.'s Macintosh Application Environment was sluggish–the emulated Macintosh seemed to perform no faster than a Mac IIsi for most on-screen tasks, but this is a problem to lay at the feet of Apple.

Our single software problem related to recognizing Tatung's CD-ROM drive under the Solaris operating system. We installed a fresh copy of Solaris 2.3 from the CD-ROM drive. Nevertheless, the Solaris failed to recognize CD-ROMs inserted into the drive until we rebooted the operating system with the `-r` flag to reconfigure the device table (something we didn't have to do after installing Solaris on a Sun SPARCclassic). After a few calls to Tatung's very friendly technical support department, we discovered that they were as baffled by this problem as we were.

Ergonomically, the Tatung's keyboard is a pleasure to use, although rigorously following Sun's key placement means that typos and accidental function-key presses are still all too common. The mechanical mouse is a vast improvement over Sun's optical mice. (Tatung does not provide a mouse pad.) Noise is another matter: The microCOMP's fan and internal hard drive make the unit stand out in a quiet office. We measured 60 decibels of noise with a sound meter sitting more than a foot from the system's base unit. (For comparison, background in a quiet office is between 52 and 55 decibels; our Macintosh IIvx barely registered 56 decibels.)

Tatung's documentation is, on the whole, a little disappointing. Along with the microCOMPstation, the company supplied us with a manual entitled "Tatung SPARC Systems," which purports to cover eight different machines, including the company's Classic/LX, SS2, SS5, SS10 and SS20 clones. A more helpful booklet is Tatung's "Guide to Basic System Administration," although it only covers administration of SunOS 4.1.x.

With savings of nearly $2,000 off Sun's list price for fully loaded systems, there are strong financial reasons to consider purchasing one of Tatung's clones. The fact that the microCOMP runs Solaris without any modifications makes the decision even easier: Even if Tatung stopped software support of microCOMPs (and there is no reason to suspect that it will), people who had purchased one of these workstations would still be able to run Solaris for many years to come.

microCOMPstation II Series

Company
Tatung Science and Technology Inc.

Address
1840 McCarthy Blvd.
Milpitas, CA 95035

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- GIS
- Virtual reality

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MAY

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- Accessing and cruising (GUIs and WWWs)
- Security
- The commercial side – CommerceNet

BONUS DISTRIBUTION
SunWorld – *San Francisco, CA*

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Carol Flanagan (617) 738-3402

NEW PRODUCTS

The product descriptions are compiled from data supplied by the vendors. To contact them for more detailed information, circle the appropriate reader service number on the card located elsewhere in the magazine.

ObjectSpace Shows Object Libraries

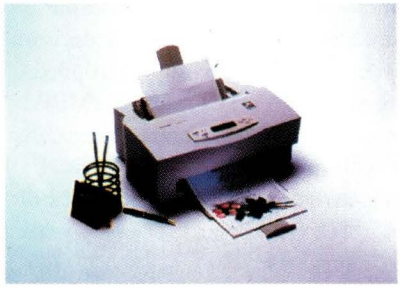
ObjectSpace has announced a line of object-oriented coding tools for developers working in Smalltalk and C++: ObjectSockets, ObjectSystems, ObjectMetrics and ObjectCatalog.

ObjectSystems, at $875 per user, is a C++ framework that resides between an application and UNIX. The company says that developers can use it as an alternative to writing their own interface to the operating system. ObjectSockets, at $695, is a class library that gives Smalltalk programs TCP/IP functionality. ObjectMetrics, at $595, is a metrics analysis tool for Smalltalk. Finally, ObjectCatalog, at $695, is an object cataloging system to help companies keep track of what software objects they own and how those objects might be reused.

ObjectSpace Inc.
14881 Quorum Drive, Ste. 400
Dallas, TX 75240
Circle 101

Tektronix Tweaks Printers

Tektronix has announced two new color printers: the low-end Phaser 140 and the midrange Phaser 540 laser printer. The 140 Bubble Jet,



at $1,695, is a color printer designed for home offices and small businesses. It supports PostScript Level 2 and uses Tektronix's thermal liquid ink-jet process to provide color output of up to one page per minute.

The $8,995 540 laser printer can output photographs, scanned images and business graphics in 300 or 600 dpi. The 540's output is 4 ppm in full color, and 14 ppm in monochrome.

Tektronix Inc.
26600 S.W. Pkwy.
P.O. Box 1000
Wilsonville, OR 97070-1000
Circle 102

SPARCstation V VME Board

Force Computers has introduced the SPARC CPU-51E, a microSPARC II-based VME board that is a SPARCstation 5-compatible in a 6U form factor. The CPU-51E is intended to be sold into telecommunications and data communications markets. The product includes dual Ethernet and fast SCSI channels. Force says this gives the CPU-51E the fault-tolerant I/O capabilities required by telephony applications.

Cray Shows 'Pocket' Supercomputer

Cray Research is to supercomputers what Xerox is to copiers and Kleenex is to tissues. So fundamental is the identification between the firm and the product class that it is an accepted, if incorrect, common usage to refer to any supercomputer as a "Cray."

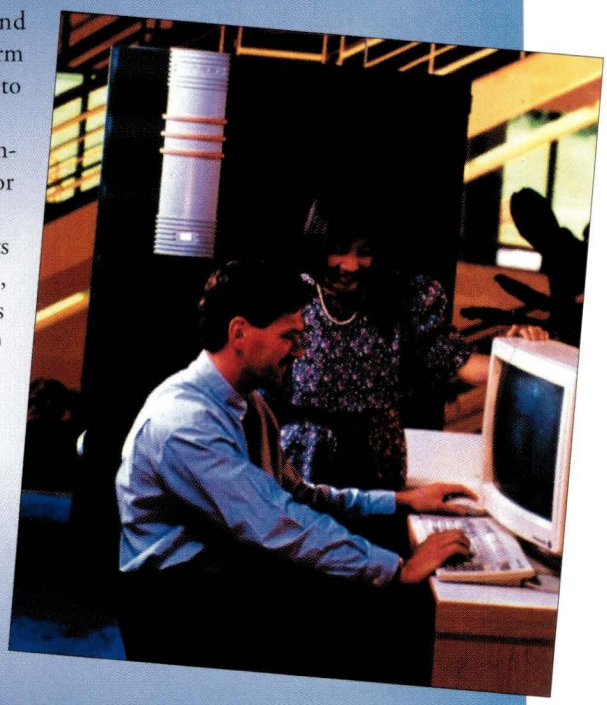
Cray has also had a long relationship with Sun users. In fact, the company's San Diego-based division, Cray Servers, markets a multiprocessor device based on the SPARC.

Now, however, Cray's Eagan, MN-based headquarters has announced its own entry into the small-size supercomputer arena. Called the Cray J916, the product is a UNIX-based server that can support up to 16 of Cray's own processors. Each of these 16 processors can provide up to 200 MFLOPS apiece, with a total peak performance of between 0.8 and 3.2 GFLOPS. The J916 has up to 250 GB of disk storage and up to 4 GB of internal memory as well as a memory bandwidth of up to 25.6 GB/s.

In addition, the J916 has 1 to 16 VME-64 I/O subsystems, for a total of 1.6 GB of I/O bandwidth, as well as one HIPPI to memory channel for each CPU. Multiple J916s can be clustered to produce a system with a peak performance approaching 100 GFLOPS.

The J916 measures 12 feet by 12 feet and weighs 1,400 pounds. Pricing begins at $225,000.

Cray Research Inc.
655 Lone Oak Drive
Eagan, MN 55121
Circle 100



The CPU-51E has two SBus slots, 8 to 128 MB of DRAM and supports Solaris 2.3 and Solaris 1.1B. Pricing begins at $6,495.

Force Computers Inc.
2001 Logic Drive
San Jose, CA 95124
Circle 103

Galaxy Building Tool

Visix Software sells Galaxy for users and developers who need a common, X-based environment across multiple platforms. Now, Visix is introducing the Galaxy Visual Builder Integration Kit, or VBI, a product that makes it easier for developers to customize and extend the Galaxy environment. It is the first Galaxy add-on to be offered by Visix.

The VBI Kit can modify, extend or build new Galaxy objects. It can also modify standard Galaxy editors to operate on the extended Galaxy objects within the VBI itself. Pricing begins at $4,995.

Visix Software Inc.
11440 Commerce Park Drive
Reston, VA 22091
Circle 104

Solaris x86 Networking

SunSoft, Sun Microsystems' software planet, has introduced an assortment of new products to provide Solaris x86 systems with WAN and LAN connections. The first of these is SunLink X.25, which enables Solaris x86 systems to act as an X.25 gateway. Pricing begins at $2,295.

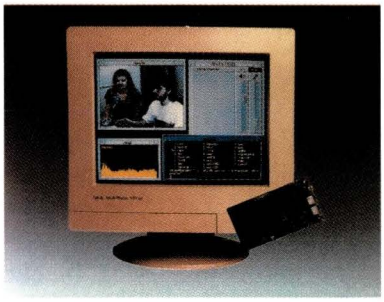
The second product is SunLink X.400 for Solaris x86, which, like SunLink, had previously been available only for SPARC. The X.400 is a mail backbone server for public and private networks and includes a gateway for connecting X.400 networks to Simple Mail Transfer Protocol (SMTP) networks, including the Internet. Pricing begins at $4,795.

SunSoft also announced SunLink OSI for Solaris x86, which allows applications that use OSI APIs to run over TCP/IP networks. Pricing begins at $1,495.

SunSoft Inc.
2550 Garcia Ave.
Mountain View, CA 94043-1379
Circle 105

Sun-Based Digitizer

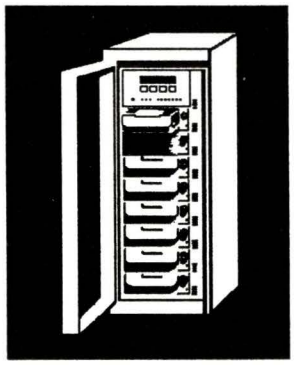
Vigra has introduced the VigraPIX, an SBus card that enables Sun workstations to capture data from standard



video sources. The card has one composite video and two S-video inputs and is capable of digitizing RS-170, NTSC, PAL and SECAM signals for display via standard frame buffers. Pricing begins at $999.

Vigra
A division of VisiCom Laboratories
6044A Cornerstone Ct.
San Diego, CA 92121
Circle 106

RAID SUBSYSTEM FROM UNI SOLUTION, INC.



Uni Solution has designed an exceptionally modular, flexible and expandable *RAID* subsystem. You can change components by simply snapping in devices, fans and power supplies without ever having to power down the system.

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Circle No. 28 on Inquiry Card

Modular Storage Galore

Box Hill Systems Corp. has introduced the Mod Box 5000, an easy-to-configure-and-maintain modular data storage and backup system. According to the company, the Mod Box 5000 features hot-swappable components and supports a high degree of fault tolerance.

Each Mod Box 5000 module can house a wide variety of components: disk, tape, solid state or optical drives and auto-loading tape media changers.

Components available for the Mod Box 5000 include 4-GB 3½-inch and 10.8-GB 5¼-inch disk drives, a fast 20-GB Digital Linear Tape drive, a 2.0-GB multifunction optical drive and a solid-state drive, with capacities of up to 856 MB. RAID level 0, 3 or 5 fault tolerance for disk storage can be added simply, as a specialized set of components made up of Box Hill's dual-ported, dual-controller, hot-sparing, Super-Fast Cache RAID Box 530 module.

Modules feature independent power supplies and cooling fans, making every component in the Mod Box 5000 hot-swappable–components can be removed and replaced without powering down the entire system. Through an intelligent front-panel display, modules are easy to configure and maintain.

The Mod Box 5000 can mount in any standard 19- or 24-inch rack, or sit on a desktop. The product is compatible with Sun Microsystems Computer Corp., Hewlett-Packard Co. HP9000 700 or 800 series, IBM RS/6000, Silicon Graphics Inc., NEC America Inc., NCR Corp., Digital Equipment Corp. Alpha and Cray Research Inc. CS6400 systems, as well as Novell Inc. networks.

Pricing depends on configuration, and Box Hill products include seven-day-a-week, around-the-clock technical support.

Box Hill Systems Corp.
161 Avenue of the Americas
New York, NY 10013
Circle 107

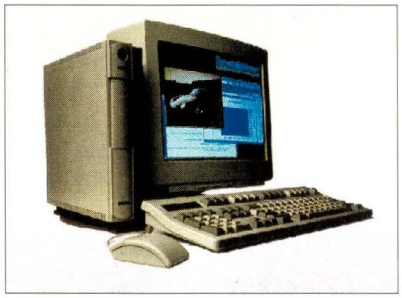
File-Shadowing Software

Zzyzx has introduced Zshadow, a UNIX file-system shadowing product. Zshadow takes "snapshots" of a SPARC workstation's file system. This allows the user to return to a previous version of the file system with a single mouse click. The product's UNIX file system "watchpoints" are placed in the application's "special save" area on a system hard drive. Any file maintained by the product can then be retrieved for browse or write access. Users can specify how much disk space Zshadow can use and how many watchpoints it will maintain. Pricing on the Zshadow begins at $1,195.

Zzyzx
5893 Oberlin Drive
San Diego, CA 92121
Circle 108

Digital Shows NT Terminal

Digital Equipment has introduced the Multia Multiclient Desktop, a terminal based on the 166-MHz Alpha RISC processor and running the NT operating system from Microsoft Corp. NT and DOS programs can be downloaded and run locally.In addition, the machine supports the X11.R6 and can display X-based applications run remotely. It can also emulate the VT100 terminal.



The Multia's effectiveness is based on the PCI bus. It comes with Ethernet connections for ThinWire, ThickWire and twisted-pair cables. It also has PCMCIA and PCI option slots, and there is a local floppy disk drive option. Included are 24 MB of memory, which can be expanded to 256 MB.

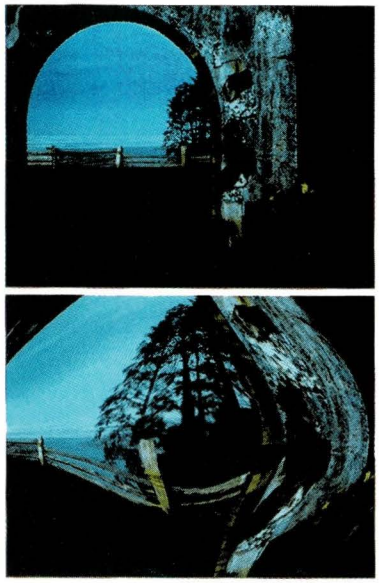
The company insists that the Multia is not a diskless RISC PC that happens to have built-in networking. Rather, says Digital, it is meant for the business executive who needs local business productivity applications, plus access to corporate resources housed on UNIX servers, but who doesn't want to deal with system and network administration issues.

Entry pricing on the Multia ranges from $3,495 to $6,000, depending on configuration.

Digital Equipment Corp.
146 Main St.
Maynard, MA 01754-2198
Circle 109

Warping Software

Autometric has introduced WarpIt, a library of C-callable subroutines that geometrically transform images and other two-dimensional data arrays. WarpIt allows the user to perform simple first-order transformations, such as rotate, scale and translate, as well as higher order warps to introduce curves and other transformations.



WarpIt can be purchased as a stand-alone package for $2,500, but OEM buyers may receive a discount.

Autometric Inc.
5301 Shawnee Road
Alexandria, VA 22312-2333
Circle 110

Web Server

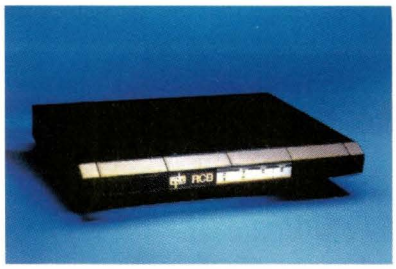
Want to get your company's products onto the World Wide Web? Unipress Software has announced its new W3 Division, offering such services as start-up, document creation and other Web server tasks to help get companies on the Net as quickly as

possible. W3's services include determining local Internet and WWW requirements, finding an Internet provider within the company's budget, converting logos and other documents to HTML and establishing an HTTP server at company headquarters or at Unipress. Unipress charges $750 per day for consulting and extensive document projects, with a minimum of one service day.

Unipress Software Inc.
2025 Lincoln Hwy.
Edison, NJ 08817
Circle 111

Remote Compression for Token Ring

Rad Network Devices has introduced the RCB-TR, a remote compression bridge for token-ring LANs. The RCB-TR provides data compression at 4:1 for link speeds of up to 2.048 Mb/s. Rad says the product thus becomes more useful for remote sites that may have to link to a corporate backbone over low-bandwidth media.



The RCB-TR comes with one token ring and two WAN interfaces. Pricing begins at $3,095.

Rad Network Devices Inc.
3505 Cadillac Ave., Ste. G5
Costa Mesa, CA 92626
Circle 112

Cognos Shows Impromptu

Cognos has announced a new version of Impromptu, a reporting tool that can interact with several leading databases. Impromptu resides on a PC or other desktop client and can be used to build reports based on information from such server-based RDBMSs as Sybase, Oracle and MS SQL Server. Impromptu Version 3.0 features easier use, a new set of "frames" (basic building blocks that users can access to build their own reports) and improved integration with Microsoft Corp.'s OLE. Pricing begins at $495 for a user's version and $595 for an administrator's version.

Cognos Corp.
67 S. Bedford St.
Burlington, MA 01803-5164
Circle 113

Upgrades, Enhancements, Additions...

• X terminal vendor Human Designed Systems has shown three applications for its video-ready X terminals. Collectively known as HDS netVideo, these applications include HDSconference, which permits X Window terminal users to set up a conference while viewing each other in windows on their terminal screens; HDS netTV, which allows one X Window terminal to broadcast video and audio over Ethernet or token ring to other terminals via IP technology; and HDStuner, which permits users of HDS X Window systems to connect a cable or antenna directly to their X Window terminals and watch broadcast video on the screen. **Human Designed Systems Inc.**, 421 Feheley Drive, King of Prussia, PA 19406. **Circle 114**

• Tech-Source has reduced the price of its GXTRA/10 image display controller subsystem. The new price is $12,950, which the company says is a 32% discount. **Tech-Source Inc.**, 442 S. North Lake Blvd., Altamonte Springs, FL 32701. **Circle 115**

• Cygnus Support and Wind River Systems Inc. have announced an agreement. Cygnus will provide support for developers who use GNU tools to produce applications that run on Wind River's VXWorks real-time operating environment. **Cygnus Support**, 1937 Landings Drive, Mountain View, CA 94043. **Circle 116**

• New graphing and hard-copy features have been added to Advanced Visual Systems' AVS 3D visualization software. The new release contains AVS/Graph, which supports a variety of plot types–including curve, bar, polar, scatter and log–and PostScript output. **Advanced Visual Systems Inc.**, 300 Fifth Ave., Waltham, MA 02154. **Circle 117**

• QMS has announced a new price on its QMS 3225 Print System, a 32-ppm network-compatible printer. The product's new price is $16,499. **QMS Inc.**, One Magnum Pass, Mobile, AL 36618. **Circle 118**

• For those who need to run X on Macintosh platforms, AGE Logic has ported its Xoftware to the Mac. The Xoftware X server is available for both Motorola Inc. 68000- and PowerPC-based Macintoshes. **AGE Logic Inc.**, 9985 Pacific Heights Blvd., San Diego, CA 92121. **Circle 119**

• Canon Computer Systems has added optical character recognition to its IX-4015 color scanner. The scanner will be bundled with a free copy of Caere Corp.'s OmniPage Direct optical character recognition software. **Canon Computer Systems Inc.**, 2995 Redhill Ave., Costa Mesa, CA 92626. **Circle 120**

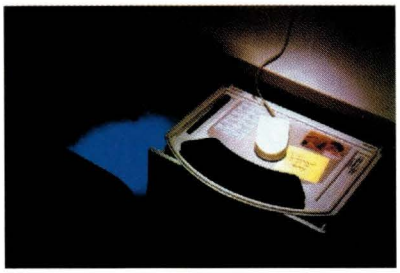
• Tower Technology has announced TowerEiffel for users who need to combine the Eiffel object-oriented language with Motif GUIs. The product combines the company's Eiffel programming environment with the X-Designer Motif development environment from VI Corp. and Imperial Software Technology. **Tower Technology Corp.**, 1501 West Koenig Lane, Austin, TX 78756. **Circle 121**

• Reasoning Systems has released Version 4.0 of its Software Refinery rapid development environment for UNIX. Version 4.0 contains Workbench, a library of reusable reverse-engineering components including structure charts, flow graphs and coding standards. **Reasoning Systems**, 3260 Hillview Ave., Palo Alto, CA 94204. **Circle 122**

• Carnegie Mellon University's Andrew Consortium has released Version 6.3.1 of its Andrew User Interface. Version 6.3.1 includes editors for drawings and images. Andrew is a compound document architecture that enables users to create formatted documents embedded with objects, such as pictures and tables. **The Andrew Consortium**, Carnegie Mellon University, Pittsburgh, PA 15213-3890. **Circle 123**

Mouse Platform

Ring King has introduced the Easy Reach Mouse Platform, designed to



reduce a computer user's hand and arm strain. The product positions the mouse at the user's side instead of forcing him or her to reach across the desk for it. The Easy Reach Mouse Platform begins at $19.95.

Ring King Visibles Inc.
2210 Second Ave.
P.O. Box 599
Muscatine, IA 52761-0599
Circle 124

Call Me Ishmail

HaL Software Systems, the software division of HaL Computer Systems, has introduced a new email package. Ishmail, short for information superhighway mail, is a multimedia email product and features a Motif GUI and MIME support. Ishmail is available on Sun OS and Solaris, AIX, HP-UX and DEC OSF 1. Pricing begins at $99.

HaL Software Systems
3006A Longhorn Blvd.
Austin, TX 78758
Circle 125

NutCracker for UNIX to Windows

Datafocus is known for its NutCracker products, which assist developers in porting UNIX code to NT. The company has now unveiled the NutCracker X/Software Development Kit (X/SDK). The X/SDK allows X- and Motif-based GUI applications to be moved to Windows NT.

The company says that X/SDK does not emulate UNIX on Win32. Rather, it allows developers to recompile their UNIX and X/Motif source code and link it to NutCracker's DLL, resulting in Win32 applications. Pricing on the X/SDK begins at $2,995.

DataFocus Inc.
12450 Fair Lakes Circle, Ste. 400
Fairfax, VA 22033-3831
Circle 126

C++ Joins SQL

Rogue Wave Software has announced DBtools.h++, a tool that supports C++ programmers who work with SQL database applications. The product is a library of foundation classes that provide developers with an interface to several major relational databases, which encapsulate relational constructions (such as tables, rows and cursors) in C++ classes.

DBtools.h++ will initially support Oracle Corp., Sybase Inc. and Microsoft Corp. SQL servers. Pricing begins at $495 for the UNIX versions and $395 for the Windows version.

Rogue Wave Software Inc.
260 S.W. Madison
P.O. Box 2328
Corvallis, OR 97339
Circle 127

New UNIX Literature

Dave Taylor, longtime software review editor at *SunWorld* magazine, has written a self-instruction guide for those new to UNIX. Called *Teach Yourself UNIX in a Week,* the book is a 700-page overview of everything the novice user could possibly want to know about the operating system. The book is put out by technical publisher Sams Publishing and has a suggested retail price of $28.

Sams Publishing
A Divsion of Prentice-Hall
Computer Publishing Inc.
201 W. 103rd St.
Indianapolis, IN 64290
Circle 128

Multiuser SBus Card

Integrix has introduced the STX200, a graphics card capable of turning a SPARCstation into a two-user system. The STX200 has a keyboard and mouse port, which allows a user to run an additional monitor off a single workstation. The company calls the product an "alternative to X terminals."

The STX200 supports resolutions and refresh rates up to 1,280 by 1,024 at 76 Hz. It offers 1.6 million 2D vectors and 560,000 3D vectors per second. Pricing begins at $1,995.

Integrix Inc.
1200 Lawrence Drive, Ste. 150
Newbury Park, CA 91320-1316
Circle 129

Ami Pro for Sun

Ami Pro is the graphical word processor that Lotus has marketed for Windows, OS/2 and, most recently, HP-UX. Lotus has now announced plans to offer the product for Solaris 2. This means that organizations that standardize on Ami Pro can have file compatibility across multiple platforms.

Lotus Ami Pro 3.0 for Sun will require a Sun SPARC workstation with 16 MB of RAM, 68 MB of hard disk space and Solaris 2.3 or higher. Ami Pro's pricing begins at $109.

Lotus Development Corp.
55 Cambridge Pkwy.
Cambridge, MA 02142
Circle 130

New Terminal Servers

Radlinx has introduced PASSaPORT, a line of terminal servers capable of connecting serial devices to Ethernet LANs at speeds up to 115.2 Kb/s. The products support TCP/IP, LAT, PPP and SLIP. Users can specify whether the product will be shipped with RJ45, RJ12 or MMJ for serial connections or 10Base2, 10Base5 or 10BaseT for Ethernet connections.

The PASSaPORTs are available in 4-, 8- and 16-serial port models. Pricing begins at $1,149.

Radlinx Inc.
900 Corporate Drive
Mahwah, NJ 07430
Circle 131

FREE INFORMATION

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314	Beame & Whiteside	76
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327	Computer Connection of CNY	79
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324	Concorde Group	78
315	CS Electronics	77
303	Dallastone	74
322	Datalease	78
329	Datalease	79
302	E.L.I. Systems	74
300	Expert Object	73
307	Generic Logic	75
328	InterContinental Computers	79
318	ISTR	77
317	KL Group	77
321	Language Systems	78
312	Loox Software	76
323	Memory Card International	78
326	Network Technologies	79
320	North American Systems International	78
330	Orange Systems	79
304	Sid Bowers Enterprises	74
301`	SiO Technology	73
310	Security Computer Sales	75
313	Solar Systems and Peripherals	76
306	Solunet	74
316	Ultraview	77
319	Unidata	78
309	Virtual Group	75
311	West Coast Computer Exchange	76
325	World Wide Technology Exchange	79

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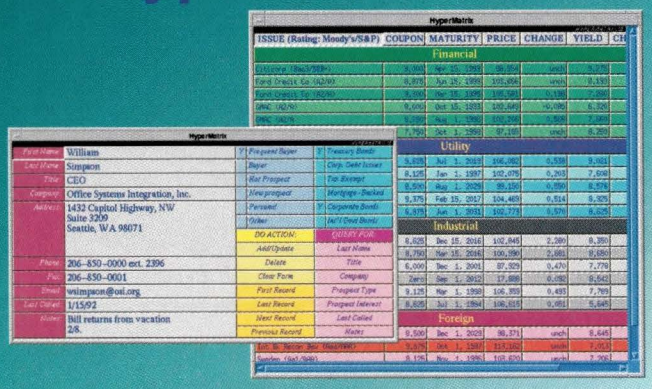
PRODUCT SHOWCASE

HyperMatrix 4.0



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Circle No. 301 on Inquiry Card

PRODUCT SHOWCASE

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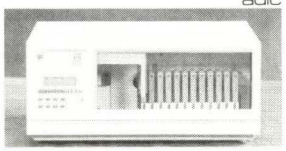

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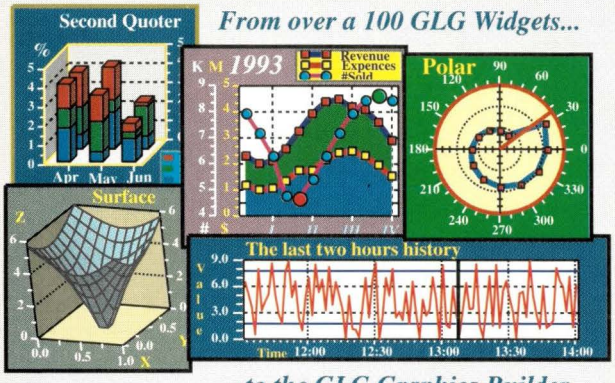

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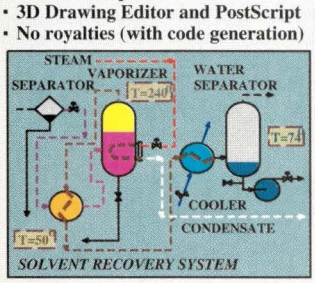

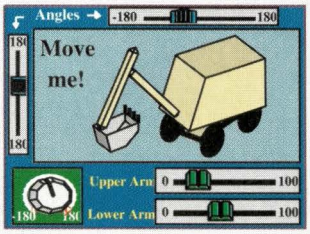

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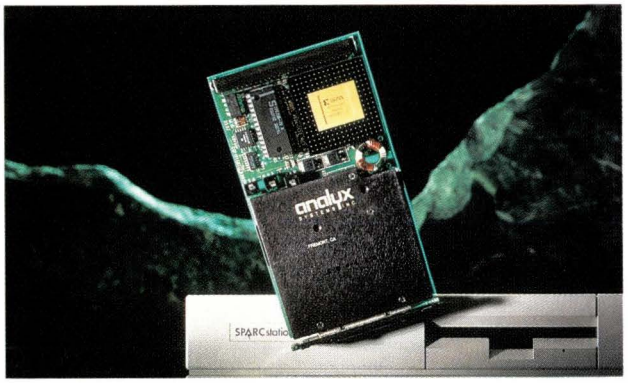

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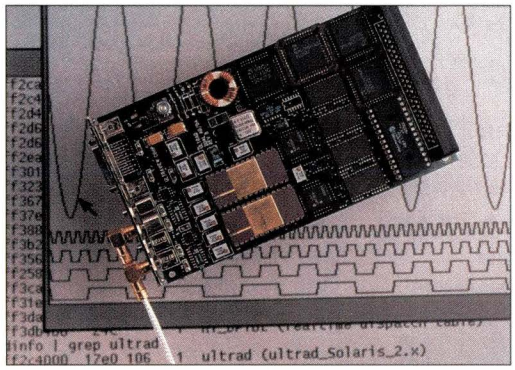

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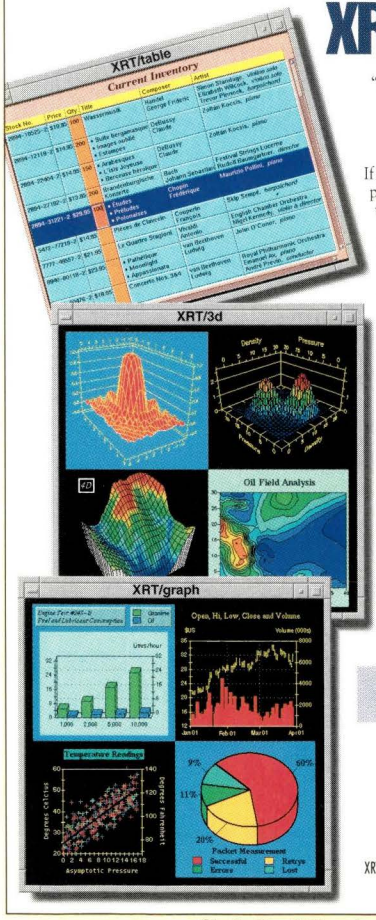

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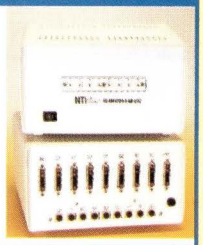

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READER INQUIRY NUMBER		PAGE
308	Analyx Systems	75
1	Apunix	11
2	Artecon	7
3	Aurora Technologies	35
4	AutoSystems	13
5	Beame and Whiteside	28-29
314	Beame and Whiteside	76
6	Box Hill Systems	Back Cover
	CAD/CAM Recruiters	79
7	Cerplex Group	25
8	Computer Associates	2
327	Computer Connection of CNY	79
324	Concorde Group	78
9	Contemporary Cybernetics	15
315	CS Electronics	77
10	Dakota Scientific Software	21
303	Dallastone	74
322	Datalease	78
329	Datalease	79
11	DataViews	19
	Digital Equipment	22-23
13	EIS Computers	63
302	E.L.I. Systems	74
300	Expert Object	73
307	Generic Logic	75
14	Human Designed Systems	5
15	Insignia Solutions	41
16	Integrix	37
328	InterContinental Computers	79
318	ISTR	77
17	Kingston Technology	Inside Front Cover
18	Kingston Technology	9
317	KL Group	77
321	Language Systems	78
312	Loox Software	76
323	Memory Card International	78
19	MiniComputer Exchange	31
326	Network Technologies	79
320	North American Systems International	78
330	Orange Systems	79
21	Pinnacle Data Systems	49
22	Rave Financial Services	25
23	Rave Computer Association	57
24	RDI Computer	43
25	Sanar Workstations	27
310	Security Computer Sales	75
304	Sid Bowers Enterprises	74
301	SiO Technology	73
313	Solar Systems and Peripherals	76
306	Solunet	74
27	Tatung Science & Technology	45
32	UniForum	Inside Back Cover
316	Ultraview	77
319	UniData	78
28	UniSolution	69
29	Veritas	1
309	Virtual Group	75
30	Visual Numerics	17
31	Weitek	33
311	West Coast Computer Exchange	76
325	World Wide Technology Exchange	79

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- Desktop use or mount in standard 19" or 24" rack
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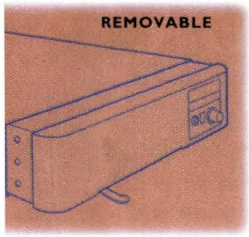
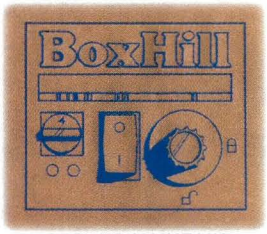


A Wide Choice of Components

- Drive options: 5.25" and 3.5" fast-narrow or fast-wide SCSI-2 disk drives
- Disk Storage: 400 MB up to the new 10.8 GB disk drive
- Tape backup: 150 MB QIC, 4mm, 8mm, up to the new 20 GB Digital Linear Tape drive
- Tape media changers: 24 to 48 GB
- Optical storage: 600 MB up to the new 2 GB multifunction drive
- The RAID Box 530: R.A.I.D. level 0, 3, or 5: dual-porting, dual controllers, hot-sparing and Super-Fast Cache: 4 GB to 216 GB
- Cost-effective MB per dollar

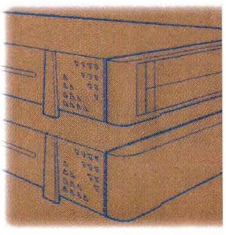


EASY TO MAINTAIN

Full Compatibility and Support

- Compatible with all major UNIX platforms, including: Sun, HP9000 700 or 800, IBM RS/6000, NEC, SGI, NCR, DEC Alpha, and Cray CS6400
- Compatible with Novell servers
- Legendary technical support: 24 hours a day, 7 days a week

STACKABLE



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