

MICROPROCESSOR TURNS 25 SOUTH AFRICA REBOOTS

ANNIVERSARY ISSUE

# Upside

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The Business Magazine for the Technology Elite

## THE GAMBLER

Bell Atlantic's Ray Smith Bets On Information Highway

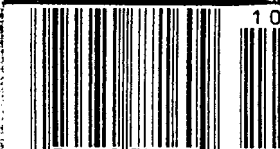
## ON THE FUTURE

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### HIGH-TECH INTEGRATION

African-Americans

Move Into Executive Ranks... Slowly



## GORDON BELL

Gordon Bell is a computer industry consultant at large. He spent 23 years at Digital Equipment Corp., where, as vice president of research and development, he was responsible for Digital's products. He was the architect of various mini- and time-sharing computers and led the development of Digital's VAX and the VAX computing environment. Bell has been involved in or responsible for the design of many products at Digital, Encore, Ardent and a score of other companies.

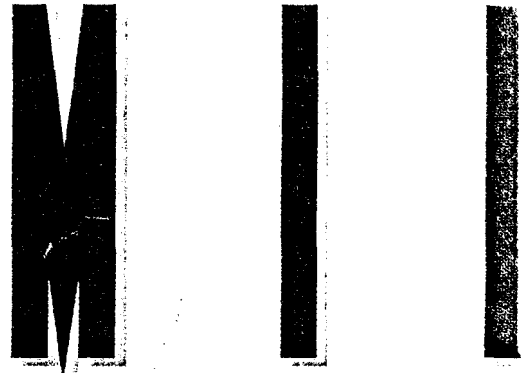
From 1966 to 1972 he was professor of computer science and electrical engineering at Carnegie-Mellon University, Pittsburgh. In 1986-1987 he was the first assistant director of the National Science Foundation's Computing Directorate. He led the National Research Network Panel that became the NII/GII and was an author of the original High-Performance Computer and Communications Initiative.

Bell has authored books and papers about computer structures and, recently, starting companies. In April 1991, Addison-Wesley published *High-Tech Ventures: The Guide to Entrepreneurial Success*.

He is a director of the Bell-Mason group, which supplies expert systems for venture development to startups, investors, government policy makers and entrepreneurial ventures. He is also a founder and overseer of the Computer Museum, Boston.

He lives in Los Altos, Calif., and Boston. His e-mail address is gbell@mojave.stanford.edu.

# MUSINGS ON THE



## THE INTERACTIVE HOME

**By the end of the decade, what kind of lines will run into the typical U.S. home: copper, coaxial, fiber, other?**

GORDON BELL: Virtually no change will occur in the type of lines by 2000. A negligible number of homes will have been wired with fiber. For cable, digital will be used on some channels to deliver bits to the settop. This will only be available in half of the current homes.

ROBERT LUCKY: All of the above, in great profusion. In addition, radio waves will envelop the home and satellites will look down wistfully in hopes of business. NATHAN MYHRVOLD: There will be different kinds of physical wires. It's not important what the wire will be. Some people will still have copper, but there will be little new twisted-pair. The new stuff will be fiber and coaxial.

JEF RASKIN: Any bidirectional channel of sufficient capacity looks pretty much the same to the user. We will see an eclectic mix and they will become increasingly interconnected. The big growth area will be in wireless, and fiber optics will not go into a majority of homes.

JOHN WARNOCK: I really don't know or care. I care what the bandwidth delivery is, how switchable the lines are and how open the architectures are.

**How many communication lines will the typical U.S. home have?**

BELL: The number of lines may not increase very much. Phone lines, including dedicated computer lines, will evolve to have ISDN speeds, which will in turn

enable high-quality video telephony.

LUCKY: I think two, not counting radio and satellite. The telcos and cable companies will both provide broadband access, and their businesses will overlap. It's hard to think of a reason why I need two broadband pipes into my home, but it will be good for us, we are assured.

MYHRVOLD: One, but you'll have multiple choices. There probably will be more than one company willing to run a line to you. You'll be able to say who your local exchange carrier will be. It may be a telco or a cable company or even an electric power company. It's like the long-distance choices today.

RASKIN: Ten bidirectional, including wireless paths.

WARNOCK: They'll have at least two major lines, one from the phone companies and one from cable companies.

**What kind of company will own the various lines: electric power, telco, cable, other?**

BELL: RBOCs are likely to be going after corporate data business because it's really lucrative, unregulated, a mess, and the customers are tired of building and operating expensive, unreliable data networks. Cable companies will make the transition to digital and they will be able to use a TC (television computer) for interactive use, including the Internet and being a PC and game computer.

LUCKY: The communication access lines will still be owned by the telcos and cable TV companies. There is an outside chance that the electric utilities will get into the business with their own network,

# LEMMING

TO CELEBRATE OUR 10TH ANNIVERSARY, UPSIDE IS LOOKING TO THE FUTURE. WE ASKED FIVE LEADING TECHNOLOGISTS WHO HAVE MADE AN IMPACT IN HIGH TECH TO TELL US WHAT THE WORLD WILL BE LIKE IN THE YEAR 2000.

OUR CONTRIBUTORS ARE: GORDON BELL, WHO LED THE DEVELOPMENT OF DIGITAL'S VAX COMPUTER; ROBERT LUCKY, VICE PRESIDENT OF APPLIED RESEARCH AT BELLCORE; NATHAN MYHRVOLD, SENIOR VICE PRESIDENT OF ADVANCED TECHNOLOGY AT MICROSOFT; JEF RASKIN, WHO LAUNCHED THE MACINTOSH PROJECT AT APPLE; AND JOHN WARNOCK, CHAIRMAN AND CEO OF ADOBE SYSTEMS.

WE ASKED THEM TO GO OUT ON A LIMB AND PREDICT WHAT THE FUTURE HOLDS FOR THE HOME, BUSINESS, THE HIGH-TECH INDUSTRY AND TECHNOLOGY. THEIR RESPONSES APPEAR BELOW.

but this doesn't seem rational from the point of view of the consumer.

MYHRVOLD: Many companies will own the lines. This is like saying, when the auto was invented, "Who is going to be the winner among the carriage makers?" People who provide you with information utility service—you won't call them a telco or cable company. They're going to be an information utility company.

RASKIN: Power companies won't have communication lines. Telco, cable and special niche services will. What customers will most care about is whether the services are easy to use and that they are transparently connected.

WARNOCK: Telephone companies are in the best position to own the lines, as well as some variant of cable companies—but probably not the same cable companies as today. I see no indication that power companies will get into this market.

### What will the average home have hooked up to these lines?

BELL: Phone: same as today (phone, videophone, fax, answering machine, computer, security and more protection including video monitoring, back channel for cable if cable isn't two-way or if you use broadcast to get video). Phone lines (e.g., ADSL) carrying cable: very small number will be in use. Cable:

the television computer linked to cable and capable of connecting to Internet via phone links, if necessary. Video on demand, in the form of a "virtual VCR" or hypertext-linked video, won't be used extensively in the home within five years. LUCKY: Probably a settop box supercomputer. From there to computers, games, televisions, home controllers, videotelephones, etc. Mainly, though, television sets for conventional entertainment and computers for everything else, including unconventional entertainment.

MYHRVOLD: A wide variety of things. Anybody who believes there's only one kind of box at the end is very wrong. Electricity was first billed as a dedicated lighting system. We don't think of it as a dedicated lighting system anymore. It's a general-purpose utility. You plug in all kinds of things. It will be the same for the information lines—your home security system, PC, intelligent television will all be plugged in.

RASKIN: TV, digital audio, phones, computers, government services (perhaps one or two areas will have electronic voting and routine communications and government payments over electronic channels), special-purpose dedicated devices.

WARNOCK: We'll continue to have televisions, but they won't be the primary interactive device. Interactivity is a singular activity, not a group activity. Computers will be the primary interactive device. While there will be many new single-



## ROBERT LUCKY

Robert Lucky is corporate vice president of applied research at Bellcore, the research arm of the seven RBOCs located in Red Bank, N.J. After receiving a Ph.D. in electrical engineering from Purdue University in 1961, Lucky joined AT&T Bell Laboratories in Holmdel, N.J., where he studied ways of sending digital information over telephone lines. The outcome of this work was his invention of the adaptive equalizer—a technique for correcting distortion in telephone signals that is used in all high-speed data transmissions today. The textbook on data communications that he coauthored was for a decade the most cited reference in the communications field.

In 1982 he became executive director of Bell Labs' Communications Sciences Research Division, where he was responsible for research on the methods and technologies for future communication systems. In 1992 he left Bell Labs to assume his present position at Bellcore.

Since 1982 he has written the bimonthly "Reflections" column of personal observations about the engineering profession in *IEEE Spectrum* magazine. In 1993 these columns were collected in the IEEE Press book *Lucky Strikes... Again*.

Lucky and his wife, Joan, live in Fair Haven, N.J. His e-mail address is rlucky@bellcore.com.

purpose information devices with computing power built into them, there will continue to be a multipurpose information machine that has a single user interface, call it a PC.

### What will the typical household spend for interactive entertainment per month?

BELL: Ten percent more than they do today, including all the money spent on games, etc.

LUCKY: When you ask consumers what they would be willing to pay for something, the answer is always \$10. The burning question, though, is whether it is another \$10, or the same \$10. My guess would be \$25 more than their basic cable bill is now, but this is on the optimistic side.

MYHRVOLD: TV today is heavily subsidized by advertising. The average household spends about \$22 a month for "free" TV by supporting it through advertising. If you include advertising subsidies and all the various forms of information like newspapers and magazines, people are spending over \$100 a month on information today. The total spent is going to be higher at the end of the decade—\$120 to \$150. Take today's spending on all information and communications and increase it by 20 or 30 percent.

RASKIN: In year 1999 dollars: \$120.

WARNOCK: It probably will not be a lot more than what they spend now for entertainment. Disposable income tends not to expand. So these new forms of entertainment will be at the expense of some other existing forms of entertainment, such as movies or magazines.

### What will the average household spend for other forms of interactive activity: computing, receiving and sending information, etc.?

BELL: My guess is, not much more than they do today for all forms of information and games.

LUCKY: Very little. I don't think that there is a big market for information in the "average" home. I could see a lot of people being willing to pay, say, \$15-\$20 a month for high-speed Internet access. They would expect that a lot of information would be free behind that access. As they begin to pay for stuff in the electronic marketplace, I would see it coming out of entertainment spending. There isn't an inexhaustible sup-

ply of new money in the average home. It has to come from somewhere, and the papers tell us no one saves anything. MYHRVOLD: The question should really be, How much will be spent on old vs new media forms? About half and half. Half of the \$120 to \$150 will still go to old forms. WARNOCK: The network will be one of the primary information sources for database searches, current news, etc. But a lot has to happen before it can replace newspapers and the like. It may take 10 years or more. Consumers still need and want the editorial judgment that editors at newspapers and magazines provide. And on-line services do not yet offer that.

### Today about one-third of U.S. homes have a PC. What percentage will have a PC by the end of the decade?

BELL: The pure PCs we know and love today will approach 50 percent. The TC—a PC that connects to cable and provides TV and Internet access—will also come into existence. Varieties of PCs (i.e., appliances) that do useful things ranging from security to news gathering to taking data from closed captions should emerge. Still no robots in the home.

LUCKY: I'll guess 80 percent. I see PCs as being the primary access method for just about everything other than entertainment television. That includes the game market.

MYHRVOLD: 70 percent.

RASKIN: 55 percent.

WARNOCK: PCs will have close to the same percent penetration as TVs do today. [Editor's note: Approximately 98.2 percent of American households have televisions.]

## THE INTERACTIVE BUSINESS

### What percentage of business communication (by number of contacts, not by volume of data) in the U.S. would you guess takes place by the following methods today, and what percent will occur at the end of the decade?

FAX

BELL: Today: 11%. End of decade: 7%.

LUCKY: 10%/10%.

MYHRVOLD: Based on the current definition, use will decline substantially. There will be little difference between fax and e-mail six years from now.

RASKIN: 25%/10%.

WARNOCK: There will be better ways to communicate than fax. Its use will decline.



## NATHAN MYHRVOLD

**Nathan Myhrvold is senior vice president of advanced technology at Microsoft Corp. His division is responsible for identifying and creating new technology that will have a commercial impact on Microsoft and incorporating it into the company's strategy and products. Myhrvold's division includes advanced product development in such areas as multimedia and new forms of consumer computing; it also includes Microsoft Research—a research lab dedicated to creating new technology in support of the company's vision of the evolution of personal computing.**

**Myhrvold joined Microsoft in 1986 as director of special projects. Prior to joining Microsoft, he was president and CEO of Dynamical Systems, a Berkeley, Calif., software company that was purchased by Microsoft. Before founding Dynamical Systems, he worked with Professor Stephen Hawking at Cambridge University on research in cosmology and quantum theories of gravitation.**

**Myhrvold holds a B.S. degree from the University of California, Berkeley, and a Ph.D. in theoretical/mathematical physics from Princeton University. His e-mail address is nathanmy@microsoft.com.**

### VOICE TELEPHONE

BELL: 15%/15%.

LUCKY: 50%/30%.

MYHRVOLD: It doesn't have to decline in absolute terms, but in proportion to e-mail, which will expand enormously, it will decline substantially.

RASKIN: 55%/45%.

WARNOCK: Its use will decline also, but not as much as fax.

### COMBINED VIDEO/VOICE CONFERENCING

BELL: 2%/10%.

LUCKY: 2%/10%.

MYHRVOLD: Increase substantially. It will be a standard feature of PCs. People will use it quite commonly. It really enables a level of work at home that is superior to other techniques. I would expect to have a substantial number of people at Microsoft working at home by then.

RASKIN: 0%/10%.

WARNOCK: Use of this technology will increase, but it will not be done the way it is today. It will be infinitely simpler to use and more useful. For example, you will be able to look at documents while communicating with voice and video.

### OVERNIGHT MAIL

BELL: 2%/1.5%.

LUCKY: 3%/5%.

MYHRVOLD: No great change. Lots of things sent FedEx today will be sent digitally in the future, like documents and diskettes. But when you're buying physical goods from the information highway, you've got to get them home somehow. So delivering all kinds of things will go way up, until we have replicators and translator beams.

RASKIN: 2%/2%.

WARNOCK: The percentage will decline.

### REGULAR MAIL

BELL: 20%/10%.

LUCKY: 25%/25%.

MYHRVOLD: Same as overnight. The area of biggest change will be in reply mail and direct mail advertising.

RASKIN: 15%/7%.

WARNOCK: The percentage will decline.

### ELECTRONIC MAIL

BELL: 50%/56%. (I assume the quality of e-mail is significantly increased to handle most corporate documents.)

LUCKY: 10%/30%.

MYHRVOLD: E-mail, including pagers and

fax, will be the predominant form of communication. This will be 90 to 95 percent of all communication by contact.

RASKIN: 3%/26%.

WARNOCK: Use will grow dramatically.

### How many traditional mainframe computers will be left in the world?

BELL: Conservative scenario: The number will not have significantly shifted. The amount spent on mainframes will actually increase by 5 percent per year. Radical scenario: The number will decline and the amount spent will decline by 10 percent a year; thus, the market size will be half of what it is today.

LUCKY: I don't know what a "traditional mainframe computer" is. Maybe all computers at the turn of the century will be traditional mainframe computers. They just will be sitting on desktops and other unlikely places. They will be networked. Nobody will know that they are traditional mainframe computers. They will keep this secret.

MYHRVOLD: A surprisingly large amount but less than today. No one will be buying new mainframes. But if some old mainframe is up and running and it's working and the application is static, there won't be much incentive to change.

RASKIN: 2,156.

WARNOCK: Mainframes are getting de-emphasized today, but there is a good likelihood we will swing back toward more centralization of information because it may be more effective than decentralizing it. The machines that sit at the centralized location will not be traditional mainframes, though. They may look more like large servers.

## THE HIGH-TECHNOLOGY INDUSTRY

### List who you think will be the world's biggest company in each of these areas.

#### SEMICONDUCTORS

BELL: I believe that Intel, IBM and Korean suppliers may all move up.

LUCKY: NEC or some other Japanese mega-company.

MYHRVOLD: If you keep it in dollar volume, Intel or maybe somebody else. If you go by unit volume, the ones we work with most are DRAM guys.

WARNOCK: Intel.

#### NETWORKING EQUIPMENT

BELL: The biggest surprise will be that IBM



## JEF RASKIN

Jef Raskin is an independent consultant on interface design, best known for creating the Macintosh project when he worked at Apple Computer Inc. He was also responsible for the one-button mouse, the click-and-drag paradigm for using it, the "Apple Style" manuals and other interface-based products. After leaving Apple, he was CEO of Information Appliance Inc.

Before joining Apple, he was a professor and computer center director at the University of California, San Diego, and a visiting scholar at the Stanford Artificial Intelligence Laboratory. He has also taught at the University of Kansas, Notre Dame University and Pennsylvania State University.

Raskin now consults on interface design and is a widely read author on a variety of subjects, from business and computers to aerodynamics and ecology.

He is also a published composer of music for recorders and other chamber ensembles. He works from his home in Pacifica, Calif., and can be reached at [raskinjef@aol.com](mailto:raskinjef@aol.com)

will enter this group with ATM switches.

LUCKY: AT&T.

MYHRVOLD: As people move to ATM and broadband, we're going to have more flux than we've seen since the field was created.

WARNOCK: AT&T.

### NETWORKING SERVICES

BELL: The big surprises: IBM will enter networking services. The other new entrants will include the long lines and RBOCs, to try to make up for their loss of not getting in on the LAN gold rush. This will be at the expense of the LAN companies.

LUCKY: AT&T.

MYHRVOLD: For the last few years in the long-distance business, AT&T has lost share to MCI and Sprint. AT&T will still be number one but will have lost more share. RBOCs and local services will have lost a small but measurable amount of share to people offering telephony and other services (e.g., cable and electric utilities). It's hard for me to see that there would be any inversion in the list in the next six years.

WARNOCK: AT&T.

### CONTENT SOFTWARE

BELL: No idea. New providers will emerge that we don't know about.

LUCKY: Microsoft.

MYHRVOLD: What we mean by content software by the end of the decade will be much different than what we mean today. The top 10 companies will include a couple of movie studios, one or two media conglomerates, a couple of PC multimedia title developers (I sure hope that includes Microsoft) and the remainder of the list will be new entrants. So much is open. Nothing is fated.

WARNOCK: No guess, though it will probably be a traditional publisher or media company like McGraw-Hill.

### SYSTEM AND APPLICATION SOFTWARE

BELL: Microsoft, IBM, Oracle, Computer Associates, Lotus, Adobe, Apple, Novell.

LUCKY: Microsoft.

MYHRVOLD: We're sure going to try to stay number one. The number of competitors we've had in system software has changed. Maybe IBM will make some comeback. Steve Jobs would say it's going to be Next. Sun has flirted with being a software company and hasn't quite made the transition. There are plenty of scenarios under which we'd be knocked out of number one.

WARNOCK: Microsoft.

### BUSINESS COMPUTING DEVICES

BELL: IBM, HP, Compaq, Fujitsu, NEC, Apple, Sun, Digital, Unisys.

LUCKY: Tough call. I'll play the long shot and take IBM.

MYHRVOLD: It's hard to guess. People were writing Compaq off two years ago. Now they're revived. Anything is possible.

WARNOCK: Too close to call.

### CONSUMER COMPUTING DEVICES

BELL: Sega and Sony will both be building PCs that are television-set based. Proprietary games will be for the portable niche, like today's organizers.

LUCKY: Whatever this is, I'll take Sony.

MYHRVOLD: Sharp makes money selling the Wizard. All the other cheap computing devices such as PDAs have not been very successful. Within the next six years it's likely we will see effective, small, handheld computers. It will be someone who's doing something quite different than has been done already, like the Newton or General Magic.

WARNOCK: Sony.

### Today IBM's revenues are about \$63 billion; what will they be at the end of the decade?

BELL: Conservative scenario: \$85 billion.

Radical scenario: \$63 billion.

LUCKY: \$50 billion, with luck.

MYHRVOLD: IBM's strategy isn't clear to me. They have enough creativity in that company, enough money and horsepower to get into a brand new business and make it very substantial. They also have enough problems to seal their fate. The question is, When can they return to real, sustainable profitability? We may discover there is a new, healthy IBM whose revenues are half what they are today. Given the turnaround nature of the task and the remaking of their business model, if I were Gerstner, revenue would not be my goal. I would be interested in the viability of the business franchise, sustainability, profitability.

WARNOCK: Less.

### What will be the dominant programming language?

BELL: Visual Basic, Mosaic markup language, C++, Cobol C, Fortran, Telescript (or Microsoft equivalent if Telescript is held proprietary).

LUCKY: C++. There will be too much investment in code to change this. Cobol is still ubiquitous, so that should tell us something about language longevity.



## JOHN WARNOCK

John Warnock is chairman and CEO of Adobe Systems Inc., Mountain View, Calif.

Since 1982, when Warnock founded Adobe Systems with his partner, Charles Geschke, the two have worked closely together to define and develop a stream of software products that leverage Adobe's core strengths in electronic document technology.

Before cofounding Adobe Systems, Warnock was a principal scientist at Xerox Palo Alto Research Center (PARC), where he spearheaded research on interactive graphics and led the development of graphics-imaging standards.

Before joining Xerox, Warnock held several key positions at Evans & Sutherland Computer Corp., where he managed research in interactive computer-aided design systems and directed the design and implementation of real-time, computer-generated imaging systems for navigation and flight simulators.

Warnock's early career experience included positions at IBM Corp. and at several Canadian computer companies. He holds a Ph.D. in electrical engineering (computer science), an M.S. in mathematics and a B.S. in mathematics philosophy from the University of Utah. He holds three patents. His e-mail address is [jw100640@eworld.com](mailto:jw100640@eworld.com).

MYHRVOLD: C and C++.  
RASKIN: Basic, I am sorry to say.  
WARNOCK: C.

### How large (in megabytes) will the average PC application be?

BELL: 100 MBytes, including the help function and the video tutorial.

LUCKY: Entertainment applications will swell toward the capacity of a CD-ROM—say, on the order of 500 MBytes—to include a lot of video. The size of these business software modules will level out at 10-20 MBytes.

MYHRVOLD: 20-30 MBytes. People won't be buying large, monolithic applications, but objects that run together in 1- to 5-MByte pieces.

RASKIN: 5 MBytes.

WARNOCK: It will probably take 32 MBytes of memory to run the typical tool set users have on their computers. But you won't necessarily know or care that you are invoking a particular application. The user interface will be what is important, and applications will fit into that environment seamlessly.

### What will the average PC application cost for the business and home?

BELL: \$50.

LUCKY: For the home, \$49.95. For business, \$300. These have become constants of the universe, like pi and e.

MYHRVOLD: You'll spend roughly the same amount as you do today. You'll get a bunch more functionality for the same price.

RASKIN: Home, \$45; business, \$250.

WARNOCK: The average amount of money that users spend on applications as a whole probably won't go down, though how much is spent on individual applications may.

### How will the average PC application be delivered: floppies, CD-ROM, downloaded over a network, other?

BELL: On average, 40 percent by floppies and CD-ROMs; 40 percent over corporate nets; 20 percent by cable.

LUCKY: More and more, on CD-ROMs. The vendors love this, because they can't be copied and they're too large to download on networks.

MYHRVOLD: Yes to all of those. Wireless is another one. There may be a new generation of CD-ROM, but that will be the single largest format because almost every machine will take that. It will remain dominant until broadband takes it away.

RASKIN: Networks and a new medium.

WARNOCK: Downloaded electronically. True for home and business.

### What microprocessor architecture will be the biggest seller at the end of the decade?

#### DESKTOP COMPUTER ARCHITECTURE

BELL: X86; Microsoft will have just introduced portable Windows 6 for the PowerPC.

LUCKY: I think the conventional wisdom would say an Intel X86 in a client-server network.

MYHRVOLD: X86. I would bet Intel if I had to bet. Six years from now they'll still be the largest installed base.

RASKIN: Probably haven't seen one yet.

WARNOCK: I don't think you'll care as a user, anymore than you care what kind of MPU you have in your Sony Walkman.

#### ARCHITECTURE FOR ALL PRODUCTS

BELL: No dominant core; 68K, X86, Mips will all be used for cars, phones, etc.

MYHRVOLD: I've got no idea.

RASKIN: Probably haven't seen one yet.

WARNOCK: I don't think you'll care.

### What will be the specifications of a typical \$2,000 desktop computer?

BELL: P7 (400 MOPS) with 128 MBytes using 64-Mbit chips, 4-GByte disk, CD-ROM; 1,280 x 1,024 x 24 bits, 3D graphics, stereo audio, voice and phone; built-in MPEG and video input, 100-Mbit Ethernet or IBM's 25-Mbit ATM connect to company/world ATM switch.

LUCKY: Everyone seems to focus on speed—like it really matters in running a word processor. The real question is, What new applications will emerge that will go gangbusters? Will we invent something like a spreadsheet that will change the nature of how computers are used? Unfortunately, I don't have a good answer to my own question, except to say that we will incorporate multimedia ever more intimately and ubiquitously and that intelligent agents will evolve that will help us handle all of this technological complexity.

MYHRVOLD: A PC will have between 20 and 30 times more processing power than today, 32-64 MBytes of RAM, will come with a keyboard, video camera, microphone, speakers and mouse. Microphones will be built in and you can add a telephone handset. Touch tablets, 3D space mice and head-mounted displays will be available, but not on most systems. 1 Gbyte of storage. Enabled to plug into

various kinds of networks, like existing phone lines, ISDN, ATM. People who buy stand-alone machines are going to be considered weird.

RASKIN: Architecture: RISC; MIPS rate: 100; MHz: 300; 400 MBytes of RAM. Input devices: microphone, one-handed keyboard, direct pointing at display; 3D (solid) optical storage.

WARNOCK: The specifications will not be as much of a selling point in the future. It will be like cars: There will be some enthusiasts who will compare the performances, but most buyers will not.

### **What will the specifications and capabilities be for the typical PDA priced at under \$500?**

BELL: Most likely, this will be a PC.

LUCKY: I think PDAs will come back, much as I hate the name. The key will be easy, transparent and truly ubiquitous communications. I don't need handwriting recognition. I'd prefer keyboards, but I don't have small, pointy fingers, so there's a little problem here.

You will have all the features of today's most advanced PCs in a palmtop device, and it will be constantly in touch with big brother machines. Somehow I don't think of it as an "assistant," though. I think of it more like the electric collar on a dog that gives it a shock when it leaves the yard. I'm sure the dog doesn't think of his collar as a "personal digital assistant."

RASKIN: This category will have disappeared as such.

WARNOCK: The format that exists today doesn't work. The screen is too small. In the future, screens will be more the size of a magazine.

### **What will be the specifications of the typical under-\$400 game machine?**

BELL: It will be a PC! Proprietary game machines will only exist as portables. Even these will be replaced by handheld platforms that are game-ready.

LUCKY: Just your standard Cray YMP. Virtual reality included. Possibly it will have voice and image recognition input, including gesture recognition.

MYHRVOLD: It is hard to see that there will be a game-only machine by the end of the decade, just as there are no kids-only TVs or VCRs today. There

will be multimedia players, which will be used by both kids and adults. They will merge with other types of devices, like a smart TV or a settop box.

RASKIN: I don't care.

WARNOCK: The PC will probably take over much of the space now occupied by game machines.

## **FUTURE TECHNOLOGIES**

### **By the end of the decade, what technological advancement will be the biggest surprise?**

BELL: The Internet, because it has a simple standard for creating and viewing documents that is better than e-mail. This will enable selling things. Use of CDPD to build smart cars, trucks, etc. Evolution of POTS [plain old telephone service] that will enable video communication at low data rates.

LUCKY: If it is to be a surprise, then how can I know about it? Let's say some new digital storage device that enables thousands of gigabytes to be put into a cigarette-box-sized case.

MYHRVOLD: That's about the worst question I can imagine. If it's a big surprise, how can I know it now? It will be the wealth of applications and services provided across broadband networks.

No matter how people talk about how great they will be, they don't understand how important they will become.

RASKIN: Volumetric storage, possibly using organic or even biologically inspired molecules.

WARNOCK: Agents, filters, language translation software and other technologies that help people deal with the vast amounts of information and communication capabilities that will be available.

### **What advancement will be the biggest disappointment?**

BELL: Object-oriented programming—no significant change in the way software is built or the industry is organized. Agents that do useful things.

Collaboration technology—people will realize it's nothing more than video in a window.

LUCKY: People will still be touting fluent speech recognition. And computers still won't deign to talk to you.

MYHRVOLD: There's a lot of competition. The level of hype on the informa-

tion highway is astounding. There is an expectation that this all happens very quickly. In its full grandeur, it's going to take 10 years for these things to roll out.

RASKIN: Pen input.

WARNOCK: I don't think software will turn into objects that communicate with one another. I think the whole object thing is a red herring. Large apps aren't built with object delivery model. Interfaces between apps are more complex than objects can deal with.

### **What technological advancement will have the biggest impact on business? On the home?**

BELL: Business: The Internet! This will create new businesses, restructure buyer-seller relationships, etc. Radical scenario: an all-pervasive ATM network that will include an interface to radio and various cable networks.

Home: Settop computers that link to TV sets and get the noncomputer people linked for communication, education, games, etc., whether they want it or not. This will move us from a current "plug and pray" computer to one that can order and install its own software and can be maintained remotely.

LUCKY: For business, electronic commerce enabled by pervasive, reliable and secure computer networking. For the home, video on demand.

MYHRVOLD: Business: the information highway. Business has been experiencing Moore's law, and it will start to hold for communications. Connectivity is going to change very dramatically.

Home: same answer. The home has had high-bandwidth one-way (TV) and low-bandwidth two-way (telephone) communication. But six years from now the home will have the ability to get interactivity on high bandwidth.

RASKIN: The answer will be the same for both—the nearly universal availability of electronic funds transfer.

WARNOCK: The networking of the country, both wired and wireless.

### **If you had \$50 million to invest in one area of research today, what would it be? Why would you choose this area? What would you hope to achieve?**

BELL: A worldwide digital dial tone that operates at video rates, enabling



networking for an ever-present, high-bandwidth, low-latency network. High-speed networking is the key enabler for virtually all future applications. Being wired, being able to make arbitrarily large computers from *in situ* computers. Being able to communicate anywhere without limits, including video for any purpose.

LUCKY: This is close to home, because I do have funds of this sort in my company, but I imagine our criteria for investing them are different.

To answer your question, let me say that I just want to do the best for the world in general. So I would want to do research on interface between people and information. This would include information navigation, indexing, intelligent agents, knowbots, surrogates, information filters, image analysis—stuff like that.

MYHRVOLD: I'd ask for more, first of all. I would spend it on developing software to support all this connectivity and increasing computing power—applications, content. There's a ton of basic work that needs to be done in that.

RASKIN: Nonmechanical (no rotating parts) volumetric data storage. It will bring orders-of-magnitude greater storage capacities and an order-of-magnitude speed increase needed to handle the increasing amounts of data, especially for storage of graphics, that individuals will have come to expect.

WARNOCK: Technologies that help information flow seamlessly across heterogeneous networks and systems.

#### What will happen to the Internet?

BELL: It will carry out commerce, complete with bandwidth and security.

LUCKY: Current projections show the number of users of the Internet intersecting with the world's population in the year 2001. But that won't happen. For one thing, there is a rising belief that the number of users is overestimated now. The other thing is that I expect some Malthusian principle to take effect that starts to limit the growth to less than the 100 percent annual growth that we now have.

However, I do expect the Internet to become the de facto information high-

way for the world. I expect it to become the backbone for electronic commerce. I expect it to begin to carry voice and video, and in the process to cause a big ruckus about unfair competition for the common carriers. Governments will want to regulate it. There will be a lot of legal turmoil about privacy, free speech, import-export law, etc.

The culture will change to be less of a frontier justice to more of an organized, businesslike world. Usage pricing will begin. Information won't be free anymore; everything will cost.

MYHRVOLD: If you view the Internet as a metaphor for the information highway and wide-area connectivity, it lives forever. If you view it as the service it is now, with no user interface standards, tons of arcane stuff, people who bitch when newcomers come on—that's a passing era.

RASKIN: It will become a for-profit corporate entity, grudgingly interconnecting with other service providers.

WARNOCK: Who knows? It will still exist in some form.

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#### By the end of the decade, how far will we have gotten to the "smart home?"

BELL: Not very far.

LUCKY: Homes will still be dumb. Nobody will really want a home that thinks for itself. Homes should know their place, and be quietly attentive.

MYHRVOLD: In most places new homes are now passed by cable. We will see access to broadband information service becoming standard, although six years may be a little early. Embedded chips in lights and appliances is coming, but for now it's a niche phenomenon.

RASKIN: In this time span the changes will be small and incremental. Most homes will not be far different than what they are now.

WARNOCK: This will not progress very far. There are so many individual preferences and situations that it will be slow going. Not many people are going to want to rewire their homes. ■

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*Editor's Note: Join us in five years when we ask these five technologists to revisit and comment on their predictions. Address questions or comments about this article to [upsidemag@eworld.com](mailto:upsidemag@eworld.com).*