Digital Village

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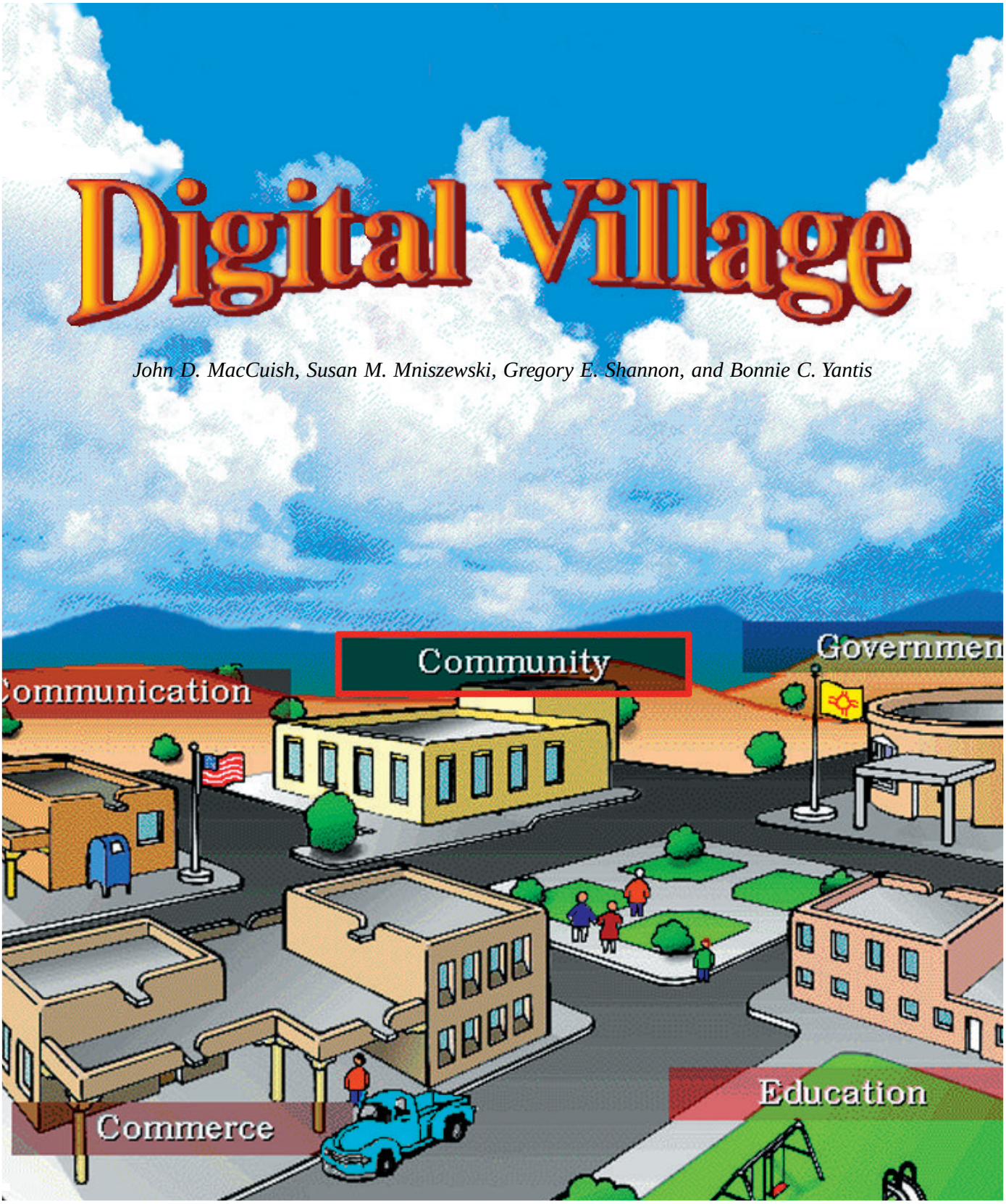


The Digital Village Initiative is a telecommunity-outreach project of the Laboratory's Computer Research and Applications Group. A telecommunity is a society that exists and functions through electronic communication. There are two types of telecommunities. The first is quite independent of geography—global, independent telecommunities exist for everything from auto repair to environmental activism to molecular biology.

The graphic at left and those scattered throughout this article are reproduced from a user-interface prototype for telecommunities that was developed at the Laboratory.

The second has its roots in a specific geographical location and is predicated on the notion that people who live in a particular town, or county, or region naturally share many interests. Established communities already have organized social and political structures, such as local government, civic groups, and business alliances, but the introduction of an electronic-telecommunity structure can facilitate and broaden many aspects of their interactions.

Several technological, economic, and social factors were influential in bringing about the emergence of telecommunities. Over the last thirty years computer hardware has become increasingly more powerful and less expensive, and the personal computer is now ubiquitous. Technologies and standards for connecting computer networks have become more efficient and robust. The Internet, the computer network used by most telecommunities, has its roots in the U.S. military's desire for an electronic-communication infrastructure that would survive a nuclear attack—the system as a whole had to remain operational even if portions of it were destroyed. In 1968, the Advanced Research Projects Agency (ARPA) initiated a prototype system, ARPAnet, with that design requirement in mind.

ARPAnet evolved as a research and development tool used by military and academic research centers around the country. In the mid-1980s the National Science Foundation (NSF) assumed much of the responsibility for administration of ARPAnet. The NSF then started its own network, NSFnet, for academic and commercial concerns, and also linked together other networks to form the NSFnet "backbone." The result was a matrix of powerful computers with high-speed connections linking the various networks together. The NSF eliminated many of the restrictions set forth by ARPAnet's appropriate-use policy, and the NSF network, or the Internet as we know it today, became an international research- and education-oriented network of over a thousand government, academic and commercial entities.

Once the strict usage policies were lifted, distinct cultures began appearing on the Internet to address a vast array of interactive human-communication needs (see Figure 1). Electronic mail—now almost as essential as the telephone for electronic communication—is the spontaneous outgrowth of technology originally developed for transmitting

scientific data. People routinely use e-mail for all types of communication from coordinating community calendars to writing their congressional representatives.

The Digital Village Initiative was launched to design and test infrastructure technologies for both local and national telecommunities. The outreach initiative operates through collaborations between Laboratory personnel and members of proposed or emerging telecommunities. That approach ensures that the technical choices associated with telecommunity development meet the specific needs of each community within the context of its culture. The collaborative work was motivated by contact with a number of emerging New Mexico telecommunities including those of San Ildefonso Pueblo, Taos, Santa Fe, Las Vegas, Farmington, and Los Alamos. In addition, the project is a response to the current administration's initiatives to develop and implement the technology for the National Information Infrastructure (NII), and it complements the strategic shift of both the Department of Energy (DOE) and the Laboratory toward greater emphasis on the nation's economic security.

Rapid advances in hardware and software present emerging telecommunities with options that are often beyond their resources to evaluate or implement. The Laboratory's strong capabilities as a premier computing, information, and communications research center are a valuable resource for evaluating available technology and recommending equipment and systems to meet the needs of a variety of telecommunities. Our abilities to test equipment in various configurations, to model customer applications, to evaluate human-computer interactions, and to analyze the performance of prototype systems will be a significant force in determining the overall scope and character of the NII.

Among the many applications being explored and modeled as part of the Digital Village Initiative are:

* telemedicine, through which doctors can consult with one another more effectively by sending

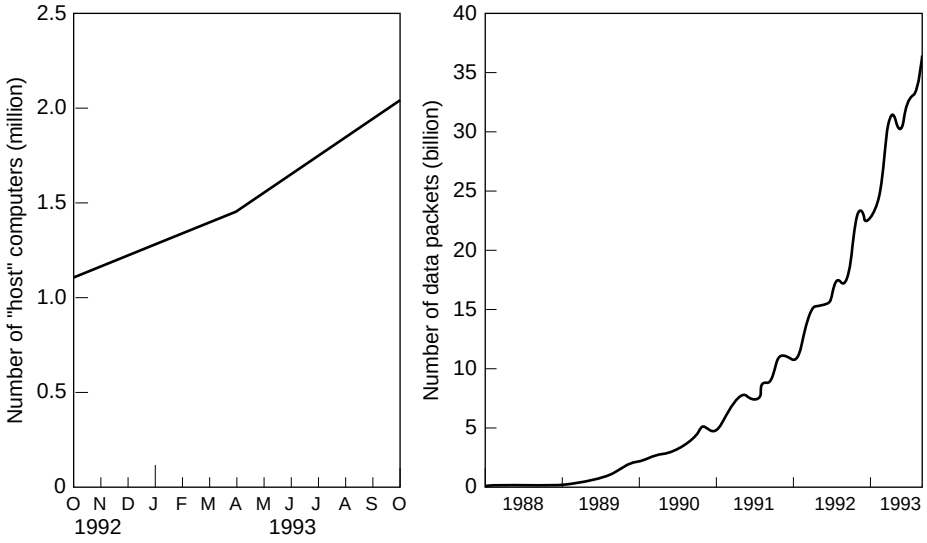


Figure 1. Growth of the Internet

The graph on the left shows, for a twelve-month period beginning October 1992, the number of computers (in millions) acting as "gateways" to the Internet, a system of networks once shared by only a few thousand users. The graph on the right shows the dramatic increase in network traffic over the last five calendar years. Plotted in the graph are the number of data packets (each equivalent to 200 typewritten characters) transmitted each month over the backbone of the Internet.

medical records or x-ray images, for example, over the Internet;

* electronic commerce through which almost any type of business can be conducted over a network such as CommerceNet;

* digital libraries, which will make local, national, and international libraries available to all members of the telecommunity;

* telecommuting, through which more and more people will be able to work from their homes;

* electronic classrooms, which will free students and teachers from the constraints of time and location;

* and electronic government services, which will provide information and facilitate many different types of transactions on a local, state, and federal level.

The collaborative nature of the Digital Village Initiative is in harmony with the underlying philosophy that telecommunities should be created and maintained by the people who "live" in them. The members of the telecommunities must decide themselves how they will provide access, whether they will guarantee universal access, how they will define appropriate use and content, and how they will fund their "mile on the information highway."

Technical Issues

The Digital Village Initiative employs a wide spectrum of dual-use technologies originally developed through the Laboratory's defense and nonproliferation efforts—specifically, research in the areas of computer security and privacy, high-performance computing, human-computer interaction, information mining, and network navigation. Our collaborations with emerging telecommunities are yielding many opportunities to assess interactions among technologies, applications, and policies as well as occasions to evaluate Laboratory research within new contexts. Technology transfer of software and hardware, for example, is central to the Initiative. A good prospect for transfer is software being developed by the DOE Digital superLab. The goal of the superLab project is to facilitate collaboration among three National Defense Laboratories (Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories) through the use of advanced computational and information-management technology. Much of the software being developed for superLab is object-oriented; that is, it makes use of a set of modules, or building blocks, that can be assembled in various configurations appropriate for specific applications. Thus it can be reconfigured to meet the specific needs of a particular telecommunity.

Security and privacy. Security and privacy issues are fundamental to the successful implementation of telecommunities. Security is critical for electronic commerce and digital cash exchanges. Furthermore, if medical records or other sensitive information will be accessible, privacy must be guaranteed. For example, a financial or medical system must guarantee that its infrastructure and content will not be damaged, that no information is divulged during transmission, and that the integrity of the information can be verified. Wireless telecommunication technologies amplify security and privacy concerns because such transmissions are accessible to virtually anyone who cares to "listen."

The Laboratory has a long history of contributions to computer-security technology. Our ability to evaluate and implement state-of-the-art encryption codes and intrusion-detection methods is being applied to the problem of safeguarding information transmitted across the network. We are currently working with the Internal Revenue Service and the Social Security Administration to explore a variety of access-control and user-identification techniques. In addi-

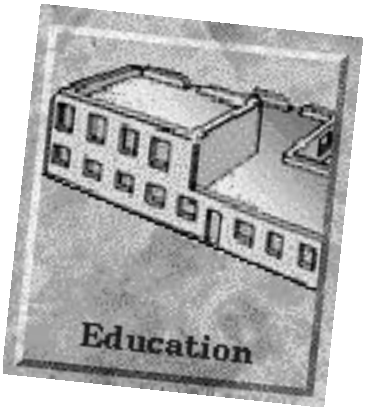
tion, we are working with the Financial Services Technical Consortium (FSTC) to examine the security issues related to electronic commerce. FSTC is a coalition of large banks, the Department of the Treasury, the Department of Commerce, and the DOE national laboratories. The coalition's mission is to facilitate nation-wide electronic commerce.

High-performance computing. High-performance computing is fundamental to the NII and its support of telecommunities. The sheer volume and complexity of data that will be made available over the Internet necessitates high-bandwidth communications and high-performance-computing resources. Consider the staggering quantity of related but quite heterogeneous information that would be necessary to provide a U.S. geographic-information database, the current conditions for all modes of transportation around the country, and the current tariffs for all common carriers. Manufacturers, shippers, and service agencies would benefit tremendously from quick, easy access to information through which they

could determine the best mode of transport for their purposes. Such a system would require high-performance-computing resources including high-speed processing and a great deal of memory. Our expertise in the parallel utilization, scheduling, and allocation of distributed computing resources will help make services of that kind a reality.

Human-computer interfaces. Creating effective human-computer interfaces for the NII or for any particular telecommunity will be challenging because of the diversity within and among communities. To make telecommunities accessible to the greatest possible number of people, we are implementing an icon-based user interface with multimedia capabilities. That interface is also being developed in conjunction with the superLab Project. The use of simple pictures or symbols will accommodate people who are unfamiliar or uncomfortable with computers. Other aspects of the interface might accommodate users who have various disabilities or who do not read or write English. For instance the interface might include audio capabilities or Braille labeling to assist sight-impaired users. Interfaces that respond to voice commands and furnish audio feedback could address a variety of user-interface issues. To build audio-driven systems, however, we must deal with the technical challenge of incorporating voice input/output into existing applications. As we plan prototype computer interfaces, we can take advantage of modern design tools that allow us to iteratively present scenarios to potential users and incorporate their evolving requirements into the design.

Information mining and network navigation. The quantity of electronic information currently available through the Internet is overwhelming. Moreover, the information exists in a wide variety of formats, including video, sound, and text. It is not uniformly accessed, organized, or stored nor is all



the information about a specific topic located in one place. The entire nation faces the challenge of developing an infrastructure that will allow efficient access to and use of information. The Laboratory is a leader in the management, visualization, and analysis of extremely large and complex datasets. The Laboratory's IBROWSE project allows doctors to view CT lung-scan images and search large databases for similar lung-scan images. Other supporting technologies include an innovative data-compression algorithm based on a mathematical technique called wavelet transforms. The Federal Bureau of Investigation has adopted this technique as a national standard for compressing digitized fingerprint records.

Several Laboratory research projects involve the development of tools that will allow a user to put a query out on the Internet and receive replies from a variety of sources. The results of the query, "Tell me about the University of New Mexico," for example, might yield a video "tour" of the campus, a sound-clip from a radio interview with the president of the University, an undergraduate catalog, a tuition spreadsheet, and an accreditation report—and each might come from a different computer system. Efficient information-mining techniques require that all of the articles, newsgroups, databases, and so forth that are accessible through the

network have some form of quantitative descriptor, perhaps obtained by an analysis of patterns of characters (see "Concept Extraction—A Data-Mining Technique"). Statistical clustering techniques could then be used to sort through the entire available dataset and obtain only the desired information.

Network navigation tools, which will help users "move" through the Internet, are being developed as part of the Laboratory's Sunrise Project. One such navigation tool presents a visual representation of the "path" a user is taking through the Internet and also initiates Internet searches by communicating with WorldWideWeb servers and Mosaic (an Internet information-browser interface). That tool allows users to search and navigate the Internet more easily and to document the paths of their searches for future reference.

Kiosks and universal access. The concept of installing kiosks to provide information and services was first realized in the early 1980s with the advent of the automated teller machine, or ATM. More recently a variety of government agencies have become interested in installing kiosks as a means of cutting costs while making services more readily available. In support of Vice President Gore's National Performance Review, the Laboratory is collaborating with a wide variety of federal agencies to develop systems that provide access to government information. Local telecommunities might choose to collaborate with these agencies and incorporate government services into a network of kiosks in locations suited to the needs of the community. A kiosk-based telecommunity is the most feasible means of guaranteeing universal access to the information superhighway at a modest cost. Of course, any personal computer will be an "information portal" to the National Information Infrastructure. However, if local telecommunities install kiosks in public places, the kiosks will serve as information portals for those who do not have access to personal computers.

Telecommunity Applications

A wide range of applications are already in use in a limited form and are only awaiting advances in technology before their full potential can be realized. For example, we are currently working with the Indian Health Service (IHS) to establish a wireless "healthnet" among Native American communities in New Mexico. The network will connect mobile units with regional clinics and the medical center at the University of New Mexico. To bring additional medical expertise to this isolated, rural health network, we are also teaming with National Jewish Hospital in Denver. National Jewish is the recognized leader in pulmonary-disease research. Drug-resistant tuberculosis occurs frequently in reservation populations, and we believe that the collaboration between the IHS and National Jewish Hospital will have immediate positive effects. The IHS healthnet can serve as a prototype for a national healthnet.

Undoubtedly, local telecommunities will provide some form of access to public-sector services and private-sector commerce. Students living in rural communities will have the opportunity to take courses and "attend" lectures at universities around the country. "Electronic visits" to the local Department of Motor Vehicles to renew registrations or transfer titles will reduce administrative costs—and there will be no need to stand in line! Telecommunities are a natural conduit to a dynamic and competitive global marketplace where commerce flows freely among local, national, and international communities. "Electronic showrooms" connected to the Internet will be perpetually open to world markets. With a greatly expanded customer base but no need for the traditional showroom expenses, small businesses will have more opportunities for growth.

The development of individual, local telecommunities as a series of pilot projects offers an innovative approach to designing the nation's Information Superhighway. Communities can determine their own needs, make their own choices, and ultimately serve as a market force that will shape development at the national level. New Mexico in particular provides a rich testing-ground for the development of telecommunities. Here in New Mexico there are both rural and urban areas, there are networks of small communities separated by considerable distances, and there are several distinct cultures throughout the state.

The Clinton administration's goal for the NII is that all people have access to the Information Superhighway. As the technology advances, there is growing concern that the design and structure of the coming web of communication technologies will be driven primarily by commercial interests and thus exclude large sectors of the population through

economic and educational barriers. The 1993 National Telecommunications and Information Administration (NTIA) report concludes that:

> An advanced information infrastructure will enable U.S. firms to compete and win in the global economy, generating good jobs for the American people and economic growth for the nation. As importantly, the NII can transform the lives of the American people—ameliorating the constraints of geography, disability, and economic status—giving all Americans a fair opportunity to go as far as their talents and ambitions will take them.

For such a vision to be realized, we must strike a balance between commercial interests and the government's goal of universal public access. Through the Digital Village Initiative the Laboratory is helping the nation realize this vision by facilitating the development of local telecommunities in which broad-based community agendas can flourish. ■

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Further Reading

Brendon P. Kehoe. 1994. *Zen and the Art of the Internet: A Beginners Guide.* Prentice Hall.

Ed Krol. 1994. *The Whole Internet: User's Guide & Catalog.* O'Reilly & Associates, Inc.

Hans Klein and Coralee Whitcomb. 1994. Developing an equitable and open information infrastructure. In *Proceedings of A Directions and Implications of Advanced Computing Symposium.* Computer Professionals for Social Responsibility.

Office of President Bill Clinton. 1993. *Technology for Economic Growth: President's Progress Report.* U.S. Government Printing Office.

U.S. Department of Housing and Urban Development, Office of Community Planning and Development. *Building Communities: Together. Guidebook for Community-Based Strategic Planning for Empowerment Zones and Enterprise Communities.* U.S. Government Printing Office. HUD-1442-CPD.

U.S. Department of Agriculture, Office of Small Community and Rural Development. 1994. *Building Communities: Together. Empowerment Zones and Enterprise Communities Application Guide.* U.S. Government Printing Office. HUD-1445-CPD.

Office of Science and Technology Policy. 1994. *High Performance Computing and Communications: Toward a National Information Infrastructure.* U.S. Government Printing Office.

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