A Nation Transformed by Information

How Information Has Shaped the United States from Colonial Times to the Present

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The Coming of the Information Age

The next four chapters focus on the creation of the infrastructure of the Information Age. Chapter 5, by Margaret Graham, deals with the broad impact of vacuum-tube technology that brought into being radio and television. Chapter 6, by James W. Cortada, reviews the coming of the modern digital computers, the mainframe, and then the minicomputer and the profound impact they had on the processing of information. First came the mainframe, the marriage of transistor and punched-card technology for broad commercial and business markets; then the smaller, more specialized minicomputer for engineers and scientists. Chapters 7 and 8 focus on the revolutionary changes caused by the coming of the microcomputer as the personal computer replaced the mainframe and the workstation the minicomputer. Richard Nolan (chapter 7) deals with the impact of the personal computer and workstation on reshaping the processes of business information, and with it transforming business practices. Lee Sproull, in chapter 8, does the same for the impact of the personal computer on U.S. households that used to relate and understand more fully the evolution of information from the Commercial through the Industrial Age. A multitude of businesses—railroads, business-machine companies, and other enterprises, many of which still dominate today's Fortune 500 list—built the larger infrastructure for the Industrial Age. Only a handful of companies brought the Information Age into being.

The historical setting for these four chapters differs sharply from that used to relate and understand more fully the evolution of information from the Commercial through the Industrial Age. A multitude of businesses—railroads, business-machine companies, and other enterprises, many of which still dominate today's Fortune 500 list—built the larger infrastructure for the Industrial Age. Only a handful of companies brought the Information Age into being.

Indeed, the historical background for the chapters 5–8 can be presented through the history of two enterprises—the Radio Corporation of America (RCA) and IBM. RCA's story provides the linchpin for the rise and fall of the American consumer-electronics industry. IBM's story is critical to any analysis of the progenitors—chips and computers—of the Information Age, as well as understanding the significance of the microcomputer revolution.

This concentration in the commercializing—the bringing to market—inventions in electrical and electronic technology occurred worldwide. In the United States, the three companies that began to commercialize electric-based products in the 1890s, AT&T, General Electric (GE), and Westinghouse, continued to dominate electrical and electronics industries for decades. In the early 1920s, RCA was a joint venture of these three enterprises. In Europe, Siemens and Allgemeine Elektricitäts-Gesellschaft (AEG), also formed in the 1890s, dominated their field. Their initial radio venture, Telefunken, was established even before RCA. During World War I, when Germany was cut off from world markets, Philips, a firm in neutral Holland that by 1900 had become Europe's third largest producer of electric light bulbs, began to compete with Telefunken. World War II hit Telefunken so hard it never recovered. After that war the Japanese leaders Matsushita and Sony built their global enterprises with products acquired from RCA, Philips, and AT&T.

As for computers, AT&T's Bell Laboratories began in 1952 to license the transistor on a worldwide basis, and the transistor soon replaced the vacuum tube as the computer's basic source of power. In the United States, Great Britain, and France, the leaders were the companies that combined the tube, and then the transistor, with the punched-card tabulator technology. In Germany and Japan, these leaders were descendants from their nation's leading industrial and electrical and telecommunications enterprises. All the Japanese computer companies received their initial electrical and communications technologies from AT&T, GE, Westinghouse, and Germany's Siemens.

Now to return to chapter 5. Margaret Graham begins that chapter describing the introduction of vacuum-tube technology, which freed the flow of information from wires and permitted it to go beyond words to provide information through sound and images. She then focuses on how the words and pictures of the new technology mobilized society by shaping public opinion in both peace and war, by enlarging consumer markets through advertising, and finally by defining an overall popular culture. This came about during two main time periods, the first between the world wars, after the advent of radio and talking films, and the second after World War II with the arrival of television.

The first period began with the formation of the Radio Corporation of America between 1919 and 1922. The corporation was created by Owen D. Young, the chief executive officer at GE, working with senior naval officers, to hold and administer “radio related patents.” Its initial purpose was a military one—to assure U.S. control of the new ship-to-shore and ship-to-ship wireless technology. By the time the major patent holders had signed the final agreement, RCA had become a joint venture in which General Electric held 30.1 percent of its equity, Westinghouse 20.6 percent, AT&T 19.3 percent and United Fruit, a shipper of bananas, 4.1 percent. The just-created RCA was then suddenly overwhelmed by an unexpected flow of “radio related” patents.

Even before the U.S. entry into World War I in 1917, hobbyists had been building crystal radio sets and communicating with one another, first by Morse code and then by voice. Their activities were much the same as the hobbyists in the mid-1970s who, by marketing kits for other hobbyists, initiated the microcomputer industry. In 1920 West-
In 1922 there were 23 licensed stations, and by 1925 there were 566. Hundreds of firms making receivers were soon in business. At the same time the Justice Department, bombarded by complaints by new entrants, began an antitrust suit over RCA’s controlling patents.

Between 1923 and 1927 David Sarnoff, RCA’s aggressive young general manager, defined the initial structure of the new industry. He fashioned a license policy that satisfied the Department of Justice’s Antitrust Division and the small competitors. RCA licensed its product at 7.5 percent of the whole value of a set. As a result of this “package licensing,” royalties became a continuing source of RCA’s income ($7.0 million in 1929).

In 1926 RCA’s two major owners, GE and Westinghouse, completed their negotiations with the third, AT&T. The telephone company withdrew from broadcasting. In return, the historian, Hugh G. H. Aitken writes, “it would receive exclusive patent rights in the field of public service telephoning but would withdraw from broadcasting; while GE, Westinghouse, and RCA would enjoy exclusive rights in the fields of wireless telegraphy, entertainment broadcasting, and the manufacturing of radio tubes for public sale.”

Sarnoff then merged the broadcasting stations received from AT&T with those that RCA owned (and would acquire) into a new enterprise, the National Broadcasting Company (NBC). He then divided NBC into two networks, the red to concentrate on commercial broadcasting, the blue on public service. In 1927, William Paley formed a competing network, Columbia Broadcasting System (CBS). In 1942, under pressure from the Federal Communications Commission (FCC), RCA sold off its blue unit, which became the American Broadcasting Company (ABC). The three remained for several decades the dominant national broadcasting networks.

After 1927 Sarnoff followed two paths to growth. One was to use the vacuum tube to develop high-fidelity recording and, in a joint venture with Hollywood producers, “talking” motion pictures. The second was to make RCA an integrated manufacturing enterprise independent of its owners, because under the 1926 agreement RCA only marketed radios and other equipment produced by General Electric and Westinghouse.

Sarnoff’s first step was to convince those two companies to finance RCA’s purchase of Victor Talking Machine Company, the U.S. pioneer in commercializing the phonograph. This purchase, besides bringing RCA into a closely related technology, provided it with a strong manufacturing and marketing base in Camden, New Jersey.

By 1932 the now independent RCA and the radio industry were staggering through the Great Depression. Sales plummeted; radio receiver sales dropped from $842 million in 1929 to $300 million in 1934. RCA to remain solvent sold off its Canadian and Latin American (but not its Japanese) holdings that had come with Victor.

As economic recovery began in the mid-1930s, however, RCA was firmly established as the nation’s only enterprise to operate successfully in several sectors of the consumer electronics industry. In radio receivers its major competitors were Philco, Zenith, Emerson, and Magnavox. In tubes and other components, Sylvania (which supplied Philco and Zenith) was the major competitor. In national broadcasting that time it was just CBS. In motion pictures Radio Keith Orpheum (RKO) divided the sound equipment market with a subsidiary of Western Electric. Most important of all in terms of the future, RCA was leading the way in the development of television. In television RCA’s base was the research unit that Westinghouse had transferred in 1930, headed by Vladimir K. Zworykin, the inventor of the basic electronic phototube. By 1932 he had sixty persons working under him in RCA’s New York research laboratory.

Within this corporate framework Graham gives her detailed account of how that infrastructure was used to provide a mass medium for entertainment, to provide a national advertising medium for branded consumer products (one that supplemented the newspapers and magazines), and finally to mobilize the civilian society with the outbreak of global war. Together such societal mobilization created a definable mass culture. After the war this culture would be redefined by television—the technology that combined sound and images.
with the Japanese attack on Pearl Harbor, the government banned commercial production of television equipment for the duration. The coming of World War II delayed the introduction of television, but, as Graham emphasizes, it rapidly advanced the broader technology required for its commercialization. Wartime demands also profoundly transformed RCA and its competitors by bringing mass production of tubes and components and by moving the companies into production of military and industrial equipment.

With the war's end RCA turned quickly to capture the huge anticipated market for television. RCA's initial postwar move was to pin down the 1941 standard. In 1946 its management announced the firm's television technologies would be open to all. In June 1947, it invited its competitors to Camden to examine RCA's postwar product (selling at $345), and to take detailed blueprints with them. This strategy worked. Television sales soared. RCA's market share of radio receiving sets dropped rapidly, but its income from licensing and tubes and other components took off. After the swift growth of hardware leveled off in the early 1950s, NBC's rising cashflow from telecasting maintained the firm's profits.

In the postwar years the industry's leaders concentrated on commercializing color TV. Again, the battle was between RCA and its competitors, led by CBS. The rivals developed contrasting types of receiving and broadcasting equipment for color. Once again RCA's standard, assisted in part by the closing down of such product development during the Korean War, was victorious in 1953.

But that victory did not assure commercial success. Much work was still to be done. RCA's competitors pulled out of the race, thus depriving the company of its income from licensing and components, but it continued (at high cost) to push on. In 1959 came its first profit from television. Zenith was the first competitor to return to color. It did so in 1961 by purchasing 500,000 RCA tubes on which RCA made a profit of $35 per tube. As the sole producer of the tricolor tube which it had recently developed and profiting from a strong pent-up demand for color—not only in television but also in motion pictures—during the 1960s RCA became one of the nation's largest industrial revenue producers (number 26), remaining the industry's dominant leader. At the same time a rapidly growing Japanese consumer-electronics industry, based in large part on licenses from RCA and those for AT&T's transistor, was becoming increasingly competitive.

From 1960 on, color television dominated electronic media for the projection of sound and images. Graham considers its impact on the existing media and then analyzes its role in the shaping of postwar popular culture, political processes, and other aspects of the role of the electronic media in the mobilizing of society.

Graham ends her chapter with a reference to the rapid transfer of RCA's technology to Japanese producers resulting from a 1957 consent decree with the U.S. Justice Department. Because that decree prohibited the use of package licensing in the domestic market, RCA focused on licensing its existing and new technology abroad, mainly to Japanese producers. At the same time it turned to markets other than those for consumer electronics.

As the Japanese were obtaining and perfecting the industry's basic technology, RCA's management embarked on a disastrous attempt to compete with IBM's System 360 mainframe computer and to diversify into unrelated products. It acquired a publishing company, a sporting goods chain, a car rental firm (Hertz), producers of frozen foods, and other enterprises.

By the mid-1970s, RCA's revenues were rapidly declining and its debts were soaring. In the early 1980s, a new management team sold off all its acquisitions, and finally in 1986 its consumer-electronics operation and NBC were sold to GE. General Electric in turn quickly sold the consumer electronics to France's Thomson Houston. The smaller producers of radio and television receivers and components had neither the scale, scope, or full line of consumer-electronics products necessary to compete in world markets. By the late 1980s, nearly all had been acquired by Matsushita, Sony, Sanyo, and Europe's Philips. Once the U.S. consumer-electronics industry had lost its RCA core, it collapsed quickly.

Chapters 6, 7, and 8 evaluate the role of the digital computer in bringing the Information Age into full flower. The authors agree on the chronology of three eras during which that role evolved: the "data-processing era" from the 1950s to the early 1980s, the "microcomputer era" from the early 1980s to the mid-1990s, and finally the "network era," beginning in 1995.

Just as RCA played a central role worldwide in providing the means of transmitting and receiving sound and images, reviewed in chapter 5, so did IBM lead in computer-based information, as covered in chapters 6 and 7. The IBM mainframe and its clones dominated world markets from the 1950s to the 1980s. IBM's "personal computers" (PCs) and its clones helped to assure continuing U.S. dominance in microcomputers after the mid-1980s.

The difference between RCA and IBM was, of course, that RCA self-destructed in the 1970s and so turned the industry over to the Japanese IBM, after recovering from the impact of the personal-
computer revolution which it did so much to create, remains today the
world leader. In 1994 it was the nation's largest revenue producer inive of the seven major sectors of the computer industry. As table 1.1
shows, IBM led in large systems, midrange systems, peripherals, services,
and software. Its software revenue was $11.5 billion as compared
with Microsoft's $4.5 billion. IBM’s revenues were a very close second
to Sun Microsystems in workstations and to Compaq in PCs.8

As has been pointed out, the modern digital commercial data-
processing computer was a marriage in the 1950s of the punched-card
Tabulating technology with that of the electronic tube and then the
transistor. The U.S. companies that successfully made the transition
from making computers for military and defense to producing them
for the commercial market were the business-machine makers had had
prewar experience or at least an awareness of punched-card tabulating
technology. These were National Cash Register (NCR), Burroughs
Adding Machine, Remington-Rand (merged with Sperry in 1955), and
Honeywell. Since IBM accounted for nearly 90 percent of the
punched-card tabulator market before World War II, IBM understand-
ingly jumped ahead of its competitors in the new computer industry.

As the world's leader in the production and marketing of punched-
card equipment, IBM had perfected the essential capabilities needed
to develop, manufacture, and sell data-processing equipment for busi-
ness purposes. The new digital computers used much the same card
readers, punches, and other peripheral equipment. Markets for these
computers were much the same large information-intensive industries
that relied on punched-card tabulators. In the early 1950s IBM
enhanced its technical capabilities in electronics by increasing the number
of its engineers and technicians from 500 to 5,000, and by hiring the
chief scientist of the Office of Naval Research, Emmanuel ("Manny")
R. Piore, to head its expanded research organization.

By 1960, IBM's revenues were twice the total of its U.S. competitors
combined. By then it was producing seven different classes of "main-
frames" (as these computers had become termed), ranging from more
broadly based ones for corporate offices and high-powered, more nar-
rowly focused ones for scientific purposes. These mainframes used
different sets of processors, peripherals, and software and relied on
outside suppliers for semiconductors and other inputs.

Thomas Watson Jr. succeeded his father as IBM's president in 1956.
In December 1960 he and his senior managers decided to make the
next generation of computers compatible with one another. That
generation would be more than a set of new lines. It would be a system
of compatible lines. The IBM System 360 would include five (later

Table 1.1 The Ten Leading American Computer Vendors in Each Industry Segment, 1994

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Compiled from “Datamation 100, 1995,” Datamation (June 1, 1995): 47, 48, 57, 61. Datamation did not list semiconductors since they were used in many industries. The figures represent worldwide revenues for each segment. 

As a merger of Burroughs and Sperry-Rand in 1986.

Sources

A new computing processors that would cover the overall market in terms of price and performance. They would all use the same input/output equipment, tapes, disk storage, terminals, and other peripherals. The power source would be a still untested transistor chip produced in a giant new plant. In addition, the products would have the same computing software and software applications. Since the company leased rather than sold computers (repeating the practice it had followed with punched cards), it provided regular service and repair. In addition, it would continue to supply computing services to customers who did not require the full-time use of one of its products. In other words, IBM System 360 would incorporate within a single set of products much of the activity that was beginning to be carried on by a growing network of supporting suppliers and vendors.

By 1967 the System 360 began to appear in volume. Its arrival quickly expanded the continuing mainframe path of learning, not only in the United States, but worldwide. In addition to the core competitors—Burroughs, Remington-Rand, and Honeywell, two others—the main’s leaders in electronics, General Electric and RCA—were also anxious to build similar systems. Both GE and RCA had the potential in terms of technical and managerial capabilities and the financial resources to attempt to produce a comparable line of products—a potential no other company in the world enjoyed at the time. Nevertheless, with IBM’s announcement in 1970 of its next generation, the System 370, both gave up their attempts after investing an inordinate amount of time and expending massive funds in research and development. In RCA’s case the cost was over half a billion dollars and a lost generation of research.

After the withdrawal of GE and RCA, the IBM System 360 and 370 became the worldwide standard for mainframe computers. The credit belongs to IBM’s chief designer, Gene Amdahl. The announcement of the System 360 in 1964 turned the European computer makers, supported by their governments, to making technological alliances with IBM’s U.S. competitors to produce comparable systems. The announcement of the System 370 was as great a shock to the four European and six Japanese computer makers as it was to GE and RCA. Several lost their technologically advanced U.S. partners. All understood more fully the challenges they faced. In response the Japanese Ministry of Trade and Industry (MITI) drew up a “New Series Project” that paired the industry’s leaders to develop similar compatible systems. In Europe Philips (still primarily a consumer electronics producer), Siemens, and the French “national champion” UNIDATA to achieve the same goal.

In 1970 Gene Amdahl left IBM to start his own company to produce and sell the largest of the machines he had designed. Unable to raise the $40 million in venture capital he estimated as necessary, he contacted Fujitsu, Japan’s most technologically advanced computer maker. Its management immediately responded with high enthusiasm. As Fujitsu’s top manager told an assistant, if the proposal “goes well, it will be incredible!”

It went very well. Fujitsu then raised the funds, primarily from the government, to acquire 20 percent of the equity of Amdahl’s company. By 1974 Amdahl’s Japanese factory was completed. By 1976 Fujitsu held 41 percent of its stock. Also in 1976, Fujitsu introduced its M-190, the first of an “M-series.” It was a “one-to-one replacement” of the Androdyne 470-V6 which, in turn, was a one-to-one copy of the model 168 of IBM’s System 370. By the end of the decade Hitachi and the NEC Corporation, as well as Fujitsu, were producing similar machines. They continued to enhance their product development and production capabilities in much the same manner as their compatriots were doing in consumer electronics, automobiles, and ships.

By 1975, the European UNIDATA project had collapsed. Germany’s Siemens then turned to Fujitsu, asking to be supplied with its
M-series on an Original Equipment Manufacturing basis (OEM), that is, selling another company's product over its own name. By 1978 it was receiving the same M-190 IBM clone. In 1981 Fujitsu agreed to supply Great Britain's International Computers Limited (ICL) on much the same basis. Hitachi then did the same for Italy's Olivetti. The fourth European company, France's Machines Bull, made comparable arrangements in 1982 with NEC. Thus by the early 1980s Europe was getting its mainframe technologies from the United States via Japan.

At home during the late 1960s and early 1970s, two entrepreneurial start-ups became significant competitors to the IBM mainframes. Each developed its product line on the edges of IBM's System 360 line. The first start-up, William Norris's Control Data (CDC), introduced a supercomputer for scientists in 1966, but its market remained highly specialized and limited.

On the other hand, Kenneth Olsen's Digital Equipment Corporation (DEC) commercialized the first minicomputer and thus opened up a small but increasingly lucrative market. Olsen's high-powered PDP series, with no advanced technological peripherals and with customers supplying much of the software, sold at unprecedented low prices. In the early 1970s a small number of firms began to follow Olsen's lead in producing minicomputers. The most successful were Data General (established by Edson DeCastro, the designer of Olsen's PDP series), Hewlett-Packard, and IBM itself. By the early 1980s IBM's minicomputer revenues were larger than those of Digital.

The stream of IBM's System 360 and Digital's PDP series quickly broadened the data-processing infrastructure for the Information Age. Between 1968 and 1972 a burst of new enterprises appeared to meet the rapidly increasing demand for peripherals, packaged software, computer services, and, most important of all, chips.

The central role of chips in information processing is described by James W. Cortada in chapter 6. The initial chip manufacturers were not the large tube makers like RCA and Sylvania; instead they were small specialized firms that had acquired Bell Laboratories' transistor license. Another set of chip companies appeared a decade later to meet the demands of the late 1960s. The early set of small specialized firms included Texas Instruments (TI), makers of geodetic instruments used in the exploration for oil; Motorola, producers of car radios; and Fairchild Semiconductor, established in 1954 in Palo Alto by Gordon Moore and Robert Noyce, and others.

Of these three, Texas Instruments proved the most innovative. After receiving its license in 1952, TI signed a contract with AT&T to produce a transistor radio. It then led the way in developing silicon-based chips, becoming IBM's semiconductor supplier in 1959. That same year Jack Kilby, one of TI's engineers, patented the integrated chip that, by placing several transistors on a single silicon wafer, became the central power source for computers. TI then began to expand aggressively overseas.

Though less innovative, Motorola quickly followed TI in building a multinational enterprise with manufacturing facilities in Europe and Asia. By 1965 TI had fifteen operating plants in ten countries, and Motorola was not far behind. One missing market was Japan. Here TI negotiated with Sony from 1963 to 1968 and finally paid the price of entry into Japan by licensing its Kilby patent to all Japanese firms. On the basis of that patent, Japanese firms quickly moved forward in the volume production of semiconductors as they were already doing in consumer electronics.¹⁰

Fairchild was a highly innovative enterprise but far less financially successful than TI or Motorola. One of its partners, Robert Noyce, patented an integrated chip in 1959, the same year as Kilby did. Fairchild's problem was that it produced entrepreneurs not products. Gordon Moore, one of Fairchild's founders and director of its research, has written: "The fact that new ideas [from his unit] were spawning new companies rather than contributing to the growth of Fairchild was immensely frustrating."¹¹ So Moore, Noye, and a younger man named Andrew Grove decided to leave Fairchild to form Intel. Grove had joined Fairchild in 1963 after receiving his Ph.D. from the University of California.

In 1967 and 1969 two other entrepreneurial firms, National Semiconductor and Advanced Micro Devices, began operations near Fairchild and Intel in what was becoming California's famous Silicon Valley. Since then, in the 1990s, these six—Intel, TI, Motorola, Fairchild, National Semiconductor, and Advanced Micro Devices—still dominate the U.S. production of chips for computers.

Although during the 1970s TI and Intel concentrated on Dynamic Random Access Memory (DRAM) chips primarily for mainframes (as did other U.S. firms), both companies pioneered in commercializing the microprocessor, the "computer on a chip" that so transformed the industry in the 1980s. During the 1970s, however, the new microprocessor was used primarily to improve the performances of machinery, appliances, automated assembly lines, and the like. By the end of
the decade all the U.S. chip makers were suffering from the increasingly powerful Japanese competitors.

By the late 1970s the infrastructure of the “data-processing era,” based on large computers used by business, government, education, and other institutions had been completed, as told by Cortada in chapter 6. Cortada describes in detail the creation of this infrastructure and its effect on the U.S. economy. After considering the impact of the transistor and the integrated chip and tracing the evolution of IBM’s Systems 360 and 370, Cortada carries the story further in terms of the evolution of hardware and software, and the resulting impact on computing power and the types of information processed. He indicates the extent of the deployment of data-processing technology through the broad sectors of the economy (manufacturing, retailing, and financial services), and its impact on the nature and the composition of the nation’s working force. He also calls our attention to the speed with which this deployment of computing technology occurred, demonstrating yet another example of America’s appetite for useful technologies.

But the drama of the evolution of computing technology and its deployment continued. The data-processing era was completed only to be dramatically reshaped in the early 1980s by the unanticipated onslaught of the personal computer.

This event brought about the computer world as we know it today—a world of microcomputers (personal computers and workstations) powered by microprocessors and used by individuals, connected with each other through networks. In expediting the microcomputer revolution, IBM played as critical a role as it did in creating the large computers of the data-processing era in the 1950s and 1960s.

The personal computer (PC) era had been foreshadowed in 1977 when Apple, Commodore, and Tandy introduced the first commercial microcomputers, which quickly replaced the pioneering kits assembled by hobbyists for hobbyists. But the PC industry’s explosive growth began with IBM’s entry in 1981 when the laboratory director of the company’s Entry Level Systems Unit, William C. Lowe, at the explicit direction of IBM’s senior management, sent a task force to Boca Raton, Florida. His charge to the task force was to design a microcomputer, build a factory to produce it in volume, and create a national and worldwide marketing and advertising organization for the mass-produced consumer product—and all this was to be accomplished within a year.

To meet the assigned schedule, the new computer would have an “open architecture,” not protected by patents as were those of its competitors. Peripherals were to be purchased from sources that could supply the equipment immediately in volumes needed for mass production. Software was to be developed separately from the central processing unit. For their processor the Boca Raton team chose a low-powered 8-bit Intel chip. For its operating system the task force’s managers chose Gary Kildall, who had written what was by 1981 the dominant operating system for microcomputers. When Kildall refused to sign a nondisclosure agreement, they turned to William Gates, whose enterprise in Seattle was producing a version of the programming language BASIC for microcomputers but had not yet built an operating system.

IBM’s Boca Raton team completed the product on schedule. By autumn 1981 the mass-production facilities were complete. By then the managers had signed contracts with retailing chains, including ComputerLand and Sears Business Centers, and built a national (later international) marketing unit to support a network of franchise dealers. In 1982, the first year of full production, IBM’s microcomputer revenues were $500 million. In 1985, the fourth year of full production, revenues had soared to $5.5 billion, a record of revenue growth unsurpassed in industrial history.

Consider the profound, but largely unintended and certainly unexpected, consequences of the Boca Raton venture.

First, it revealed a mass consumer market for computers. Hitherto the market had been institutional—corporations, government offices, universities, research laboratories, and the like.

Second, by making its PC an open system, IBM created an unprecedented opportunity for both existing and start-up companies to enter this new market, an opportunity denied by Apple and the other existing proprietary systems. The clones indeed poured in. As Business Week reported in July 1986, “Now more than 200 clone suppliers using the same software and working with the same hardware” were challenging the standard’s progenitor. IBM’s entry into the microcomputer business profoundly changed the structure of the computer industry in barely five years.

Third, because the development of the chip and the operating system were so intimately connected—one could not be created without the other—Intel and Microsoft had received the franchise to produce for this new unexpected multi-billion-dollar market. They quickly became the microcomputer industry’s two major players. By the early 1990s their near monopolistic position provided them with far greater funding for continuing research and development than any of their competitors.
Fourth, the swift proliferation of desktop computers created a demand for new types of packaged software written for individuals in offices and also at home rather than for corporate information technology managers. First came spreadsheets, designed by VisiCalc and Lotus, then database management systems, graphic word processing, and other types of application software offered by such firms as Oracle, Computer Associates, and Borland. Software for personal computers became the industry’s fastest-growing sector. By the 1990s, it had become a major U.S. industry by itself, with some vendors’ stock values (but certainly not revenues) exceeding venerable U.S. manufacturers (e.g., Microsoft over General Motors).

Fifth, the sudden appearance of personal computers on a multitude of desks within corporations and other institutions demanded creation of internal enterprise networks to connect individuals within and between operating units. As early as 1983 start-ups Novell and 3Com were providing software for what had become termed the local area networks (LANs). Others soon followed.

Sixth, because the personal-computer industry was not created in the normal evolutionary manner, with the successful pioneers developing their proprietary systems, these new and unexpected demands led to a burst of entrepreneurial start-ups in the United States. This did not occur elsewhere. Foreign competitors, primarily Japanese, were quickly left behind. From its start, U.S. firms dominated the microcomputer industry worldwide.

During the mid-1980s the entrepreneurial start-ups in personal computers were IBM clones—Dell, Gateway 2000, Packard Bell, and AST Research had begun as innovators in marketing rather than technology. In 1994 the leading producers of PCs were Compaq (the first successful IBM clone, which shipped its first production in 1983), IBM itself, and Apple (the one remaining producer with a proprietary operating system), followed by the four marketing pioneers (see Table 1.1). In peripherals the largest revenue producers included two 1980 start-ups, Quantum and Conner, while Hewlett-Packard became one of the world leaders. Indeed by 1994, Hewlett-Packard was a major player in five of the industry’s sectors, excluding large systems and software. In chips, however, Intel became and remained the ruling firm. In 1994, of the worldwide production of microprocessors by U.S. makers, Intel had 74 percent, Motorola (then working with IBM) 12 percent, Advanced Micro Devices (IBM’s second source for IBM Boca Raton venture) 7 percent, and Texas Instruments 3 percent.

Because IBM’s clones dominated the PC market, Microsoft’s operating system (powered by Intel chips) controlled the gateway to application software development. Gates quickly used that advantage to attack aggressively Lotus, Oracle, Computer Associates, Borland, and Novell, and other new producers of applications and networking software. By 1994 approximately 63 percent of Microsoft’s income came from application software, 34 percent from operating systems, and 4 percent from hardware. As the Information Age came into its own, U.S. firms accounted for 87 percent of packaged PC software worldwide. In Japan, U.S. vendors accounted for 50 percent of the application software and Microsoft provided 70 percent of the operating systems.

Nevertheless, the Intel/Microsoft combination of chip and operating system did not completely dominate the new microprocessor industry, for during the 1980s the PC had increasing competition from the workstation using a different combination. By the mid-1980s the makers of minicomputers—IBM, Hewlett-Packard, Digital, Apollo (which emerged from the earlier out of Prime Computer, Inc.), and the innovative start-up Sun Microsystems—used proprietary RISC (Reduced Instruction Set Computing) microprocessors and UNIX operating systems (initially developed by AT&T) to manufacture workstations that met the needs of their existing customers in engineering and scientific fields. Their success lay in developing a highly effective intra-enterprise network technology by which high-powered “servers” stored information and then transmitted it on call to “clients” (desktop computers) to be analyzed and manipulated in order to obtain the information required. In 1993 Gates moved Microsoft into the workstation market with his Windows NT. At the same time Microsoft was challenging Novell’s much improved NetWare file/server for PC local and wide area networking.

By the early 1990s most major U.S. companies were using one network technology or the other—or a combination of them—to build their own intra-enterprise networks, or intranets. At the same time they were beginning to tie their intranets to the growing external Internet. Richard Nolan, in chapter 7, provides an excellent brief review of the Internet’s evolution from the government’s Advanced Research Project Network, the ARPANET. This was first used by government agencies and universities to communicate with one another and then by corporations, interest groups, and other associations to do the same.

However, to connect enterprise intranets with those of other enterprises and with the larger Internet required the development of a specialized hardware and software, the router and the browser. With that connection the Information Age had arrived.
Cisco, a company formed in 1984, introduced in 1986 the router, a selector of the most effective routes for data to flow from one network to another. Cisco’s initial markets for these routers were universities and research centers and other groups using ARPANET. By 1988 its major customers had become mainstream corporations that communicated internally through private local and wide area intranets. As the pioneer, Cisco continued to enjoy 50 percent of that market through 1994.

The final step uniting the intranets to the internet was Mosaic, the initial “browser” software, written at the University of Illinois, Champaign–Urbana, for expediting the connecting of the intranets and the Internet. In 1994 the university licensed Mark Andreesen, one of its creators, who formed Netscape. Its Navigator software became the dominating browser for the World Wide Web, whose initial code for the public Internet was written in 1990. At the same time, another one of Mosaic’s creators formed Spyglass, whose license was acquired by Microsoft in 1995 and then bundled free of charge as Internet Explorer with Windows 95. As versions of Mosaic software came on stream, Cisco’s income from its hardware and services shot up from $650 million in 1993 to $2 billion in 1995.

In chapter 7, “Information Technology Management, 1960–2000” Richard Nolan focuses on the changes in IT management in business enterprises from the data-processing era through the microcomputer revolution and then to the challenges IT managers face with the coming of the network era in 1995. Nolan does this by relating the firms’ IT architecture to corporate organizational structure.

Nolan first considers how the budgeting and managing techniques developed in the data-processing era reflected the needs of large vertically integrated, multidivisional enterprises. Next he reviews how these needs were transformed by the impact of the explosion of information that accompanied the coming of the personal computer, considering the tensions that this created for data-processing managers, the resulting shaping of IT management, and the coming of new benchmarks for organizational performance. Finally the chapter considers the challenges for IT management caused by the marriage of intranets and the Internet “to coordinate the thousands of computers that made up their internal networks, as well as tens of thousands of computers with which the organizations communicated through various connections with other Intranets of suppliers and customers and the overall Internet.” Nolan then describes and evaluates the resulting impact on the enterprises’ working forces, on their methods of resource allocation and management, and on other business and managerial concerns.

In chapter 8, “Computers in U.S. Households, 1977–1997,” Lee Sproull reviews the evolution of the home computer “from a sociological point of view.” The computer, of course, appeared in the household only after the coming of the personal computer. Sproull divides the ensuing evolution into three periods.

The first period, from 1977 to 1984, was one of standing machines, acquired primarily for two purposes, entertainment (games and hobbies) and self-improvement, both educational and for home office work using VisiCalc spreadsheets. The second period began in 1984, as the output of personal computers soared, and continued until 1994. In that ten years the household machines became connected with a variety of databases such as airline schedules, news wires, financial services, entertainment, and education. Because the home computers were unable to store much data in permanent form, “on-line service companies” were formed to provide that access via a modem and a telephone call with charges paid for each call. Although such firms as Prodigy, Delphi, and America Online began operations in the 1980s, they had limited use until the late 1980s when the ARPANET was turning into the Internet. Sproull’s third period began when the router and browser, by linking the Internet to other networks, marked the arrival of the full-fledged Information Age.

After covering the chronological development of the home computer, Sproull reviews its impact on society in terms of social status, gender, income, and race. She considers its impact on children and family dynamics, on the changing boundaries between the household and office, between home and markets (including on-line purchasing transactions), and those between home and government, and then the differences between rural, suburban, and inner-city dwellers in the defining of these boundaries. Particularly intriguing is Sproull’s analysis of the role of the home computer in changing family and personal relationships, in bringing individuals and interest groups to communicate with each other via the Usenet, and later the Internet—including communication between people who have never met face to face. As the chapter ends, “One of the most amazing features of the information revolution has been its character as a people’s revolution, once the household computer went on-line.”

But let us begin the story with the Colonial Period, because it is in this era that some of the fundamentals of the American experience started late in the Commercial Age.
Notes

Chapter 1

8. In 1996 Datamation changed its classification of the industry’s sectors. Workstations were reclassified as Server Suppliers and PCs as Table Tops. That year IBM was the number one revenue producer in all six sectors.


Chapter 2


2. Ibid., chap. 3, 8.


8. Philip G. Davidson, Propaganda and the American Revolution, 1763–1783 (Chapel Hill: University of North Carolina Press, 1941); John C. Miller, Sam Adams: Pioneer in Propaganda (Boston: Little, Brown, 1936); Richard D. Brown, Revolutionary Politics in Massachusetts: The Boston Committee