

NERDS^{2.0.1}

**A BRIEF HISTORY
OF THE INTERNET**

Stephen Segaller

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Introduction

Very, Very Long Legs

JEFF BEZOS, FOUNDER OF AMAZON.COM, the online bookstore, says this about the contrast between his solid products and the intangible medium in which the transactions are processed: “I think there’s a sort of a fundamental irony that we’re using bits to sell atoms. And, yeah, it’s a little wacky. But it works and it’s extremely efficient and people recognize the value.”

It is a statement that neatly captures both the tone and the attitude of the most dynamic and rapidly growing industry in history. The language is a mixture of the technical, the juvenile, and the profit-motivated. But it is this geeky pragmatism that has transformed a technology once reserved for computer scientists in research laboratories into a global medium of instantaneous communications—and commerce. If the invention and propagation of the personal computer in all its forms was the Triumph of the Nerds, then the evolution of the wired world is truly the Glory of the Geeks. How it got to be that way is the subject of this book.

Of course, there’s also “sort of a fundamental irony” in writing a book at all on this subject. But as long as computers take many seconds to boot up and minutes to print more than a couple of pages, the book has a user-friendliness that’s unbeatable.

Just ask Jeff Bezos: he sold \$87 million worth of these cumbersome old devices last year, without the trouble or overhead of either a bookstore or a printed catalog. Amazon’s 1997 results—a net loss of just over \$9 million, \$6 million *worse* than the previous year—was greeted on Wall Street as a triumph, and the stock shot up. The company is valued at about \$1.6 billion at the time of writing. Not for its earnings, but for its rate of growth and potential reach. In 1996, Amazon had sales of less than \$16 million. The following year, sales rose by almost ten times, to \$148 million. In the final quarter of its fiscal year, Amazon’s customer ac-

counts grew 50 percent, to \$2.26 million. But in the Internet economy, 15 percent growth a month is barely worthy of comment.

According to the U.S. Commerce Department report of April 1998, *The Emerging Digital Economy*, “The Internet’s pace of adoption eclipses all other technologies that preceded it. Radio was in existence thirty-eight years before fifty million people tuned in; TV took thirteen years to reach that benchmark. Sixteen years after the first PC kit came out, fifty million people were using one. Once it was opened to the general public, the Internet crossed that line in four years.”

The speed with which the Internet industry is evolving, and the Internet marketplace is growing, guarantees that this book, like any reference text, will become dated. However, it is the only work so far to attempt a general history of the wired and networked world, and the Internet’s thirty years of development represent a solid and intriguing preamble to its current, ever-accelerating growth. As John Doerr, leading Silicon Valley venture capitalist, observes, “Think of this as just a few milliseconds after the Big Bang. We only barely discern the fundamental laws of physics, the business models that are going to work. And it’s got very, very long legs because, unlike the PC, it leverages the top line. It helps us entertain and inform and educate and inspire and sell and make community, even make meaning out of life and out of death. And that’s a far more powerful dynamic than cranking out memos and doing financial analyses with a spreadsheet.”

The Department of Commerce, not prone to hyperbole, lines up the statistics of Internet growth thus:

- Fewer than 40 million people worldwide were connected to the Internet in 1996. A year later, the figure had more than doubled, to 100 million people.
- In the same year, domain names registered rose from 627,000 to 1.5 million.
- Cisco Systems (the leading manufacturer of routers, a key element of the Internet’s own infrastructure) made \$100 million worth of sales on the Internet in 1996. In 1997, its Internet sales totalled \$3.2 billion.
- In 1998, it takes only 100 days for the Internet’s volume of traffic to double.

As a consequence, this book, like the television series it ac-

companies, makes no effort to predict the likely outcome of events unfolding today. All it can attempt is a reasonable stab at recounting the events of the recent past and an explanation of why they unfolded as they did.

In fact, another “sort of a fundamental irony” can be found in the fact that this volume may be in danger of adding to a growing, but not very appealing category of books that extol in linear, analog, page-by-page fashion the elusive appeal and importance of the non-linear, digital, interactive communication phenomenon. A welter of these volumes—slim books, making broad claims—have been appearing since the rise of the World Wide Web in 1994; collectively they represent a compelling argument for the utility of history over futurology.

Those who cover this industry on an hourly, daily, or weekly basis long ago exhausted the supply of metaphors and superlatives with which to describe a working environment of twenty-hour days, intense rivalries, and immense rewards. The rate of growth is breathtaking in the short term, unsustainable in the long term. In the 1950s, it was calculated that if long-distance phone traffic continued to increase at the same rate for twenty years, every American citizen would have to be employed as a telephone operator. (What happened to them, by the way?) But between the short term and the long term, there is a lot of market capitalization to be generated. And an immense churning of talent and stress. Rohit Khare, a twenty-two-year-old wunderkind of the World Wide Web Consortium, claims that in the Web universe, “a person with two years’ experience has gotten more experience in Web years than someone who’s got twenty years of the previous generation of programming. That’s a bit of an overstatement, but Web years are a wonderful curiosity to the general public and an actual health threat to those who work in the industry.”

Other than for children in science class, or those wanting to get jobs in software development, learning *how* the Internet works may not be of any real value. For users of the Internet, its *use* is the point, not its mechanics. There will be a minority of people who really do care about the encoding of words into digits; the capsulizing of batches of digits into packets; the labeling of packets; their distribution by electrical impulse along copper wires, coaxial cables, fiber-optic cables, or radio waves; the redirection

of packets to their final destination; their reassembly into ordered streams of digits by IMPS (the original network switches) and nodes, and later by hubs and servers; and the retranslation of digits into words appearing as pixels on a screen. Some people will care about that, and they may come away from reading this book feeling undernourished. Others, like the author, may prefer just to accept (uneasily) that it simply does work—like the internal combustion engine, or photosynthesis, or a flea circus.

I am not a technologist or scientist, but a journalist. I once produced (with the aid of my psychologist wife) a television series on the life and work of C.G. Jung. After seeing these films, a prominent Jungian analyst concluded that filmmaking was like anthropology. The task, he said, was to enter a more or less closed community, in which people spoke their own language, observed their own customs and rituals, enjoyed and perpetuated arcane feuds, shared a set of far-from-universal beliefs and secrets, and claimed to have a special understanding of the human condition. Having gained their confidence, the filmmaker settled down to trying to capture their worldview; and then returned to the outside world to offer a report to the wider community. This kind of television documentary is indeed a little like anthropology; and the self-enclosed world of the nerds and geeks is no less baffling to the outsider, perhaps more so, than that of analytical psychology.

My job here, as in our television series *Triumph of the Nerds* and *Nerds 2.0.1*, is to tell a coherent and enlightening story of a cultural phenomenon that is truly changing many aspects of many people's lives. The technology is inseparably a part of the story, but the emphasis here is on the people who did it, the ideas they were pursuing, the ambitions they shared, and its meaning to them at the time and in retrospect. In the modern, Western, industrialized nations at least, the advent of the universal syntax of www. and dot-com appears to be startlingly rapid and deeply entrenched.

The story we now try to tell is how it got to be that way. In producing our television series *Nerds 2.0.1*, we have had the good fortune to be granted access to almost all of the pioneers, inventors, and prime movers who made the Internet and the wired world happen, from unsung researchers who are most comfortable in white laboratory coats, to tycoons and corporate executives whose faces routinely appear on covers of the world's

newsmagazines. Much of this story, therefore, will be told in the words of the people who did the work . . . and changed the world. Like Frank Heart, the manager of the original development team that first connected computers together into a network: “It feels wonderful. I think it’s incredibly exciting. It’s the kind of thing where now you go down the street to your neighbors, who never knew what a computer was in the days you were doing this, and they’re all of a sudden experts at using the Web, and I think that’s a lot of fun. So, it’s quite nice.”

Drawing on the interviews given by more than seventy people for our television series, this book will recount the history and evolution of networking from the time before it existed until approximately yesterday. The story lasts roughly forty years, and the book is divided into four parts, by decade.

It is inevitable, in presenting a historical review of events, that one identifies a starting point, milestones, and continuing trends as a way of organizing and rationalizing the material that is mostly accurate, partly arbitrary. This case is no exception.

The earliest beginnings remind us of a historical truth and a modern one: American technology has been driven by the urge to explore and open the frontier, and the perennial desire for personal communication that works ever more easily, across longer distances. Thus the first antecedent of modern networking can be identified as Samuel Morse, whose eponymous code consists of timed pulses of electricity. He chose to transmit over electrical wires, which can only transmit a pulse, or no pulse: on or off. That binary choice is the fundamental basis of all “digital computing.” The digits are 1 and 0, on and off. The difference is that today they travel billions of times faster.

On May 24, 1844, Morse sent his famous message “What hath God wrought?” to a receiver thirty-seven miles away in Baltimore. He assigned his patents to the Magnetic Telegraph Company, which signed up licensees. By 1851, there were fifty competing telegraph companies, and Western Union was formed by a merger of a dozen of these. By 1866, Western Union had over four thousand offices—opening a new office about every other day—and became the first communications giant in U.S. history. That pace of growth comes close to rivaling the uptake of the Net.

Looking back, on the eve of the new century and millennium,

it seems apparent that the revolution in computing derives most directly from the mid-century war, when technology was most fully engaged in the service of military efforts. World War II gave birth to radar, cryptographic machines, battlefield communications methods, and a pace of operations that combined to create a legacy in computer science. Problem-solving, communications, automation, and remote command-and-control processes all resulted from the impetus of wartime necessity. Among the first pioneers of the world of networking, Dr. Vannevar Bush left a legacy that can be clearly traced. Bush was the wartime director of the Office of Scientific Research and Development in the Roosevelt and Truman administrations, was closely involved in the Manhattan Project, and was appointed the first director of the National Science Foundation in 1950. His July 1945 article in the *Atlantic Magazine*, “As We May Think,” describing a “memex” device that today would be called a laptop or palmtop computer, inspired the first postwar generation of computer scientists (before they had that name) to experiment with ways of using computing power to augment human efficiency.

These trends might have remained truly a backwater of academic thought and laboratory experimentation had it not been for the Cold War, which provided the next great historical impetus. The Sputnik launch, on October 4, 1957, brought the importance of science to defense to everyone’s attention. While the space race was to become the most visible, even glamorous representation of the Cold War struggle, and technology in itself a weapon of Cold War rivalry, the seeds of computer networking—sown at the same time—can be argued to have had more lasting, profound, and widespread consequences. Both space exploration and networking programs got started around the turn of the decade, and both proceeded towards their ultimate success in 1969. Networking was a bold experiment in the 1960s.

The hyperbolic growth of the Internet suggests that a brief history is timely. With Net usage doubling every hundred days, the vast majority of users come to the Net in its Web-faced, graphical, media-savvy form. Many of them perhaps will be surprised to learn that the Net has been thirty years in the making, and that for the first fifteen years it was as obscure as any other Pentagon-funded backwater of research. The earliest pioneers are still

mostly at work in the field, or just old enough to retire by choice. In a way, the Net is both older and younger than it seems; its beginnings came before most present-day users were born, but its heyday, so far, has come in the nineties. One entity links both origins and apogee: the United States government, in both executive and legislative branches.

Reading source materials, and interviewing early participants, one senses a surreal contrast between the image of the Department of Defense (DoD) as a funding source for the earliest adventures in networking, and the ideology of many of the people (though not all) who thought networking important. Who would expect to see the DoD described in *Rolling Stone*, on December 7, 1972—of all times, a month after Richard Nixon's reelection—as “enlightened”? The ethos of the sixties and seventies, usually thought of as “hippie” but almost interchangeable with “hacker,” had a significant effect on the evolution of computer networking and its uses. Computer science was a cool new area to be working in, with so little history that one central figure claimed that most of computer science could be mastered in one year of close attention. Networking was funky in the 1970s.

The historical trends and milestones are categorized quite neatly by decade. Sputnik in the fifties spawned the beginnings of networking experiments; and the ARPAnet, the first fledgling academic and governmental computer network, was developed in the sixties. The ethos of the sixties helped promote and distribute more widely the gospel of networking. As Steve Jobs points out, “The sixties really happened in the seventies.” The late seventies and early eighties marked the next major milestone of network expansion, caused by the invention of the personal computer.

In some respects, the story of the Internet owes nothing to the personal computer, for network experiments predate any form of personal computer by at least a decade. Yet without the PC (a term whose coining is claimed by the networker par excellence Stewart Brand), networking might have remained stuck in the limited enclaves of computer-science departments, federally funded research projects, and a few large corporate ventures. But it was not so much the PC as a *personal* device that in the eighties multiplied the value and reach of networking; rather, it was the PC as a *business* machine, whose utility was multiplied when

the prospect of networking and connecting data became real. The IBM PC, launched in 1981; the Sun Microsystems workstation in 1982; the Apple Macintosh in 1984; and IBM clones led by Compaq in 1983 coincided with the deregulation of financial services in the United States and Europe. Increasingly powerful desktop computers, especially when networked to share and exchange information, were a key tool of the financial industry in the decade that later earned the smear slogan “Greed Is Good.” Networking became professional in the 1980s.

The personal computer generation had begun in about 1978, with the introduction of the first computer that was truly personal, affordable, and usable by almost anyone—the Apple II. So anyone born after 1970, into a family with the funds and imagination to equip the home with an Apple (or a Tandy, Commodore, Osborn, etc.) can be considered a member of the PC generation. In the late eighties and early nineties, these kids were in college, having lived with computers all their lives. And it was among this community, of people entirely at home with computers as tools and toys, that a cool new medium, accessible *only* by computer, began to take hold.

By the 1990s, computer science was no longer a field that could be learned in one year of close attention. It was established, and produced people who suddenly became immensely rich. Despite the best efforts of many self-confessed “nerds” to speak a language other people cannot understand, the results of computer science began to be widely understood. Two milestones of the nineties portray the half-accidental, half-predictable evolution of the Net. The first was the World Wide Web, created by the individual brilliance of one information technology consultant, an Englishman named Tim Berners-Lee, in a nuclear research laboratory in Europe. The second was the Mosaic browser, or Web browser, developed by university students from the PC generation in an out-of-the-way campus that just happened to house one of the vertebrae on the National Science Foundation’s powerful supercomputer network backbone. In both cases, these efforts betray the classic nerd trait of deep impatience at things that don’t work as well as they should, or (they imply) as their finely tuned brains would accommodate more easily.

In 1992, the Net was freed by the U.S. government of its non-

commercial restrictions and became a medium not just for information, but for commerce. (Although the Net is not strictly an American entity, so much of its technology has evolved in the United States that it has been de facto American from the start. All internationally based Web site addresses end with a two-digit country designation like *uk* or *fr*, while American-based sites have no such suffix.) Suddenly people with money (advertisers) and merchandise (everyone from Amazon to Z.Z. Top) wanted to promote a medium that was previously reserved for connoisseurs of a sort. The predictable result was a vast increase in awareness of the Net, together with an inevitable tidal wave of digital dross. But the commercial impulse, and its effective underwriting of the medium in all its expressions, has probably done more good than harm. General use is subsidized by the commerce, but no one is forced to participate in the commerce. One may still use the Net for its social, informational, and artistic content. In the 1990s, the Net became a mass, ubiquitous phenomenon.

So this is a story in which the government is the good guy. Networking began as a U.S. government experiment, and twenty-four years later networking was empowered (or prostituted) as a mass medium for commerce by an act of the United States Congress. At no time in the story have the supposedly restrictive instincts of government been allowed to limit networking, and its exponential growth has been facilitated by the hands-off attitude of the government officials who took charge or took an interest.

Despite the military/diplomatic origins of the Sputnik-provoked ARPAnet, the experimental mainframe network that provided the fundamental roots of all subsequent computer networking, its protocols were always in the public domain, its activities were unclassified, and its architects either by chance or design belonged to that school of thought that said computers can be used to assist people and improve their lives. Thirty years later, a variety of outcomes can be claimed for the Net, from the suggestion that the booming information-technology sector is responsible for a negative 1 percent trend in U.S. inflation, as the Department of Commerce states, to the less measurable, but widely believed argument that the Net was responsible for facilitating social and political liberation in places as diverse as Myanmar, Russia, and China. The narrative comes almost full circle: a

Pentagon program prompted by Cold War rivalry has evolved into a communications medium that helps overthrow, or at least publicize the activities of, tyrants. Today's tyrants are attempting to restrict or dominate computer networks, almost certainly in vain.

One of the most striking themes in the history of networking is the fact that each new breakthrough is, on closer examination, a repetition, a new way of solving much the same problem over and over again. The core problem of getting computers to communicate with each other is, by definition, one of compatibility. As the network grows bigger, incompatibilities must be overcome. As separate networks present the prospect of interconnection, compatibility hurdles arise. And as the pressure grows to connect all data resources together and make them universally accessible, the key technological obstacle is incompatibility. While the value and user-friendliness of networked computers is also driven by speed, memory, bandwidth (known to lay people as capacity or power), and interface design (how the screen looks to the user), none of these matters without a compatible platform of hardware and software.

Thus a number of episodes in this book tell a somewhat similar story: how the ARPAnet overcame the challenge of connecting computers made to different specifications by different manufacturers; how both the Stanford University Network and Cisco Systems linked disparate hardware in different departments or locations; and how the first Mosaic browser and the World Wide Web both provided software solutions to "translate" material from anywhere into a common language of words, images, and addresses.

Cumulatively, the wealth-generation of the Net thunders on. Our interviews with those who have started companies, raised venture funding, taken their ventures public, and ridden the information-technology wave on a rising tide of investor funding, driving the Dow Jones and NASDAQ exchanges upwards, all demonstrate the astonishing vigor and profitability of Internet-driven businesses. Carnegies, Mellons, and Rockefellers were surely never as accessible, frank, and direct about profits as the founders of Amazon, Excite, Sun, Cisco Systems, or 3Com. But the revolution of their products and technology is the wealth-creating engine of the world, at least into the beginning of the next century. What is so different about this revolution, however, is the low price of entry.

To industrialize a nation, a century ago, required a massive physical infrastructure, the import or extraction of huge amounts of raw materials, large amounts of capital to create and build industry, and decades of amortizing those costs before productivity and profitability repaid them. In the information economy, the cost of the infrastructure keeps dropping. Geographical, physical barriers that used to obstruct or raise the cost of imports are largely irrelevant. Citizens and governments alike can get online for very modest investments, and there's no catching-up required. Today's neophyte user starts with much the same access to the Net as someone who has been online since the ARPAnet first ticked into existence in 1969. The accumulated knowledge of how the Net used to work when it was *difficult* is of no further use now that it is *easy*. This has a curious effect on employment patterns and career paths in high technology. It may be no advantage, or could even be a disadvantage, to have twenty years of experience because that experience probably relates to an obsolete technology.

In the 1970s, when hippies weren't protesting about the Vietnam War they were worrying about multinational corporations and "cultural imperialism." The concern was that white Anglo-American culture and the English language were going to overrun the world to the detriment of ethnicity and minority identity elsewhere. The Internet has definitively delivered on that prognosis.

English *is* the language of the Internet, and predominantly of the computer and software industries. The accelerating spread of the Net is only going to deepen and strengthen this reality. It has interesting consequences, in that well-educated Anglophone engineers—most notably in India but also in Hong Kong, Singapore, Malaysia, and elsewhere—find themselves in great demand for employment in Silicon Valley, Boston, Austin, and Seattle. However, only Silicon Valley has a really thriving cricket league, populated by batting and bowling programmers from South Asia. This trend might continue and grow, pending a greater liberalization of professional immigration rules by Congress. Another trend may accelerate: the use of the Internet to enable the import of programmers' work, not programmers. The industry generally calls this "outsourcing." Many American companies have established contracting relationships or full-scale subsidiary ventures in India—typically in Bangalore, where English is spoken, engineer-

ing education is of high quality, and Internet connections have perfected telecommuting and the twenty-four-hour workday.

On May 18, 1998, the U.S. Department of Justice, in the person of Attorney General Janet Reno, gave the Internet the ultimate accolade of legitimacy and maturity, by bringing suit for anti-competitive practices in the browser market against Microsoft. It was not Microsoft's de facto monopoly in the personal computer operating system market, but its giveaway Web browser that attracted the attention of the federal regulators. Had anyone at the Justice Department heard of "browsers" five years earlier? Still, all the details of the case were there for anyone to survey, at <http://www.usdoj.gov>.

There's no ready conclusion to this story, neither the Bill Gates/Uncle Sam confrontation nor the onrushing Internet narrative. The day this manuscript is completed, it becomes outdated. Growth will race on, though it must level off at some point. Before that happens, some information technology boosters argue there will be a twenty- to thirty-year "long boom" in the stock markets. But this brief history—in identifying trends and milestones of the past, with insights and perspectives of the pioneers—can only aim to help show how things have been, and hint at what might come next.

Appendices provide the reader with a cast of characters, a timeline of events, and a glossary of technical terms that need to be defined. There is also a selection of photographs, provided mostly by the pioneers whose story is told in these pages.

A note on vocabulary: in everyday speech in 1998, the terms "Internet," "Net," and "Web" have become almost completely interchangeable. All three convey in general all the data one can reach by computer modem, wherever it may be. In referring to this general resource, I too have used the terms interchangeably, especially in later chapters. Separately, the terms "ARPAnet," "Internet," and "World Wide Web" refer to specific technological entities, created at particular times in the chronology, and I have used them accordingly. I hope that the difference between specific language in the narrative and generic use in quotation and interpretation is clear.

This book is an oral history—anecdotal, selective, and impressionistic—that attempts to present a coherent, broadly chrono-

logical account of a history spanning four decades. Because this book relies primarily on interviews, and secondarily on published sources, it is clear that for any one piece of the story the interested reader has a choice of more detailed and more technical books—on the ARPAnet alone, the impact of the Cold War on American science, the ups and downs of Xerox Palo Alto Research Center, and so on. Since 1994, we have been interviewing the pioneers of both the personal computer industry and the networking industry. From more than 120 interviews, we have tried to assemble two coherent television series and one useful book to provide what one Internet professional refers to as “strong consensus and working code.” The material here is a synthesis of memories, interpretation, and anecdote, but a strong consensus of narrative does emerge. Whether the author has produced “working code,” the reader may decide.