Introduction

Between the 1960s and the 1980s, computing technology underwent a dramatic transformation: the computer, originally conceived as an isolated calculating device, was reborn as a means of communication. Today we take it for granted that information can travel long distances instantaneously. For many Americans, and for an increasing portion of the world’s population, it has become easy and commonplace to send electronic mail or to access online multimedia information. The transcendence of geographic distance has come to seem an inherent part of computer technology. But in the early 1960s, when computers were scarce, expensive, and cumbersome, using a computer for communication was almost unthinkable. Even the sharing of software or data among users of different computers could be a formidable challenge. Before the advent of computer networks, a person who wanted to transfer information between computers usually had to carry some physical storage medium, such as a reel of magnetic tape or a stack of punch cards, from one machine to the other. Modems had been introduced in the late 1950s, but setting up a telephone connection between two machines could be an expensive and error-prone undertaking, and incompatibilities between computers compounded the difficulty of establishing such communications. A scientist who needed to use a distant computer might find it easier to get on a plane and fly to the machine’s location to use it in person.

The worldwide system called the Internet played a major role in developing and popularizing network technology, which placed computers at the center of a new communications medium. Between the late 1960s and the 1990s, the Internet grew from a single experimental network serving a dozen sites in the United States to a globe-spanning system linking millions of computers. It brought innovative data communications techniques into the mainstream of networking practice, and it enabled a large number of Americans to experience the possibilities of cyberspace for the first time. By making long-distance interaction among different types of computers a common-place reality, the Internet helped redefine the practice and the meaning of computing.

Like all technologies, the Internet is a product of its social environment. The Internet and its predecessor, the ARPANET, were created by the US Department of Defense’s Advanced Research Projects Agency (ARPA), a small agency that has been deeply involved in the development of computer science in the United States. My curiosity about the Internet grew out of my experiences as a computer programmer in the mid 1980s, when few people outside the field of computer science had heard of this network. I was aware that the Internet had been built and funded by the Department of Defense, yet here I was using the system to chat with my friends and to swap recipes with strangers—rather like taking a tank for a joyride! This apparent contradiction goes to the heart of the Internet’s history, for the system evolved through an unusual (and sometimes uneasy) alliance between military and civilian interests.

The history of the Internet holds a number of surprises and confounds some common assumptions. The Internet is not a recent phenomenon; it represents decades of development. The US military played a greater part in creating the system than many people realize, defining and promoting the Internet technology to serve its interests. Network projects and experts outside the United States also made significant contributions to the system that are rarely recognized. Above all, the very notion of what the Internet is—its structure, its uses, and its value—has changed radically over the course of its existence. The network was not originally to be a medium for interpersonal communication; it was intended to allow scientists to overcome the difficulties of running programs on remote computers. The current commercially run, communication-oriented Internet emerged only after a long process of technical, organizational, and political restructuring.

The cast of characters involved in creating the Internet goes far beyond a few well-known individuals, such as Vinton Cerf and Robert Kahn, who have been justly celebrated for designing the Internet
architecture. A number of ARPA managers contributed to the Internet's development, and military agencies other than ARPA were active in running the network at times. The manager of the ARPANET project, Lawrence Roberts, assembled a large team of computer scientists that included both accomplished veterans and eager graduate students, and he drew on the ideas of network experimenters in the United States and in the United Kingdom. Cerf and Kahn also enlisted the help of computer experts from England, France, and the United States when they decided to expand the ARPANET into a system of interconnected networks that would become known as the Internet. As the popularity of networking spread, a new set of interest groups - telecommunications carriers, vendors of network products, international standards bodies - exerted influence on the evolution of the Internet. The National Science Foundation took over responsibility for the Internet in the 1980s, when ARPA willingly gave it up, only to turn the network over to private businesses in the 1990s. And far from the American centers of networking, at the CERN physics laboratory in Geneva, Tim Berners-Lee took advantage of the Internet's unique capabilities to invent an application that he called the World Wide Web. These individuals and organizations had their own agendas, resources, and visions for the future of the Internet. The history of the Internet is not, therefore, a story of a few heroic inventors; it is a tale of collaboration and conflict among a remarkable variety of players.

In this book I trace the history of the Internet from the development of networking ideas and techniques in the early 1960s to the introduction of the World Wide Web in the 1990s. I have chosen to focus on a set of topics that illuminate what I believe to be the most important social and cultural factors shaping the Internet. In chapter 1, I present the development of packet switching, the main technique used in the Internet, as a case study of how technologies are socially constructed. In chapter 2, I describe the creation of the ARPANET and discuss the significance of ARPA's unique system-building strategies. In its initial form the ARPANET was little more than an experimental collection of hardware and software; in chapter 3, I recount the struggles of the ARPANET's early users to find some practical applications for this infrastructure and their eventual success with electronic mail. In chapter 4, I describe the unusual convergence of defense and research interests that resulted in the creation of the Internet and the overlooked role of the military in the transition from ARPANET to Internet technology. In chapter 5, I place the Internet in the context of contemporary networking efforts around the world, examining the ways in which technical standards can be used as social and political instruments. In chapter 6, I survey the complex events and interactions that transformed the Internet into a commercially based popular medium in the 1990s and the accompanying fragmentation of control among diverse communities of producers and users. I conclude that the emergence of new applications such as the World Wide Web continues the trend of informal, decentralized, user-driven development that characterized the Internet's earlier history.

In telling the story of the Internet, I also try to fill a gap in historical writing about computers. Much of the literature on the history of computing has focused on changes in hardware, on the achievements of individual inventors, or on the strategies of commercial firms or other institutions. Relatively few authors have looked at the social shaping of computer communications. There have been many social and cultural studies of computing in recent years, including compelling analyses of networking by Sherry Turkle (1995), Gene Rochlin (1997), and Philip Agre (1998a,b), but these works tend not to examine in detail the origins of computer technologies, focusing instead on how they are used once they exist. In this book I hope to cross this divide that exists between narratives of production and narratives of use. I demonstrate that the kinds of social dynamics that we associate with the use of networks also came into play during their creation, and that users are not necessarily just "consumers" of a technology but can take an active part in defining its features. Indeed, the culture of the Internet challenges the whole distinction between producers and users. I also try to provide some historical grounding for cultural studies of the Internet by documenting the events and decisions that created the conditions of possibility for the Internet's current status as a popular communication medium and the associated social experiments in cyberspace.

Is there something unique about the Internet's seemingly chaotic development? What, if anything, can the history of the Internet tell us about the nature of technology? Perhaps the fluid, decentralized structure of the Internet should be viewed as typical of late-twentieth-century technological systems, as it exemplifies both the increased complexity of many "high-tech" fields and new forms of
organization that favor flexibility and collaboration among diverse interest groups. In computing, especially, systems and organizations have had to adapt to survive the relentless pace of technological change. The Internet also shares the protean character of communications media: since “information” (that infinitely malleable entity) is at the heart of the technology, media are particularly susceptible to being adapted for new purposes. Communications media often seem to dematerialize technology, presenting themselves to the user as systems that transmit ideas rather than electrons. The turbulent history of the Internet may be a reminder of the very real material considerations that lie behind this technology and of their economic and political consequences.

As I have already suggested, one of my aims in this book is to show how military concerns and goals were built into the Internet technology. My account of the origins of the network demonstrates that the design of both the ARPANET and the Internet favored military values, such as survivability, flexibility, and high performance, over commercial goals, such as low cost, simplicity, or consumer appeal. These values have, in turn, affected how the network has been managed and used. The Department of Defense's ability to command ample economic and technical resources for computing research during the Cold War was also a crucial factor in launching the Internet. At the same time, the group that designed and built ARPA's networks was dominated by academic scientists, who incorporated their own values of collegiality, decentralization of authority, and open exchange of information into the system. To highlight these social and cultural influences on its design, I compare the Internet with networking projects from other contexts and other countries, showing how the ARPA approach differed from alternative networking philosophies. The wider history of networking also reveals the reciprocal influences between the Internet and other projects in the United States and abroad.

I also emphasize the importance of network users in shaping the technology. In the early days of the ARPANET, the distinction between producers and users did not even exist, since ARPA's computer experts were building the system for their own use. Their dual role as users and producers led the ARPANET's builders to adopt a new paradigm for managing the evolution of the system: rather than centralize design authority in a small group of network managers, they deliberately created a system that allowed any user with the requisite skill and interest to propose a new feature. As access to the ARPANET and the Internet spread beyond the initial group of computer scientists, non-expert users also exerted influence, improvising new ways of using the network and deciding which applications would become standard features of the system and which would fade away. I argue that much of the Internet's success can be attributed to its users' ability to shape the network to meet their own objectives. Electronic mail and the World Wide Web are prominent examples of informally created applications that became popular, not as the result of some central agency's marketing plan, but through the spontaneous decisions of thousands of independent users.

In reconstructing the history of the Internet, I have been struck time and again by the unexpected twists and turns its development has taken. Often a well-laid plan was abandoned after a short time and replaced by a new approach from an unexpected quarter. Rapid advances, such as the introduction of personal computers and the invention of local-area networks, continually threatened to make existing network technologies obsolete. In addition, responsibility for operating the Internet changed hands several times over the course of its first thirty years or so. How, in the face of all this change and uncertainty, did the system survive and even flourish? I believe that the key to the Internet's success was a commitment to flexibility and diversity, both in technical design and in organizational culture. No one could predict the specific changes that would revolutionize the computing and communications industries at the end of the twentieth century. A network architecture designed to accommodate a variety of computing technologies, combined with an informal and inclusive management style, gave the Internet system the ability to adapt to an unpredictable environment.

The Internet's identity as a communication medium was not inherent in the technology; it was constructed through a series of social choices. The ingenuity of the system's builders and the practices of its users have proved just as crucial as computers and telephone circuits in defining the structure and purpose of the Internet. That is what the title of this book, Inventing the Internet, is meant to evoke: not an isolated act of invention, but rather the idea that the meaning of the Internet had to be
invented -and constantly reinvented- at the same time as the technology itself. I hope that this perspective will prove useful to those of us, experts and users alike, who are even now engaged in reinventing the Internet.

Notes

1. I use “managers” as a generic term for directors and program managers. All these individuals were directly involved in research management.

2. The first scholarly work to treat the history of the Internet, Arthur Norberg and Judy O’Neill’s *Transforming Computer Technology* (1996), is a strong example of the institutional approach. In it, Norberg and O’Neill (see also their 1992 work) drew on specially arranged access to the ARPA archives and on an extensive oral-history project to present a detailed analysis of ARPA’s forays into network research and development. That book is not, however, intended as a full-scale history of the Internet; its focus is on ARPA’s role in managing research in computer science. Only one of four case studies is devoted to networks, and it does not follow networking developments beyond ARPA’s involvement. In the years since the Internet became a media sensation, a number of more popular books have appeared that deal in some way with its origins, often in a heroic manner. Hafner and Lyon’s journalistic history *Where Wizard Stay Up Late* (1996) focuses mainly on the ARPANET. For more technically detailed accounts, see Salus 1995 and Quarterman 1990.

3. A notable recent exception is Paul Edwards; see his 1996 book *The Closed World*. 