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BROADENING THE APPEAL

MOST NEW TECHNOLOGIES start out imperfect, difficult to master, and capable of being used only by enthusiastic early adopters. In the early 1920s, radios used crude electronic circuits that howled and drifted and needed three hands to tune; they ran on accumulators that had to be taken to the local garage for recharging, while the entertainment available often consisted of nothing more than a broadcast from the local dance hall. But over a period of a few years, the super-hetrodyne circuit transformed the stability and ease of tuning of radio sets, and it became possible to plug one into any electrical outlet; the quality of programs—drama, music, news, and sports—came to rival that available in the movie theaters. Soon "listening in" was an everyday experience.

Something very similar happened to personal computers in the 1980s, so that people of ordinary skill would be able to use them and want to use them. The graphical user interface made computers much easier to use, while software and services made them worth owning. A new branch of the software industry created thousands of application programs, while the CD-ROM disc brought information in book-like quantities to the desktop. And when computer networks enabled users to reach out to other individuals, by "chatting" or exchanging e-mail, the personal computer had truly become an information machine.

MATURING OF THE PERSONAL-COMPUTER SOFTWARE INDUSTRY

On 24 August 1995 Microsoft launched Windows 95, its most important software product to date. The advance publicity was unparalleled. In the weeks before the launch, technology stocks were driven sharply higher in stock markets around the world, and in the second half of August the Microsoft publicity juggernaut reached maximum speed. Press reports estimated that the Windows 95 launch cost as much as $200 million, of which $8 million alone was spent acquiring the rights to use the Rolling Stones' "Start Me Up" as background music on television commercials. In major cities theaters were hired and video screens installed so that Microsoft's chairman Bill Gates could deliver his address to the waiting world.

When we left Microsoft in the last chapter, in 1980, it was a tiny outfit with thirty-eight employees and annual sales of just $8 million. Ten years later, in 1990, it had 5,600 employees and sales of $1.8 billion. As suggested by the rise of Microsoft, the important personal-computer story of the 1980s was not hardware but software.

The personal-computer software industry developed in two phases. The first phase, which can be characterized as the gold-rush era, lasted from about 1975 to 1982; during this period, barriers to entry were extremely low, and there were several thousand new entrants, almost all of which were undercapitalized two- or three-person start-ups. The second phase, which began about 1983, following the standardization of the personal-computer market around the IBM-compatible PC, was a period of consolidation in which many of the early firms were shaken out, new entrants required heavy inputs of venture capital, and a small number of (American) firms emerged as global players.

Apart from its meteoric growth, the most remarkable aspect of the industry was its almost total disconnection from the existing software-products industry, which in 1975 was a billion-dollar-a-year business with several major international suppliers. There were both technical and cultural reasons for this failure to connect. The technical reason was that the capabilities of the existing software firms—with their powerful software tools and methodologies for developing large, reliable programs—were irrelevant for developing programs for the tiny memories of the first personal computers; indeed, they were likely to be counterproductive. Entrants to the new industry needed not advanced software-engineering knowledge but the same kind of savvy as the first software contractors in the 1950s: creative flair and the technical knowledge of a bright undergraduate. The existing software companies simply could not think or act small enough: their overhead costs did not allow them to be cost-competitive with software products for personal computers.

But the cultural reasons were at least as important. Whereas the traditional packaged-software firms marketed their programs using dark-suited salespeople with IBM-type backgrounds, the personal-computer software companies sold their products through mail order and retail outlets. And if anyone attended an industry gathering wearing a tie, someone would "cut it off and throw you in the pool."

Despite the large number of entrants in the industry, a small number of products quickly emerged as market leaders. These included the VisiCalc spreadsheet, the WordStar word processor, and the dBase database. By the end of 1983 these three products dominated their respective markets, with cumulative sales of 800,000, 700,000, and 150,000, respectively.

Personal-computer software was a new type of product that had to evolve its own styles of marketing. When industry pundits searched for an analogy, they often likened the personal-computer software business to pop music or book publishing. For example, a critical success factor was marketing. Advertising costs typically took up thirty-five cents of each retail dollar. Promotions took the form of magazine advertising, free demonstration diskettes, point-of-sale materials, exhibitions, and so on. Marketing typically accounted for twice the cost of actually developing a program. As one industry expert put it, the barriers to entry into the software business were "marketing, marketing, and marketing." By contrast, the manufacturing cost—which consisted simply of duplicating floppy disks and manuals—was the smallest cost component of all.

The analogy with pop music or book publishing was a good one. Every software developer was seeking that elusive "hit," so that the marketing and R&D costs would be spread over as high a number of sales as possible.

By about 1983 the gold rush was over. It was estimated that fifteen companies had two-thirds of the market, and three significant barriers had been erected to entry into the personal-computer software business. The first was technological, caused by the dramatically improving performance of personal computers. The new generation of IBM-compatible PCs that had begun to dominate the market was capable of running software comparable with that used on small mainframes and required similar technological

resources for its development. Whereas in 1979 major software packages had been written by two or three people, now teams of ten and often many more people were needed. (To take one example, while the original VisiCalc had contained about 10,000 instructions, mature versions of the Lotus 1-2-3 spreadsheet contained about 400,000 lines of code.) The second barrier to entry was know-how. The sources of knowledge of how to create personal-computer software with an attractive interface had become locked into the existing firms. This knowledge was not something that could be learned from the literature or in a computer science class. The third, and probably the greatest, barrier was access to distribution channels. In 1983 it was said that there were thirty-five thousand products competing for a place among the two hundred products that a typical computer store could stock—three hundred word-processing packages just for the IBM-compatible PC. A huge advertising expenditure, and therefore a large injection of capital, was needed to overcome this barrier.

One might have expected that these barriers to entry would have protected the existing firms such as VisiCorp, MicroPro, and Ashton-Tate, but this was not the case. By 1990 these and most of the other prominent software firms of the early 1980s had become also-rans, been taken over, or gone out of business altogether.

The reasons for this transformation are complex, but the dominating cause was the importance of a single "hit" product whose arrival could transform a balance sheet for several years, but whose demise could send the firm into a spiral of decline. Perhaps the most poignant of these dramatic turns of fortune was that of VisiCorp, the publisher of VisiCalc. At its peak in 1983, VisiCorp had annual revenues of $40 million, but by 1985 it had ceased to exist as an independent entity. VisiCorp was effectively wiped out by the arrival of a competing product, Lotus 1-2-3.

To create a software hit, one needed access either to big sources of venture capital or to a healthy revenue stream from an existing successful product. The story of the Lotus Development Corporation, which was formed by a thirty-two-year-old entrepreneur, Mitch Kapor, in 1982, illustrates the financial barriers that had to be overcome to establish a successful start-up in computer software. Kapor was a charismatic freelance software developer who had produced a couple of successful packages in 1979 for VisiCorp. He had originally received a royalty on sales from VisiCorp but decided to sell all the rights to his packages to the company for a single payment of $1.7 million. He used this cash—plus further venture-capital funds, totaling $3 million—to develop a new spreadsheet called Lotus 1-2-3, which would compete head-on with the top-selling package, VisiCalc. In order to beat VisiCalc in the marketplace, Lotus 1-2-3 needed to be a much more technically sophisticated package, and it was estimated to cost $1 million to develop. Lotus reportedly spent a further $2.5 million on the initial launch of its new spreadsheet. Of the retail price of $495, it was said that about 40 percent went into advertising. With this blaze of publicity, Lotus 1-2-3 sold 850,000 copies in its first eighteen months and instantly became the market leader.

The story of Microsoft illustrates the value of an income stream from an already successful product as an alternative to raising venture capital. By 1990 Microsoft had emerged as the outstanding leader of the personal-computer software industry, and biographies and profiles of its founder, William Henry Gates III, poured forth. In 1981, when firms such as MicroPro and VisiCorp were on the threshold of becoming major corporations, Microsoft was still a tiny outfit developing programming languages and utilities for microcomputers. Microsoft's market was essentially limited to computer manufacturers and technically minded hobbyists. However, as described in the previous chapter, in August 1980 Gates signed a contract with IBM to develop the operating system MS-DOS for its new personal computer.

As the sales of IBM-compatible computers grew, a copy of Microsoft's MS-DOS operating system was supplied with almost every machine. As hundreds of thousands, and eventually millions, of machines were sold, money poured into Microsoft. By the end of 1983 half a million copies of MS-DOS had been sold, netting $10 million. Microsoft's position in the software industry was unique: MS-DOS was the indispensable link between hardware and applications software that every single user had to buy.

This revenue stream enabled Microsoft to diversify into computer applications without having to rely on external sources of capital. But, contrary to the mythology, Microsoft has had many more unsuccessful products than successful ones, and without the MS-DOS revenue stream it would never have grown the way it did. For example, Microsoft's first application was a spreadsheet called Multiplan, which was intended to compete with VisiCalc in much the same way that Lotus 1-2-3 had. In December 1982 Multiplan even got a Software of the Year award, but it was eclipsed by Lotus 1-2-3. This would have been a major problem for any firm that did not have Microsoft's regular income. In mid-1982 Microsoft also began to develop a word-processing package called Word. The product was released in November 1983 with a publicity splash that rivaled even that of Lotus 1-2-3. At a cost of $350,000 some 450,000 diskettes demonstrating the program were distributed in the *PC World* magazine. Even so, Word was initially not a successful product and had a negligible impact on the market leader, WordStar. Microsoft was still no more than a medium-sized company living off the cash cow of its MS-DOS operating system.

GRAPHICAL USER INTERFACE

For the personal computer to become more widely accepted and reach a broader market, it had to become more "user-friendly." During the 1980s user-friendliness was achieved for one-tenth of computer users by using a Macintosh computer; the other nine-tenths would later achieve it through Microsoft Windows software. Underlying both systems was the concept of the *graphical user interface.*

Until the arrival of the Macintosh, personal computers communicated with the user through a disk operating system, or DOS. The most popular operating system for the IBM-compatible PC was Microsoft's MS-DOS. Like so much else in early personal computing, DOS was derived from mainframe and minicomputer technology—in this case the notoriously efficient but intimidating Unix operating system. The early DOS-style operating systems were little better than those on the mainframes and minicomputers from which they were descended, and they were often incomprehensible to people without a computer background. Ordinary people found organizing their work in MS-DOS difficult and irritating.

The user interacted with the operating system through a "command line interface," in which each instruction to the computer had to be typed explicitly by the user, letter-perfect. For example, if one wanted to transfer a document kept in a computer file named SMITH from a computer directory called LETTERS to another directory called ARCHIVE, one had to type something like:

COPY A:\LETTERS\SMITH.DOC B:\ARCHIVE\SMITH.DOC DEL A:\LETTERS\SMITH.DOC

If there was a single letter out of place, the user had to type the line again. The whole arcane notation was explained in a fat manual. Of course, many technical people delighted in the intricacies of MS-DOS, but for ordinary users—office workers, secretaries, and authors working at home—it was bizarre and perplexing. It was rather like having to understand a carburetor in order to be able to drive an automobile.

The graphical user interface (GUI, pronounced "gooey") was an attempt to liberate the user from these problems by providing a natural and intuitive way of using a computer that could be learned in minutes rather than days, for which no user manual was needed, and which would be used consistently in all applications. The GUI was also sometimes known as a WIMP interface, which stood for its critical components: Windows, Icons, Mouse, and Pull-down menus. A key idea in the new-style interface was to use a "desktop metaphor," to which ordinary people could respond, and which was far removed from technical computing. The screen showed an idealized desktop on which would be folders and documents and office tools, such as a notepad and calculator. All the objects on the desktop were represented by "icons"—for example, a document was represented by a tiny picture of a page of typing, a picture of a folder represented a group of documents, and so on. To examine a document, one simply used the mouse to move a pointer on the screen to select the appropriate icon; clicking on the icon would then cause a "window" to open up on the screen so that the document could be viewed. As more documents were selected and opened, the windows would overlap, rather like the documents on a real desk would overlap one another.

The technology of user-friendliness long predated the personal computer, although it had never been fully exploited. Almost all the ideas in the modern computer interface emanated from two of the laboratories funded by ARPA's Information Processing Techniques Office in the 1960s: a small human-factors research group at the Stanford Research Institute (SRI) and David Evans's and Ivan Sutherland's much larger graphics research group at the University of Utah.

The Human Factors Research Center was founded at the SRI in 1963 under the leadership of Doug Engelbart, later regarded as the doyen of human-computer interaction. Since the mid-1950s, Engelbart had been struggling to get funding to develop a computer system that would act like a personal-information storage and retrieval machine—in effect replacing physical documents by electronic ones and enabling the use of advanced computer techniques for filing, searching, and communicating documents. When ARPA started its computer research program in 1962 under the leadership of J.C.R. Licklider, Engelbart's project was exactly in tune with Licklider's vision of "man-computer symbiosis." ARPA funds enabled Engelbart to build up a talented group of a dozen or so computer scientists and psychologists at SRI, where they began to develop what they called the "electronic office"—a system that would integrate text and pictures in a way that was then unprecedented but is now commonly done on computers.

The modern GUI owes many of its details to the work of Engelbart's group, although by far the best-known invention is the mouse. Several pointing devices were tried, but, as Engelbart later recalled, "[t]he mouse consistently beat out the other devices for fast, accurate screen selection in our working context. For some months we left the other devices attached to the workstation so that a user could use the device of his choice, but when it became clear that everyone chose to use the mouse, we abandoned the other devices." All this happened in 1965; "[n]one of us would have thought that the name would have stayed with it out into the world, but the thing that none of us would have believed either was how long it would take for it to find its way out there."

In December 1968 a prototype electronic office was demonstrated by Engelbart's group at the National Computer Conference in San Francisco. By means of a video projector, the computer screen was enlarged to twenty-foot width so that it could be clearly seen in the large auditorium. It was a stunning presentation, and although the system was too expensive to be practical, "it made a profound impression on many of the people" who later developed the first commercial graphical user interface at the Xerox Corporation.

The second key actors in the early GUI movement came from the University of Utah's Computer Science Laboratory where, under the leadership of David Evans and Ivan Sutherland, many fundamental innovations were made in computer graphics. The Utah environment supported a graduate student named Alan Kay, who pursued a blue-sky research project that in 1969 would result in a highly influential computer science PhD thesis. Kay's research was focused on a device, which he then called the Reactive Engine but later called the Dynabook, that would fulfill the personal-information needs of an individual. The Dynabook was to be a personal-information system, the size of a notebook, that would replace ordinary printed media. By using computer technology the Dynabook would store vast amounts of information, provide access to databases, and incorporate sophisticated information-finding tools. Of course, the system that Kay came up with for his PhD program was far removed from the utopian Dynabook. Nonetheless, at the end of the 1960s, Engelbart's electronic office and Kay's Dynabook concept were "the two threads" that led to the modern graphical user interface.

What held back the practical development of these ideas in the 1960s was the lack of a compact and cost-effective technology. In the mid-1960s a fully equipped minicomputer occupied several square yards of floor space and cost up to $100,000; it was simply not reasonable to devote that much machinery to a single user. But by the early 1970s prices were falling fast and it became feasible to exploit the ideas commercially. The first firm to do so was the Xerox Corporation, America's leading manufacturer of photocopiers.

In the late 1960s strategic planners in Xerox were becoming alarmed at the competition from Japanese photocopier manufacturers and saw the need to diversify from their exclusive reliance on the copier business. To help generate the products on which its future prosperity would depend, in 1969 Xerox established the Palo Alto Research Center (PARC) in Silicon Valley to develop the technology for "the office of the future." Approximately half of the $100 million poured into PARC in the 1970s was spent on computer science research. To head up this research, Xerox recruited Robert Taylor, a former head of the ARPA Information Processing Techniques Office. Taylor was an articulate disciple of Licklider's "man-computer symbiosis" vision, and his mission at PARC was to develop "an architecture of information" that would lay the foundations for the office products of the 1980s.

The concrete realization of this mission was to be a network of "Alto" desktop computers. Work on the Alto began in 1973, by which time a powerful team of researchers had been recruited—including Alan Kay from Utah; Butler Lampson and Charles Simonyi, originally from the University of California at Berkeley; and several other now well-known industry figures such as Larry Tesler. Many of PARC's academic recruits had been previous beneficiaries of support from ARPA's IPTO, but found it difficult to secure funding in the 1970s after the agency became more focused on mission-critical military research. In the course of developing the Alto, Xerox PARC evolved the graphical user interface, which became "the preferred style in the 1980s just as time-sharing was the preferred style of the 1970s."

The Alto computer was designed as a desktop computer with a specially constructed monitor that could display an 8½ × 11-inch sheet of "paper." Unlike ordinary terminals, it displayed documents to look like typeset pages incorporating graphical images—exactly as Kay had envisaged in the Dynabook. The Alto had a mouse, as envisaged by Engelbart, and the now-familiar desktop environment of icons, folders, and documents. In short, the system was all one would now expect from a Macintosh or a Windows-based IBM-compatible PC. However, all this was taking place in 1975, before the advent of personal computers, when "it was hard for people to believe that an entire computer" could be "required to meet the needs of one person."

Xerox decided to produce a commercial version of the Alto, called the Xerox Star computer—or, more prosaically, the model 8010 workstation. The new computer was the most spectacular product launch of the year when it was unveiled at the National Computer Conference in Chicago, in May 1981. With its eye-catching graphical user interface and its powerful office software, it was unmistakably a glimpse of the future. Yet, in commercial terms, the Xerox Star turned out to be one of the product disappointments of the decade. While Xerox had gotten everything right technically, in marketing terms it got almost everything wrong. Fundamentally, the Xerox Star was too expensive: it was hard to justify the cost of a year's salary for a powerful workstation when a simple personal computer could do much the same job, albeit less glamorously, for one-fifth of the cost. Despite being a failure in commercial terms, the Xerox Star presented a vision that would transform the way people worked on computers in the 1980s.

STEVE JOBS AND THE MACINTOSH

In December 1979 Steve Jobs was invited to visit Xerox PARC. When he made his visit, the network of prototype Alto computers had just begun to demonstrate Xerox's office-of-the-future concept, and he was in awe of what he saw. Larry Tesler, who demonstrated the machines, recalled Jobs demanding, "Why isn't Xerox marketing this? . . . You could blow everybody away!" This was of course just what Xerox intended to do with the Xerox Star, which was then under development.

Returning to Apple's headquarters at Cupertino, Jobs convinced his colleagues that the company's next computer would have to look like the machine he had seen at Xerox PARC. In May 1980 he recruited Tesler from Xerox to lead the technical development of the new computer, which was to be known as the Lisa.

The Lisa took three years to develop. When it was launched in May 1983, it received the same kind of ecstatic acclaim that the Xerox Star had received two years earlier. The Lisa, however, was priced at $16,995 for a complete system, which took it far beyond the budget of personal-computer users and even beyond that of the corporate business-machine market. Two years earlier Xerox, with its major strength in direct office sales, had not been able to make the Star successful because it was too expensive. Apple had no direct sales experience at all, and so, not surprisingly, the Lisa was a resounding commercial failure.

The failure of the Lisa left Apple dangerously exposed; its most successful machine, the aging Apple II, had been eclipsed by the IBM-compatible PC; its new machine, the Lisa, was far too expensive for the personal-computer market. What saved Apple Computer from extinction was the Macintosh.

The Macintosh project originated in mid-1979, as the idea of Jef Raskin, then manager of advanced systems at Apple. He had spent time at Xerox PARC in the early 1970s and conceived of the Macintosh as an "information appliance," which would be a simple, friendly computer that the user would simply plug in and use. Physically, he envisaged the machine as a stand-alone device, with a built-in screen and a small "footprint" so that it could sit unobtrusively on the user's desk, just like a telephone. The Macintosh was named for Raskin's favorite California-grown apple—and that, as it sadly turned out for Raskin, was one of the few personal contributions to the machine he was able to make before the project was appropriated by Jobs. Raskin left Apple in the summer of 1982.

A powerful mythology has grown up around the Macintosh development. Jobs cocooned the Macintosh design group of eight young engineers in a separate building over which—only half jokingly—a pirate's flag was hoisted. Jobs had a remarkable intuitive understanding of how to motivate and lead the Macintosh design team. John Sculley, later the CEO of Apple, recalled that "Steve's 'pirates' were a hand-picked band of the most brilliant mavericks inside and outside Apple. Their mission, as one would boldly describe it, was to blow people's minds and overturn standards. United by the Zen slogan 'The journey is the reward,' the pirates ransacked the company for ideas, parts, and design plans."

The Macintosh was able to derive all the key software technology from the Lisa project. The Lisa achieved its excellent performance by using specialized hardware, which was reflected in the high price tag. Much of the design effort in the Macintosh went into obtaining Lisa-like performance at a much lower cost.

In its unique and captivating case, the Macintosh computer was to become one of the most pervasive industrial icons of the late twentieth century. As the computer was brought closer to the market, the original design team of eight was expanded to a total of forty-seven people. Jobs got each of the forty-seven to sign his or her name inside the molding from which the original Macintosh case was pressed. (Long obsolete, those original Macintoshes are now much sought after by collectors.)

In early 1983, with less than a year to go before the Macintosh launch, Jobs persuaded Sculley to become CEO of Apple. This was seen by commentators as a curious choice because the forty-year-old Sculley had achieved national prominence by masterminding the relaunch of Pepsi-Cola against Coca-Cola in the late 1970s. But behind the move lay Jobs's vision of the computer as a consumer appliance that needed consumer marketing.

In what was one of the most memorable advertising campaigns of the 1980s, Apple produced a spectacular television advertisement that was broadcast during the Super Bowl on 22 January 1984:

> Apple Computer was about to introduce its Macintosh computer to the world, and the commercial was intended to stir up anticipation for the big event. It showed a roomful of gaunt, zombie-like workers with shaved heads, dressed in pajamas like those worn by concentration camp prisoners, watching a huge viewing screen as Big Brother intoned about the great accomplishments of the computer age. The scene was stark, in dull, gray tones. Suddenly, a tanned and beautiful young woman wearing bright red track clothes sprinted into the room and hurled a sledgehammer into the screen, which exploded into blackness. Then a message appeared: "On January 24, Apple Computer will introduce the Macintosh. And you'll see why 1984 won't be like 1984."

Apple ran the commercial just once, but over the following weeks it was replayed on dozens of news and talk shows. The message was reinforced by a blaze of publicity eventually costing $15 million. There were full-page newspaper advertisements and twenty-page

copy inserts in glossy magazines targeted at high-income readers.

Although priced at $2,500—only 15 percent of the cost of the Lisa—sales of the Macintosh after the first flush of enthusiasm were disappointing. Much of the hope for the Macintosh had been that it would take off as a consumer appliance, but it never did. Sculley realized that he had been misled by Jobs and that the consumer appliance idea was ill-conceived:

> People weren't about to buy $2,000 computers to play a video game, balance a checkbook, or file gourmet recipes as some suggested. The average consumer simply couldn't do something useful with a computer. Neither could the home market appreciate important differences in computer products. Computers largely looked alike and were a mystery for the average person: they were too expensive and too intimidating. Once we saturated the market for enthusiasts, it wasn't possible for the industry to continue its incredible record of growth.

Apple Computer was not the only manufacturer whose anticipation of a consumer market for personal computers was premature. In October 1983 IBM had launched a new low-cost machine, the PC Jr., hoping to attract Christmas buyers for the domestic market. The machine was so unsuccessful it had to be withdrawn the following year. If the domestic market for computers did not exist, then the only alternative was for Apple Computer to relaunch the Macintosh as a business machine.

Unfortunately the Macintosh was not well suited to the business market either. Corporate America favored an IBM-compatible personal computer for much the same reasons that an earlier generation had preferred IBM mainframes. The Macintosh fared much better in the less conservative publishing and media industries, where its powerful "desktop publishing" capabilities made it the machine of choice. The Macintosh was also popular in education, where its ease of use made it especially attractive for young children and casual student users.

Microsoft had been made privy to the Macintosh project in 1981, when it was contracted to develop some minor parts of the operating software. Although Microsoft had been successful with its MS-DOS operating system for IBM-compatible computers, it had very little success in writing applications such as spreadsheets and word processors in the face of strong competitors such as Lotus and MicroPro. The Macintosh enabled Microsoft to develop a range of technologically sophisticated applications, largely insulated from the much more competitive IBM-compatible market. Later it would be able to convert the same applications so that they would run on the IBM-compatible PC. By 1987 Microsoft was deriving half of its revenues from its Macintosh software.

More important, working on the Macintosh gave Microsoft firsthand knowledge of the technology of graphical user interfaces, on which it based its new Windows operating system for the IBM-compatible PC.

MICROSOFT'S WINDOWS

The launch of the Macintosh in January 1984 made every other personal computer appear old-fashioned and lackluster, and it was clear that the next big thing in personal computing would be a graphical user interface for the IBM-compatible PC.

In fact, following the launch of the Xerox Star in 1981, several firms had already started to develop a GUI-based operating system for the PC—including Microsoft, Digital Research, and IBM itself. The rewards of establishing a new operating system for the PC were immense—as Microsoft had already demonstrated with MS-DOS. The firm securing the new operating system would be assured of a guaranteed stream of income that would power its future growth.

The development of a GUI-based operating system for the PC was technologically very demanding for two reasons. First, the PC was never designed with a GUI in mind, and it was hopelessly underpowered. Second, there was a strategic problem in working around the existing MS-DOS operating system; one had to either replace MS-DOS entirely with a new operating system or else place the new operating system on top of the old, providing a second layer of software between the user's applications and the hardware. In the first case, one would no longer be able to use the thousands of existing software applications; but in the second case, one would have an inherent inefficiency.

Perhaps the company with the strongest motive for developing a GUI-based operating system was Gary Kildall's Digital Research, the original developer of CP/M, the operating system used on 8-bit microcomputers. It was estimated that 200 million copies of CP/M were eventually sold. As noted in the previous chapter, Kildall's Digital Research failed to obtain the contract to develop the IBM PC operating system, in favor of Gates's Microsoft. Although Digital Research did develop a PC operating system called CP/M 86, it was delivered too late, it was too expensive, and by Kildall's own account, it "basically died on the vine." The development of a new operating system presented a last chance for Digital Research to reestablish itself as the leading operating systems supplier.

Digital Research's GEM operating system (for Graphics Environment Manager) was launched in the spring of 1984. Unfortunately, as users quickly discovered, the system was in reality little more than a cosmetic improvement; although visually similar to the Macintosh, it lacked the capability of a full-scale operating system. Sales of GEM could not compensate for the ever-declining sales of Digital Research's CP/M operating system for the now largely obsolete 8-bit machines. In mid-1985, amid growing financial problems, Kildall resigned as CEO of Digital Research and the company he had formed faded from sight. IBM's TopView fared no better. It was released in 1984 but was so slow it "was dubbed 'TopHeavy' by customers and became one of the biggest flops in the history of IBM's PC business."

Microsoft Windows was the last of the new operating systems for the PC to appear. Microsoft began work on a graphical user interface project in September 1981, shortly after Gates had visited Steve Jobs at Apple and seen the prototype Macintosh computer under development. The Microsoft project was initially called the Interface Manager, but was later renamed Windows in a neat marketing move designed "to have our name basically define the generic." It was estimated that six programmer-years would be needed to develop the system. This proved to be a gross underestimate. When version 1 of Windows was released in October 1985—some two and a half years and many traumas after it was first announced—it was estimated that the program contained 110,000 instructions and had taken eighty programmer-years to complete.

Microsoft's Windows was heavily based on the Macintosh user interface—partly because it was a design on which it was very hard to improve, but also because it was felt the world would benefit from having a similar user interface in both Macintosh and Windows environments. On 22 November 1985, shortly after Windows was launched, Microsoft signed a licensing agreement with Apple to copy the visual characteristics of the Macintosh.

Although Windows was competitively priced at $99, sales were sluggish at first because it was "unbearably slow." This was true

even on the most advanced PC then available, which used the new Intel 286 microprocessor. Although a million copies were eventually sold, most users found the system little more than a gimmick, and the vast majority of users stayed with the aging MS-DOS operating system. Thus, in 1986, the PC GUI appeared to be technologically unsupportable on the existing generation of IBM-compatible computers. It would only be in the late 1980s, when the next generations of microprocessors—the Intel 386 and 486—became available, that the GUI would become truly practical. Only two firms had the financial stamina to persist with a GUI-based operating system: Microsoft and IBM. In April 1987 IBM and Microsoft announced their intention to jointly develop a new operating system, OS/2, for the next generation of machines. This would be the long-term replacement for MS-DOS.

Microsoft, meanwhile, was still being carried along by the revenues from MS-DOS and was beginning to succeed in the applications market at last, with its Excel spreadsheet and Word. Gates decided that, notwithstanding OS/2, there would be short-term gains to be derived from relaunching Windows to take advantage of its own improving software technology and the faster PCs. In late 1987 Microsoft announced a new release of Windows, version 2.0. This was a major rewrite of the earlier version and had a user interface that was not merely like the Macintosh interface—as had been the case with Windows 1.0—but was for all intents and purposes identical to it. It appeared that a convergence was taking place in which, by copying the look and feel of the Macintosh, the IBM-compatible PC would become indistinguishable from it and Apple's unique marketing advantage would be lost.

Three months later, on 17 March 1988, Apple filed a lawsuit alleging that Microsoft's Windows version 2 had infringed "the Company's registered audiovisual copyrights protecting the Macintosh user interface." (Microsoft's original 1985 agreement with Apple had covered only version 1 of Windows, and Microsoft had not sought to renew the agreement for version 2.) The suit was of enormous importance for the future of the personal-computer industry. If it were upheld, then it would have a severe negative effect on the great majority of users who did not use Macintosh computers and would be interpreted by developers as meaning that all user interfaces had to be different. If Apple were to succeed in the suit, it would be like a car manufacturer being able to copyright the layout of its instruments and every manufacturer having to ensure that its autos had a novel and different instrument layout. This would clearly be against the public interest.

The lawsuit would rattle on for three more years before it was finally dismissed. In the meantime, while the law ran its leisurely pace, Microsoft was achieving one of the most dramatic growth spurts of any business in the twentieth century, and Gates had become the world's youngest self-made billionaire. Some 2 million copies of Windows had been sold by early 1989, massively outselling IBM's OS/2 operating system, which had been launched in early 1988 (and in which Microsoft no longer expressed any interest). It was moot as to which of the systems was technically superior; the important factor was that Microsoft's marketing was much better.

Much of the software industry's rapid growth in the late 1980s, including that of Microsoft, was due to the ever-increasing sophistication of its products. Applications packages were routinely updated every eighteen months or so, generating additional revenues as users traded up for more sophisticated packages, making better use of rapidly improving hardware. Windows was no exception. Undeterred by the Apple-Microsoft lawsuit, by mid-1990 Windows was ready for yet another relaunch. It now consisted of 400,000 lines of code, nearly four times the size of the first version released in 1985. In total it was estimated to have cost $100 million to develop.

On 22 May 1990 Windows 3.0 was launched around the world:

> [S]ome 6,000 people were on hand as the City Center Theater in New York City became center stage for the multimedia extravaganza. Gala events took place in 7 other North American cities, which were linked via satellite to the New York stage for a live telecast, and in 12 major cities throughout the world, including London, Amsterdam, Stockholm, Paris, Madrid, Milan, Sydney, Singapore, and Mexico City. The production included videos, slides, laser lights, "surround sound," and a speech by Bill Gates, who proclaimed Windows 3 "a major milestone" in the history of software, saying that it "puts the 'personal' back into millions of MS-DOS-based computers."

Ten million dollars was spent on a blaze of publicity for Windows. By Gates's own account, it was "the most extravagant, extensive, and expensive software introduction ever."

In a way that became fully apparent only in the mid-1990s following the launch of Windows 95, Microsoft had come to own the "platform" of personal computing. This would give Microsoft an industry prominence comparable with that of IBM in its heyday.

CD-ROMS AND ENCYCLOPEDIAS

As well as software, users of personal computers wanted information—ranging from reference works such as encyclopedias and dictionaries to multimedia entertainment. By the late-1990s such information would be routinely obtained from the Internet, but even though consumer networks and online videotex services existed in the mid-1980s (discussed later in this chapter), the speed and capacity of these networks was simply too limited for supplying large volumes of information. The principal bottleneck was the *modem*—the device that connected a home computer to a network through a telephone line. To transmit an article—of, say, the length of a chapter in this book—would have taken thirty minutes; add a few images and that time would have been doubled. Until inexpensive high-speed communications arrived, the CD-ROM disc played a historic role in the way that large volumes of information were shipped to home computers.

The CD-ROM (Compact Disc-Read Only Memory) was the outcome of a joint research development by Sony and Philips in the early 1980s, and devices were first marketed in 1984. The CD-ROM was based on the technology of the audio CD and offered a storage capacity of over 500 megabytes—several hundred times that of a floppy disk. Although CD-ROM drives were expensive upon their introduction, costing $1,000 or more for several years, their huge capacity gave them the potential to create an entirely new market for computer-enabled content that the embryonic computer networks would not be able to satisfy for another fifteen years.

As long as the price of a CD-ROM drive remained around $1,000, its use was limited to corporations and libraries, mainly for business information and high-value publications. In the consumer arena, two of the industry leaders in personal-computer software, Gary Kildall and Bill Gates, played critical roles in establishing a market for CD-ROM media. Both Kildall and Gates hit on the idea of the CD-ROM encyclopedia as the means to establish the home market for CD-ROMs. Kildall explained: "Everyone knows encyclopedias usually cost about $1,000. Someone can rationalize buying a computer that has the encyclopedia, if it's in the same price range as the printed encyclopedia."

While still running Digital Research, Kildall started a new CD-ROM publishing operation as a separate company. He secured the rights to the *Grolier Encyclopedia*, a venerable junior encyclopedia established shortly after World War I. The *Grolier Encyclopedia* on CD-ROM was released in 1985, well ahead of any similar product. Priced at several hundred dollars, the Grolier CD-ROM can best be described as worthy but dull. It sold well to schools, but it did not induce consumers to invest in CD-ROM equipment.

Microsoft took much longer to get an encyclopedia onto the market. As early as 1985 Gates had tried to get the rights to the *Encyclopedia Britannica*, the leader in both content and brand. However, Encyclopedia Britannica Inc. was wary of cannibalizing its lucrative hard-copy sales, and in any case it already had a CD-ROM version of its lesser-known *Compton's Encyclopedia* under way. Next, Microsoft tried the *World Book Encyclopedia*, but it too had its own CD-ROM project in the pipeline.

Microsoft gradually worked its way down the pantheon of American encyclopedias, finally obtaining the rights to *Funk and Wagnall's New Encyclopedia* in 1989. *Funk and Wagnall's* had an unglamorous but profitable niche as a $3-per-volume impulse purchase in supermarkets. Microsoft's decision to acquire the rights to *Funk and Wagnall's* has frequently been derided as pandering to the educationally challenged working class, a criticism more than a little tinged by academic snobbery. But it was in truth very much a junior encyclopedia of negligible authority. Microsoft, however, proceeded to sculpt this unpromising material into *Encarta*, adding video and sound clips and other multimedia elements to the rather thin content. Released in early 1993 at a price of $395, it sold only modestly.

In fact, the CD-ROM encyclopedia did not turn out to be the killer application that would start the CD-ROM revolution. Quite independently, the cost of CD-ROM drives had fallen slowly but continuously over a period of about seven years, to a price of about $200 by 1992—comparable to that of a printer or a hard disk drive. With the fall in price of CD-ROM drives, there was at last the possibility of a mass market for CD-ROM media. In 1992 the recreational software publisher Broderbund released *Grandma and Me* for $20, which became an international bestseller and probably the best-known CD-ROM title of its time. Thousands of other titles from hundreds of publishers soon followed. At about the same time publishers of video games started to release CD-ROM titles with multimedia effects. The price of CD-ROM encyclopedias, so recently priced at several hundred dollars, fell into line. The price of *Encarta* was cut to $99 for the 1993 Christmas season, and its competitors followed suit.

The availability of low-cost CD-ROM encyclopedias had a devastating effect on the market for traditional hard-bound encyclopedias. As *Forbes* magazine put it:

> How long does it take a new computer technology to wreck a 200-year-old publishing company with sales of $650 million and a brand name recognized all over the world? Not very long at all. There is no clearer, or sadder, example of this than how the august Encyclopedia Britannica Inc. has been brought low by CD-ROM technology.

In 1996, under new ownership, a CD-ROM edition of the *Encyclopedia Britannica* finally hit the market for less than a hundred dollars. In 2012 the *New York Times* reported that the encyclopedia's current print edition would be its last—in "acknowledgement of the realities of the digital age."

THE RISE AND FALL OF VIDEOTEX

It sometimes seems that the Internet arrived from nowhere in the early 1990s, but in the United States, Europe, and Japan, vibrant information networks had already been established for businesses and consumers by the 1980s. Whereas in the United States such networks were largely developed by the private sector, elsewhere government sponsorship played a much greater role. The dominant technology of these subsidized networks was known as *videotex.*

Videotex evolved from a technology developed in the mid-1960s by RCA known as teletext, which provided a one-way transmission of text data to specially modified televisions. The British Broadcasting Corporation was an early adopter of teletext, and in the early 1970s the British Post Office moved to the forefront of research and development of an interactive videotex system—two-way communication using the telephone network. This system, initially called View Data, was soon branded as Prestel. The Post Office had an early lead in videotex systems when pilot tests of Prestel were conducted in 1976. Yet by 1985 Prestel had secured only 62,000 subscribers, far short of the original goal of 2 million. Inflated expectations and disappointing fates similarly characterized other national videotex systems including Germany's Bildschirmtext, Japan's CAPTAIN, and Canada's Telidon. Development of international standards and a videotex global network were hampered by politics and national pride as well as by the fact that each country had developed its own display standards.

But there was one magnificent exception—France. The French system, Minitel, thrived owing to political, technological, and cultural factors coupled with key early decisions by the French government. The 1973 Arab OPEC oil embargo, the United States' dominance in the computing industries, France's woeful telecommunications infrastructure (only 8 percent of French households possessed a telephone in 1970), and the growing recognition of the future importance of the services economy to developed countries all contributed to a sense of crisis in France in the early to mid-1970s. In 1974 the government's telecommunications agency—Direction Générale des Télécommunications—submitted a plan to add 14 million new phone lines in seven years to better position the country for growth in the increasingly services-oriented economic environment. By 1981, 74 percent of French households had telephones. And by 1989, that number had increased to 95 percent—a level roughly equal to or exceeding that in other major European nations and the United States.

British Telecom's Prestel and other videotex systems had lacked a compelling means of driving widespread public demand. To be sure, Prestel provided services such as weather information and transport timetables, but there were few consumer-oriented offerings such as online shopping, banking, entertainment, or chat rooms. Until the early 1980s Minitel grew slowly. However, France's eventual expansion of telephone service and infrastructure created a unique opportunity for the government to partially offset the rapidly rising costs of printing and distributing phone books, thereby providing the impetus for Minitel to take off. Between 1983 and 1991 the French government distributed more than 5 million Minitel units and developed an online telephone/address directory that people could use for free. The Minitel terminals, with their monochrome nine-inch screen and small keypads, cost approximately 500 francs (less than $100) to manufacture. The massive free distribution of these basic terminals (in place of white-page directories) led to

what economists call "network effects": more Minitel users generated the need for more service providers, more service providers attracted more users, and so on. The provision of new services, in turn, accelerated the demand for upscale Minitel units with larger screens and color monitors, which were sold or leased by France Télécom.

A further contribution to Minitel's financial success was the permissiveness of France Télécom and the French government regarding the types of services offered. One example from early in Minitel's history was the proliferation of "messageries roses," or sex-chat services. In 1987 "calls" to such sites "totaled 2 million hours a month, or close to half of all [Minitel] consumer calls at the time." This paralleled an Internet phenomenon of the 1990s, when *Penthouse* and *Playboy* were among the "top ten" most popular sites: late in the decade, these sites—along with "PornCity"—were receiving millions of visitors daily. As with the Internet, when more services and content became available on Minitel—from news and sports to travel, weather, and business—the proportion of sexually oriented material offered and usage declined. By 1992 Minitel had more than 20,112 services and the number of terminals distributed had reached nearly 6.3 million. In addition to home units, Minitel terminals were available in post offices and other public locations. Given Minitel's ease of use, the system had many unlikely IT adopters. For example, until the near-present, about 2,500 dairy farmers in northwestern France's Brittany region relied on Minitel to "call the inseminator when a cow [was] in heat or to request [that] the authorities come to haul away animal carcasses," to track market prices, and to relay the results of chemical tests on their dairy products.

Minitel was finally decommissioned in mid-2012. It had been an extraordinary development that, for more than twenty years, gave almost everyone in France facilities later associated with the Internet. Inevitably, the existence of Minitel inhibited France's mass adoption of the Internet until the early 2000s, but the country soon caught up.

CONSUMER NETWORKS IN THE UNITED STATES

In the United States neither the government nor videotex played a significant role in the early development of consumer networks. The leading consumer network throughout the 1980s was CompuServe. The network had originally been set up in 1969, as an old-line time-sharing service of the type described in Chapter 9. Unfortunately, CompuServe was established just as the fad for computer utilities was on the wane. Only after two years of heavy losses did it begin to turn a modest profit, selling time-sharing services to the insurance industry.

Rather like electric utilities, business-oriented time-sharing services suffered from wildly fluctuating demand. During nine-to-five office hours, the service was used to capacity, but in the evening when the business day was over, and on weekends, the system was heavily underused. In 1978, with the arrival of personal computers, CompuServe's founder and leader Jeff Wilkins saw an opportunity to sell this spare capacity to computer hobbyists. Working with the Midwest Association of Computer Clubs—which distributed the access software to its members—he created a service called MicroNet. Subscribers could access the system at off-peak times for a few dollars an hour. MicroNet proved very popular and Wilkins decided to extend the service nationally. However, he first had to get the access software into the hands of consumers nationwide. To do this he made an arrangement with the Tandy Corporation to distribute a $39.95 "starter kit" in its eight thousand Radio Shack stores. The kit included a user manual, access software, and $25 worth of free time.

Unlike CompuServe's corporate customers, who mainly wanted financial analysis programs and insurance services, home-computer users were much more interested in "content" and in communicating with other subscribers. Newspapers were signed up—starting with the *Columbus Dispatch* in 1980, but eventually including major newspapers such as the *New York Times*. CompuServe services included computer games, electronic mail, and a precursor to chat rooms that allowed users a forum through which they could communicate in real time. By summer 1984, CompuServe had 130,000 subscribers in three hundred cities, served by twenty-six mainframe computers and a staff of six hundred in its Columbus headquarters. For the basic monthly fee of $12/hour ($6 on nights and weekends), CompuServe subscribers could book an airline reservation, read newspapers, check a stock portfolio, browse a data bank or encyclopedia, and participate with bulletin boards by posting messages. It was also possible to use CompuServe for its original purpose: time-sharing on a large computer.

CompuServe was the most successful early consumer network, and for several years the number of subscribers exceeded those of all the other services put together. As PCs moved into the workplace, CompuServe also tapped the business market, offering "Executive Services"—primarily access to conventional databases such as Standard & Poor's company information service and Lockheed's Dialog information database. Users paid a premium for these services, which were shared between CompuServe and the information provider.

Although only about one in twenty computer owners used online services in the mid-1980s, such services were widely perceived as an opportunity with tremendous potential, and CompuServe began to attract some major competitors. The two most important were The Source and Prodigy. The Source was a network set up by the Reader's Digest Association and the Control Data Corporation, while Prodigy was created by Sears and IBM. In each case, one partner saw the network as an extension to its existing business while the other provided the computing know-how. Thus Reader's Digest Association saw consumer networks as a new form of publishing (which in time it became, though not until long after the Association had quit the business), and Sears saw the network as an extension of its famous mail-order catalog. Both organizations also had excellent distribution channels through which they could get access software into the hands of their subscribers. But success was elusive, and it proved very difficult to compete with CompuServe. The Source was sold to CompuServe in 1989, while Prodigy incurred huge losses before its owners abandoned it in 1996.

CompuServe's relative success benefited from network effects. At a time when users of one network could not communicate with those of another, it made sense to belong to the biggest network. By 1990, CompuServe had 600,000 subscribers and it offered literally thousands of services: from home banking to hotel reservations, from Roger Ebert's movie reviews to *Golf Magazine*. In 1987 CompuServe had extended into Japan (with a service called NiftyServe) and in the early 1990s it began a service in Europe.

CompuServe did, however, prove vulnerable to one newcomer in the mid-1980s: America On-Line (AOL). AOL's success was fairly modest until it developed a service for the Macintosh computer. Rather in the way the Macintosh carved a successful niche with its graphical user interface, the AOL service for the Macintosh benefited from developing a distinctive friendly interface. In 1991 the service was extended to the IBM-compatible PC, providing "an easy-to-use point-and-click interface anyone's grandmother could

install." As always with consumer networks, a major barrier was getting access software into the hands of consumers and inducing them to try out the service. AOL hit on the idea of inserting a floppy disc with access software in computer magazines, together with a free trial period. AOL became famous for "carpet-bombing" America with floppy discs and, later, CD-ROMs. By making the service free to try out, it encouraged hundreds of thousands of consumers to do just that. And because the service was user-friendly, many of them stayed on as paying customers. True, an even greater number did not stay, creating a phenomenon known as "churn"—whereby as many subscribers were said to be leaving as joining. Nonetheless, by the end of 1995 AOL claimed that it had 4.5 million subscribers (including many in Europe where, surprisingly, AOL did not feel the need to make its name less imperialistic).

THE INTERNET WAS to become overwhelmingly the most important development in computing from the mid-1990s onward. But this was possible only because in the previous decade the personal computer had been transformed from an unfriendly technological system into something approaching an information appliance. Software companies provided application programs that transformed the general-purpose personal computer into a special-purpose machine that met the needs of particular users—whether they were business analysts using spreadsheets, individuals word-processing documents, or players of games. While many of these applications simplified using a computer—for example, by making a word-processor program appear like a familiar typewriter—it was the graphical user interface that opened up the computer to the wider society. Instead of typing complicated commands, users could now simply point and click their way through the most complex software, while knowing essentially nothing about the inner workings of a computer.

Although the computer of the mid-1980s had become easier to use, it was an isolated machine. It was the modern replacement for the typewriter or electronic calculator, and even a popular new item in the games room—but it was no substitute for a library or a telephone. To become truly useful, the personal computer needed access to large quantities of information comparable with that of a modest library, and it needed the ability to communicate with other computers. CD-ROM technology, consumer networks, and videotex systems played complementary roles in this transformation. CD-ROM technology provided information in high volume, but it was information that was static and rapidly became obsolete. Consumer networks and videotex systems held large volumes of information, but users could obtain it only in tiny quantities as it trickled through the bottleneck of a modem. In the early years of the twenty-first century, the rise of the Internet and high-speed broadband connections would at last provide users with the information they needed at an acceptable speed.

12

THE INTERNET

IN THE EARLY 1990s the Internet—the system that links millions of computers around the world—became big news. In the fall of 1990 there were just 313,000 computers attached to the Internet; five years later the number was approaching 10 million, and by the end of 2000 the number had exceeded 100 million. Although computer technology is at the heart of the Internet, its importance is economic and social: the Internet gives computer users the ability to communicate, to gain access to information sources, and to conduct business.

I. From the World Brain to the World Wide Web

The Internet sprang from a confluence of three desires, two that emerged in the 1960s and one that originated much further back in time. First, there was the rather utilitarian desire for an efficient, fault-tolerant networking technology, suitable for military communications, that would never break down. Second, there was a wish to unite the world's computer networks into a single system. Just as the telephone would never have become the dominant person-to-person communications medium if users had been restricted to the network of their particular provider, so the world's isolated computer networks would be far more useful if they were joined together. But the most romantic ideal—perhaps dating as far back as the Library of Alexandria in the ancient world—was to make readily available the world's store of knowledge.

FROM THE ENCYCLOPEDIA TO THE MEMEX

The idea of making the world's store of knowledge available to the ordinary person is a very old dream. It was the idea, for example, that drove the French philosopher Denis Diderot to create the first great encyclopedia in the eighteenth century. The multivolume *Encyclopédie* was one of the central projects of the Age of Enlightenment, which tried to bring about radical and revolutionary reform by giving knowledge and therefore power to the people. The *Encyclopédie* was in part a political act; similarly, the Internet has a political dimension. The first English-language encyclopedia, the *Encyclopedia Britannica*, appeared in 1768 and was modeled directly on the *Encyclopédie.* Of course, neither the *Encyclopédie* nor the *Encyclopedia Britannica* could contain *all* of the world's knowledge. But they both contained a significant fraction of it and—at least as important—they brought order to the universe of knowledge, giving people a sense of what there was to know.

The nineteenth century saw an explosion in the production of human knowledge. In the early decades of the century, it was possible for a person of learning to be comfortable with the whole spectrum of human knowledge, in both the arts and the sciences. For example, Peter Mark Roget—now famous only as the compiler of the thesaurus—earned his living as a physician, but he was also an amateur scientist and a member of the Royal Society of London, an educationalist, and a founder of the University of London. And Charles Babbage, besides being famous for his calculating engines, was an important economist; he also wrote works on mathematics and statistics, geology and natural history, and even theology and politics.

By the twentieth century, however, the enormous increase in the world's knowledge had brought about an age of specialization during which it was very unusual for a person to be equally versed in the arts and the sciences, and virtually impossible for anyone to have a deep knowledge of more than a very narrow field of learning. It was said, for example, that by 1900 no mathematician could be familiar even with all the different subdisciplines of mathematics.

In the years between the two world wars, a number of leading thinkers began to wonder whether it might be possible to arrest this trend toward specialization by organizing the world's knowledge systematically so that, at the very least, people could once again know what there was to know. The most prominent member of this movement was the British socialist, novelist, and science writer H. G. Wells, best known in the United States as the author of *The War of the Worlds* and *The Time Machine.* During his own lifetime, Wells had seen the world's store of knowledge double and double again. He was convinced that narrow specialization—such that even educated people were familiar with no more than a tiny fraction of the world's knowledge—was causing the world to descend into barbarism in which people of learning were being "pushed aside by men like Hitler." During the 1930s he wrote pamphlets and articles and gave speeches about his project for a World Encyclopedia that would do for the twentieth century what Diderot had done for the eighteenth. Wells failed to interest publishers owing to the enormous cost of such a project and, in the fall of 1937, embarked on a US lecture tour hoping to raise funds.

He covered five cities, and his last venue, in New York, was also broadcast on the radio. In his talk, titled "The Brain Organization of the Modern World," Wells explained that his World Encyclopedia would not be an encyclopedia in the ordinary sense:

> A World Encyclopedia no longer presents itself to a modern imagination as a row of volumes printed and published once for all, but as a sort of mental clearing house for the mind, a depot where knowledge and ideas are received, sorted, summarized, digested, clarified and compared. . . . This Encyclopedic organization need not be concentrated now in one place; it might have the form of a network [that] would constitute the material beginning of a real World Brain.

Wells never explained how his "network" for the World Brain would be achieved, beyond supposing that it would be possible to physically store all the data on microfilm. All the information in the world would do no good, however, if it were not properly organized. He thus envisaged that "[a] great number of workers would be engaged perpetually in perfecting this index of human