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Thomas A. Kalil

04/11/2000 10:10:23 AM



Record Type: Record

To: Natasha F. Bilimoria/OPD/EOP@EOP

cc:

Subject: new digital divide survey by Round Table Group (fwd)

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"Carvin, Andy" <acarvin@benton.org>

04/11/2000 09:44:56 AM

Please respond to digitaldivide@list.benton.org

Record Type: Record

To: "'Digitaldivide (E-mail)" <digitaldivide@list.benton.org>

cc:

Subject: new digital divide survey by Round Table Group (fwd)

FYI... -ac

Company Press Release

New Internet Survey Supports
Clinton Call to Narrow the 'Digital Divide'

Nationwide Phone Survey Shows Poor, Elderly, and
Less Educated Rapidly Falling Behind in Accessing
the Benefits the Internet Brings

April 10, 2000-- The poor, the
elderly and the less highly educated continue to fall behind in the
race to enjoy the educational and consumer benefits brought
about through the rise of the Internet, according to a new survey
released by the Round Table Group, a Chicago-based consortium
of 3,000 university professors that consults on high tech start-ups
and provides high level executive education.

According to a nationwide telephone poll of 1,014 households
commissioned by the group, 46% of Americans now live in

households with access to the Internet. But the "digital divide" looms large: In American households with incomes under \$25,000, 68% do not have access to the Internet, and 67% of Americans who have not completed high school do not have Internet users in their households. Of those aged 65 and higher, 70% live in households that do not use the Internet.

By contrast, only 25% of Americans in households with incomes of \$50,000 or more lack access to the Internet. The survey's statistics support the call made by President Clinton in a speech last week to take strenuous efforts to even the Internet gap between rich and poor.

The survey did have some good news: Internet usage by white, black and Hispanic households is approximately equal, with only 43% of white households and 43% of black households lacking Internet access, compared to 38% of Hispanic households that lack Internet access. The telephone survey of 1,014 American households was conducted with the assistance of Opinion Research Corp. International of Princeton, N.J.

The survey results point out the critical role that the Internet has quickly taken on in the public and private lives of Americans. According to the survey, 49% of households currently using the Internet say that they receive more "useful information" from the Internet than from newspapers, and a separate 49% say that they currently receive more "useful information" from the Internet than from television. Seventy-one percent of households currently using the Internet say that they are more likely to use the Internet to retrieve information than go to the public library. Forty five percent of current Internet households expressed an interest in taking a class over the Internet.

"The Internet has in essence brought the public library right into the living rooms of middle America," stated Russ Rosenzweig, CEO of The Round Table Group. "That's a benefit that should be shared by all Americans. The academic community overwhelmingly supports President Clinton's efforts to make this happen."

Among other initiatives, the President announced last week \$12.5 million in funding for 750 Americorps volunteers to serve as tutors in community centers and provide technical support to local schools through the Corporation of National Service. And he announced a \$3 million partnership between 3Com and the YWCA to create programs to train teenage girls in computer networking.

President Clinton is scheduled to speak on the subject of the digital divide to the Comdex/Spring conference in Chicago on April 18. It will be the first time a U.S. president has addressed an information technology event.

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[Digital Divide Overview](#)

[Digital Divide in the News](#)

[Event Calendar](#)

[Research and Data](#)

[Grants and Funding](#)

[Digital Divide Initiatives](#)

[In the Field](#)

[Find an Effort](#)

[Guestbook](#)

[Discussion List](#)

[About This Site](#)

[Home](#)

Digital Divide Initiatives

[Corporate](#)
[Nonprofit](#)
[Foundation](#)
[Government](#)

Corporate Initiatives

AT&T

The AT&T Learning Network: This program offers free online resources to help families, schools and communities use technology effectively to enhance teaching and learning.

Leadership Conversations for the Next America: AT&T is launching "Leadership Conversations for the Next America" to bring together high school students, Youth Opportunity Movement participants and Job Corps partners with local, state and national policymakers to discuss economic opportunities, education, job skills and leadership for the 21st century.

Academy of Information Technology: AT&T is helping to launch the Academy of Information Technology, a high-school level curriculum designed to prepare young students for the information technology workplace.

Job Corps Funding: AT&T is investing in the Edison (N.J.) Job Corps program by developing a three-year initiative to address the shortage of skilled workers in the information-technology industry that includes providing paid internships for training program graduates, mentors, equipment and materials.

Community Technology Centers: AT&T is collaborating with the NAACP, the National Urban League and the Community Technology Centers' Network to give under-resourced communities access to technology.

Los Angeles Neighborhood Technology Centers: AT&T supports the Los Angeles County Office of Education's Technology for Learning initiative, an effort to establish 25 neighborhood-based technology centers. To reach communities of color and other under-served groups, AT&T is supporting LACOE's partnership with the Greenlining Institute, a multi-ethnic advocacy center.

Computer Learning: AT&T is supporting The Puente Learning Center in South Central Los Angeles to help provide free computer-based education programs to children, youth and adults, and to encourage other community agencies to do the same.

New York City Housing Resources: AT&T is helping settlement houses in New York City serve as centers where technology resources can be accessed, shared and used by settlement staff, community residents and program participants.

Cable in the Classroom Program: AT&T Broadband and Internet Services offers free cable modem and service to every school in its area of service, and through its support for Cable in the Classroom, provides a free cable connection and over 540 hours per month of commercial-free educational programming to schools across the country.

School Safety: AT&T's Safe School Program provides free AT&T Wireless service and Ericsson wireless phones to selected schools to support school safety efforts.

GetNetWise: AT&T is a founding sponsor of GetNetWise: You're One Click Away, a comprehensive Web-based resource designed to ensure parents and

families have the technology tools and tips, safety referral contacts and suggestions on quality content they need to help kids have safe and enriching experiences online.

America Online, Inc.

AOL Rural Telecommunications Leadership Awards: The National Telecommunications and Information Administration (NTIA) recently reported that among all income groups, rural areas have the lowest online participation rate. To address this issue, the AOL Foundation is partnering with the National Center for Small Communities to manage the AOL Rural Telecommunications Leadership Awards, which seek to reduce the digital divide by recognizing and promoting telecommunications innovations in rural areas.

The Digital Divide Grants Initiative: The AOL Foundation's Digital Divide Grant Initiative seeks to invest in nonprofit organizations, social entrepreneurs, and collaboratives working to empower disadvantaged communities and populations through technology. The Foundation hopes to support a variety of ventures to foster innovative and effective approaches to bridging the Digital Divide.

National Digital Divide Clearinghouse: AOL's goal of this initiative is to create a single source of all available information about efforts to provide underserved communities with access to technology and provide tools for information sharing and community building among those working to bridge the Digital Divide.

PowerUP: PowerUP is comprised of more than a dozen nonprofit organizations, major corporations and federal agencies that have joined together to launch a major new multimillion dollar initiative to help ensure that America's underserved young people acquire the skills, experiences and resources they need to succeed in the digital age. AOL has pledged 100,000 AOL accounts for free Internet access to sites throughout the country.

Bell Atlantic

Asian American Technology Hub: The Asian American Federation of New York plans to launch a technology hub for the Asian Pacific nonprofit community. With the aid of a major grant, the Asian American Federation will become an Internet Service Provider and will build the technology infrastructure of community-based organizations, extending the power of the Internet and computer networking to its 34-member health and human service agencies throughout the New York metropolitan area that need it but do not have the wherewithal to get it. The Federation's ambitious plans for ushering Asian American nonprofits into the 21st century and the digital future will enable not only instant access to community-based news and information, but communication with Asian communities across the globe.

NAACP Funding: Bell Atlantic enabled the NAACP to improve the Association's Internet-based communications system with a major challenge grant offered by Bell Atlantic. The funds will enable the nation's oldest and largest civil rights organization to more effectively communicate with its network of 2,200 branches, units and chapters across the U.S.

Employee and Retiree Activism & The Bell Atlantic Pioneers: Numbering over 170,000 strong, Bell Atlantic volunteers log in over six million hours a year in donated time. Bell Atlantic Pioneers are active and retired employees who volunteer their time to help meet the needs of their communities. From painting maps on school playgrounds, mentoring through Junior Achievement, wiring classrooms for the Internet, to swinging hammers to build homes for the homeless, Bell Atlantic Pioneers offer their personal time for the betterment of their communities.

Technology Centers: The National Urban League, enabled by Bell Atlantic, established five community technology centers in Binghamton and White Plains, N.Y.; Baltimore, Md.; Boston, Mass.; and Newark, N.J. At these centers, people have access to hardware and software they need to plug into cyberspace, thereby crossing the digital divide that separates so many communities from the world of technology. Not only do these centers provide underserved communities with a direct on-ramp to the information superhighway, they also provide, in some cases, a safe haven for children in inner-city communities - where they can study, learn and explore in safe,

nurturing environments.

Hispanic Federation Web Site: The New York-based Hispanic Federation, enabled by Bell Atlantic, to develop an interactive Web site designed to provide its nonprofit network of more than 60 member agencies with a host of powerful online tools. The Hispanic Federation Web site, a database-driven, dynamic information gathering system, offering more interactivity than conventional Web sites, was made possible through a major Bell Atlantic Foundation grant, along with in-kind contributions from Bell Atlantic and IBM.

Gateway

PowerUP: PowerUP is comprised of more than a dozen nonprofit organizations, major corporations and federal agencies that have joined together to launch a major new multimillion dollar initiative to help ensure that America's underserved young people acquire the skills, experiences and resources they need to succeed in the digital age. Gateway and the Waitt Family Foundation will provide 50,000 Gateway computers.

Microsoft

Public libraries: In partnership with the Bill and Melinda Gates Foundation, Microsoft will donate an estimated \$200 million in software to create access to technology at public libraries that serve low-income communities.

Boys & Girls Clubs: Microsoft has teamed with Boys & Girls Clubs of America to establish technology centers at 15 Boys & Girls Clubs nationwide, and to develop a model for other clubs to use in establishing their own technology centers. In the program's first year, Microsoft donated \$1.1 million in cash and \$540,000 in software.

Connected Learning Community grants: CLC grants enhance learning and communications in disadvantaged communities by expanding access to information technology. More than 95 community-based nonprofit groups across the United States have received grants totaling \$1.25 million in cash and \$2.4 million in software during the past three years.

Working Connections: This 5-year, \$30 million grant program supports the development and enhancement of information technology training for underserved populations through the nation's community college system.

Higher education for minorities: To ensure excellent technology infrastructure, teacher preparedness, training and access for minority college students, Microsoft has long supported Historically Black Colleges and Universities, Hispanic-Serving Institutions and tribal colleges.

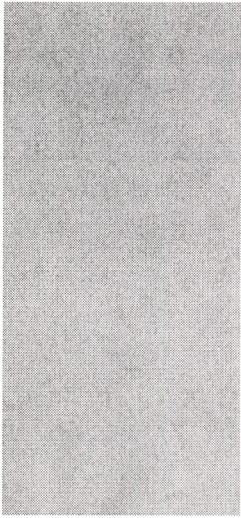
TRIO programs : Microsoft has donated more than \$20 million in software to increase technology access for low-income students participating in the federally funded TRIO programs at 49 colleges and universities across the United States, benefiting more than 70,000 students.

Microsoft Technology Leadership Grants: Technology Leadership Grants provide major software donations to large, national nonprofit organizations to expand their use of information technology to support their mission. In the three years of this program, Microsoft has donated over \$18 million in software to 20 organizations.

SBC

Community Partnership Agreement: The Community Partnership Agreement is a nonprofit collaboration between SBC subsidiary Pacific Bell and nine California community coalitions representing 134 Latino, Asian American, African American, civil rights, and disability organizations that is dedicated to closing the digital divide by bringing communications technologies to traditionally disadvantaged communities. SBC is providing a \$50 million monetary contribution to the fund, which is distributing \$5 million per year over a ten year period.

Major National Urban League Grant: In November, 1999, SBC announced a \$1 million grant to the National Urban League to support the League's technology programs. The grants will help fund the Urban League's efforts to close the digital divide by helping them create and maintain community



technology centers that bring technology to underserved communities. Community Technology Centers were heralded in the Falling Through the Net reports as key access points for low-income communities.

National Urban League Midwest Technology Centers: SBC subsidiary Ameritech has also given \$350,000 to the Urban League to fund community technology centers in Aurora, Ill., Cleveland, Detroit, Indianapolis, and Milwaukee.

"Links to Learning & Closing the Digital Divide" Initiative: Just recently in Connecticut, SBC subsidiary SNET awarded \$500,000 to institutions of higher education under a grant program designed specifically to close the digital divide. Seven colleges and universities have received grants and are administering programs such as: hands-on technology training for the visually impaired, women in transition, senior citizens and young adults from difficult family situations at Housatonic Community Technical College; a basic computer literacy training program for the underserved population of eastern Connecticut at Eastern Connecticut State University; and an "Introduction to Computers" curriculum for women in transition at Gateway Community Technical College.

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[Digital Divide Overview](#)

[Digital Divide in the News](#)

[Event Calendar](#)

[Research and Data](#)

[Grants and Funding](#)

[Digital Divide Initiatives](#)

[In the Field](#)

[Find an Effort](#)

[Guestbook](#)

[Discussion List](#)

[About This Site](#)

[Home](#)

Digital Divide Initiatives

[Corporate](#)
[Nonprofit](#)
[Foundation](#)
[Government](#)

Government Initiatives

[DigitalDivide.gov \(www.DigitalDivide.gov\)](#) serves as a gateway for Federal government-related digital divide initiatives. The site was announced at the December 9, Dept. of Commerce Digital Divide Summit. Among other resources, RealVideo transcripts of the Summit's morning Executive Roundtable session are available [here](#).

The [Community Technology Centers program](#) of the U.S. Department of [Education](#): CTC promotes programs that demonstrate the educational value of technology in urban, rural and economically distressed communities. The program provides startup money to CTCs that are diverse in the populations they serve and programs they offer, but similar in that they provide technology access to individuals, communities, and populations that typically wouldn't otherwise have places to use computer and telecommunications technologies. The affiliates are organized under [CTCNet](#).

The [Schools and Libraries Division \(SLD\) of the Universal Service Administrative Company \(USAC\)](#): SLD helps to provide schools and libraries with affordable access to telecommunications services. The Universal Service Fund for Schools and Libraries, known as the E-rate, provides discounts of 20% to 90% --based on the number of students eligible for the National Free Lunch Program -- on the cost of telecommunications, Internet Access, and network wiring within school and library buildings. The Federal Communications Commission has authorized the SLD to administer up to \$2.25 billion annually as part of the Fund.

The [Telecommunications and Information Infrastructure Assistance Program \(TIIAP\)](#): TIIAP provides matching grants to improve the quality of, and the public's access to, education, health care, public safety, and other community-based services. Part of the [National Telecommunications and Information Administration of the Department of Commerce](#), the TIIAP Program is a highly competitive grant program focusing on model projects demonstrating innovative uses of network technology. Since 1994, TIIAP has awarded 421 grants, in all 50 states, the District of Columbia, and the U.S. Virgin Islands, totaling \$135.8 million and leveraging \$203 million in local matching funds.

The [Neighborhood Networks Program](#) is an initiative of the U.S. Department of [Housing and Urban Development](#). Neighborhood Networks encourages the development of resource and computer learning centers in privately owned HUD-assisted and HUD-insured housing. As the needs of each area are unique, there is no typical Neighborhood Network. Funding relies primarily on local support for development needs of the centers -- such as computer software and hardware, furniture, personnel and capital funding -- and long-term sustainability. The program's Web site serves as a clearinghouse of information for community-building efforts.

the digital divide network



[Digital Divide Overview](#)

[Digital Divide in the News](#)

[Event Calendar](#)

[Research and Data](#)

[Grants and Funding](#)

[Digital Divide Initiatives](#)

[In the Field](#)

[Find an Effort](#)

[Guestbook](#)

[Discussion List](#)

[About This Site](#)

[Home](#)

Digital Divide Initiatives

[Corporate](#)
[Nonprofit](#)
[Foundation](#)
[Government](#)

Foundation Initiatives

The Kellogg Foundation: The Kellogg Foundation helps rural citizens use electronic communications and information systems as a tool to meet current and future challenges through the [Managing Information with Rural America grant program](#). Each MIRA round provides grants for Clusters of Community Teams, Community Support Organizations, and Policy Support Organizations to apply electronic communications and information systems uses in rural America. No additional grants will be made under MIRA after 2000, as MIRA will be folded into a new rural development initiative currently in the planning stages.

The Markle Foundation: The Markle Foundation sponsors the [E-mail for All Outreach Campaign](#), an integral part of the Foundation's work to encourage the use of new communications technologies for socially beneficial purposes. The Outreach Campaign component is partnered with Markle-funded research designed to stimulate a national dialogue on this issue.

The National Indian Telecommunications Institute (NITI): NITI works to employ advanced technology to serve American Indians, Native Hawaiians and Alaskan Natives in the areas of education, economic development, language and cultural preservation, tribal policy issues and self-determination. The [Education Technology Improvement Plan Project \(ETIP\)](#) is a targeted program of NITI that works with the Colleges of Education at the University of New Mexico and Northern Arizona University to train teams of parents teachers, and administrators in instructional technologies and instructional technology training methods.

The Technology Access Foundation: The Technology Access Foundation coordinates the [Technical Teens Internship Program \(TTIP\)](#). TTIP is designed to give students enough computer and job readiness experience to obtain a summer internship at a local business. In addition, TTIP prepares students for higher education by assisting them in course selection, SAT training and entrance applications. Completion of the program leads to a \$1000 scholarship to the student's college or university of choice.

the digital divide network



[Digital Divide Overview](#)

[Digital Divide in the News](#)

[Event Calendar](#)

[Research and Data](#)

[Grants and Funding](#)

[Digital Divide Initiatives](#)

[In the Field](#)

[Find an Effort](#)

[Guestbook](#)

[Discussion List](#)

[About This Site](#)

[Home](#)

Digital Divide Initiatives

[Corporate](#)
[Nonprofit](#)
[Foundation](#)
[Government](#)

Nonprofit Initiatives

Alliance for Community Technology (ACT): ACT is a strategic partnership between the Kellogg Foundation and the University of Michigan's School of Information to help underserved populations use information technology more effectively. ACT serves as a test bed and promoter of technologies that can be used to build and strengthen communities.

Alliance for Latino Community Technology (ALCT) ALCT provides conference updates, tracks policy, and gathers Latino market data. The alliance is dedicated to preparing Latinos to acquire the skills of technology literacy to effectively compete in the next century, capturing the full benefits of the Information Age. ALCT maintains a listing of Latino Sites of Interest on the Web.

Appalachian Center for Economic Networks (ACEnet): ACEnet is a community-based economic development organization located in rural, southeastern Ohio. Through ACEnet's Community Computer Center, small businesses can receive training on business software and the Internet. Local businesses can also market products through ACEnet's Web site, the Public Webmarket. Together with Ohio University, ACEnet administers a community network, the Southeastern Ohio Regional Freenet, which provides residents with low-cost access to the Internet.

CitySkills.org: CitySkills.org is a nonprofit information resource that works to bring urban job training organizations and Internet companies together. CitySkills.org helps job training organizations train urban workers for high demand Internet jobs and helps Internet companies find, hire and retain those workers.

Community Technology Centers' Network (CTCNet): CTCNet is a membership organization of over 300 community technology centers where people can access computers and computer related technology, such as the Internet. CTCNet offers assistance, support for organizations who wish to integrate technology into their services, and an arena for such groups to share ideas and strategies in servicing their communities.

Community Technology Institute: The Community Technology Institute seeks to improve the delivery of social services and increase opportunities for employment through its Community Voice Mail program. CVM now operates in 25 cities including Boston, Houston, Los Angeles and Spokane, bringing community-wide access to voice mail for an estimated 15,000 homeless or phoneless people every day.

Trace: Trace is a research center at the University of Wisconsin - Madison that focuses on making off-the-shelf technologies and systems like computers, the Internet, and information kiosks more accessible through the process known as universal or accessible design. The Cooperative Electronic Library is an online menu-based directory of products, services, and information on disabled and cooperative services.

INTERNET POLICY INSTITUTE

[Home](#)[What's New](#)[Board of Directors](#)[Research Program](#)[Briefing the President](#)

- ▶ [Project Description](#)
- ▶ [Advisory Board](#)
- ▶ [Current Paper](#)
- ▶ [Previous Papers](#)

[Publications](#)[Sponsors](#)[In the News](#)[Links to other Resources](#)[Fellows](#)[Staff](#)

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What Is The Internet (And What Makes It Work) -

December, 1999

By Robert E. Kahn and Vinton G. Cerf

[<< Back to Preface](#)

In this issue:

- [INTRODUCTION](#)
- [THE EVOLUTION OF THE INTERNET](#)
- [THE INTERNET ARCHITECTURE](#)
- [GOVERNMENT'S HISTORICAL ROLE](#)
- [A DEFINITION FOR THE INTERNET](#)
- [WHO RUNS THE INTERNET](#)
- [WHERE DO WE GO FROM HERE?](#)

This paper was prepared by the authors at the request of the Internet Policy Institute (IPI), a non-profit organization based in Washington, D.C., for inclusion in their upcoming series of Internet related papers. It is a condensation of a longer paper in preparation by the authors on the same subject. Many topics of potential interest were not included in this condensed version because of size and subject matter constraints. Nevertheless, the reader should get a basic idea of the Internet, how it came to be, and perhaps even how to begin thinking about it from an architectural perspective. This will be especially important to policy makers who need to distinguish the Internet as a global information system apart from its underlying communications infrastructure.

INTRODUCTION

[Return to top](#)

As we approach a new millennium, the Internet is revolutionizing our society, our economy and our technological systems. No one knows for certain how far, or in what direction, the Internet will evolve. But no one should underestimate its importance.

Over the past century and a half, important technological developments have created a global environment that is drawing the people of the world closer and closer together. During the industrial revolution, we learned to put motors to work to magnify human and animal muscle power. In the new Information Age, we are learning to magnify brainpower by putting the power of computation wherever we need it, and to provide information services on a global basis. Computer resources are infinitely flexible tools; networked together, they allow us to generate, exchange, share and manipulate information in an uncountable number of ways. The Internet, as an integrating force, has melded the technology of communications and computing to provide instant connectivity and global information services to all its users at very low cost.

Ten years ago, most of the world knew little or nothing about the Internet. It was the private enclave of computer scientists and researchers who used it to interact with colleagues in their respective disciplines. Today, the Internet's magnitude is thousands of times what it was only a decade ago. It is estimated that about 60 million host computers on the Internet today serve about 200 million users in over 200 countries and territories. Today's telephone system is still

much larger: about 3 billion people around the world now talk on almost 950 million telephone lines (about 250 million of which are actually radio-based cell phones). But by the end of the year 2000, the authors estimate there will be at least 300 million Internet users. Also, the total numbers of host computers and users have been growing at about 33% every six months since 1988 – or roughly 80% per year. The telephone service, in comparison, grows an average of about 5-10% per year. That means if the Internet keeps growing steadily the way it has been growing over the past few years, it will be nearly as big as today's telephone system by about 2006.

[top](#)

THE EVOLUTION OF THE INTERNET

[Return to top](#)

The underpinnings of the Internet are formed by the global interconnection of hundreds of thousands of otherwise independent computers, communications entities and information systems. What makes this interconnection possible is the use of a set of communication standards, procedures and formats in common among the networks and the various devices and computational facilities connected to them. The procedures by which computers communicate with each other are called "protocols." While this infrastructure is steadily evolving to include new capabilities, the protocols initially used by the Internet are called the "TCP/IP" protocols, named after the two protocols that formed the principal basis for Internet operation.

On top of this infrastructure is an emerging set of architectural concepts and data structures for heterogeneous information systems that renders the Internet a truly global information system. In essence, the Internet is an architecture, although many people confuse it with its implementation. When the Internet is looked at as an architecture, it manifests two different abstractions. One abstraction deals with communications connectivity, packet delivery and a variety of end-end communication services. The other abstraction deals with the Internet as an information system, independent of its underlying communications infrastructure, which allows creation, storage and access to a wide range of information resources, including digital objects and related services at various levels of abstraction.

Interconnecting computers is an inherently digital problem. Computers process and exchange digital information, meaning that they use a discrete mathematical "binary" or "two-valued" language of 1s and 0s. For communication purposes, such information is mapped into continuous electrical or optical waveforms. The use of digital signaling allows accurate regeneration and reliable recovery of the underlying bits. We use the terms "computer," "computer resources" and "computation" to mean not only traditional computers, but also devices that can be controlled digitally over a network, information resources such as mobile programs and other computational capabilities.

The telephone network started out with operators who manually connected telephones to each other through "patch panels" that accepted patch cords from each telephone line and electrically connected them to one another through the panel, which operated, in effect, like a switch. The result was called circuit switching, since at its conclusion, an electrical circuit was made between the calling telephone and the called telephone. Conventional circuit switching, which was developed to handle telephone calls, is inappropriate for connecting computers because it makes limited use of the telecommunication facilities and takes too long to set up connections. Although reliable enough for voice communication, the circuit-switched voice network had difficulty delivering digital information without errors.

For digital communications, packet switching is a better choice,

because it is far better suited to the typically "burst" communication style of computers. Computers that communicate typically send out brief but intense bursts of data, then remain silent for a while before sending out the next burst. These bursts are communicated as packets, which are very much like electronic postcards. The postcards, in reality packets, are relayed from computer to computer until they reach their destination. The special computers that perform this forwarding function are called variously "packet switches" or "routers" and form the equivalent of many bucket brigades spanning continents and oceans, moving buckets of electronic postcards from one computer to another. Together these routers and the communication links between them form the underpinnings of the Internet.

Without packet switching, the Internet would not exist as we now know it. Going back to the postcard analogy, postcards can get lost. They can be delivered out of order, and they can be delayed by varying amounts. The same is true of Internet packets, which, on the Internet, can even be duplicated. The Internet Protocol is the postcard layer of the Internet. The next higher layer of protocol, TCP, takes care of re-sending the "postcards" to recover packets that might have been lost, and putting packets back in order if they have become disordered in transit.

Of course, packet switching is about a billion times faster than the postal service or a bucket brigade would be. It also has to operate over many different communications systems, or substrata. The authors designed the basic architecture to be so simple and undemanding that it could work with most communication services. Many organizations, including commercial ones, carried out research using the TCP/IP protocols in the 1970s. Email was steadily used over the nascent Internet during that time and to the present. It was not until 1994 that the general public began to be aware of the Internet by way of the World Wide Web application, particularly after Netscape Communications was formed and released its browser and associated server software.

Thus, the evolution of the Internet was based on two technologies and a research dream. The technologies were packet switching and computer technology, which, in turn, drew upon the underlying technologies of digital communications and semiconductors. The research dream was to share information and computational resources. But that is simply the technical side of the story. Equally important in many ways were the other dimensions that enabled the Internet to come into existence and flourish. This aspect of the story starts with cooperation and far-sightedness in the U.S. Government, which is often derided for lack of foresight but is a real hero in this story.

It leads on to the enthusiasm of private sector interests to build upon the government funded developments to expand the Internet and make it available to the general public. Perhaps most important, it is fueled by the development of the personal computer industry and significant changes in the telecommunications industry in the 1980s, not the least of which was the decision to open the long distance market to competition. The role of workstations, the Unix operating system and local area networking (especially the Ethernet) are themes contributing to the spread of Internet technology in the 1980s into the research and academic community from which the Internet industry eventually emerged.

Many individuals have been involved in the development and evolution of the Internet covering a span of almost four decades if one goes back to the early writings on the subject of computer networking by Kleinrock [i], Licklider [ii], Baran [iii], Roberts [iv], and Davies [v]. The ARPANET, described below, was the first wide-area computer network. The NSFNET, which followed more than a decade later under the leadership of Erich Bloch, Gordon Bell, Bill Wulf and Steve

Wolff, brought computer networking into the mainstream of the research and education communities. It is not our intent here to attempt to attribute credit to all those whose contributions were central to this story, although we mention a few of the key players. A readable summary on the history of the Internet, written by many of the key players, may be found at www.isoc.org/internet/history. [vi]

From One Network to Many: The role of DARPA

Modern computer networking technologies emerged in the early 1970s. In 1969, The U.S. Defense Advanced Research Projects Agency (variously called ARPA and DARPA), an agency within the Department of Defense, commissioned a wide-area computer network called the ARPANET. This network made use of the new packet switching concepts for interconnecting computers and initially linked computers at universities and other research institutions in the United States and in selected NATO countries. At that time, the ARPANET was essentially the only realistic wide-area computer network in existence, with a base of several dozen organizations, perhaps twice that number of computers and numerous researchers at those sites. The program was led at DARPA by Larry Roberts. The packet switches were built by Bolt Beranek and Newman (BBN), a DARPA contractor. Others directly involved in the ARPANET activity included the authors, Len Kleinrock, Frank Heart, Howard Frank, Steve Crocker, Jon Postel and many many others in the ARPA research community.

Back then, the methods of internetworking (that is interconnecting computer networks) were primitive or non-existent. Two organizations could interwork technically by agreeing to use common equipment, but not every organization was interested in this approach. Absent that, there was jury-rigging, special case development and not much else. Each of these networks stood on its own with essentially no interaction between them – a far cry from today's Internet.

In the early 1970s, ARPA began to explore two alternative applications of packet switching technology based on the use of synchronous satellites (SATNET) and ground-based packet radio (PRNET). The decision by Kahn to link these two networks and the ARPANET as separate and independent networks resulted in the creation of the Internet program and the subsequent collaboration with Cerf. These two systems differed in significant ways from the ARPANET so as to take advantage of the broadcast and wireless aspects of radio communications. The strategy that had been adopted for SATNET originally was to embed the SATNET software into an ARPANET packet switch, and interwork the two networks through memory-to-memory transfers within the packet switch. This approach, in place at the time, was to make SATNET an "embedded" network within the ARPANET; users of the network would not even need to know of its existence. The technical team at Bolt Beranek and Newman (BBN), having built the ARPANET switches and now building the SATNET software, could easily produce the necessary patches to glue the programs together in the same machine. Indeed, this is what they were under contract with DARPA to provide. By embedding each new network into the ARPANET, a seamless internetworked capability was possible, but with no realistic possibility of unleashing the entrepreneurial networking spirit that has manifest itself in modern day Internet developments. A new approach was in order.

The Packet Radio (PRNET) program had not yet gotten underway so there was ample opportunity to change the approach there. In addition, up until then, the SATNET program was only an equipment development activity. No commitments had been obtained for the use of actual satellites or ground stations to access them. Indeed, since there was no domestic satellite industry in the U.S. then, the only two viable alternatives were the use of Intelsat or U.S. military satellites. The time for a change in strategy, if it was to be made, was then.

[top](#)

THE INTERNET ARCHITECTURE

[Return to top](#)

The authors created an architecture for interconnecting independent networks that could then be federated into a seamless whole without changing any of the underlying networks. This was the genesis of the Internet as we know it today.

In order to work properly, the architecture required a global addressing mechanism (or Internet address) to enable computers on any network to reference and communicate with computers on any other network in the federation. Internet addresses fill essentially the same role as telephone numbers do in telephone networks. The design of the Internet assumed first that the individual networks could not be changed to accommodate new architectural requirements; but this was largely a pragmatic assumption to facilitate progress. The networks also had varying degrees of reliability and speed. Host computers would have to be able to put disordered packets back into the correct order and discard duplicate packets that had been generated along the way. This was a major change from the virtual circuit-like service provided by ARPANET and by then contemporary commercial data networking services such as Tymnet and Telenet. In these networks, the underlying network took responsibility for keeping all information in order and for re-sending any data that might have been lost. The Internet design made the computers responsible for tending to these network problems.

A key architectural construct was the introduction of gateways (now called routers) between the networks to handle the disparities such as different data rates, packet sizes, error conditions, and interface specifications. The gateways would also check the destination Internet addresses of each packet to determine the gateway to which it should be forwarded. These functions would be combined with certain end-end functions to produce the reliable communication from source to destination. A draft paper by the authors describing this approach was given at a meeting of the International Network Working Group in 1973 in Sussex, England and the final paper was subsequently published by the Institute for Electrical and Electronics Engineers, the leading professional society for the electrical engineering profession, in its Transactions on Communications in May, 1974 [vii]. The paper described the TCP/IP protocol.

DARPA contracted with Cerf's group at Stanford to carry out the initial detailed design of the TCP software and, shortly thereafter, with BBN and University College London to build independent implementations of the TCP protocol (as it was then called – it was later split into TCP and IP) for different machines. BBN also had a contract to build a prototype version of the gateway. These three sites collaborated in the development and testing of the initial protocols on different machines. Cerf, then a professor at Stanford, provided the day-to-day leadership in the initial TCP software design and testing. BBN deployed the gateways between the ARPANET and the PRNET and also with SATNET. During this period, under Kahn's overall leadership at DARPA, the initial feasibility of the Internet Architecture was demonstrated.

The TCP/IP protocol suite was developed and refined over a period of four more years and, in 1980, it was adopted as a standard by the U.S. Department of Defense. On January 1, 1983 the ARPANET converted to TCP/IP as its standard host protocol. Gateways (or routers) were used to pass packets to and from host computers on "local area networks." Refinement and extension of these protocols and many others associated with them continues to this day by way of the Internet Engineering Task Force [viii].

[top](#)

GOVERNMENT'S HISTORICAL ROLE

[Return to top](#)

Other political and social dimensions that enabled the Internet to come into existence and flourish are just as important as the technology upon which it is based. The federal government played a large role in creating the Internet, as did the private sector interests that made it available to the general public. The development of the personal computer industry and significant changes in the telecommunications industry also contributed to the Internet's growth in the 1980s. In particular, the development of workstations, the Unix operating system, and local area networking (especially the Ethernet) contributed to the spread of the Internet within the research community from which the Internet industry eventually emerged.

The National Science Foundation and others

In the late 1970s, the National Science Foundation (NSF) became interested in the impact of the ARPANET on computer science and engineering. NSF funded the Computer Science Network (CSNET), which was a logical design for interconnecting universities that were already on the ARPANET and those that were not. Telenet was used for sites not connected directly to the ARPANET and a gateway was provided to link the two. Independent of NSF, another initiative called BITNET ("Because it's there" Net) [ix] provided campus computers with email connections to the growing ARPANET. Finally, AT&T Bell Laboratories development of the Unix operating system led to the creation of a grass-roots network called USENET [x], which rapidly became home to thousands of "newsgroups" where Internet users discussed everything from aerobics to politics and zoology.

In the mid 1980s, NSF decided to build a network called NSFNET to provide better computer connections for the science and education communities. The NSFNET made possible the involvement of a large segment of the education and research community in the use of high speed networks. A consortium consisting of MERIT (a University of Michigan non-profit network services organization), IBM and MCI Communications won a 1987 competition for the contract to handle the network's construction. Within two years, the newly expanded NSFNET had become the primary backbone component of the Internet, augmenting the ARPANET until it was decommissioned in 1990. At about the same time, other parts of the U.S. government had moved ahead to build and deploy networks of their own, including NASA and the Department of Energy. While these groups originally adopted independent approaches for their networks, they eventually decided to support the use of TCP/IP.

The developers of the NSFNET, led by Steve Wolff who had the direct responsibility for the NSFNET program, also decided to create intermediate level networks to serve research and education institutions and, more importantly, to allow networks that were not commissioned by the U.S. government to connect to the NSFNET. This strategy reduced the overall load on the backbone network operators and spawned a new industry: Internet Service Provision. Nearly a dozen intermediate level networks were created, most with NSF support, [xi] some, such as UUNET, with Defense support, and some without any government support. The NSF contribution to the evolution of the Internet was essential in two respects. It opened the Internet to many new users and, drawing on the properties of TCP/IP, structured it so as to allow many more network service providers to participate.

For a long time, the federal government did not allow organizations to connect to the Internet to carry out commercial activities. By 1988, it was becoming apparent, however, that the Internet's growth and use in the business sector might be seriously inhibited by this restriction.

That year, CNRI requested permission from the Federal Networking Council to interconnect the commercial MCI Mail electronic mail system to the Internet as part of a general electronic mail interconnection experiment. Permission was given and the interconnection was completed by CNRI, under Cerf's direction, in the summer of 1989. Shortly thereafter, two of the then non-profit Internet Service Providers (UUNET [xii] and NYSERNET) produced new for-profit companies (UUNET and PSINET [xiii] respectively). In 1991, they were interconnected with each other and CERFNET [xiv]. Commercial pressure to alleviate restrictions on interconnections with the NSFNET began to mount.

In response, Congress passed legislation allowing NSF to open the NSFNET to commercial usage. Shortly thereafter, NSF determined that its support for NSFNET might not be required in the longer term and, in April 1995, NSF ceased its support for the NSFNET. By that time, many commercial networks were in operation and provided alternatives to NSFNET for national level network services. Today, approximately 10,000 Internet Service Providers (ISPs) are in operation. Roughly half the world's ISPs currently are based in North America and the rest are distributed throughout the world.

[top](#)

A DEFINITION FOR THE INTERNET

[Return to top](#)

The authors feel strongly that efforts should be made at top policy levels to define the Internet. It is tempting to view it merely as a collection of networks and computers. However, as indicated earlier, the authors designed the Internet as an architecture that provided for both communications capabilities and information services. Governments are passing legislation pertaining to the Internet without ever specifying to what the law applies and to what it does not apply. In U.S. telecommunications law, distinctions are made between cable, satellite broadcast and common carrier services. These and many other distinctions all blur in the backdrop of the Internet. Should broadcast stations be viewed as Internet Service Providers when their programming is made available in the Internet environment? Is use of cellular telephones considered part of the Internet and if so under what conditions? This area is badly in need of clarification.

The authors believe the best definition currently in existence is that approved by the Federal Networking Council in 1995, <http://www.fnc.gov> and which is reproduced in the footnote below [xv] for ready reference. Of particular note is that it defines the Internet as a global information system, and included in the definition, is not only the underlying communications technology, but also higher-level protocols and end-user applications, the associated data structures and the means by which the information may be processed, manifested, or otherwise used. In many ways, this definition supports the characterization of the Internet as an "information superhighway." Like the federal highway system, whose underpinnings include not only concrete lanes and on/off ramps, but also a supporting infrastructure both physical and informational, including signs, maps, regulations, and such related services and products as filling stations and gasoline, the Internet has its own layers of ingress and egress, and its own multi-tiered levels of service.

The FNC definition makes it clear that the Internet is a dynamic organism that can be looked at in myriad ways. It is a framework for numerous services and a medium for creativity and innovation. Most importantly, it can be expected to evolve.

[top](#)

WHO RUNS THE INTERNET

[Return to top](#)

The Domain Name System

The Internet evolved as an experimental system during the 1970s and early 1980s. It then flourished after the TCP/IP protocols were made mandatory on the ARPANET and other networks in January 1983; these protocols thus became the standard for many other networks as well. Indeed, the Internet grew so rapidly that the existing mechanisms for associating the names of host computers (e.g. UCLA, USC-ISI) to Internet addresses (known as IP addresses) were about to be stretched beyond acceptable engineering limits. Most of the applications in the Internet referred to the target computers by name. These names had to be translated into Internet addresses before the lower level protocols could be activated to support the application. For a time, a group at SRI International in Menlo Park, CA, called the Network Information Center (NIC), maintained a simple, machine-readable list of names and associated Internet addresses which was made available on the net. Hosts on the Internet would simply copy this list, usually daily, so as to maintain a local copy of the table. This list was called the "host.txt" file (since it was simply a text file). The list served the function in the Internet that directory services (e.g. 411 or 703-555-1212) do in the US telephone system - the translation of a name into an address.

As the Internet grew, it became harder and harder for the NIC to keep the list current. Anticipating that this problem would only get worse as the network expanded, researchers at USC Information Sciences Institute launched an effort to design a more distributed way of providing this same information. The end result was the Domain Name System (DNS) [xvi] which allowed hundreds of thousands of "name servers" to maintain small portions of a global database of information associating IP addresses with the names of computers on the Internet.

The naming structure was hierarchical in character. For example, all host computers associated with educational institutions would have names like "stanford.edu" or "ucla.edu". Specific hosts would have names like "cs.ucla.edu" to refer to a computer in the computer science department of UCLA, for example. A special set of computers called "root servers" maintained information about the names and addresses of other servers that contained more detailed name/address associations. The designers of the DNS also developed seven generic "top level" domains, as follows:

- Education - EDU
- Government - GOV
- Military - MIL
- International - INT
- Network - NET
- (non-profit) Organization - ORG
- Commercial - COM

Under this system, for example, the host name "UCLA" became "UCLA.EDU" because it was operated by an educational institution, while the host computer for "BBN" became "BBN.COM" because it was a commercial organization. Top-level domain names also were created for every country: United Kingdom names would end in ".UK," while the ending ".FR" was created for the names of France.

The Domain Name System (DNS) was and continues to be a major element of the Internet architecture, which contributes to its scalability. It also contributes to controversy over trademarks and general rules for the creation and use of domain names, creation of new top-level domains and the like. At the same time, other resolution schemes exist as well. One of the authors (Kahn) has been involved in the development of a different kind of standard identification and resolution scheme [xvii] that, for example, is being used as the base

technology by book publishers to identify books on the Internet by adapting various identification schemes for use in the Internet environment. For example, International Standard Book Numbers (ISBNs) can be used as part of the identifiers. The identifiers then resolve to state information about the referenced books, such as location information (e.g. multiple sites) on the Internet that is used to access the books or to order them. These developments are taking place in parallel with the more traditional means of managing Internet resources. They offer an alternative to the existing Domain Name System with enhanced functionality.

The growth of Web servers and users of the Web has been remarkable, but some people are confused about the relationship between the World Wide Web and the Internet. The Internet is the global information system that includes communication capabilities and many high level applications. The Web is one such application. The existing connectivity of the Internet made it possible for users and servers all over the world to participate in this activity. Electronic mail is another important application. As of today, over 60 million computers take part in the Internet and about 3.6 million web sites were estimated to be accessible on the net. Virtually every user of the net has access to electronic mail and web browsing capability. Email remains a critically important application for most users of the Internet, and these two functions largely dominate the use of the Internet for most users.

The Internet Standards Process

Internet standards were once the output of research activity sponsored by DARPA. The principal investigators on the internetting research effort essentially determined what technical features of the TCP/IP protocols would become common. The initial work in this area started with the joint effort of the two authors, continued in Cerf's group at Stanford, and soon thereafter was joined by engineers and scientists at BBN and University College London. This informal arrangement has changed with time and details can be found elsewhere [xviii]. At present, the standards efforts for Internet is carried out primarily under the auspices of the Internet Society (ISOC). The Internet Engineering Task Force (IETF) operates under the leadership of its Internet Engineering Steering Group (IESG), which is populated by appointees approved by the Internet Architecture Board (IAB) which is, itself, now part of the Internet Society.

The IETF comprises over one hundred working groups categorized and managed by Area Directors specializing in specific categories.

There are other bodies with considerable interest in Internet standards or in standards that must interwork with the Internet. Examples include the International Telecommunications Union Telecommunications standards group (ITU-T), the International Institute of Electrical and Electronic Engineers (IEEE) local area network standards group (IEEE 801), the Organization for International Standardization (ISO), the American National Standards Institute (ANSI), the World Wide Web Consortium (W3C), and many others.

As Internet access and services are provided by existing media such as telephone, cable and broadcast, interactions with standards bodies and legal structures formed to deal with these media will become an increasingly complex matter. The intertwining of interests is simultaneously fascinating and complicated, and has increased the need for thoughtful cooperation among many interested parties.

Managing the Internet

Perhaps the least understood aspect of the Internet is its management. In recent years, this subject has become the subject of intense commercial and international interest, involving multiple

governments and commercial organizations, and recently congressional hearings. At issue is how the Internet will be managed in the future, and, in the process, what oversight mechanisms will insure that the public interest is adequately served.

In the 1970s, managing the Internet was easy. Since few people knew about the Internet, decisions about almost everything of real policy concern were made in the offices of DARPA. It became clear in the late 1970s, however, that more community involvement in the decision-making processes was essential. In 1979, DARPA formed the Internet Configuration Control Board (ICCB) to insure that knowledgeable members of the technical community discussed critical issues, educated people outside of DARPA about the issues, and helped others to implement the TCP/IP protocols and gateway functions. At the time, there were no companies that offered turnkey solutions to getting on the Internet. It would be another five years or so before companies like Cisco Systems were formed, and while there were no PCs yet, the only workstations available were specially built and their software was not generally configured for use with external networks; they were certainly considered expensive at the time.

In 1983, the small group of roughly twelve ICCB members was reconstituted (with some substitutions) as the Internet Activities Board (IAB), and about ten "Task Forces" were established under it to address issues in specific technical areas. The attendees at Internet Working Group meetings were invited to become members of as many of the task forces as they wished.

The management of the Domain Name System offers a kind of microcosm of issues now frequently associated with overall management of the Internet's operation and evolution. Someone had to take responsibility for overseeing the system's general operation. In particular, top-level domain names had to be selected, along with persons or organizations to manage each of them. Rules for the allocation of Internet addresses had to be established. DARPA had previously asked the late Jon Postel of the USC Information Sciences Institute to take on numerous functions related to administration of names, addresses and protocol related matters. With time, Postel assumed further responsibilities in this general area on his own, and DARPA, which was supporting the effort, gave its tacit approval. This activity was generally referred to as the Internet Assigned Numbers Authority (IANA) [xix]. In time, Postel became the arbitrator of all controversial matters concerning names and addresses until his untimely death in October 1998.

It is helpful to consider separately the problem of managing the domain name space and the Internet address space. These two vital elements of the Internet architecture have rather different characteristics that color the management problems they generate. Domain names have semantics that numbers may not imply; and thus a means of determining who can use what names is needed. As a result, speculators on Internet names often claim large numbers of them without intent to use them other than to resell them later. Alternate resolution mechanisms [xx], if widely adopted, could significantly change the landscape here.

The rapid growth of the Internet has triggered the design of a new and larger address space (the so-called IP version 6 address space); today's Internet uses IP version 4 [xxi]. However, little momentum has yet developed to deploy IPv6 widely. Despite concerns to the contrary, the IPv4 address space will not be depleted for some time. Further, the use of Dynamic Host Configuration Protocol (DHCP) to dynamically assign IP addresses has also cut down on demand for dedicated IP addresses. Nevertheless, there is growing recognition in the Internet technical community that expansion of the address space is needed, as is the development of transition schemes that allow interoperation between IPv4 and IPv6 while migrating to IPv6.

In 1998, the Internet Corporation for Assigned Names and Numbers (ICANN) was formed as a private sector, non-profit, organization to oversee the orderly progression in use of Internet names and numbers, as well as certain protocol related matters that required oversight. The birth of this organization, which was selected by the Department of Commerce for this function, has been difficult, embodying as it does many of the inherent conflicts in resolving discrepancies in this arena. However, there is a clear need for an oversight mechanism for Internet domain names and numbers, separate from their day-to-day management.

Many questions about Internet management remain. They may also prove difficult to resolve quickly. Of specific concern is what role the U.S. government and indeed governments around the world need to play in its continuing operation and evolution. This is clearly a subject for another time.

[top](#)

WHERE DO WE GO FROM HERE?

[Return to top](#)

As we struggle to envision what may be commonplace on the Internet in a decade, we are confronted with the challenge of imagining new ways of doing old things, as well as trying to think of new things that will be enabled by the Internet, and by the technologies of the future.

In the next ten years, the Internet is expected to be enormously bigger than it is today. It will be more pervasive than the older technologies and penetrate more homes than television and radio programming. Computer chips are now being built that implement the TCP/IP protocols and recently a university announced a two-chip web server. Chips like this are extremely small and cost very little. And they can be put into anything. Many of the devices connected to the Internet will be Internet-enabled appliances (cell phones, fax machines, household appliances, hand-held organizers, digital cameras, etc.) as well as traditional laptop and desktop computers. Information access will be directed to digital objects of all kinds and services that help to create them or make use of them [xxii].

Very high-speed networking has also been developing at a steady pace. From the original 50,000 bit-per-second ARPANET, to the 155 million bit-per-second NSFNET, to today's 2.4 – 9.6 billion bit-per-second commercial networks, we routinely see commercial offerings providing Internet access at increasing speeds. Experimentation with optical technology using wavelength division multiplexing is underway in many quarters; and testbeds operating at speeds of terabits per second (that is trillions of bits-per-second) are being constructed.

Some of these ultra-high speed systems may one-day carry data from very far away places, like Mars. Already, design of the interplanetary Internet as a logical extension of the current Internet, is part of the NASA Mars mission program now underway at the Jet Propulsion Laboratory in Pasadena, California [xxiii]. By 2008, we should have a well functioning Earth-Mars network that serves as a nascent backbone of the interplanetary Internet.

Wireless communication has exploded in recent years with the rapid growth of cellular telephony. Increasingly, however, Internet access is becoming available over these networks. Alternate forms for wireless communication, including both ground radio and satellite are in development and use now, and the prospects for increasing data rates look promising. Recent developments in high data rate systems appear likely to offer ubiquitous wireless data services in the 1-2 Mbps

range. It is even possible that wireless Internet access may one day be the primary way most people get access to the Internet.

A developing trend that seems likely to continue in the future is an information centric view of the Internet that can live in parallel with the current communications centric view. Many of the concerns about intellectual property protection are difficult to deal with, not because of fundamental limits in the law, but rather by technological and perhaps management limitations in knowing how best to deal with these issues. A digital object infrastructure that makes information objects "first-class citizens" in the packetized "primordial soup" of the Internet is one step in that direction. In this scheme, the digital object is the conceptual elemental unit in the information view; it is interpretable (in principle) by all participating information systems. The digital object is thus an abstraction that may be implemented in various ways by different systems. It is a critical building block for interoperable and heterogeneous information systems. Each digital object has a unique and, if desired, persistent identifier that will allow it to be managed over time. This approach is highly relevant to the development of third-party value added information services in the Internet environment.

Of special concern to the authors is the need to understand and manage the downside potential for network disruptions, as well as cybercrime and terrorism. The ability to deal with problems in this diverse arena is at the forefront of maintaining a viable global information infrastructure. "IOPS.org" [\[xxiv\]](#) – a private-sector group dedicated to improving coordination among ISPs - deals with issues of ISP outages, disruptions, other trouble conditions, as well as related matters, by discussion, interaction and coordination between and among the principal players. Business, the academic community and government all need as much assurance as possible that they can conduct their activities on the Internet with high confidence that security and reliability will be present. The participation of many organizations around the world, including especially governments and the relevant service providers will be essential here.

The success of the Internet in society as a whole will depend less on technology than on the larger economic and social concerns that are at the heart of every major advance. The Internet is no exception, except that its potential and reach are perhaps as broad as any that have come before.

[top](#)

[i] Leonard Kleinrock's dissertation thesis at MIT was written during 1961: "Information Flow in Large Communication Nets", RLE Quarterly Progress Report, July 1961 and published as a book "Communication Nets: Stochastic Message Flow and Delay", New York: McGraw Hill, 1964. This was one of the earliest mathematical analyses of what we now call packet switching networks.

[ii] J.C.R. Licklider & W. Clark, "On-Line Man Computer Communication", August 1962. Licklider made tongue-in-cheek references to an "inter-galactic network" but in truth, his vision of what might be possible was prophetic.

[iii] [BARAN 64] Baran, P., et al, "On Distributed Communications", Volumes I-XI, RAND Corporation Research Documents, August 1964. Paul Baran explored the use of digital "message block" switching to support highly resilient, survivable voice communications for military command and control. This work was undertaken at RAND Corporation for the US Air Force beginning in 1962.