CONFERENCE ANALYSIS

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INET 99, The Internet Global Summit

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Reported by Larry Press

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Introduction

INET is the annual, International Networking Conference of the Internet Society (http://www.isoc.org). The Internet Society (ISOC) grew out of the early academic and research internetworking community. Its founders are the "graybeards" who were working on networks long before the commercialization of the Internet, and have helped guide its transition and growth.

At first, ISOC placed heavy emphasis on technical standards and the standard formation process through its Internet Engineering Task Force (IETF), but as the Internet has grown and moved beyond the academic community, ISOC has focused to an increasing degree on social and policy issues. At this INET, ISOC formed the Internet Social Task Force, paralleling the IETF. The new ISOC mission statement is "To assure the beneficial, open evolution of the global Internet and its related internetworking technologies through leadership in standards, issues, and education."

ISOC's most noteworthy education project has been its annual workshop on networking technology and national network management for people from developing nations, which has made a significant contribution to the training of a generation of networking leaders throughout the developing world. These workshops reflect the fact that ISOC has been global from the start. The INET Conferences are held throughout the world,[1] and there are active members in 150 countries and chapters in 35 countries. The elected trustees represent all continents. This diversity is an important part of INET, and is reflected in the program and the attendance.

INET 99 was dedicated to the memory of Jon Postel who had been an internetworking leader from the time he was a graduate student working on the ARPANet until he died last year at age 55.[2]

The theme of the conference might have been "ubiquitous networking," because nearly all of the keynote speakers focused on this topic. The consensus was that, in the "post PC" era, people will use a variety of Internet devices like handheld computers,

augmented cell phones and pagers and TV sets. Machines from microwave ovens to vending machines will also be connected to the Internet. Once the Internet is everywhere and everything is connected to it, it will cease to be remarkable; it will be taken for granted.[3] We summarize these keynote speeches, and comment on the technical program and exhibits below.

The Internet Is for Everyone

Vint Cerf, Senior Vice President, Internet Architecture and Technology, MCI WorldCom

INET 99 was proceeded by one-day symposia on K-12 networking and on networking in developing countries. Vint Cerf, co-inventor of the Internet's TCP/IP protocol and a founder of the Internet Society gave his keynote presentation at the Developing Countries Networking Symposium.

Dr. Cerf began with statistics on the rapid growth of the Internet, which is now used by approximately 165 million people in 206 countries. While this is impressive, he pointed out that it is far short of the scope of the telephone network with approximately 830 million termination points worldwide (700 million wire-line and 130 million cellular). On the other hand, the Internet is growing much faster than the telephone network, and may catch up, connecting approximately 900 million devices around 2006. Like the speakers who followed him, Dr. Cerf emphasized that the majority of these devices would not be computers, and that many people would have more than one. If voice over IP succeeds as some feel it may, the Internet may be the telephone network in 2006.

Cerf pointed out that, like the telephone network, the global distribution of the Internet is highly skewed, with the approximate numbers of users as follows:

Region	Users(millions)
US/Canada	90
Europe	40

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Asia/Pacific Rim	27
Latin America	5
Africa	1
Middle East	1

This skew is, of course, central to the attendees from developing nations. Cerf attributed this distribution to the historical accident that the Internet began in the United States, and that as local content and connectivity develop in other nations, there will be some tendency for the gap to narrow.

However, economic forces are tending to widen it. Commercial activity is growing much faster on the Internet than applications in education, research, health care and other socially-oriented areas. Dr. Cerf predicted that up to 10 percent of the world economy ($3.2 trillion) might be on the Internet in four years. As such, the ISOC and networking leaders in developing nations must become increasingly involved in shaping policy with respect to taxation, privacy, cryptography, telecommunication competition, etc. He also urged attendees to work for the buildup of local infrastructure - national and regional backbone networks and traffic exchange points - to reduce the need for expensive circuits to the United States and Europe.

Dr. Cerf concluded his remarks with a brief discussion of plans for connectivity in an even less represented region, outer space. The next target for Internet growth is Mars, and NASA has plans for connected sensors and rovers. Protocols for this long-distance networking may be tested from the moon in as few as two years, and there are plans for seven communication satellites orbiting Mars in 2008.

The keynote was followed by sessions titled "Emerging Internet Organizations in Latin America and Africa," "International Development Agencies," "International Communication Tariffs," "Success Stories," "Legal and Policy Issues" and "Universal

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Access and Penetration: A Dream or Reality in the Developing World?" Some of the premises and highlights of these sessions were:

• The barriers are not just technological, but political and institutional.

• The information revolution in developing countries requires information revolutionaries. They must fight established interests.

• The Internet has the potential to make a significant difference in the health, education, economy and quality of life in developing nations, but equity must be at the heart of the revolution or it is not a revolution.

• The revolution will fail if cultural factors and national and regional differences are not taken into account.

• Developing nations are under-represented in the International Telecommunications Union, the World Trade Organization the World Intellectual Property Organization, and Internet Policy and Standards bodies. This reflects both lack of resources and lack of government commitment.

• Organizations to manage the assignment of Internet names and numbers are being formed in Latin America and Africa. Progress has been slow due to a lack of resources, relatively low levels of Net penetration and difficulty in building consensus in such diverse regions, but progress is being made. Africa expects to have such an organization in place by the end of the year. (Today, these nations are handled by organizations in the US and Europe).

• There were reports on the activities of several development agencies, but some expressed concern that they may have lost a sense of urgency now that nearly all nations have achieved some level of connectivity. That is only the first step.

• Many ISPs in developing nations connect to the Internet through core backbone providers in the US and Europe. This is expensive, and partly a function of politics and regulation and partly a reflection of traffic and content patterns (most content and users

are in the US and Europe). Several satellite companies are targeting the communication needs and constraints of developing nations.

• This concentration in the US and Europe will be reduced by local content, local peering (traffic exchange), regional exchange points and content mirroring and caching, but these may be offset by rapid growth of the Internet in the US and Europe.

• Efforts encouraging the Internet in French-speaking developing nations were described. The emphasis was on local content in French.

• Developing nations need to be involved in shaping new international regulations and should also be aware of the ways U.S. laws and regulations will affect them.

• Difficulties with currency conversion and international payment mechanisms will hinder e-commerce in developing nations.

• Telecenters have and will continue to play a role in expanding Internet access in developing nations. While they may be self-sustaining in urban areas, they will have to be subsidized in rural areas.

• Widespread access requires a strongly-perceived need, which is lacking in many developing nations.

• Donated used or surplus equipment has been valuable in many cases, but shipping and delivery logistics and the risk of getting obsolete or difficult-to-maintain equipment make it unlikely that this will become a staple of development.

• The Internet will become increasingly important for connecting local people and information as well as for reaching out of the developing nations.

John Gage, Chief Science Officer, Sun Microsystems

As an early employee of and spokesman for Sun Microsystems, Dr. Gage is not a supporter of today's personal computers or of Microsoft. He began by stating that older

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PCs are difficult to network, and should therefore be thrown out. His podium stood next to a draped table with PCs for use by speakers. He pulled back the drape revealing a tangle of cables and a hub, stating that this sort of complexity was not viable without a networking professional.

He contrasted that with his wireless Palm Pilot and his cell phone which only had to be turned on to become connected to the network and immediately ready to use. A PC boots from a disk, but a cell phone and Palm Pilot do not have a disk because they are too small and disks are too fragile. The cell phone and Palm Pilot go to the network to boot up, not a disk. Mr. Gage's advice is to throw away the PCs, but retain the network.

Dr. Gage cited a recent Commerce Department report as evidence of his proposition that the network is critical. The report, The Emerging Digital Economy II (http://www.ecommerce.gov/), shows how IT is transforming the American economy. Electronic commerce (business transactions on the Web) and the IT industries that make e-commerce possible are growing and changing at breathtaking speed, altering fundamentally the way Americans work, consume, communicate and play. Some conclusions of the report were:

• Growth of consumer and business e-commerce is outpacing last year's most optimistic projections, though it is still less than one percent of the economy.

• Between 1995 and 1998 producers of computer and communications hardware, software and services accounted for only about 8 percent of U.S. GDP, but contributed on average 35 percent of the nation's real economic growth.

• During 1990 to 1997, the productivity (gross product originating per worker) of IT-producing industries averaged 10.4 percent annual growth. In the goods-producing subgroup of the IT-producing sector it was an extraordinary 23.9 percent. These productivity increases are responsible to some extent for our low inflation and unemployment during a time of economic growth.

• By 2006, almost half of the U.S. workforce will be employed by industries that are

either major producers or intensive users of information technology products and services.

• In 1996 and 1997 (the last years for which detailed data are available), falling prices in IT-producing industries brought down overall inflation by an average of .7 percent.

Dr. Gage pointed out that a few years ago, high job growth rates were found in the automobile, oil, mining, aerospace, agriculture and chemical industries, but they are now in IT and networking. He quoted a Japanese study predicting future job growth in microelectronics, biotechnology, material science, telecommunication, robotics and machine tools, hardware and software. He quoted MIT's Lester Thurow: "The comparative advantage for an economy is now man-made - the dominant competitive weapon of the 21st century will be education and skills of the workforce." This increasing economic importance means we will have to find a way of taxing e-commerce in order to replace traditional taxes.

Dr. Gage returned to his initial theme of networked portable devices by pointing out that the availability of those devices would be facilitated in part by electronic progress. The Apple II was the first single board computer with full functionality, but we are now ready for single chip machines. They will sell hundreds of millions of machines.

In March 1999, Sun put all of its processor designs on the Web, inviting anyone to innovate by incorporating them into system designs. Dr. Gage pointed out that chip design is now highly automated and separated from production. He referred to an ARPA-sponsored educational program that, between 1979 and 1995, allowed university students to submit chip designs and receive four working chips in return. (This prototype fabrication service has since been commercialized, http://www.mosis.org/). Dr. Gage suggested that with modern tools, high school students could now design and simulate the operation of single-chip systems using the Internet. He stopped short, however, of offering Sun's extensive simulation and fabrication facilities for that purpose.

Dr. Gage stated that Java was the second force behind the rapid proliferation of

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portable, networked devices. He noted the goal of being able to run any Java program on any device that incorporated a Java virtual machine, and pointed out that the week before, 25,000 enthusiastic programmers had met at Sun's Java developers conference. He painted a picture of attendees enthusiastically "beaming" information between handheld machines (that may be a poor choice of words, as it was used in the ill-fated Apple Newton community).

Dr. Gage went on to describe Jini, a set of protocols using Java and designed to allow devices to automatically connect to or leave a network. For example, there might be a wireless network in your home. When you entered the house, and turned on a Jini-ready device, it would automatically join the network and advertise its presence and capability. Other networked devices would have done the same earlier, so your device would be able to determine what sorts of services - large displays, printers, e-mail, storage, etc., were available. Your device would automatically be removed from the network when you turned it off or left the house, and any services it offered would become unavailable. Such effortless networking will be necessary if we are to have ubiquitous computing in offices, homes, schools, automobiles and so forth.

This will be achieved by having devices automatically download high-level drivers to enable them to access network services. This will be feasible because all of these will be Java programs. Dr. Gage quoted Bill Joy, Sun's Chief Scientist as stating that "The future of system design will rely upon the rules for the assembly of a collection of communicating programs."

The Jini vision of zero-administration networks of ubiquitous portable devices is similar to that of Microsoft with its Universal Plug and Play (UPnP) effort (http://www.microsoft.com/homenet). It achieves the same sort of effortless connection to and leaving of networks, but Microsoft envisions a different architecture. With UPnP, devices share descriptions of their capabilities, not code. Thus, when a new device joins a network, it advertises its characteristics and control mechanisms in an XML document, which is placed on a server.

While the goals of Jini and UPnP seem quite similar, their architectures are fundamentally different. This leads to the question of interoperability, but it is difficult to imagine how this will be achieved. Will I have a sign that says "Jini-equipped" on the front door of my home? Will I need to carry both Jini and UPnP smartcards in order to pay for rides in cabs and for meals at restaurants?

The battle between Jini and UPnP may make Beta vs. VHS look like small potatoes. Both Microsoft and Sun are making major investments and commitments. Microsoft featured UPnP at its Windows Hardware Developer's Conference in April, 1999. It had an interoperability island in the exhibit area with UPnP devices from 21 companies, and featured UPnP in many of the technical sessions. The UPnP forum (http://www.upnp.org) lists 56 supporting organizations at present.

For its part, Sun is hoping to capture a large, creative developer community with The Sun Community Source Code License. Source code will be open, but Sun will allow proprietary modifications and extensions and will perform product testing to ensure compatibility. There will be no charge for research, education or limited internal deployment within an organization. (http://www.sun.com/jini/licensing/). Sun is also working with eight large consumer electronic companies on the Home Audio-Visual Interoperability specification (http://www.havi.org).

This is shaping up to be a major battle, and one should not be mislead by the emphasis on homes and consumers. The same technology will connect the business person's cell phone, PDA, portable computer, pager, data entry terminal, etc., to the home network, office LAN or the Internet. Furthermore, Sun envisions the ease of operation of Jini scaling up to high speed storage area networks.

Dr. Gage also described NetDay (http://www.netday.org/), a grass-roots effort he organized to wire schools. Rather than wait for school administrators to install a LAN and establish an Internet connection, Gage says "just do it." A handful of volunteers can wire a school in a day. He organized the purchase of wiring kits, and used the Internet

to publicize the idea. The first Net Day was March 9, 1996, and now nearly 140,000 schools have been wired. This illustrates the power of the Internet to propagate an idea and to provide a mechanism for the loose coordination of a highly decentralized effort. Gage's main task was to "make the invisible visible," thus allowing people to voluntarily help the schools they cared about. The primary mechanism is a database of schools and contact people. People volunteer locally, and, if their school is not listed, they add it to the database (they have "found" over 1,000 California schools that had not previously been known to the authorities).

Dr. Gage concluded with a reminder that the era of the difficult-to-network PC is giving way to a time of embedded intelligence in distributed, networked devices. He quoted Polaroid camera inventor Edward Land as stating that "redesign is not so much having a new idea as stopping having an old idea."

The Internet: Transforming Business and Society

Irving Wladawsky-Berger, General Manager, Internet Division, IBM

Mr. Wladawsky-Berger was introduced as a key architect of IBM's Internet and e-commerce strategy. He organized much of his talk around four stages of the evolution of any technology: laboratory research, early adopters, public recognition and mass adoption. He used electricity as an example:

Laboratory research: Experiments by Benjamin Franklin and the researchers who followed him.

Early adopters: Manufacturers and others who used electric motors to replace steam, water and human power. Re-engineering of processes is not necessary for applications at this stage. The motor replaces one element in a system, but the system is not otherwise modified. Retrofitting an electric motor on a treadle-driven sewing machine is another example.

Public recognition: The invention of the light bulb and the development of a power

generation and distribution system to support it brought electricity into the general public. This transformed the way we lived.

Mass adoption: Technology becomes ubiquitous and ordinary. It is taken for granted. The use of electric motors in blenders or toothbrushes illustrates this level of penetration.

Mr. Wladawsky-Berger then described the Internet in this framework.

Laboratory research: The ARPANet and experiments that preceded it.

Early adopters: Members of the university and research communities who used the networks that followed ARPANet.

Public recognition: The invention and proliferation of the World Wide Web, which coincided with the transition of the operation of the Internet backbone from the U. S. National Science Foundation to the private sector.

Mass adoption: E-business and ubiquitous networking.

He showed a graph of IDC's projection of the growing number of Internet users as evidence that we are now in the public recognition stage. IDC predicts that the number of Internet users will grow from roughly 200 million today to 500 million by 2003. The graph broke the projections down by region, and Mr. Wladawsky-Berger noted that while the majority of users are in the US today, other parts of the world are growing at a faster rate, and by 2003 the US share will have fallen closer to 50 percent.

He expanded upon his mass adoption application: e-business. E-business is the theme of IBM's current television commercials, and they clearly see it as an important area. (Mr. Wladawsky-Berger pointed out that IBM had considered trademarking e-business, but decided that that would be counter to the spirit of the Internet and also counterproductive because they clearly will be only one of many players in this area.)

He sees an evolution of e-business. The first phase was essentially online brochures

and catalogs, the era of static Web pages. Those gave way to online ordering, billing and payment. E-merchants like Amazon.com, e-Bay, E*TRADE, exemplify this sort of application. The next stage will be personalization. An e-merchant will recognize individual customers, look up preferences, and treat them appropriately. He gave an example from Safeway Markets in England. They allow remote shopping via the Web. In addition to an electronic catalog, they maintain a staple order for each customer, so, say, once per week, you merely indicate things you wish to change. This is reminiscent of shopping before the time of supermarkets when one had a standing order with the milkman, which could be overridden by placing a note in an empty bottle. Safeway also sends personalized promotions to customers based upon their profiles. For more on the growing trend toward personalization and customer relationship management, see our coverage of the 1999 Networld+Interop Conference.

Mr. Wladawsky-Berger feels the next stage in the evolution of e-commerce will be the integration of business processes including supply chain management, enterprise resource planning, the management of product design and customer relationship management. Information will be shared by the appropriate people working in each of these areas, enabling cooperation, the gathering of business intelligence and management of the knowledge derived from that intelligence. He used Safeway in England as an example again. They have opened their inventory and sales databases to their suppliers, which directly manage their products in Safeway's warehouses and stores. A supplier can drill down to the level of a specific product in a specific store to see sales data and plan stocking.

Mr. Wladawsky-Berger feels technical and policy issues regarding privacy, payment mechanisms, confidentiality of information and encryption will shape e-business. He pointed out that these may be decided by government regulation or voluntary, market-based activity.

Another area of technological evolution due to the Internet is the evolution of community, in which he sees organizations being enhanced and transformed. All

members of an organization, sales and marketing people, product design and production, etc., will be able to collaborate directly among themselves and with outside stakeholders like customers, suppliers, dealers and other business partners. This began with e-mail, which did not fundamentally alter the way we work, but made us more efficient. It provided a better way to do something we had already been doing before.

LAN-based conference rooms in which participants in a meeting can electronically brainstorm, vote, share documents, etc., were another early application. Given sufficient bandwidth and quality of service, the Internet will enable us to take this sort of collaboration out of the decision support meeting room and let people work together at the same time from remote locations.

But collaboration and sharing of knowledge will go beyond the enterprise. We see the beginnings in today's Internet portals and search engines. We are also seeing early efforts at distributed learning. Mr. Wladawsky-Berger cited the example of the Monterey, Mexico, Institute of Technology, which has 27 campuses, 80,000 students and 5,700 faculty. It is now offering online courses, facilitating collaborative teaching and learning in which instructors, students and outside exerts work together, developing and delivering multimedia content, and sharing content among the campuses. This represents the first phase in the transformation of this organization (and education itself) as a result of technology.

Finally, Mr. Wladawsky-Berger addressed the evolution of content in which we transform the way we deal with information. The early days of the Internet were characterized by the simple publishing of text data and programs, accessed through menus or keyword searches. Today, we have images, sound and other data types in addition to text and richer user interfaces than menus and keyword searches. As an illustration, Mr. Wladawsky-Berger showed a bit of a virtual tour of the Louvre Museum in which the user could browse (and zoom in on) the collection and drill down for further information on works of art and artists.

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In the future, we will see applications of powerful computers and techniques to achieve "deep" computing. His example here was the success of IBM's Deep Blue chess playing program. We will be performing highly sophisticated analysis of vast amounts of information with super fast computers. He feels work on analysis, collaboration, visualization, etc., being done at our NSF Super Computer Facilities and on the Internet will lead to important applications.

He also sees pervasive computing as transforming business and society. He agreed with other keynote speakers that we are entering an era of networked homes and vehicles in which we use a variety of Internet access devices like palm computers and smart cards. He showed another IDC study forecasting an increasing number of devices per user.

Year	Users(MM)	Devices(MM)	Devices/User
1999	200	210	1.05
2000	250	305	1.22
2001	320	405	1.27
2002	400	530	1.33
2003	500	725	1.45

Source: IDC

Mr. Wladawsky-Berger feels this proliferation of connected devices will eventually lead to a ubiquitously connected world with complete societal integration of the Internet.

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eBay and E*TRADE

Meg Whitman, Chief Executive Officer, eBay

Debra Chrapaty, President and Chief Operating Officer, E*TRADE Technologies

At past INET conferences, keynotes have been given by representatives of infrastructure and technology companies, but this year there were two Internet application companies, online auctioneer eBay and online security trader E*TRADE. We cover them together because their presentations and histories are similar.

eBay (http://www.ebay.com) is the largest person-to-person online auction site. The idea for eBay grew out of the hobby of the founder's fiancée, collecting and trading Pez dispensers. Today it has 2,255,026 items for sale in 1,627 categories and serve up over 1.5 billion page views per month. It receives roughly 800,000 bids per day, and over 45 million auctions have been completed.

Unlike most "dot com" companies, E*TRADE existed prior to the Internet, providing online quote and trading services to brokers. They moved to America Online and Compuserve in 1992, and launched www.etrade.com in 1996, enabling consumers to trade stocks directly, without using a broker. Since that time, it has experienced the same sort of explosive growth as eBay. Ms. Chrapaty heads the subsidiary that develops and operates its Web site.

I was struck by the similarities of these companies and their presentations. Both speakers devoted large parts of their talks to growth statistics, and both companies are following a strategy of postponing profit and dividends while expanding as quickly as possible. They feel they will establish brand recognition this way (Ms. Whitman's background is in retail marketing) and that attracting new customers today is much cheaper than it will be in the future.

The search for new customers is not limited to the US. Both companies are expanding internationally as quickly as possible. Through a combination of direct investment and partnership with others, they are seeking physical and virtual presence in other nations,

and E*TRADE already has customers in 119 nations. Both companies are also expanding their product lines. For example, eBay began with a stress on collectibles sold by individuals, but it is now used by many businesses both for selling to consumers and other businesses.

This rapid growth and constant redefinition of their product line has led to technological growing pains. Both speakers devoted considerable time to well-publicized outages or slowdowns.[4] In each case, they accepted responsibility for the problems, and compensated customers; however, there is still pending legal action against E*TRADE. Ms. Chrapaty showed short clips of many TV newscasters and financial analysts describing an outage, and reporting again when they were back on line. She suggested that this exposure may have been worth $20 million in publicity, but someone quipped that Schwab would have gladly paid for the campaign.

Both companies are also investing heavily in complex, redundant, manageable back-end systems. Ms. Chrapaty stressed that E*Trade has patented software techniques for high reliability.

Still, there will always be hardware malfunctions, bugs in software, operator errors, problems with software upgrades, and peak loads that exceed capacity - we should not kid ourselves that these companies or our own can ever be 100 percent reliable. It also leads one to wonder about the relative efficacy of server "farms" and mainframes for such demanding applications.

Both speakers also stressed that they have shifted emphasis from transactions to offering information to their customers and creating community among them.[5] Both of their Web sites have top-level tabs for this service (labeled Newschat at eBay and Community at E*TRADE). At eBay one finds chat rooms and discussion groups on all sorts of collectibles and other topics. As a result, its site is very "sticky." During December 1998, eBay users averaged more than 126.7 minutes on the site. Ms. Whitman also related several anecdotes in which community members had made

donations or taken other steps to help someone in distress. E*TRADE also has discussion groups for individual stocks and for general topics of interest to investors. It began this service in September 1998, and by June, 1999 had over 150,000 active participants. Ms. Chrapaty pointed out that E*TRADE has come to see the provision of information as an important part of its service, and now have over 10,000 pages online along with their dynamically generated views of stock price and history.

Both speakers emphasized that their Web sites undergo constant redesign and change. For example, Ms. Whitman stated that eBay had originally displayed text descriptions of items with links to pictures, but it has discovered that displaying pictures initially is more effective. Constant change, rapid growth and the centrality of the Web site to their business keep these two companies on the edge.

How Light, Air, Sand, Genes and More Bites Might Shape the Next Phase of the Net

Eric Benhamou, Chairman and CEO, 3Com

Mr. Benhamou opened with a profile of Ethernet pioneer 3Com. The company has roughly $6 billion in annual sales and 13,000 employees. Its products cover wired and wireless network interfaces and a wide range of routers and switches, and it has the largest patent portfolio in the industry. 3Com is twenty years old - a networking grandfather - and has sold over 200 million connections to date. Its vision of the future is for pervasive, intuitive networking with billions of connections.

Mr. Benhamou showed 3Com's recently revised mission statement, and emphasized that it called for simple and reliable networking. He remarked that this represented a significant shift from a few years ago when it would have stressed performance, bandwidth and features. These remain important, but they are now secondary to fundamental progress in the directions of simplicity and reliability because the most exciting markets in the early part of the 21st century will be small businesses and consumers, not technologists.

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This shift also dictates that 3Com change its emphasis from the network to the user. One of the key promises of the Internet has been to deliver mass customization of goods and services. Therefore there has to be a certain amount of personalization associated with a connection. People will connect in increasingly diversified ways to all kinds of different networks, and the access infrastructure has to be malleable enough to adapt to their individual needs, personalities and ultimately different genes. Today, 3Com emphasizes consumers and organizational users; whereas a few years ago the network was the starting point.

As indicated in the title of his talk, Mr. Benhamou spoke of data transmission (light), wireless connectivity (air), integrated systems on single chips (sand), network convergence (more bites) and personalization (genes).

Wave-division multiplexing is a breakthrough data transmission technology. We are now able to transmit multiple data streams at different frequencies over a single fiber, increasing single fiber transmission speeds from 10 to 320 billion bits per second. Transmission speed improvement is outrunning Moore's Law, and we will soon have almost free bandwidth in the Internet core.

This shift from expensive to abundant core bandwidth will lead to simpler routing and fully meshed connections in the core. On the other hand, we will have more complex applications running at the edges of the network, and will need standards for authentication, user profile maintenance and quality of service. Mr. Benhamou foresees a fast, simple core with intelligent devices at the edges.[6] He also predicts significant increases in international connectivity. Today, the US, Japan and Europe are the most heavily connected and interconnected continents, but wave division multiplexing will lead to rapid increases in intercontinental and undersea links throughout the world.

Mr. Benhamou also envisions an untethered future. The Holy Grail is completely transparent, untethered connectivity. As you move about, you should not be aware of the fact that you may move from a personal area network to a local area network, to

wide area network. Wired or wireless, at home or in the office, your experience of the network would be the same and you would not be aware of transitions.

To reach this goal, there are hurdles to be overcome. We need seamless technology for personal area networks, for example connecting one's cell phone and PDA, and personal computer or connecting ones portable to the small hub in a conference room. He mentioned the Bluetooth communication standard (http://www.bluetooth.com) as a solution for this sort of connectivity.[7] We also have to make substantial progress in cost, power dissipation and size. While he does not see the same rate of progress here as in optical communication, he believes we are on an aggressive improvement curve for each of these dimensions. Perhaps the most daunting issues have to do with the deployment of a true mobility architecture enabling transparent movement from one environment to another. He feels we must do better than the cellular phone system does when handing a call off from one cell to another when you are in a moving car. A final hurdle is the building out of wireless infrastructure as we migrate from tethered to untethered access. We are talking about substantial amounts of money, even though you don't have cables to pull. He foresees infrastructure and wireless data services that target devices like laptops, wireless terminals, phonetops and even plain telephones.

The 3Com wireless Palm VII PDA is an early step in this direction. It allows Web and e-mail users to communicate over a wireless network to the Palm.Net Data Center, which has a gateway to the Internet. Servers at the gateway also format material retrieved from the Web for the small screen of the Palm machine. They use a Bell South network, but other architectures like GSM will also have to be supported. They find Palm users sending short messages and transactions, reading news and sports, querying databases and other simple things. The average user connects about 20 times per day. They are quite bullish about the early reception of these kinds of products and services, and feel we are learning how to live completely untethered.

Mr. Benhamou understands that this is not the equivalent of wired Internet access, but is confident that advances in chip technology will yield significant improvement in

portable, wirelessly connected devices. Today we build systems by combining chips (intellectual property) from several vendors, but, Mr. Benhamou agrees with Mr. Gage that we are now moving toward integrated systems.

Now that deep, submicron technologies are becoming broadly available, we can design full systems on silicon. He showed an example of a board from one of their switches in which 18 custom ICs had been replaced by one. The PC industry has been characterized by horizontal specialization - companies build CPUs, database management systems, operating systems, etc. He predicted that the need for simplicity and reliability will tend to make these horizontal layers somewhat "porous," with more integration in relatively specialized machines.

He agreed with Dr. Gage that future designers will combine libraries of pre-designed circuits to produce single chip systems for wireless devices. Design and fabrication will be separated, with foundries producing chips designed by systems vendors. Vendors like 3Com will increasingly own their own tools and intellectual property. He is optimistic that these improvements will overcome the cost, power and capability hurdles mentioned earlier, and that they will lead to a more balanced, less monopolistic industry.

Mr. Benhamou also foresees many more bits on the Net. We will have pictures, video, 3-D worlds, high fidelity sound, etc. He referred to Ms. Whitman's observation that eBay users prefer pictures to text descriptions of items offered for auction. Telephony, multimedia messaging, remote collaboration and a host of yet unforeseen applications will all be found on a single, integrated network.

There are several challenges here. One is ensuring sufficient and consistent quality of service (QoS) over packet switched networks to support real-time traffic for telephony, video conferencing, etc. He noted that the IETF and others were working on appropriate standards.[8]

We also need simplified network administration. The cost of network administration has risen dramatically during the last four or five years. He estimates that the proportion of

IT budgets devoted to management and maintenance of networks has roughly doubled in that time. Today's networks do not scale, and this trend must be reversed. This is particularly the case in the small office and home, where networking professionals are not available and it is expensive to send people to customer premises for installation and maintenance (the term truckroll has now entered the networking vocabulary to describe such visits, and truckrolls are expensive).

The third challenge is to improve to the "5 nines" reliability of today's telephone network. The fourth challenge is to move from manual configuration of the routers, switches and other devices in networks, to policy-driven networks in which devices are automatically configured as a function of rules in a policy database.

We do not have to wait for the full transition to zero-administration, reliable, policy-driven networks with guaranteed QoS to begin deploying converged applications. Mr. Benhamou pointed out that 3Com has already had good results with IP-based telephone systems in small businesses. These organizations typically move quickly and do not have investments in legacy PBX telephone systems. He stated that in the last three months, 3Com has deployed 400 small business LAN telephone networks with several thousand handsets, and the users seem to be absolutely astonished, "ecstatic" about the experience. The costs of acquisition and of operation are only 60 percent to 75 percent of those of traditional systems, and new applications that integrate telephony and data processing are enabled.

To counter claims that voice quality is poor, he played several sample sound clips using algorithms they had developed, comparing them to alternatives. He stated that the point was not who had the best algorithms, but that quality could and would be improved. To emphasize that point, he played clips comparing 1957 radio sound quality to today's television sound, which is noticeably improved.

The final element in Mr. Benhamou's presentation was customization of devices and applications to suit individual users. You could have any color you wanted in the Ford

Model T as long as it was black, and that same sort of mentality continued when we started building PC's. Their architectures were all the same. Mr. Benhamou predicts this will change. We will have a proliferation of network access devices, tailored to the demands of individual consumers. Users will not only have different devices, they will have different profiles and characteristics, which must be exposed to policy-based networks if they are to scale effectively to billions of devices. The network and applications will adapt to the user's preferences automatically. We will have different "identities" for different virtual environments and applications.[9]

User interfaces must also change to suit individual differences and the form factors of diverse machines. We will move from today's window-icon-mouse-pointing device interface to tomorrow's sound-image-language-knowledgebase interface.

He stated that nearly every hurdle he mentioned during his talk required fundamental research, and noted that research support has been declining. We require fundamental research on software, large-scale, high-performance networking infrastructures, knowledge representation and the socio-economic impact of ubiquitous networks. Mr. Benhamou pointed out that today's Internet is the result of strategic support and sponsorship of research by the Federal Government,[10] and he feels that investment should be continued.

Mr. Benhamou is confident all of the hurdles he mentioned can be overcome, and his vision of a global Internet with billions of devices achieved. We have compelling economic and societal incentives - this is a truly global enterprise, and our process for creating, experimenting and growing the Internet works.

Technical Program and Exhibits

INET is historically an academic conference rather than a trade show, so there are very few commercial exhibits, but there is a high-quality, refereed technical program. Most of the 20 or so exhibit booths were from Conference sponsors like 3Com, IBM and MCI. There were also booths from several undersea cable and satellite communication

companies. The most interesting exhibit was the Internet 2 booth. Internet 2 is a cooperative effort by 150 U.S. universities to develop technology and applications for the next generation high-speed Internet. A number of participating universities demonstrated applications they are developing. For example, the University of Wisconsin showed remote access to a powerful research microscope and NASA demonstrated a telemedicine application in which the user examined manipulated imaging equipment for remote observation and consultation during surgery.

The technical program consisted of xx papers organized into four tracks: e-commerce and e-business, education and information resources, social, legal and regulatory issues and technology. The conference is relatively selective, and the quality is high. The full text of all the papers is available on-line at http://www.isoc.org/inet99/proceedings/

About the Reporter

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Footnotes

1. INET 2000 will be in Yokohama.

2. Postel's contributions included the invention and management of "Request for Comment" documents, which underlie the creation of Internet standards, the initial definition of the e-mail protocol and naming scheme for Internet hosts, being a founding member and director of ISOC, and heading the Internet Assigned Numbers Authority since its inception. His entire family accepted the award.

3. This view of ubiquitous computing was first articulated by Mark Weiser at the

Computer Science Lab at Xerox PARC (http://www.ubiquitous.com/hypertext/weiser/UbiHome.html), and he continued this line of research until his death at age 46 earlier this year.

4. PC Week reported that E-Trade has experienced four outages or slowdowns and E-Bay seven since October, 1998 (http://www.zdnet.com/pcweek/stories/jumps/0,4270,2279010,00.html).

5. For more on customer support and community building, see our coverage of Networld+Interop.

6. For more on this approach to network design, see Isenberg, D. S., The Dawn of the Stupid Network, ACM Networker 2.1, February/March 1998, pp. 24-31, www.isen.com/papers/Dawnstupid.html.

7. As reported in our coverage of Network+Interop, 3Com plans to support Bluetooth in future wireless products.

8. This topic was covered in our coverage of Network+Interop.

9. These comments are consistent with Novell's plan to introduce personal "passports," as reported in our coverage of Networld+Interop.

10. For a review of the history of the government role, see Press, L., Seeding Networks: the Federal Role, Communications of the ACM, p.p. 11-18, Vol. 39., No. 10, October, 1996, som.csudh.edu/cis/lpress/articles/govt.htm.

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