Machines That Keep Wall Street Going

By Ira Sager

To come up with a figure for how much the Commodities Exchange stands to lose if a computer breaks down, Farhad Froozan, director of computer and technical services suggests you take, for example, gold, one of twenty-six commodities traded at the exchange. Over $700 billion worth of gold was traded in 1983. Just divide that by the number of trading hours last year and you have the possible per hour loss in just one commodity.

Most exchanges and brokerage houses cannot come up with a figure for how much they would drop if a particular computer fails.

Not too long ago, the only way for a company, or an exchange, to make certain that costly breakdowns did not happen was to buy two complete systems—one to handle the work and the other as a backup in case the first system failed.

Now such Wall Street firms as Merrill Lynch, Kidder Peabody, Dean Witter, Donaldson Lufkin & Jenrette, Oppenheimer and Morgan are finding no other way. They are using computers—known sometimes as *fault tolerant, redundant, fail safe* or *high availability* systems—that contain, in one box, many of the features that had to be custom-designed by the data processing department on two separate computers. These fault tolerant computers are turning up as the core of order processing systems, trading systems and quote systems.

In fact, Morgan is building a real-time quote system on a fault tolerant computer it eventually hopes to use to replace its 500 Quotron terminals. "The data coming in from the exchange you can only get one shot at," says Scott Abbey, vice president of data administration in Morgan's MIS department. "You can't come back 30 seconds later with a hot standby (a backup computer) and regain that information. It's lost forever. If you want a continuous ticker, you have to have fault tolerance."

But some firms believe the need for fault tolerance is not pressing. Take for example, Norman Epstein, executive vice president in charge of data processing at E.F. Hutton, on the

Illustration by Pasternak

subject of fault tolerant computers: "As far as I'm concerned," he says, " given the reliability of hardware, fault tolerance is not priority number one, two or even three. It depends on the value you place on the function you're doing. We make money, we don't save lives. There's nothing that important that you have to be up 100 percent of the time."

However, the use of fault tolerant computers on Wall street is growing. The force behind fault tolerance and its growing popularity on Wall Street is transaction processing—the ability to put large commercial databases on-line in real time where they can be updated immediately to reflect changes as they occur. And, by definition, fault tolerant computers are perfect for transaction processing because they are made to provide continuous, normal operation despite the failure of one or more hardware components or glitches in the software.

"With the proliferation of PCs we are distributing intelligence to the brokers' and traders' desks. That is the way we are going," says Les Kalmus, vice president of equity trading for Merrill. "These guys have to use some kind of database, and that database has to be available at all times." Kalmus says he has seven fault tolerant systems supplied by Stratus Computer, Inc. The systems read such tickers as NASDAQ, Consolidated Quotation System (CQS), and the Consolidated Tape System (CTS). Merrill has a 24 hour foreign trading system, a corporate bond trading system and a portion of its OTC system on the Stratus equipment.

"Basically we are taking data coming in from the exchange and putting in analysis programs designed to help make trading decisions. The quotes, at least, always have to be available if you are going to a broker's desk. If he presses a button and doesn't get a response, he'll break someone's neck," says Morgan's Abbey, another Stratus customer.

Although Morgan is still in the prototype stage of the real-time quote system, the Stratus-based computers currently offer Dow Jones headlines, equities, options, NYSE bond trading, and Market Minder, a program that automatically updates the screen when there is a change in price.

Abbey says that at $400 per month for a Quotron terminal, cost was a motivating factor, but more important in the firm's decision to build its own system is that quote vendors are "inflexible and very difficult to work with to get features that give you a competitive advantage." The system is currently in use within MIS and

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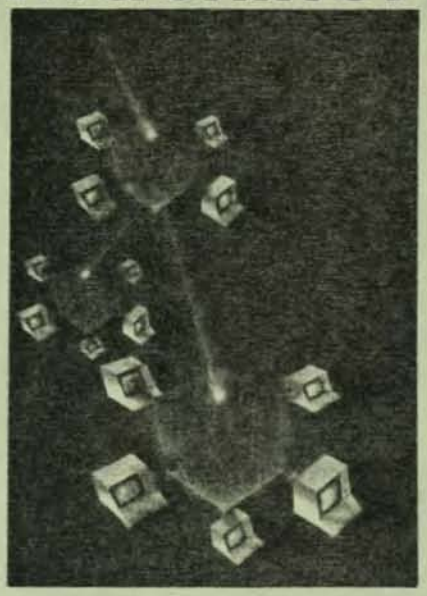


investment banking. "We felt that since investment banking didn't already have Quotron terminals the risk was small," adds Abbey.

Dick Ward is vice president of Network Concepts, a New Jersey consulting and software firm that sells Stock Aid, a package that runs on a fault tolerant computer, and is used to build a database with quotes from SIAC or NASDAQ. Ward says "If ADP or Bunker Ramo comes out with a feature, they have to be evenhanded. If they do it for company A, then they have to do it for company B."

Further, Ward explains that brokerage firms are interested in Stock Aid because they can create a database from quotes and then customize it, for example, to do an order matching system. He believes Wall Street firms are giving fault tolerant computers a very serious look. "There's no way a firm is going to change their computer system overnight. But they are assessing fault tolerant computers as a high priority for new applications. Many of the data processing people who built fault tolerant features into systems for their firms several years ago have now moved to higher positions within the firm. These guys remember what it took and they surely don't want to put together their own fault tolerant system." However, they understand the urgent need and requirements for such a system.

"The requirement for fault tolerance was never as large as it is today," asserts Bob Stoltz, N.Y. district manager for Stratus, which has been shipping fault tolerant computer systems for two years. "Fault tolerance has become more important because of the explosion of real-time applications. There has always been a need for real-time applications in the past, but the large growth of new applications is only recent." Stratus began offering real-time quotes via their financial ticker protocol to such customers as Merrill, Morgan and First Albany Corp., a regional member of the New York Stock Exchange.

And Auragen Systems, another relative newcomer to the fault tolerant market, plans to begin pursuing the brokerage business in the next few months. "We do consider the brokerage industry to be one target market," says Bob Gardner, vice president of sales.

Tandem Computers was the first manufacturer to offer a system that eliminated the need for a user to buy two separate computers to ensure that the system would always be operating. The Cupertino, Calif. firm found a ready market. Sales of its NonStop computer soared from $7.7 million in 1977 to $418.2 million last year.

"The beauty of Tandem is that what we once had to do through special hardware and software, we found a vendor supplying off the shelf. The value to me is that they provide many of the things we had to code to make systems fault tolerant," says Richard Lyhe, senior vice president for corporate planning at the Securities Industry Automation Corp. (SIAC).

Network Concepts' Ward adds that he built his first fault tolerant system back in the late sixties with Digital Equipment hardware when the terminology for such systems was *fail safe* or *redundant*. "When I got exposed to Tandem in late '77, I said here's something out of the crate that has all the features that we sweat and bleed to get."

SIAC is one of the first and foremost users of fault tolerant systems in the securities industry. Lyhe estimates that by mid-year they will have 135 Tandem computers running various services. Lyhe also traces his experience with fault tolerant systems back to the sixties when he designed those features into equipment from Sperry, IBM and DEC. "Every system in real-time trading is always fully duplexed," he adds.

SIAC is not just a Tandem shop. It has a large base of IBM equipment and uses IBM mainframes for the batch processing work it does for the National Securities Clearing Corp., as well as the Market Data for the New York Stock Exchange and Futures Exchange. The Market Data for the American Exchange uses DEC machines, as does the odd lot service for the NYSE. The Common Message Switch, a real-time system that han-

illustration by Pasternak

dles communications between the two major exchanges and their member organizations, is based on Sperry mainframes, but Lyhe says SIAC will be converting that system to Tandem machines. He adds that although the makers of those computers do not sell their machines as fault tolerant systems, SIAC has designed many fault tolerant features into the equipment.

SIAC uses fault tolerant computers from Tandem to run such services as: the Intermarket Trading System (ITS), CQS, Designated Order Turnaround System (DOT), Amex Post Execution Reporting System (PER), Opening Automated Reporting System (OARS), and Amex Options Switch (AMOS).

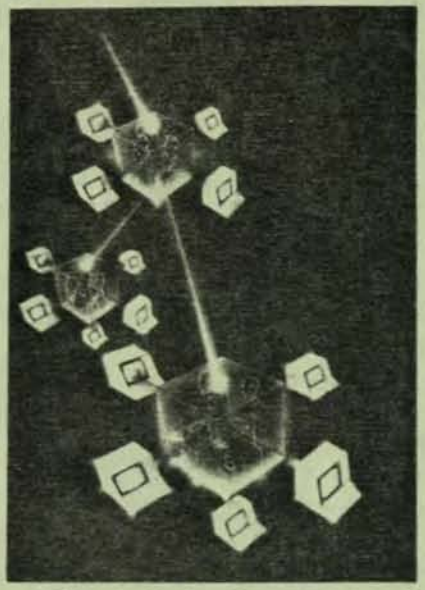
"We probably have more computer horsepower per employee than most corporations in the world because we are a computer intensive corporation. Everything we do is backed up by hardware," proclaims Lyhe. SIAC, Lyhe adds, uses its fault tolerant Tandem machines in configurations from 10 to 16 computers handling anywhere from five messages per minute up to 60 messages per minute on the Common Message Switch.

Encouraged by Tandem's spectacular success at SIAC and elsewhere, as well the declining cost of computer hardware, several new companies are incorporating fault tolerance into the design of their computers. With over $75 million from venture capitalists, new companies specializing in fault tolerance have formed including: Auragen, No Halt Computers, Corinthian Systems, Parallel Computers, Sequoia Systems, Stratus Computer, Inc., Synapse Computer and Tolerant Systems.

"There's a race for brokerage houses and banks to capture the market for unique information they can provide," claims Bill Kaseta, New York regional sales manager for Synapse, which began shipping fault tolerant computer systems last June. "Every house now has the ability to bring information in from SIAC and the other exchanges, but where they can grow is by taking that information and doing something special to provide a unique service."

"All brokerage firms need fault tolerance and they need to have transaction oriented machines. The bottom line is they want something that isn't going to go down and they want a real-time environment," claims Ron Gillespie, who heads business development for Applied Communications, Inc., an Omaha, Neb. firm planning to branch out from its electronic funds transfer business and into the securities industry with a package based on fault tolerant hardware.

Machines



ACI, which develops automated teller machine networks using Tandem and Stratus equipment, is currently evaluating machines from all the fault tolerant vendors for its entrance into the the business of selling brokerage services later this year. Gillespie says initially, the firm plans to come out with a system for discount brokers and banks wanting to add brokerage services. A system for full service brokerage houses will follow. "They (discount brokers and banks) have more pressure to get some system up and running. There's pressure to offer more services," Gillespie says.

He estimates there are about six hundred banks already involved in brokerage activities and some 135 discount brokers, with the numbers growing daily. Gillespie likens the potential popularity for its system with banks and discount brokers to the early days of ATMs (Automatic Teller Machines). "Banks adding brokerage services is just like ATMs six years ago. One day an ATM appeared in front of a bank, and then every bank decided they have to have ATMs."

But Gillespie may find a cool reception at some wirehouses on Wall Street when he brings out the full service brokerage system.

"Fault tolerance is no good unless you have 100 percent backup. That means providing your own power in case of failure," argues William Tuite, senior vice president for Drexel. "We don't have what you would call fault tolerant computers, although the new generation of equipment is very reliable. Since everything is backed up, while we may not have the ability to automatically recover, we can bring the system up promptly."

Hutton's Epstein argues that fault tolerant vendors attack the problem that is the easiest to solve—hardware. He says the biggest problems arise with communications lines, disks and operating systems. "It really is a question of economics. Do I do redundant lines, mirror disks? There is an economic value you put on these things that indicates whether you say yea or nay."

But some fault tolerant vendors are finding that customers want to use their equipment precisely as front end processors or communication controllers. "Take a large brokerage house with 1,000 broker terminals. One burp in that system creates tremendous havoc," says Howard Weinrick, a district sales manager for Auragen. "Fault tolerant equipment is being used as communication controllers because theoretically mainframes don't go down that often. But communications gear does."

Froozan at the Commodities exchange believes the use of a fault tolerant computer from a vendor specializing in such systems depends on the application and the kind of environment the system is used in.

Although Froozan says the exchange has one of the better records, last October trading was stopped for 66 minutes because of a component failure in the power supply of a computer. That problem knocked out two Quotron computers that had been designed for fault tolerance by Froozan. He describes the failure as a "fluke" and says he still may not go to a system such as Tandem's when he has to plan the exchange's next system toward the end of the year.

"For my application the overhead in a fault tolerant computer is a disadvantage. The overhead is in the operating system where there is a wide assortment of tasks. Some are useful, some are not. Those tasks I do not use are still there and take up code and memory. It chews up your time," he says.

Froozan does have some Tandem computers he uses for a clearing system that takes in all the trades of the day and matches that with buyers and sellers. But the main system that does the price reporting and updates about 250 terminals is on a Quotron computer.

"We are using Tandem for that application because the price was right basically. Fault tolerance for something like that was needed because it is an operation that has to be done within a certain timeframe." But, cautions Froozan, "You're always at the mercy of the phone company and certain carriers, no matter what you do."

Illustration by Pasternak

4/9/84

LEVEL 1 - 1 OF 596 STORIES

The Associated Press

April 6, 1984, Friday, PM cycle

SECTION: Business News

LENGTH: 178 words

DATELINE: NEW YORK

KEYWORD: Business Highlights

BODY:

Exxon Corp. retained the top position on the Fortune 500 list of U.S. industrial companies in 1983 despite a sales drop of $8.6 billion, to $88.6 billion, Fortune magazine says.

The Associated Press, April 6, 1984

General Motors Corp. remained second on the list _ which ranks industrial companies by annual sales. GM's sales climbed $14.6 billion to $74.6 billion, widening its lead over third-ranked Mobil Corp. by $20 billion.

Ford Motor Co.'s sales jumped $7.4 billion last year and the automaker replaced Texaco Inc. in the No. 4 slot. Texaco fell out of the top five for the first time since 1974, as International Business Machines Corp. moved up a notch from No. 6.

Behind Texaco in sixth position was No. 7 Du Pont Co.; No. 8, Standard Oil Company (Indiana); No. 9, Standard Oil Company of California.

General Electric Co. returned to the Top 10 as No. 10 after a two-year hiatus.

By profit, IBM was first, with $5.5 billion, followed by Exxon's nearly $5 billion.

The 500th-ranked company was **Tandem Computers** Inc., which made the list for the first time with sales of $418.3 million.

LEVEL 1 - 2 OF 596 STORIES

The Associated Press

April 6, 1984, Friday, PM cycle

SECTION: Domestic News

LENGTH: 307 words

HEADLINE: Top 500 Companies Named For 1983

DATELINE: NEW YORK

KEYWORD: Fortune 500

BODY:
Oil companies dominated the 1983 Fortune 500, with Exxon Corp. leading the list of industrial rankings for a second consecutive year and four other oil companies making the top 10.

The Associated Press, April 6, 1984

Exxon is still No. 1, but its sales dropped by $8.6 billion to $88.6 billion, according to the list released Thursday by Fortune magazine. Not far behind was General Motors Corp., whose sales soared by $14.6 billion to $74.6 billion, widening its lead over Mobil Corp., No. 3, by $20 billion.

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By profit, IBM was first, with $5.5 billion, followed by Exxon's nearly $5 billion.

Here are the Top 10, followed by sales and 1982 position:

1_Exxon, $88.56 billion (1).

2_GM, $74.58 billion (2).

3_Mobil, $54.61 billion (3).

4_Ford, $44.45 billion (5).

5_IBM, $40.18 billion (6).

6_Texaco, $40.07 billion (4).

7_Du Pont, $35.38 billion (8).

8_Standard Oil (Indiana), $27.63 billion (10).

9_Standard Oil of California, $27.34 billion (7).

10_GE, $26.8 billion (11).

Newcomers to the list include Coachmen Industries Inc., maker of campers and motor homes, No. 463; and Rolm Corp., a Silicon Valley telecommunications company, No. 454; and **Tandem Computers** Inc., which joined the list at 500.

The biggest sales increase _ 114.3 percent _ was by James River Corp., the paper company, No. 209. Coachmen was second with 80.4 percent.

Apple Computer Inc. moved up 112 places to No. 299 with a sales gain of 68.6 percent.

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LEVEL 1 - 3 OF 596 STORIES

April 6, 1984, Friday, AM cycle

SECTION: Domestic News

LENGTH: 255 words

HEADLINE: Exxon, G.M. top Fortune 500 again

DATELINE: NEW YORK

KEYWORD: Fortune500

BODY:

Exxon Corp., General Motors and Mobil Corp. kept their rankings as the three largest industrial corporations in the United States on the basis of sales, according to the Fortune magazine's annual list of the top 500 released Friday.

International Business Machines Corp., No. 5 in sales, was the company with the biggest profit, however, earning $5.5 billion last year.

Overall, the profit picture was rosy, with Fortune calculating that total profits for the top 500 industrial companies went up 12.1 percent in 1983 for the first real increase, adjusting for inflation, since 1979.

Exxon's $88.6 billion in sales kept it in the top spot despite a decline of $8.6 billion from the previous year.

General Motors' sales increased $14.6 billion to $74.6 billion, considerably narrowing the gap between the two leaders. Mobil had $54.6 billion in sales last year.

There were changes in the rankings by sales after the top three companies. Ford Motor Co. and IBM, ranked fifth and sixth, respectively, last year, each moved up one position while last year's No. 4 company, Texaco, slipped to sixth. That ranking is likely to change on next year's list as a result of Texaco's merger with Getty Oil.

Newcomers on the top 500 list included Coachmen Industries, No. 463, ROLM Corp. at 454th, and **Tandem Computers,** just making it at number 500.

On the list of the largest companies by sales, the seventh through 10th positions were occupied by Dupont, Standard Oil of Indiana, Standard Oil of

LEVEL 1 - 4 OF 596 STORIES

April 6, 1984, Friday, BC cycle

SECTION: Financial

LENGTH: 257 words

HEADLINE: Exxon, G.M. top Fortune 500 again

DATELINE: NEW YORK

KEYWORD: Fortune500

BODY:

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OF 1984.
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REVENUE WILL BE BELOW THAT OF ITS FIRST
FISCAL QUARTER.
ANALYSTS - WHO SAY THEY ARE LOWERING
THEIR FISCAL YEAR ESTIMATES FOR THE
COMPUTER MAKER FROM ABOUT $1.20 A SHARE
TO ABOUT $1 - SAY THEY SEE FURTHER
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04/09 TANDEM ANALYSIS -2-
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NY - DJ - IN ITS RELEASE TANDEM COMPUTERS INC. SAID IT EXPECTED THAT REVENUE IN ITS SECOND FISCAL QUARTER WOULD BE LOWER THAN IN ITS FIRST QUARTER. TANDEM'S FISCAL YEAR ENDS IN SEPTEMBER.

THE COMPANY EARNED $10 054 000 OR 24 CENTS A SHARE ON REVENUE OF $126 069 000 IN THE FIRST QUARTER.

SOME ANALYSTS ARE EXPECTING REVENUE OF ABOUT $122 MILLION FOR THE SECOND QUARTER.

DAVID WU OF MONTGOMERY SECURITIES SAYS ONE PROBLEM MAY BE THAT ORDERS CAME IN LATE IN THE SECOND QUARTER.

'THE COMPANY HAS A POLICY THAT IF IT'S NOT INSTALLED IN 15 DAYS THEY DON'T BOOK IT AS REVENUE ' SAYS WU.

BUT THE ANNOUNCEMENT MAY BE SYMPTOMATIC OF LARGER PROBLEMS WITH THE

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COMPUTER COMPANY SAY OTHER ANALYSTS.
THE COMPANY HAD BEEN EXPERIENCING
VERY NARROW PROFIT MARGINS IN THE PAST
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'NOW IT LOOKS LIKE THOSE MARGINS
AREN'T GOING TO COME BACK ' SAYS HOWARD
SCHACTER OF DONALDSON LUFKIN JENRETTE.
'THEY MAY BE FACING A SQUEEZE INVOLVING
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HORTFALL.'
'WILL TANDEM'S SHIPMENT SHORTFALL BE
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AT&T TAKES ITS FIRST GIANT STEPS INTO COMMERCIAL COMPUTERS

Question: What company invented the transistor, currently produces one of the world's most sophisticated computer memory chips, and employs 10,000 software engineers, yet has never sold even one computer to another company? Answer: American Telephone & Telegraph Co. For years, the communications giant could not market computers outside its own company, thanks to a consent decree that it signed in 1956 with the Justice Dept.

Now all that has changed. By agreeing to spin off its 22 regulated, local telephone operating companies on Jan. 1, AT&T was free to enter the competitive world of data processing. And on Mar. 27, AT&T took advantage of its newfound independence to introduce its first line of commercial computers. "We intend to play in [the computer] market, and play in it well," declares James E. Olson, vice-chairman of AT&T and head of AT&T Technologies, which makes and markets the new machines.

Hardly anyone expects AT&T to rival the annual computer sales of its chief adversary, International Business Machines Corp., anytime soon. "AT&T has a long learning curve" ahead of it, predicts Robert C. Downs, president of Enmasse Computer Corp. Over the long run, however, AT&T will be the only company large enough to mount a serious challenge to IBM's dominance of the market, industry observers say.

'A BIG CLUB.' AT&T already has sufficient financial and technological clout to give major headaches to such leading computer makers as Data General, Digital Equipment, Hewlett-Packard, Tandem, and Wang. "They swing a big club, and anyone in the business not watching what AT&T's doing is fooling themselves," cautions a senior executive at one large computer maker.

AT&T's success in the computer business is vital to its long-term future. While it expects that its basic communications businesses will keep growing, AT&T is convinced that the markets for "data processing and the office of the future will grow far faster than our traditional voice-data communications markets," says Olson. "To meet our long-term strategic goals and attain the kind of growth we want, the office information systems industry is crucial to us."

Divestiture left AT&T with two basic businesses: long-distance services run by AT&T Communications and equipment manufacturing run by AT&T Technologies, which encompasses what was Bell Telephone Laboratories Inc. and Western Electric Co. Both new units already are having their share of problems.

Long-distance services, which were forecast to generate nearly $35 billion of AT&T's projected $56 billion in 1984 revenues, was supposed to be the company's cash cow. But unless the Federal Communications Commission speeds up its restructuring of the nation's long-distance rates, Chairman Charles L. Brown warns that AT&T "has no chance whatsoever" of producing the $2.1 billion in net income this year that the company projected in its prospectus last November. As a result, when AT&T in late March announced its first-quarter dividend of 30¢, the company cautioned that it may not be able to pay the same dividend for the remainder of the year.

AT&T Technologies is not doing much better. Divestiture has left it bereft of the huge captive market of local Bell operating companies for its network switching equipment. At the same time, it is facing severe competition from companies such as ITT, Rolm, Japan's NEC, and Canada's Northern Telecom in its efforts to sell communications equipment to big corporations.

DUAL APPROACH. To enter the office information systems business, AT&T is following a two-pronged strategy. The first drive centers on Unix, a powerful operating system program that was originally developed by Bell Labs engineers. Unlike other operating systems—the housekeeping programs that control basic computer functions—Unix makes it possible for the applications programs that perform specific tasks to be transferred easily from one brand of system to another. Unix can also readily handle several tasks at once, an important feature in an office where many people use a computer at the same time.

To create a market for its machines, AT&T has been actively seeking software developers to write applications programs that run on Unix. "It's the most aggressive third-party software [recruiting] movement I've ever seen," says

WHERE AT&T'S NEW MODELS FIT IN

AT&T COMPUTERS	COMPETITORS
3B20A: The most powerful model in the new line handles up to 150 users, runs 1.5 million to 1.8 million instructions per second (MIPS), is equipped with a main memory ranging in size from 4 to 24 megabytes (24 million characters), and costs $330,000 and up	Data General Eclipse MV/10000 Digital Equipment VAX 11/782 IBM 4341-12
3B20S: Up to 100 users, 1 MIPS, 2 to 12 megabytes of memory, $230,000 and up	Data General Eclipse MV/8000 Digital Equipment VAX-11/780 IBM 4341-11
3B20D: The high-reliability version comes with two 3B20S processors, each with 5 to 16 megabytes of memory, and costs $340,000 and up	Tandem Computers NonStop II
3B5/200: The medium-size model can be used simultaneously by up to 60 people, runs at 0.8 MIPS, comes with 2 to 8 megabytes of memory, and is priced at $73,000 and up	Data General Eclipse MV/6000 Digital Equipment VAX-11/750
3B5/100: Up to 30 users, 0.6 MIPS, 1 to 8 megabytes of memory, $57,000 and up	Data General Eclipse MV/4000 Digital Equipment VAX-11/730
3B2/300: The entry-level microcomputer version is aimed at offices with up to 18 users. It runs at 0.5 MIPS, has 0.5 to 2 megabytes of memory, and sells for $9,950 and up	Apollo Domain 300, Digital Equipment MicroVAX I Fortune Systems 32:16 Hewlett-Packard 9000

DATA: AT&T, BW

John R. Rowley, president of Digital Research Inc., which is helping AT&T build a Unix software library.

"We didn't want to enter the computer business as a me-too with an IBM-compatible [computer]," asserts Jack M. Scanlon, the vice-president who heads AT&T Technologies' Computer Systems Div. in Lisle, Ill. So the company first "set out to build a new market around [the Unix] operating system," he says. AT&T appears to be succeeding: The market for Unix applications software will explode from $260 million last year to $2 billion by 1987, estimates Jean L. Yates, president of Yates Ventures, a Los Altos (Calif.) market researcher.

The second prong of the AT&T strategy is its new series of computers. One of the broadest product lines on the market, AT&T's computers range from the 3B2 microcomputer, which will be priced for less than $10,000, to the 3B20 superminicomputers, which will sell for $300,000 and up (table). Desktop personal computers were not in the initial product offering, but they are expected shortly. The machines appear to be comparably priced and about as powerful as those of the competition. What AT&T hopes will set its machines apart is their high reliability and that they all employ Unix. "No one has a line from superminis to desktops with one operating system, all compatible," says Scanlon.

MAKING MONEY. Unlike most computer makers introducing new products, AT&T is already in full production at its factory in Oklahoma City. Nearly 1,500 of the minicomputers are installed around AT&T and the former Bell telephone operating companies. Scanlon maintains that the company is already making money on its computers, although some industry experts question if the former Western Electric, with its unionized workers, can compete on a cost basis with other computer makers. "We've been serving our internal needs for several years, and we are doing it on a profitable basis," answers Scanlon. "The commercial business is just incremental capacity."

The new AT&T computers are aimed squarely at two of the fastest-growing information processing markets. More than $5 billion worth of superminicomputers were sold last year, and shipments of these machines should nearly double by 1986, predicts International Data Corp., a Massachusetts market researcher. And AT&T wants to use its microcomputers to penetrate the $2.8 billion office automation market, which the researcher estimates will grow to $6.2 billion annually in the next three years.

To move its products quickly into these markets, AT&T is using several distribution channels. The Computer Systems Div. will sell to so-called value-added remarketers, which buy computers and add applications software to customize the machines for specific technical applications. AT&T Information Systems will sell to those value-added remarketers that are business-oriented and to corporations and other end-users. And Italy's Olivetti, 25% of which is owned by AT&T, will distribute some of AT&T's computers in Europe.

Even before it ships its first computer to an outsider later this spring, AT&T has earned a high reputation among potential customers. "If you look at AT&T's technological track record for developing the Unix language and the proven reliability of their communications products, they're starting off with a lot of strengths," says Charles Carroll, vice-president at Days Inns of America Inc.

Even with that high regard, AT&T faces a hard battle. "Not many people are going to buy computers because they have the AT&T name on them," says Robert Capone, vice-president and director for systems and data processing at J. C. Penney Co. David L. Cotterill, executive vice-president for operations at Wachovia Bank & Trust Co. in Winston-Salem, N. C., agrees. "They are the new kid on the block. They have to prove to all of us that they can do it better."

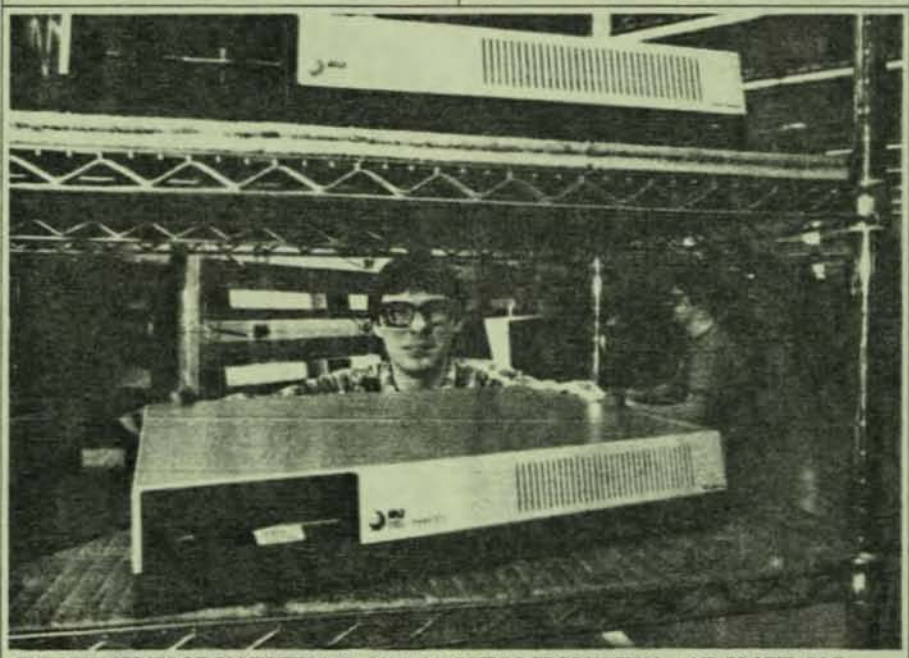
One big reason why AT&T may find it difficult to convince prospective customers is that the industry still considers marketing to be the company's Achilles' heel. Although AT&T has striven for nearly a decade to train its sales force, horror stories about its gaffes still abound. One company, which does not want to be identified, says it tried numerous times in recent months to get AT&T to bid on a PBX for a large building, but no one at AT&T responded. Another customer claims that when the company was asked to bid on an order for several thousand data communications products last year, an AT&T sales representative answered: "We don't know how to price that—we've never had anybody order that many." Even AT&T's Olson concedes that "we are not as happy with the success of the sales force as we had hoped."

TOUGH TRANSITION. Computer marketing may also be weak at AT&T, say some industry analysts. They claim the company's prices are not aggressive enough to win customers. "Why would a big user take the risk of going with AT&T, a new player, unless he is saving something?" asks Stephen P. Cohen, an analyst with Gartner Group Inc.

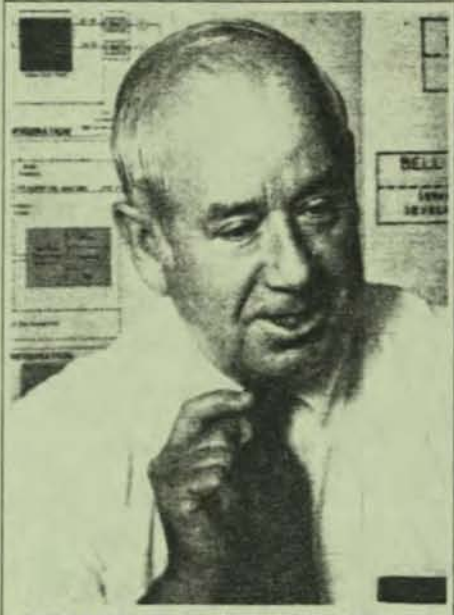
AT&T's marketing push must extend all the way to its product designers, who must do a better job of matching new computer products to the needs of prospective customers. "Although telecommunications is now much closer to computer technology, it is not the computer business," maintains Richard M. Moley, vice-president for marketing at Rolm Corp. "It's a difficult transition to make." For example, AT&T has been designing and building its products for the 10-to-15-year product life cycles typical of telephone equipment, not the five-year cycles of the computer business.

The Bell Labs engineers who created and refined the Unix operating system also have little experience in office applications at large corporations. Instead, they have concentrated on more technically oriented tasks. "They haven't operated in the commercial setting," says Andrea J. Curtis, product requirements manager at Data General Corp., which offers Unix on its equipment. "They still aren't tuned in to customers."

AT&T claims that it is solving most of



THE NEW SERIES OF COMPUTERS IS ALREADY IN FULL PRODUCTION—AND PROFITABLE



VICE-CHAIRMAN OLSON: A VOW TO PLAY IN THIS MARKET, "AND PLAY IN IT WELL"

VICE-PRESIDENT SCANLON: NO INTEREST IN "ME-TOO" IBM-COMPATIBLE COMPUTERS

these problems. One example of its growing market savvy is the kind of communications networks that it rolled out with its new computers. As a latecomer to the commercial computer business, AT&T acknowledges that it must adapt to equipment that is already in place, especially IBM equipment. So the company has designed its new 3B Net, a local-area network for office buildings, which will link multiple AT&T computers to each other as well as to other brands of computers.

An even more important network is PC Interface, which permits IBM Personal Computers (PCs) to be used as terminals for an AT&T system, making it easy for PC owners to retrieve files and run programs on the powerful AT&T systems. "We wanted to be able to go into an installed base and grow gracefully with it," explains Scanlon. Eventually, he says, AT&T will even link its products into IBM's mainframe computers.

USING OUTSIDERS. AT&T also seems to have learned that it cannot do everything itself, a policy that it usually followed in the days of its telephone monopoly. In addition to relying on the value-added remarketers and other outside companies to supply the applications software for its machines, AT&T is turning to outsiders for hardware. The company has already signed a deal with Convergent Technologies Inc., a Santa Clara (Calif.) microcomputer maker, to make desktop terminals for AT&T to sell. And Olivetti is expected to turn out office automation equipment for AT&T to sell in the U. S.

AT&T is working hard to give its sales force more of a computer slant. It has raised the number of people with data processing sales experience to almost 20% of the total force, reports Robert J. Casale, division president for marketing and sales. And he says that training is proceeding apace—by July, some 2,000 of AT&T's 6,000 salespeople will have been taught about its new computers.

AT&T customers already are beginning to report a new attitude among AT&T salespeople. "They really have changed within the past year," says Cotterill of Wachovia Bank. "They seem to be a lot more professional." Mayford L. Roark, executive director of systems at Ford Motor Co., adds that AT&T "comes across as having a much more aggressive marketing organization than [the company] we used to know before."

One more thing that may help AT&T: A good many people in the industry are actively rooting for the company to make it in computers. "Somebody's got to find a way to compete with IBM," says Randy J. Goldfield, president of the Omni Group Ltd., a New York office automation consulting firm. Adds Neal Nelson, president of Neal Nelson & Associates, a small Chicago computer remarketer: "I'd like to have another big name [besides IBM] to offer a customer." With that kind of reception from the marketplace—coupled with its $34 billion in assets—AT&T could very well be the next big name in computers. ■

COMPUTERS

CAN COMMODORE REBUILD THE BRIDGES IT BURNED?

Jack, the warrior in the Jack Attack computer game from Commodore International Ltd., has but one goal: squash his enemies by jumping on their heads before they jump on his. That strategy is not unlike that of Commodore's founder and former president, Jack Tramiel. It was Tramiel who, with obvious pleasure, spurred on Commodore through the bloody price wars last year to grab 38% of the home computer market and force competitors Texas Instruments, Mattel, and Timex out of the business.

Today, however, Commodore's battle is at a critical juncture, and Tramiel is not around to help. He unexpectedly quit the company in January, giving no explanation for his mysterious departure (BW—Jan. 30). Tramiel sold much of his 7% stake in the company and retreated to Hong Kong. Chairman Irving Gould quickly replaced him with Marshall F. Smith, president of the U. S. subsidiary of Thyssen-Bornemisza, an industrial conglomerate headquartered in the Netherlands.

Smith, who has no experience in computers, is trying to take control of Commodore as it streaks toward $1 billion in sales for the year ending June 30, up from last year's $681 million in sales. And he has arrived on the scene just as Commodore appears on the verge of diversifying into a new U. S. market: personal computers for professional use. His strategy is to achieve some balance between Commodore's aggressiveness and good relations with the company's suppliers, dealers, and investors.

RUTHLESSNESS. The Tramiel legacy at Commodore is both good and bad. Smith inherits a company that dominates the home computer market. "It will have to make serious strategic errors to lose its hold," comments Patricia H. Parks, an industry analyst at Future Computing Inc. Over the next two years, Commodore plans to introduce as many as three new products in the less-than-$500 price range. But Tramiel's ruthless management style has also engendered an industrywide distrust of Commodore. He is infamous for driving the hardest

(LEFT) LAWRENCE DAVIS; (RIGHT) MARK LEIBE

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Dear Executive:

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LIBERATED AT&T CAREFULLY STEPS INTO THE COMPUTER BUSINESS

AT&T has finally entered the information processing business, the field it coveted enough to shed 2/3 of its assets for the privilege of joining. Last week the trimmed-down AT&T announced it is making available to original equipment manufacturers and value added remarketers, 6 versions of its 32-bit 3B minicomputer, which previously were marketed only to the Bell System.

AT&T also introduced an Ethernet compatible local area network to connect its computers within 1/2 km. Operating over coaxial cable, the network interfaces, called 3BNet, use the same WE 32000 microprocessors as AT&T's computers to load protocol, flow control and maintenance overhead to the network rather than connected computers.

Another network product, PC Interface, connects personal computers running MS-DOS, such as IBM's PC, to one of AT&T's new models. It is offered in an asychronous RS232 model running at up to 19.2 Kbps; a Corvus Systems Inc. Omninet version with a 1 Mbps data rate; and a 10 Mbps Ethernet version. The PC Interface was developed in conjunction with Locus Computing Corp., Santa Monica, Calif.

While choosing a segment of the market that is not IBM's strong suit, AT&T is avoiding a direct confrontation with Big Blue at the outset. But that's not to say AT&T has chosen a wide open niche, either. Digital Equipment Corp., Wang, Labs, Digital Research Inc. and Harris Corp. are all multi-billion dollar companies with state-of-the-art minicomputers, established sales forces and distribution channels, customer recognition and years headstart in all markets except the Bell operating companies.

AT&T announced 3 versions of its 3B20 line--its largest supermini--that will compete against DEC's VAX 11/780 top of the line and are comparably priced. The 3B20S, the basic model, supports about 100 terminals, is designed for uninterrupted use and has a price tag of $230,000. The 3B20A, with a second 32-bit processor, nearly doubles the processing power of the S model and costs about $100,000 more. The S model can be upgraded to the A.

Finally, AT&T is offering the 3B20D, essentially the same unit that is used in the nationwide telephone network. It offers fault-tolerant operation and an enhanced Unix system called Unix Real-Time Reliable. Designed for banking, financial and military applications requiring maximum uptime, the D model will compete against other redundant systems such as Tandem Computer Corp.'s fault tolerant computers.

Also introduced was a desktop multi-user 32-bit supermicro called the 3B2. It has 256K bytes of memory and will compete against other supermicros built by DEC, Altos Computer and Prime Computer. It can support up to 18 users and will cost $10,000. AT&T announced 2 other models as well, midrange superminis, supporting 30-60 users and costing $57,000-73,000.

...ANNOUNCEMENTS SEEN AS 'SYMBOLIC'

George Colony, president of Forrester Research Inc., Cambridge, Mass., acknowledged that the announcement was important, but said it was "symbolic rather than substantive."

Rather than unveiling any revolutionary products, he maintained, AT&T is simply stating "We are now in the computer business."

He called the 3B2 an excellent product because it is designed to optimally run Unix, and would be attractive to Unix OEMs. Unix System V, the most advanced version AT&T is currently licensing, is standard on the 2B2, and is becoming increasingly popular for multi-user computers. Colony expects a major selling point for OEMs will be Unix V upgrades that will flow to them before being offered to Unix licensees.

Still, AT&T will have problems marketing its products, Colony told us. He described AT&T's sales force as "the white belt and shoes crowd" with no experience outside the heretofore locked-up Bell System, and called its distribution network inadequate. (Separately, M/A-Com Inc. said AT&T has awarded subsidiary M/A-Com Sigma Data Inc. rights to market AT&T's new computer products to the U.S. government.)

...WHERE'S THE PC?

Absent from the announcement was AT&T's entre for the personal computer market, perhaps suggesting AT&T's unwillingness--for now--to battle toe-to-toe against IBM's strongest market. Industry pundits have been asserting that AT&T's PC would run Unix as its other computers do. But there are clues that the forthcoming PC may in fact use DOS.

One of those clues is AT&T's announced PC Interface, which connects its new desktop supermicro to an undisclosed number of IBM compatibles. The interface will permit transparent file transfers between Unix and DOS programs.

Why wouldn't AT&T be consistent and use Unix for its PC (assuming it really does introduce one) as well as for its minis? For one thing, AT&T may be demurring to IBM's domination of the personal business computer and the de facto DOS standard. But another problem is that Unix consumes a great deal of computer memory and simply may not be suitable for micros. Connecting a supermicro with Unix to a PC with the interface may be the best AT&T can do for now.

In any event, where is "the missing guest at the wedding," as Colony described the PC's absence from AT&T's product announcement? Colony shares the view that the PC Interface announcement signals that AT&T "is willing, initially, to coexist with IBM" in the PC market. Having no experience in the PC field, AT&T will probably have to look outside to either market or jointly develop a PC.

AT&T has agreed to invest $500 million in Olivetti, half to purchase 25% of the Italian office automation equipment manufacturer's equity, and half to buy equipment. Olivetti's PC is a likely candidate for AT&T to market in the United States, but AT&T is also reportedly talking with U.S. manufacturers such as Columbia Data Systems and Eagle Computers, both of which make IBM compatibles.

Whether or not Olivetti provides AT&T with a personal computer, it does stand to offer AT&T a key to its long-term strategy--a door into the European marketplace. The Italian firm will almost surely market AT&T's new computers--as well as its telecommunications products--throughout the continent.

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Packet Networks

AT&T FILES TARIFF RESTRUCTURE FOR BPSS

AT&T has proposed a restructuring of existing tariffs relating in part to its Accunet packet switch network. The company said, if approved, the tariff revisions would become effective May 5.

Rick Brayall, an AT&T spokesman, told DATA CHANNELS the proposed changes would make Accunet more generally available for business customers to transmit and receive packets of information among different locations simultaneously. "Whereas before, we offered just the packet switch machine, the new revisions call for a shared use of network trunk lines and new speeds," said Brayall. Brayall said the new speeds would provide service between 4.8-56 Kbps.

According to Brayhill, customers would still be required to provide equipment to assemble and disassemble information into packets as well as arrange access service connecting their computer terminal with the AT&T network.

The new rates go as follows: 56 Kbps service would be $950 per month, 9.6 Kbps at $550 per month, and 4.8 Kbps at $420. Additionally, on a monthly basis customers would be charged 75 cents per 1,000 packets, or kilopacket, for the first 4,000 kilopackets transmitted during normal business hours. Rates for the second 4,000 kilopackets would be 70 cents apiece; the third 4,000 kilopackets at 65 cents each; and every kilopacket beyond 12,000 would incur charges of 60 cents each.

New York, Chicago and Atlanta will be the first existing packet service points for the nationwide service while later in 1984, Los Angeles, Denver and Dallas are expected to be added.

...AT&T ADDS ENHANCED T1.5 OPTION

For an enhancement in another part of the Accunet family, AT&T has promised a private network service that may one day compete against Local Area Data Transport services, such as those offered by Southern Bell and Ameritech, says Brayhill.

The new service will be an enhancement of AT&T Communications' already tariffed Accunet T1.5 service. T1.5 is composed of leased point-to-point transmission links running at 1.5 Mbps. The new enhancement will permit the network to be geographically reconfigured. Subchannels can be reconnected to provide capacity where it is needed as traffic peaks and lows occur at various points.

Brayhill says the enhancement will be offered only with totally private networks of T1.5 subchannels for a start.

ILLINOIS BELL LOOKS TO VIDEOTEX '84 FOR PACKET NETWORK DEBUT

Preparing to launch its Local Area Data Transport (LADT) service for the Keyfax videotex project in Chicago, Illinois Bell is planning to have at least part of the service ready for Keyfax's roll-out during the Videotex '84 conference the week of April 11, according to Illinois Bell spokesman Ken Hildreth. A Keyfax spokesman told DATA CHANNELS that transmission operations for the interactive service are essentially in place, with system checks to be completed this month.

The Bell operating company (BOC) is planning to establish network service in a 6-county, 90 by 40 square mile area for the city of Chicago and metropolitan area. Although the network is similar in design to BellSouth's LADT system in Southern Florida for the Viewtron videotex system, the Illinois Bell network will not require an additional dedicated phone line for users (DC, June 22, 1983, p. 1).

The network will use the customer's existing phone line, with access to one of 14 nodes at 13 switching centers in the Chicago area. The end user will have either a Keyfax terminal--manufactured by Honeywell subsidiary Synertek--or a modem-equipped personal computer to place the local call needed to reach the nearest node. "We actually intercept those calls at a very local level," Hildreth said. And by doing so, he said, the BOC can offer the service at a "minimal charge," with the connection included as part of the customer's regular phone service.

Tandem, MIS Information Systems sign market pact

CUPERTINO, Calif. — Tandem Computers, Inc. and Santa Clara, Calif.-based MIS Information Systems, Inc. have announced an agreement to market jointly the MIS Batch software system.

Under the terms of the agreement, a Tandem spokeswoman said, MIS Information Systems will license MIS Batch directly to Tandem Non Stop superminicomputer users and will provide support and service for the system.

MIS Batch reportedly schedules and manages the execution of batch-oriented programs on Non Stop systems.

The software is said to operate in a fault-tolerant mode to assure reliable execution of tasks on a single Non Stop processor or across networks of Non Stop systems. MIS Batch reportedly also allows users to display the status of all batch jobs in process, and it provides a complete log of activities.

The package is also said to share system resources with on-line transaction processing applications as required.

MIS Batch is compatible with existing applications that run under Tandem Non Stop system software products, the spokeswoman said. MIS Batch licenses for $18,600 for the first system and $9,300 for each additional system.

More information is available from Tandem Computers, 19333 Vallco Pkwy., Cupertino, Calif. 95014.

SYSTEMS SOFTWARE

COMPUTER ASSOCIATES INTERNATIONAL, INC.
CA-Jasper/JA Release 2.1

Computer Associates International, Inc. has introduced an enhanced version of its performance evaluation software that reportedly includes more than 100 new reports on system activity, utilization and performance for IBM OS/MVS installations.

CA-Jasper/JA Release 2.1 features more than 120 reports covering computer performance and utilization, the vendor said. In addition, 27 trend graphs are provided on a monthly basis for planning purposes. The graphs give an historical view of the past year and an automatic projection for the next six months for areas such as work load turnaround time, idle time, paging rate and TSO usage.

Regular monthly reports include system summary graphs, typical job profiles, significant changes, TSO summaries, printer forms usage, job class summaries, disk utilization graphs, tape utilization graphs, system trends and production summary

Prime asynchronous multiline controller (AMLC) line on the system.,

The enhanced software reportedly also includes the capability to display system idle time for any user. The software involves a change to the Prime operating system, Primos. Source code for the change is provided with the order, a vendor spokesman said.

Prices for AMLC Status start at $250, the vendor said.

Computronics, 130 N. Ash, Wood Dale, Ill. 60191.

DATASTREAM COMMUNICATIONS, INC.
Software options

Datastream Communications, Inc. has announced four software options for its 874 Systems Network Architecture (SNA) controller for remote IBM 3270 network operations.

The options, which reportedly widen the scope of 3270 access and user integration, include CRT Attached Printer Support (Caps), which allows a serial printer attached to a CRT or personal computer to access the IBM host computer via a single connection to the Datastream controller.

Another option, the Multiple Ses-

on a host running SAS Institute, Inc.'s SAS/Graph package.

A Keyboard Printer feature allows interactive access to 3270 applications with the application-oriented

keyboard printers frequently used in time-sharing or remote locations, according to the vendor.

The options are $100 each per sys-

Continued on page 46

100 WHO MADE THE MOST

Here is a list of the 100 entrepreneurs who made the most, at least on paper, by taking their companies public in 1983.

excerpt only

	Entrepreneur	Company	Offering Price per Share/ Month of Offering	Value of Entrepreneur's Stock at Offering* (in millions)
1.	Allen E. Paulson Chmn./Pres/CEO	Gulfstream Aerospace Corp. Savannah, Ga.	$19 Apr.	$550.9
2.	K. Philip Hwang Pres./CEO/Chmn.	TeleVideo Systems Sunnyvale, Calif.	$18 Mar.	$520.4*
3.	Malcolm McLean Pres./Dir.	McLean Industries New York	$8 Aug.	$280.0
4.	Sy Syms Merns Chmn./CEO/COO	Syms Corp. Lyndhurst, N.J.	$15 Sept.	$249.8[1]
5.	Andrew F. Kay; Mary M. Kay Pres./CEO/Chmn.; Sec./Dir.	Kaypro Corp. Solana Beach, Calif.	$10 Aug.	$244.9
6.	Monroe Milstein; Henrietta Milstein CEO/Pres; VP	Burlington Coat Factory Warehouse Burlington, N.J.	$28 June	$188.3
7.	Michael P. Richer Chmn./CEO/Dir.	Combined Network Chicago	$11 Apr.	$173.9[1]
8.	Roy H. Park Chmn./Pres./CEO	Park Communications Ithaca, N.Y.	$19 Oct.	$159.6
9.	Martin Himmel; Harriet Himmel Chmn./Pres.; VP	Jeffrey Martin Inc. Union, N.J.	$13 May	$130.0*
10.	William N. Pennington Pres./Dir.	Circus Circus Enterprises Inc. Las Vegas, Nev.	$15 Oct.	$121.0
11.	William G. Bennett Chmn./CEO	Circus Circus Enterprises Inc. Las Vegas, Nev.	$15 Oct.	$121.0
12.	James L. Jaeger Pres./Treas./Dir.	Cincinnati Microwave Cincinnati	$12 Dec.	$105.9
13.	Samuel J. Frankino Chmn./Dir.	Agency Rent-A-Car Bedford, Ohio	$15.50 June	$93.0
14.	Joe Hrudka Pres./CEO/Dir.	Mr. Gasket Co. Brkln. Heights, Ohio	$12 Oct.	$87.0
15.	J.B. Hunt Chmn.	J.B. Hunt Transport Lowell, Ark.	$15.50 Nov.	$85.7
16.	Arthur Rock Chmn.	Diasonics Inc. Milpitas, Calif.	$22 Feb.	$83.8*
17.	Melvyn Goodman Pres./Dir.	Combined Network Chicago	$11 Apr.	$83.5[1]
18.	Philip D. Goodman Dir.	Combined Network Chicago	$11 Apr.	$83.5[1]
19.	Donald Tomlin Jr. Chmn./Pres.	U.S. Capital Corp. Columbia, S.C.	$13.50 July	$82.6
20.	Wilfred J. Corrigan Pres./Dir.	LSI Logic Corp. Milpitas, Calif.	$21 May	$80.5*
21.	Terje Mikalsen Chmn.	Norsk Data Oslo, Norway	$37.75[2] May	$78.3*
22.	James P. Lennane Pres./CEO/Dir.	System Integrators Sacramento	$10 Nov.	$74.7*
23.	Leslie C. Quick Jr. Chmn./Pres./CEO	Quick & Reilly Group New York	$18 June	$72.8*
24.	Robert Noyce Dir.	Diasonics Inc. Milpitas, Calif.	$22 Feb.	$72.3*
25.	Albert Waxman Dir./Pres./CEO	Diasonics Inc. Milpitas, Calif.	$22 Feb.	$69.6

* Refers to total shares prior to cashing in
* Includes shares owned by other members of the entrepreneur's family and/or trusts for them
[1] Includes shares held in voting trust
[2] American Depositary Receipts

Information for this chart was prepared by Judy Davis, Sid Kane, and CompuServe, Columbus, Ohio

#2. K. Philip Hwang, TeleVideo Systems Inc. "My wife's had the same car for five years," he says. "We're very simple and the only difference now is we've got savings for a rainy day." Mrs. Hwang's jalopy is a white 300D Mercedes and she parks it at their Welsh castle replica with sauna and spa in the master bedroom. Hwang began TeleVideo in a garage, making video games. Smuggled out of North Korea by U.S. soldiers, he immigrated at age 12, later washed dishes and waited on tables for college expenses. Hwang is proud of being the first Korean-born entrepreneur to take a U.S. company public

#5. Andrew F. and Mary Kay, Kaypro Corp., cashed $6 million of their $244.9 million holding. "I can probably buy an airplane or yacht," says Andrew, "but I chose to pay off mortgages and save a little for income tax." The Kays may donate to preventive medicine research or opera. His wife and mother helped stuff circuit boards for the company's first digital voltmeters in 1953. Heavy mortgaging of personal property has made Mary Kay nervous since then. "It's more fun now," says Andrew. "I don't have to scramble to meet payrolls. And my children are pretty well taken care of; they have stock in the company"

	Entrepreneur	Company	Offering Price per Share/ Month of Offering	Value of Entrepreneur's Stock at Offering* (in millions)
26.	Gene M. Amdahl Chmn.	Trilogy Ltd. Cupertino, Calif.	$12 Nov.	$68.4
27.	Carlton G. Amdahl V. Chmn.	Trilogy Ltd. Cupertino, Calif.	$12 Nov.	$68.4
28.	Neil S. Hirsch Pres./CEO/Dir.	Telerate Inc. New York	$20 Apr.	$67.6
29.	Raymond G. Chambers Dir.	Gibson Greetings Inc. Cincinnati	$27.50 May	$66.0[3]
30.	Francis W. Winn; Nancy K. Winn Chmn.; Investor	Computer Language Research Inc. Carrollton, Tex.	$21 May	$65.6
31.	William E. Simon Dir.	Gibson Greetings Cincinnati	$27.50 May	$65.1
32.	Lorraine Mecca Dir./Pres.	Micro D Fountain Valley, Ca.	$16 July	$59.1
33.	Stephen T. Winn Pres./Dir.	Computer Language Research Inc. Carrollton, Tex.	$21 May	$59.1*
34.	David L. Winn Dir.	Computer Language Research Inc. Carrollton, Tex.	$21 May	$59.1*
35.	Carol Winn Dunaway Investor	Computer Language Research Inc. Carrollton, Tex.	$21 May	$59.1*
36.	Chas. Kappenman Chmn.	Eagle Computer Inc. Los Gatos, Calif.	$12 June	$58.7
37.	James L. Clayton Pres./Chmn./CEO	Clayton Homes Inc. Knoxville, Tenn.	$16 June	$58.5
38.	Brownell Combs II Pres./CEO/Dir.	Spendthrift Farm Lexington, Ky.	$12 Nov.	$57.2[1]
39.	J.V. Taylor Chmn./Pres./CEO	Applied Circuit Technology Inc. Anaheim, Calif.	$11 Aug.	$57.2
40.	Mitchell D. Kapor Pres./Dir.	Lotus Development Cambridge, Mass.	$18 Oct.	$56.2
41.	Wilfred Schwartz Chmn./CEO	Federated Group City of Commerce, Calif.	$12.50 Nov.	$55.3[4] *
42.	Ronald G. Harper Chmn./Pres./CEO	MPSI Group Inc. Tulsa	$12 Mar.	$54.8*
43.	Tharald Brøvig V. Chmn.	Norsk Data Oslo, Norway	$37.75[2] May	$54.5*
44.	Aldo A. Croatti Pres./Dir.	Interstate Uniform Services Corp. Woburn, Mass.	$14 June	$52.1*
45.	Leslie Combs II Chmn.	Spendthrift Farm Lexington, Ky.	$12 Nov.	$52.0
46.	Richard T. Farmer Chmn./Pres./CEO	Cintas Corp. Cincinnati	$17 Aug.	$51.7*
47.	Robert Rosenkranz Chmn./Dir.	Hyponex Corp. Fort Wayne, Ind.	$11.50 Oct.	$50.7
48.	Hal Lashlee Dir./Sec.	Ashton-Tate Culver City, Calif.	$14 Nov.	$48.9
49.	George Tate Chmn.	Ashton-Tate Culver City, Calif.	$14 Nov.	$47.9
50.	Fayez Sarofim Investor	Diasonics Inc. Milpitas, Calif.	$22 Feb.	$47.8*

* Refers to total shares, prior to cashing in
* Includes shares owned by other members of the entrepreneur's family and/or trusts for them

[1]Includes shares held in voting trust
[2]American Depositary Receipts
[3]Shares held in trust for shareholder
[4]Shares held in limited partnership

Rick Browne/Picture Group

#22. James P. Lennane, System Integrators Inc. Two years out of college, he quit IBM in 1966 with the intention of becoming a millionaire, and made it in 1976. "After the first one, it gets a whole lot easier," he says. To firm up the books for the public offering, Lennane sold two company Learjets, although he kept his three personal jets. When the $2 million check from selling his stock arrived, Lennane had photos of the occasion taken in his company's parking lot and then it was back to the work that stacked up during the offering period. Later he bought an $89 Sears tool kit to tinker with his Corvette

#8. Roy H. Park, Park Communications. "Going public made absolutely no difference in my life," insists Park, who made his first fortune when he sold Duncan Hines Foods in 1956. Then he started buying media companies; Park Communications now consists of seven TV stations, 14 radio stations, and 75 newspapers. Park, a watch collector who wears one timepiece on each wrist, drives a 1972 Lincoln Continental Mark IV to the office, but also owns a 1929 Duesenberg and a 1949 Packard Darrin

	Entrepreneur	Company	Offering Price per Share/ Month of Offering	Value of Entrepreneur's Stock at Offering* (in millions)
51.	Edward J. Richardson Pres./Dir.	Richardson Electronics Ltd. Franklin Park, Ill.	$16 Oct.	$47.2*
52.	James S. Toreson Chmn./Pres./CEO	Xebec Sunnyvale, Calif.	$17 Mar.	$44.3
53.	Joel Newman Chmn./CEO/Dir.	Cosmo Communications Corp. Miami	$22 May	$44.0
54.	William E. Bindley Chmn./Pres./Dir.	Bindley Western Industries Inc. Indianapolis	$20 Aug.	$43.8
55.	Kosti Shirvanian Chmn./Pres.	Western Waste Industries Carson, Calif.	$17 June	$43.4
56.	Kevork S. Hovnanian Chmn./Pres./Dir.	Hovnanian Enterprises Red Bank, N.J.	$13.50 Sept.	$42.6
57.	Elliot S. Jaffe; Roslyn S. Jaffe Pres./CEO; Sec./Treas./Dir.	Dress Barn Inc. Stamford, Conn.	$23 May	$42.4*
58.	Charles Saatchi Dir.	Saatchi & Saatchi London, England	$22[2] Dec.	$42.1[5]
59.	Maurice Saatchi Dir.	Saatchi & Saatchi London, England	$22[2] Dec.	$42.1[5]
60.	Harold Goldsmith Chmn.	Merry-Go-Round Enterprises Inc. Towson, Md.	$21 July	$42.0
61.	Leonard Weinglass V. Chmn.	Merry-Go-Round Enterprises Inc. Towson, Md.	$21 July	$42.0
62.	Peter Preuss Pres./Dir.	Integrated Software Systems Corp. San Diego	$16 Mar.	$41.6
63.	Laurence Z. Moh; Celia Zung Moh Chmn./CEO/Dir.; Investor	Universal Furniture Ltd. Hong Kong	$12.50 Oct.	$41.1
64.	Philippe Villers Pres.	Automatix Inc. Billerica, Mass.	$19 Mar.	$40.9
65.	Abraham Gosman Chmn./Pres./Treas.	Mediplex Group Inc. Newton, Mass.	$15 Oct.	$39.6
66.	Richard A. Auhll Chmn./Pres./CEO	Circon Corp. Santa Barbara, Calif.	$22 July	$39.2
67.	Marvin Rounick Dir./Pres./CEO	Deb Shops Inc. Philadelphia	$17.50 Apr.	$38.6
68.	Philip J. Gomez Chmn./CEO/Dir.	ATV Systems Inc. Santa Ana, Calif.	$10 Oct.	$38.6
69.	Frank G. Gleason Pres./COO/Dir.	ATV Systems Inc. Santa Ana, Calif.	$10 Oct.	$38.6*
70.	Thomas R. Devlin Pres./CEO/Dir.	Rent-A-Center Inc. Wichita	$14.50 Nov.	$38.1
71.	W. Frank Barton Chmn./Dir.	Rent-A-Center Inc. Wichita	$14.50 Nov.	$38.1
72.	Richard L. Swarz Chmn./Pres./CEO	Protocol Computers Wdlnd. Hills, Calif.	$12 Sept.	$37.8
73.	Lance McFaddin Chmn./CEO	McFaddin Ventures Houston	$12.50 Dec.	$37.3
74.	Arthur Golden; Gladys Golden Chmn./CEO; Dir.	Chargit Inc. New York	$5 Nov.	$37.0
75.	Thomas R. Brown Chmn.	Burr-Brown Corp. Tucson	$17 Mar.	$36.6†

*Refers to total shares, prior to cashing in
* Includes shares owned by other members of the entrepreneur's family and/or trusts for them
†Includes shares held in voting trust
#American Depositary Receipts
§Shares held by a corporation controlled by the Saatchis

Jay Paris/Picture Group

#14. Joe Hrudka, Mr. Gasket Co. He has a crew of 35 restoring the Woolworth Mansion in Palm Beach, Fla., which he bought for $4.5 million, "the highest priced home ever sold in Florida," he believes. After starting Mr. Gasket in 1965 with $5, Hrudka took the company public in 1969, sold it to W.R. Grace & Co. for $17 million in 1971, and bought it back for $4 million in 1981

#51. Edward J. Richardson, Richardson Electronics Ltd., took a three-day weekend at his private 50-acre game refuge after offering day. Once a student veterinarian, he shelters a resident flock of greater Canada geese on a 300-acre Illinois country place. Within days of the offering, the stock price skidded to $12 from $16—and 155 of Richardson's 300 workers had invested. "Every hour somebody was checking the price," he recalls. The stock turned around and stood at $19 by January. Richardson joined his father's vacuum tube business at 19. Still in tubes, he's expanding now in the field he calls "the trailing edge of the electronics industry"

Gerald Davis

#9. Martin Himmel, Jeffrey Martin Inc., sold $27.7 million worth of his $130 million in stock in his health-and-beauty aids company, but insists his lifestyle didn't change. He and his wife Harriet bought a "pretty nice house" in affluent Short Hills, N.J., 20 years ago; his company Rolls-Royce was a gift nine months earlier from Harriet (who also sold $21.7 million). Says son Jeffrey, a vice-president at Jeffrey Martin: "His hobby is his work—he has very big dreams." Himmel made his first $1 million selling the expensive Zizanie men's cologne line to Faberge in 1971

	Entrepreneur	Company	Offering Price per Share/ Month of Offering	Value of Entrepreneur's Stock at Offering* (in millions)
76.	Edward L. Taylor Chmn./Pres./ CEO/Dir.	Satellite Syndicated Systems Inc. Tulsa	$12 Aug.	$36.0*
77.	Warren Weiner EVP/Sec./Treas.	Deb Shops Inc. Philadelphia	$17.50 Apr.	$36.0
78.	William Lyon Chmn./Pres./CEO	AirCal Inc. Newpt. Beach, Calif.	$12 Aug.	$36.0
79.	George L. Argyros V. Chmn./Sec./Dir.	AirCal Inc. Newpt. Beach, Calif.	$12 Aug.	$36.0
80.	Charles C. Gay Chmn.	Builders Transport Camden, S.C.	$17 Oct.	$35.4
81.	Howard S. Stern Chmn./Pres.	E-Z-Em Inc. Westbury, N.Y.	$14 Oct.	$35.3
82.	Andres Lagueruela Chmn./CEO/Dir.	Satelco Inc. San Antonio	$12 July	$34.6
83.	Rafael F. Veve V. Chmn./Dir.	Satelco Inc. San Antonio	$12 July	$34.6
84.	Hughes L. Potiker; Sheila M. Potiker Pres./Chmn.; VP/Sec./Dir.	Entertainment Publications Inc. Birmingham, Mich.	$12 Dec.	$34.6
85.	Phillip H. Meyers; Betty S. Meyers Sr VP/Dir.; Investor	E-Z-Em Inc. Westbury, N.Y.	$14 Oct.	$34.5
86.	Michael C. Goldberg Chmn./Pres.	FDP Corp. Miami	$13 Aug.	$34.0
87.	William L. Pierpoint Pres./CEO/Dir.	Summit Health Ltd. Studio City, Calif.	$7 Oct.	$31.5
88.	Dustin H. Heuston; Nancy Heuston Chmn./CEO; Sec.	WICAT Systems Inc. Orem, Utah	$18 June	$31.3*
89.	Terry G. Johnson Pres./CEO/Dir.	Miniscribe Corp. Longmont, Colo.	$11.50 Nov.	$30.9*
90.	Leonard Abramson Pres./Dir.	U.S. Health Care Systems Inc. Willow Grove, Pa.	$20 Feb.	$30.8*†
91.	Gary B. Friedman Pres./CEO/Chmn.	Fortune Systems Belmont, Calif.	$22 Mar.	$30.7
92.	Charles Lankford Chmn./CEO	Penta Systems Int'l Baltimore	$12.50 Mar.	$30.4
93.	Lazer Milstein VP	Burlington Coat Factory Warehouse Burlington, N.J.	$28 June	$29.5
94.	Stephen E. Milstein VP	Burlington Coat Factory Warehouse Burlington, N.J.	$28 June	$29.5
95.	Andrew R. Milstein Dir.	Burlington Coat Factory Warehouse Burlington, N.J.	$28 June	$29.5
96.	Patrick J. Rooney Chmn.	Rooney Pace Group New York	$8 Oct.	$29.0*
97.	Randolph K. Pace Pres./Dir.	Rooney Pace Group New York	$8 Oct.	$29.0*
98.	Donald E. Hess Pres./Dir.	Parisian Inc. Birmingham, N.Y.	$14.50 Nov.	$28.4*
99.	Richard MacNeal Chmn./CEO	MacNeal-Schwendler Los Angeles	$23 May	$28.3
100.	Peter R. Spirer Chmn./Pres.	Horizon Industries Calhoun, Ga.	$13.75 July	$28.2*

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* Includes shares owned by other members of the entrepreneur's family and/or trusts for them
†Includes shares held in voting trust

Patricia Do

#4. Sy Syms Merns, Syms Corp. With $1 million of the $35 million he received from selling personal stock in his off-price apparel chain, Merns endowed a marketing chair at New York's Yeshiva University. A son of Russian immigrants, he sees his fortune as "mind-boggling." After the offering, the family (four of six children work at Syms Corp.) had a celebration brunch. Negative side of going public: Disclosure of top managers' salaries sparked jealousy leading to in-house rivalries

HOW UNDERWRITERS STACKED UP IN 1983

Lead underwriters of 1983 initial public offerings are ranked according to the average percentage change in their stocks from the offering price to the price as of Dec. 30, 1983. Obviously, those companies that went public early in the year will have had a longer period to see their stocks rise or fall than more recent IPOs. In the case of mini- maxi-offerings, the offering size reflects only the *minimum* number of shares needed to complete the offering. Underwriter overallotments are not included in any figures. Excluded were self-underwritten, mutual funds, bank holding company, and savings and loan association stocks. Listed separately are: underwriters of stocks priced $1 and up with five or more offerings; two to four offerings; one offering. Penny stock underwriters are also listed separately.

Underwriters of Five or More Issues, priced at $1 and Up

	Lead Underwriter/ Location	Avg. % Change From Offering Date to 12/30	No. of IPOs Under-written	Avg. Offering Size ($ Millions)	Avg. Price* ($ per share)
1.	Swartwood, Hesse Inc. New York	139.7	5	3.0	3.760
2.	Adams, James, Foor Oklahoma City	53.7	5	3.1	4.550
3.	William Blair Chicago	53.3	6	9.5	11.920
4.	Muller & Co. New York	34.9	12	3.8	1.979
5.	Dain Bosworth Minneapolis	18.6	7	6.1	8.570
6.	Hambrecht & Quist Inc. San Francisco	16.8	9	18.0	12.940
7.	Moseley, Hallgarten, Estabrook & Weeden New York	16.5	6	9.5	9.042
8.	Advest Inc. Hartford	14.8	6	6.5	8.542
9.	Drexel Burnham Lambert Inc. New York	12.5	13	26.9	12.830
10.	D.H. Blair New York	10.6	34	4.5	4.531
11.	Bear Stearns New York	7.3	9	16.7	11.361
12.	Prescott, Ball & Turben Inc. Cleveland	7.1	6	5.1	4.917
13.	Robertson, Colman & Stephens San Francisco	7.0	7	27.9	14.429
14.	Ladenburg, Thalmann New York	6.4	8	7.8	7.672
15.	Salomon Bros New York	5.7	7	53.7	16.464
16.	Bunker Securities Great Neck, N.Y.	5.5	5	1.0	2.410
17.	Dean Witter Reynolds Inc. New York	5.1	9	15.9	12.444
18.	Lehman Brothers Kuhn Loeb New York	3.3	13	21.8	14.962
19.	E.F. Hutton New York	2.7	9	16.5	13.170
20.	J.C. Bradford Nashville	2.7	6	11.3	13.820
21.	Alex. Brown & Sons Baltimore	2.3	19	21.5	15.303
22.	Rooney, Pace New York	1.1	13	7.9	4.885
23.	Robinson-Humphrey/ American Express Inc. Atlanta	.5	8	13.5	12.080
24.	Smith Barney, Harris Upham New York	-1.9	5	20.1	14.750
25.	L.F. Rothschild, Unterberg Towbin New York	-2.1	29	37.6	13.655
26.	Kidder, Peabody & Co. New York	-2.6	10	31.9	16.100
27.	Morgan Stanley & Co. New York	-3.1	12	50.8	21.979
28.	Goldman Sachs & Co. New York	-6.8	10	60.3	17.800
29.	Donaldson, Lufkin & Jenrette Securities New York	-7.5	9	15.7	13.430
30.	Prudential-Bache Securities New York	-7.9	29	26.9	16.474
31.	Merrill Lynch Capital Markets New York	-9.0	19	36.7	14.630
32.	Blyth Eastman Paine Webber New York	-10.7	8	24.9	13.563
33.	The First Boston Corp. New York	-11.7	5	38.7	14.400
34.	Shearson/ American Express New York	-12.5	9	45.1	14.833
35.	Paulson Investment Co. Portland, Ore.	-12.7	10	2.6	502.575
36.	Laidlaw Adams & Peck Inc. New York	-17.0	8	6.0	6.188
37.	Bateman, Eichler, Hill Richards Inc. Los Angeles	-17.9	5	9.2	10.100
38.	Boettcher Denver	-19.0	5	5.0	6.500

Source: CompuServe Corp., Columbus, Ohio; Judy Davis

*Adjusted for stock splits; unit offerings at the offerings are adjusted to per share prices at the offering date and yearend.

IBM Unveils Products to Allow PC to Swap Data With Its Larger Computer Systems

By Dennis Kneale
Staff Reporter of The Wall Street Journal

NEW YORK—International Business Machines Corp. yesterday announced several new products designed to allow its Personal Computer to exchange information with most of its larger computer systems and other office products.

Among the introductions was a minicomputer that will sell for $13,000 to $28,000, accommodate as many as 86 user terminals, and appears to compete with one of the 3B series computers announced last week by American Telephone & Telegraph Co.

In addition, IBM unveiled a device that enables its Personal Computer and PCjr home computer to act as receiving terminals for videotex data. IBM also unveiled a new color video-screen monitor for the PCjr that will sell for about $430.

Most of the products, IBM executives said, represent a major—if incomplete—step toward integrating the Personal Computer into IBM's broad range of data-processing and office systems. Various products announced yesterday hook up the PC family, which includes the high-power XT, PCjr, and the portable PC, with several products. These include IBM's Displaywriter word processing terminal, the 5520 computer system, the 5218 printer normally used with Displaywriters, the System/36 minicomputer, the 8100 system, and the widely used Profs mainframe software system.

There still are missing links in making the PC a fully functioning work station in an office. At some point, IBM is expected to provide local-area networks, which let computers share files, printers and other devices; capabilities for routing and storing voice messages, and devices that permit revision of non-electronic images entered into computer networks.

IBM computers currently work in "hierarchical" patterns, using a central computer as relay station. Eventually, users will expect computers to be able to talk freely to each other as users of telephones do today.

IBM's announcements represent a "big step in the right direction, to make sense of their product line and revitalize their trust into office automation," said Bob Fertig, president of Enterprise Information Systems Inc., a Greenwich, Conn., consulting concern.

IBM's Personal Computer has been used as a stand-alone office device. Most of the new products will enable, for the first time, interaction between the PC and other products without requiring arduous format changes and reentry of incompatible files.

"This just about turns the PC into a whole new system," said Philip D. Estridge, president of IBM's Entry Systems division, which makes and markets the Personal Computer, PCjr, the portable PC and the high-power PC XT model. "This takes the new family of products (personal computers) into the mainstream IBM office strategy," he said.

This integration is accomplished largely with the help of four software programs IBM announced yesterday. These make it easier for the Personal Computer to be used by workers familiar with the IBM Displaywriter, a word-processing terminal, or IBM's 5520 and Datamaster office-system computers. The programs emulate many of the commands of the other products; two packages also allow for the first time hook-up and data exchange for Personal Computers and Displaywriters. IBM has sold about 200,000 Displaywriters and about one million Personal Computers for office use.

Most of the PC-related products will be available within a few months. Next month, IBM begins shipping the new minicomputer announced yesterday. Known as the 5362, it is described as a "little brother" of IBM's System/36 minicomputer and runs the same software. Priced from $13,000 to $28,000 depending on accessories, the new computer may compete with AT&T's 3B2/300 computer, which takes as many as 18 users and is priced at about $10,000.

Included in IBM's software introduction was PCWriter, a word-processing program that imitates commands used on the 5520 computer system and sells for $199. That could mean tough competition for other word-processing programs such as MicroPro International Corp.'s WordStar, which provides about 80% of the company's sales.

In composite trading on the New York Stock Exchange yesterday, IBM closed at $111.125, down 87.5 cents. AT&T closed, also on the Big Board, at $15.625, unchanged. MicroPro was quoted in the over-the-counter market at $8.75, up 25 cents.

New system manages hundreds of transactions per second

Parallel data paths, pipelining, large cache memory, and 32-bit hardware combine to increase transaction system performance

by Robert Horst and Sandra Metz, *Tandem Computers Inc., Cupertino, Calif.*

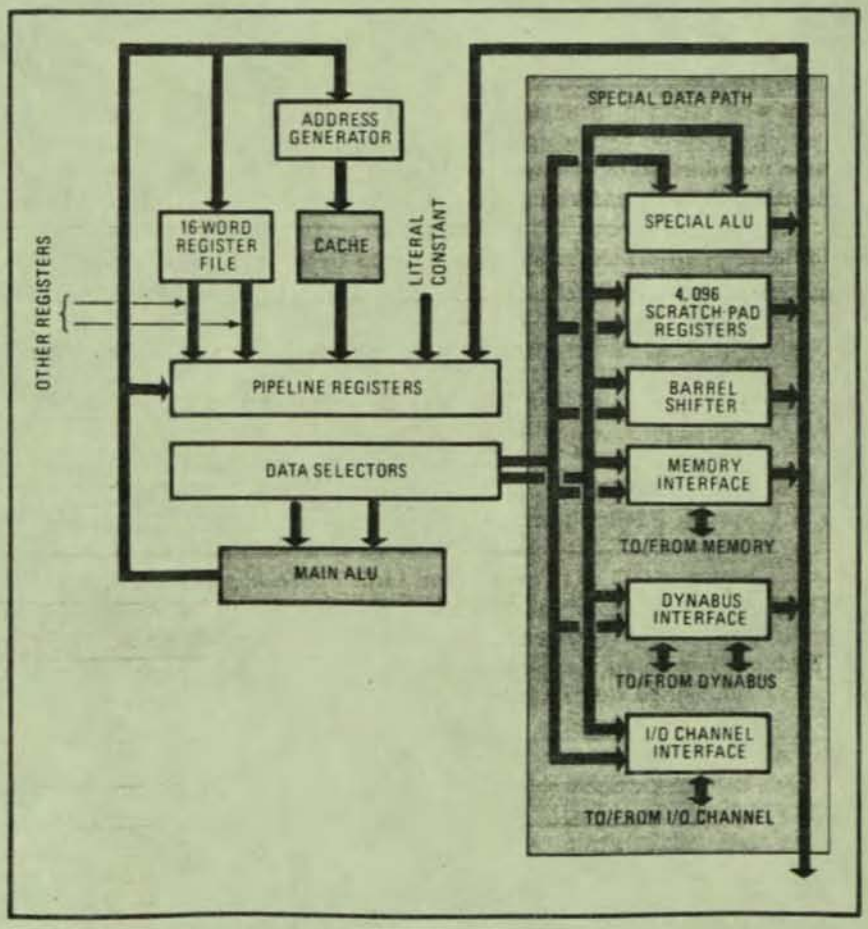
☐ Computer systems for on-line transaction processing have a unique set of requirements that pose an enormous challenge to designers. These systems have to be fault-tolerant, expandable through the addition of modules, and able to process multiple transactions at a reasonable cost, while maintaining data integrity. The coming generation of transaction-processing systems must also address a fast-growing need for very high-volume applications that require the processing of more and more transactions per second.

Designed to handle very high-volume transaction processing, the 32-bit NonStop TXP system reaches two to three times the speed of the NonStop II system it supercedes, while retaining complete software compatibility. Without reprogramming, a TXP system can grow from a single system containing from 2 to 16 processors, to a local cluster of up to 224 processors linked with fiber-optic cables, to a worldwide network of up to 4,080 processors.

Many of the problems in designing the TXP processor had already been solved in the NonStop II processor and system design. The NonStop II extended the instruction set of the NonStop 1+ system to handle 32-bit addressing but did not efficiently support that addressing in hardware. The existing 5-megabyte input/output bus and 26-megabyte Dynabus, Tandem's proprietary bus structure, had more than enough bandwidth to handle a processor with two to three times the performance. The existing packaging had an extra central-processing-unit card slot for future enhancements, and the existing power supplies could be reconfigured to handle a higher-power CPU.

The main problems involved designing a new microarchitecture that would efficiently support the 32-bit instructions at much higher speeds, with only 33% more printed-circuit-board real estate and an existing backplane. This involved eliminating some features that were not critical to performance and finding creative ways to save area on the pc board, including clever uses of programmable array logic and an unusual multilevel control-store scheme.

Since the new TXP processor was to be object-code-compatible with the Nonstop II system yet have a significant price-performance advantage, it was expected that soon after announcement much of the company's produc-



1. Parallel data paths. The NonStop TXP's architecture lets the main arithmetic and logic unit operate in parallel with either a special ALU, one of 4,096 scratch-pad registers, a barrel shifter, the memory interface, the Dynabus interface, or the input/output channel.

TABLE 1 COMPARE-BYTE INSTRUCTIONS (INNER LOOP)

Clock cycle	NonStop TXP		Traditional architecture
	Main ALU	Special ALU	
1	extract byte 1	extract byte 2	extract byte 1
2	compare bytes	—	extract byte 2
3	(repeat)	(repeat)	compare bytes
4	—	—	(repeat)

TABLE 2 DYNABUS RECEIVE MICROCODE INSTRUCTIONS (INNER LOOP)

Clock cycle	NonStop TXP		Traditional architecture
	Main ALU	Special data path	
1	compute checksum on previous word	read next word from bus queue	compute checksum on previous word
2	address next memory location	write data to cache and memory	read next word from bus queue, increment address
3	(repeat)	(repeat)	write data to cache and memory
4	—	—	(repeat)

tion would have to shift quickly from the NonStop II system to the TXP system. This required that efficient board-testing procedures be in place by the time the product was announced and precluded the use of traditional functional board testers, which need months of programming after the design is finished. Instead, scan logic was designed into the processor and a scan-based board-test system using pseudorandom test vectors was developed.

Performance improvements

The performance improvements in the NonStop TXP system were attained through a combination of advances in architecture and technology. The NonStop TXP architecture uses dual 16-bit data paths, three levels of macroinstruction pipelining, 64-bit parallel access from memory, and a large cache (64 kilobytes per processor). Additional performance gains were obtained by increasing the hardware support for 32-bit memory addressing.

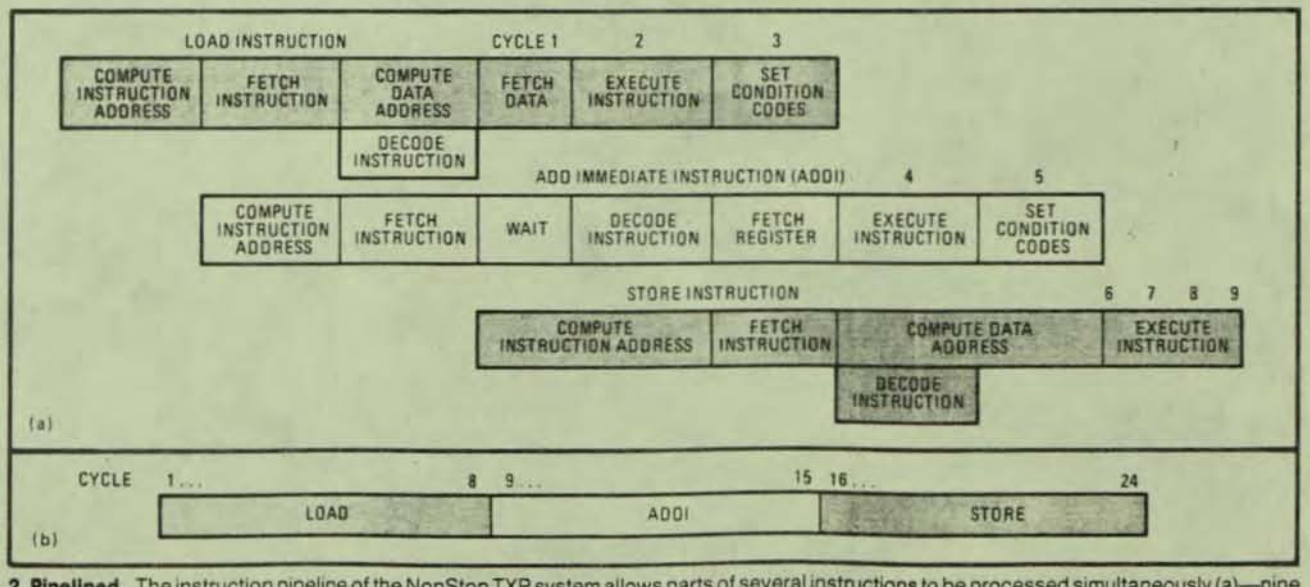
The machine's technology includes 25-nanosecond programmable array logic, 45-ns 16-K static random-access-memory chips, and Fairchild Advanced Schottky Technology (FAST) logic. With these high-speed components plus a reduction in the number of logic levels in each path, a 12-megahertz (83.3 ns per microinstruction) clock rate could be used.

The system's dual-data-path arrangement increases performance through added parallelism (Fig. 1). A main-arithmetic-and-logic-unit operation can be performed in parallel with another operation done by one of several special modules. Among them are a second ALU that performs both multiplications and divisions, a barrel shifter, an array of 4,096 scratchpad registers, an interval timer, and an interrupt controller. Other modules provide interfaces among the CPU and the interprocessor bus system, I/O channel, main memory, and a diagnostic processor.

The selection of operands for the main ALU and the special modules is done in two stages. In the first, data is accessed from the dual-ported register file or external registers and placed into two of the six registers. During the same cycle, the other four pipeline registers are loaded with cache data, a literal constant, the results of the previous ALU operation, and the result of the previous special-module operation.

In the next stage, one of the six pipeline registers is selected for each of the main ALU inputs and one for each special-module operand. Executing the register selection in two stages, so that the registers can be two- rather than four-ported, greatly reduces the cost of multiplexers and control storage, while the flexibility in choosing the required operands is unimpaired.

Some examples of the way microcode uses the parallel data paths are shown in Tables 1 and 2. The first example shows the inner loop of the compare-bytes instruction. Each of the dual ALUs in the TXP system extracts one byte; then the extracted bytes are compared. This operation takes two clock cycles on the TXP system



2. Pipelined. The instruction pipeline of the NonStop TXP system allows parts of several instructions to be processed simultaneously (a)—nine cycles are required to execute three typical instructions. Without pipelining (b), 24 clock cycles would be required.

Hardware-performance monitor helps optimize design

While new architectural concepts were being developed for the TXP system, a hardware-performance monitor was built to record measurements of the software-compatible NonStop II processor. Xplor consists of two large Wire-Wrap boards plus a small board to interface to the processor under test. It has approximately 800 Schottky TTL components and took more than two years to develop.

This general-purpose tool is capable of capturing 64 bits of data every 100 nanoseconds and reducing that data to usable form. The 256 kilobits of internal memory can be configured in many different word lengths to record, for instance, a 64-bit count of 4,096 different events, a 32-bit count of 8,192 different events, or a single flag for 256-K events. In addition, Xplor has programmable state machines with which data can be captured based on complex sequences of events; it includes hardware for the emulation of various cache organizations.

Two different Xplor configurations were developed to gather data for the TXP processor. The first was an instruction histogram measurement that records the frequency with which each instruction occurs, the percentage of time spent in each instruction, and the average number of code and data reads and writes performed by each instruction. The data is recorded in 64-bit counters, so in effect an unlimited amount of real-time data can be taken before the counters overflow.

The second Xplor configuration monitors memory addresses and emulates the tag store of a cache. Hit ratios for many different cache organizations can be determined by varying the effective cache size, associativity (one-, two, or four-way), block size, and replacement algorithm. Because the data is taken in real-time and reduced on-line, the hit-ratio measurements are much more accurate than the traditional technique, in which short address traces are recorded on tape for later analysis. This is especially important in transaction processing, since a large amount of process switching takes place; some individual transactions can last several seconds, during which millions of memory references take place.

Once the measurement methods were working, Xplor was attached to an eight-processor NonStop II system. A typical transaction-processing benchmark was brought up on the system, and transactions then were generated by another system, running software that simulated users at a number of terminals. At that point, histogram and cache measurements were taken for several of the central processing units.

The results of the histogram measurements helped determine some of the data-path widths and organizations for the TXP processor. Once the most frequently executed instructions were known, the design was modified to provide more hardware support for them. Since the measurements distinguished different paths through some instructions, tradeoffs could be made in the microcode to make the frequent cases faster.

The results of the cache measurements brought about some major changes in the original cache organization. In one measurement, the hit ratio went from 97% for the original cache to 99% for the final one, for an overall CPU performance gain of over 15%.

but would require three if the extract operations could not be done simultaneously.

The dual 16-bit data paths tend to require fewer cycles than a single 32-bit path when manipulating byte and 16-bit quantities and slightly more cycles when manipulating 32-bit quantities. A 32-bit add takes two cycles rather than one, but the other data path is free to use the two cycles to perform either another 32-bit operation or two 16-bit operations.

Time disadvantage

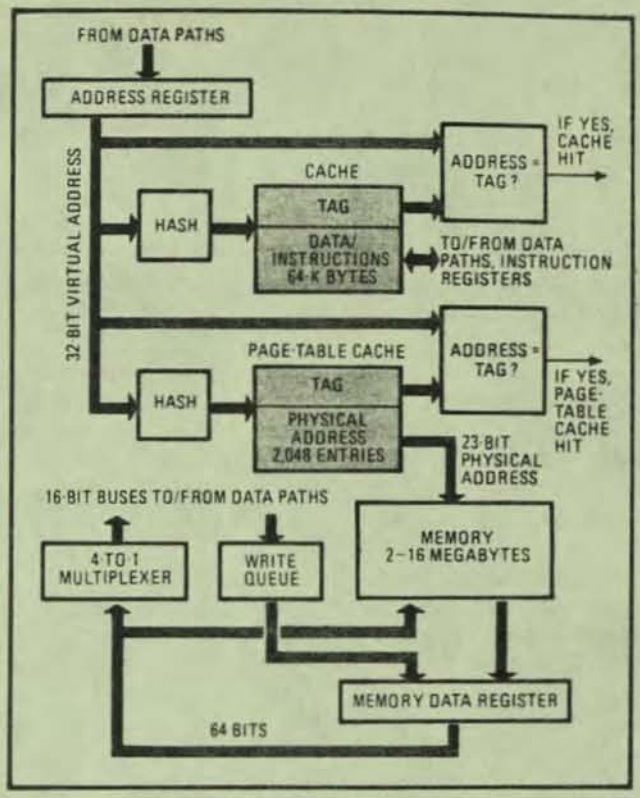
The time disadvantage in performing a single 32-bit operation is partially offset by the cycle-time advantage for 16- versus 32-bit arithmetic (32-bit arithmetic requires more time for carry propagation). Measurements of transaction-processing applications have shown that the frequencies of 32-bit arithmetic are insignificant relative to data-movement and byte-manipulation instructions, which are handled more efficiently by the dual data paths than by a single 32-bit data path. Most instructions have enough parallelism to let the microcode make effective use of both data paths.

To control the large amount of parallelism in the NonStop TXP system processor, a wide control-store word is required. The effective width of the control store is over 100 bits. To reduce the number of RAMs required, the control store is divided between a vertical control store of 8-K 40-bit words and a horizontal control store of 4-K 84-bit words. The vertical control store controls the first stage of the microinstruction pipeline and includes a field that addresses the horizontal control store, whose fields control the pipeline's second stage. Lines of microcode that require the same or similar horizontal controls can share horizontal-control-store entries.

Unlike microprocessor-based systems that have microcode fixed in read-only memory, the NonStop TXP system microcode is implemented in RAM, so it can be changed along with normal software updates and new performance-enhancing instructions can be added.

The NonStop TXP processor uses three-stage pipelining for both macro- and microinstructions. Figure 2 illustrates the operation of the macroinstruction pipeline for a sequence of three instructions. The first is a load instruction that loads a word into the hardware stack. The second is an add immediate instruction that adds a constant to a register on the hardware stack, and the third is a final store, which stores the result in memory.

With no pipelining, this sequence would require 24 (8+7+9) clock cycles to execute, but because the prefetch and part of the execution of each instruction can be overlapped with previous instructions, the actual execution time is just 9 (3+2+4) clock cycles. Because instructions are pipelined, the TXP processor can execute its fastest instructions in just two clock cycles (167 ns),



3. Memory access. The simple but extensive organization of the TXP cache provides an average hit ratio of over 96%. With a cache hit, the data is read out of the cache in 83 nanoseconds. When the data requested is not in cache, a cache miss results and the 64-bit-wide access to memory speeds the cache refill.

and it can execute load and branch instructions, which are frequently used, in only three clock cycles (250 ns).

Each NonStop TXP processor has a 64-K-byte cache that holds both data and code. A 16-processor NonStop TXP system has a full megabyte of cache memory. To determine the organization of the cache, a number of measurements were performed on a NonStop II system using a specially designed hardware monitor (see "Hardware-performance monitor helps optimize design," p. 149). The measurements showed that higher cache hit ratios resulted with a large, simple cache (directly mapped) than with a smaller, more complex cache (organized as two- or four-way associative). Typical hit ratios for transaction processing on the NonStop TXP system are in the range of 96% to 99%.

Cache miss

Cache misses are handled in a firmware subroutine rather than by the usual method of adding a special state machine and dedicated data paths for handling a miss. Because of the large savings in cache hardware, the cache can reside on the same board as the primary data paths; keeping these functions proximal reduces wiring delays and contributes to the fast 83.3-ns cycle time.

The cache is addressed by the 32-bit virtual address rather than by the physical address, thus eliminating the extra virtual-to-physical translation step that would otherwise be required for every memory reference. The virtual-to-physical translation, which is needed for refilling the cache on misses and for storing through to memory, is handled by a separate page table cache that holds mapping information for as many as 2,048 pages of 2-K bytes each (Fig. 3).

A cache memory by itself does not necessarily boost a processor's performance significantly. It is of little use for the cache to provide instructions and data at a higher rate than the rest of the CPU can process. In the TXP processor, the cache's performance was tuned to provide instructions and data at a rate consistent with the enhancements to instruction processing provided by increased pipelining and parallelism.

32 bits and more

The two concerns related to a system's word length are capability and performance. The NonStop TXP system has 32-bit virtual addressing built into the hardware, so is capable of addressing a gigabyte of virtual memory. In addition, the TXP processor can manipulate 32 bits of data at a time through its dual 16-bit data paths. Thus the 32-bit NonStop TXP system has the additional advantage of being able to run software that was originally written for the 16-bit NonStop II system; both systems have been provided with instructions that can operate on 8-, 16-, 32-, and 64-bit data types.

In transaction processing, measurements of instruction frequencies show that data-movement instructions (loads, stores, and moves) occur much more frequently than 32-bit arithmetic instructions. For this reason, the NonStop TXP system is optimized to handle data movement by providing 64-bit access to main memory and 32-bit buses and address registers to make memory addressing as efficient as possible.

The NonStop TXP processor was implemented on four large pc boards using high-speed FAST logic, PALs, and high-speed static RAMs. The CPU's logical and physical partitioning was carefully controlled to ensure that the machine's basic cycle time would not be slowed by long propagation delays. The four CPU boards are:

- SQ: containing the control store and sequencing logic.
- CC: containing the I/O channel and various special modules.
- IP: holding the main data paths and cache.
- MC: providing the memory interface, barrel shifter, and interprocessor bus interface.

Each CPU module also has from one to four memory boards. On the initial release, each memory board contains 2 megabytes of error-correcting memory implemented with 64-K dynamic RAMs. A 16-processor NonStop TXP system can therefore contain up to 128 megabytes of physical memory.

The NonStop TXP system was designed to be easy to manufacture and efficient to test. Data and control registers were implemented with shift registers configured into several serial-scan strings. The scan strings are of value in isolating failures in field-replaceable units. This serial access to registers also makes board testing much faster and more efficient because the tester can directly observe and control many control points. A single custom tester was designed for all four CPU boards and for the memory-array board as well.

The NonStop TXP system is the first product to be

MIPS and transactions per second

Determining relative performance among computer systems has never been an easy task. The often-quoted millions-of-instructions-per-second rate is intended as a way to compare basic central-processing-unit-hardware performance. Comparisons are also made on the basis of benchmarks. CPU-intensive benchmarks measure the performance of the CPU hardware and compiler; more extensive benchmarks measure the entire system performance—including the hardware, compiler, operating system, and data-base-management system. In general, the more extensive benchmarks give a more accurate prediction of actual system performance.

Each of the various measurement techniques has pitfalls. The MIPS rate is perhaps the least accurate way to compare systems. One reason is that there is no easy way to relate the power of one instruction set to another. In addition, vendors vary in the way they measure MIPS: some use it for the speed of the fastest instructions, others measure the speed of the most frequently executed instructions, and still others measure the speed of a "typical" mix of instructions. According to these definitions, each NonStop TXP processor is 6, 4, or 2 MIPS, respectively.

developed using Tandem's proprietary computer-aided-design system. The CAD system's capabilities for logic entry, logic simulation, and automated pc-board routing were instrumental in reducing the design time. While most high-performance CPUs require four to five years to develop, the NonStop TXP processor took just 2½ years—six months to complete a written specification, one year to construct a working prototype, and another year to reach volume production.

Performance measurement

Some simple benchmark programs have recently become popular in measuring performance (see "MIPS and transactions per second," p. above). One is the Puzzle benchmark, which is a CPU-intensive program to solve a three-dimensional puzzle. Execution times for Puzzle can vary widely for the same machine, depending on whether the program accesses arrays through subscripts or pointers and whether frequently used variables are assigned to registers. Versions of the Puzzle benchmark with pointers and registers were used to compare relative performance for a TXP processor.

Puzzle was written in TAL (transaction application language, the company's system-programming language); the execution time, using a single TXP processor, was measured at 1.67 s. This compares with 4 s on a VAX-11/780 for Puzzle written in C.[1] Because Puzzle does not measure such system features as support for virtual memory, I/O bandwith, and the ability to do fast context switching, a standard benchmark for comparing transaction-processing systems is still needed.

One transaction-processing benchmark has been developed by a third party, however. The U. S. Public Health Service ran an extensive benchmark in 1981 to determine which system to select for a large on-line medical-information system.[2] In that study, a 15-processor Tandem NonStop system running a 1981 version of Tandem's Encompass DBM system performed the benchmark at a rate of 4.5 transactions/s. An International Business Machines Corp. System 370/168-3 running version 3 of the Adabas DBM system performed the same benchmark at 2 transactions/s.

TABLE 3: TANDEM VERSUS IBM PERFORMANCE COMPARISONS

	U.S. Public Health Service benchmark: results (transactions per second)	USPHS benchmark: extrapolated results* (transactions per second)
IBM 370/168-3	2	—
Tandem NonStop 15-processor system	4.5	—
IBM 4381-2	—	2.25
Tandem NonStop TXP 3-processor system	—	2.7

*Not actual measurements

This benchmark gives a data point for comparisons between Tandem and IBM systems. A 15-processor NonStop system performs the Public Health Service benchmark 2.25 times as fast as an IBM 370/168-3. Though it would be desirable to compare the TXP system directly to one of IBM's newest systems, such as the IBM 4381-2, no competitive benchmarks have been published. However, comparisons of the MIPS rate of different processors within a single family are fairly accurate and can be used to extrapolate to newer systems.

According to market research performed by the Gartner Group,[3] the IBM 4381-2 is rated at 2.7 MIPS, compared with the older IBM 370/168-3's 2.4 MIPS rating—a ratio of 1.125 : 1. Company tests have shown the NonStop TXP to have a MIPS rate approximately three times that of the NonStop processor. The extrapolation of the Public Health Service benchmark performance to the two newer systems is shown in Table 3.

Unlike many shared-memory multiprocessor systems, Tandem systems provide linear growth in transaction-processing power as the system expands. A single system can include up to 16 processors, and clusters with as many as 224 NonStop TXP processors may be configured with Tandem's fiber-optic link. Clusters with up to 60 processors are currently in operation, and their users have verified the linear-performance growth within a cluster of this size.

The largest IBM mainframe today is the IBM 3084, which is rated at approximately 23 MIPS. Extrapolation from the benchmark data suggests that the performance of a cluster of 224 TXP processors is on the order of 10 times as powerful as IBM's top-of-the-line 3084 processor. □

References

[1]Malcolm A. Gieser, Judith Bayard, and David D. Lang, "Benchmarking for the Best," Datamation, May 1981

[2]Computer Architecture News, 10 : 1, March 1982, p. 29.

[3]Gartner Group Inc., Stamford, Conn., market research surveys.