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THE COMPUTER BECOMES A BUSINESS MACHINE

AN APOCRYPHAL tale about Thomas J. Watson Sr., the onetime president of IBM, claims that, probably around 1949, he decided that there was a market for no more than about a dozen computers and that IBM had no place in that business. This anecdote is usually told to show that the seemingly invincible leader of IBM was just as capable of making a foolish decision as the rest of the human race. Conversely, the story portrays as heroes those few individuals, such as Eckert and Mauchly, who foresaw a big market for computers. There is perhaps some justice in this verdict of posterity on the conservative Watson versus the radical Eckert and Mauchly. Another way of interpreting these responses to the computer is as the rational versus the irrational, based on business acumen and past experience. Thus Watson was rational but wrong, while Eckert and Mauchly were irrational but right. It could just as easily have been the other way around—and then Watson would have still been a major business leader, but not many people would have heard of Eckert and Mauchly.

What really happened in the 1950s, as suggested by the title of this chapter, is that the computer was reconstructed—mainly by computer manufacturers and business users—to be an electronic data-processing machine rather than a mathematical instrument. Once IBM had recognized this change, in about 1951, it altered its sales forecasts, rapidly reoriented its R&D, manufacturing, and sales organizations, and used its traditional business strengths to dominate the industry within a period of five years. This was a heroic achievement too, though not one of which myths are made.

In the late 1940s and early 1950s, some thirty firms entered the computer business in the United States. The only other country to develop a significant computer industry at this time was the United Kingdom, where, in an effort to
capture a share of what was seen as a promising new postwar industry, about ten computer companies came into being—size for size, a comparable performance with the United States. Britain even had the world’s first computer on the market. This was a machine known as the Ferranti Mark I, based on the Manchester University computer and delivered in February 1951. Unfortunately the enthusiasm for manufacturing computers in Britain was not matched with an enthusiasm for using them by its old-fashioned businesses, and by the end of the decade Britain’s computer industry was fighting for survival.

As for the rest of the world, all the industrially developed countries of continental Europe—Germany, France, Holland, and Italy—were so ravaged by World War II that they would not be capable of entering the computer race until the 1960s. The Eastern bloc and Japan were even slower to develop computers. Hence, for the 1950s, U.S. firms had the biggest market for computers—the United States—to themselves, and from this springboard they were able to dominate the world.

There were actually three types of firms that entered the computer industry: electronics and control equipment manufacturers, office-machine companies, and entrepreneurial startups. The electronics and control equipment manufacturers—including RCA, General Electric, Raytheon, Philco, Honeywell, Bendix, and several others—were the firms for whom the computer was the most “natural” product. They were well used to selling high-cost electronic capital goods, such as radio transmitters, radar installations, X-ray equipment, and electron microscopes. The computer, for which these firms coined the term “mainframe,” was simply another high-value item in their product line.

The second class of firm entering the computer market was the business-machine manufacturers such as IBM, Remington Rand, Burroughs, NCR, Underwood, Monroe, and Royal. They lagged the electronics firms by a couple of years because, quite rationally, they did not see the manufacture of mathematical computing instruments as being an appropriate business for them to enter. It was not until Eckert and Mauchly produced the UNIVAC computer in 1951, proving that computers had a business application, that they entered the race with conviction.

The third class of firm to enter the computer business—and in many ways the most interesting—was the entrepreneurial start-up. The period from 1948 to 1953 was a narrow window of opportunity when it was possible to join the computer business at a comparatively low cost, certainly less than a million dollars. A decade later, because of the costs of supplying and supporting peripherals and software, one would need $100 million to be able to compete with the
established mainframe computer companies. The first entrepreneurial computer firms were Eckert and Mauchly’s Electronic Control Company (set up in 1946) and Engineering Research Associates (ERA, also set up in 1946). These firms were soon taken over by Remington Rand to become its computer division: Eckert and Mauchly became famous as the pioneers of a new industry, while William Norris, one of the founders of ERA, moved on to found another company—the highly successful Control Data Corporation.

Following quickly on the heels of the Eckert-Mauchly company and ERA came a rush of computer start-ups, sometimes funded with private money, but more often the subsidiaries of established electronics and control companies. Firms emerging in the early fifties included ElectroData, the Computer Research Company, Librascope, and the Laboratory for Electronics. The luckiest of these firms were taken over by office-machine companies, but most simply faded away, unable to survive in the intensely competitive environment. The story of the Eckert-Mauchly company illustrates well the precarious existence shared by virtually all the start-up companies.

“More Than Optimistic”:

**UNIVAC and BINAC**

When Eckert and Mauchly established their Electronic Control Company in March 1946, they were almost unique in seeing the potential for computers in business data processing, as opposed to science and engineering calculations. Indeed, even before the end of the war, Eckert and Mauchly had paid several visits to the Bureau of the Census in Washington, canvassing the idea of a computer to help with census data processing, though nothing came of the idea at the time. The vision of computerized data processing probably came more from Mauchly than from Eckert. Thus, at the Moore School Lectures in the summer of 1946, while Eckert had talked about the technical details of computer hardware, Mauchly was already giving a lecture on sorting and collating—topics that really belonged in the world of punched-card business machines, not mathematical computation.

When Eckert and Mauchly set out to build their business, there were few venture-capital firms of the kind we are now familiar with. They therefore decided that the most effective way to fund the firm would be to obtain a firm order for their computer and use a drip feed of incremental payments to develop the machine. Those wartime visits to the Census Bureau paid off. In the spring
of 1946, the Bureau of the Census agreed to buy a computer for a total purchase price of $300,000. Eckert and Mauchly, who were hopelessly optimistic about the cost of developing their computer, thought it would cost $400,000 to develop the machine (much the same as ENIAC), but $300,000 was the best deal they could negotiate. They hoped to recover their losses in subsequent sales.

In fact, the computer would cost closer to a million dollars to develop. As one historian has noted, "Eckert and Mauchly were more than optimistic, they were naive." Perhaps it was a foolish way to start a business, but, like entrepreneurs before and after, Eckert and Mauchly wished away the financial problems in order to get on with their mission. If they had stopped to get financially rewarding terms, the project would likely have been strangled at birth. The contract to build an EDVAC-type machine for the Census Bureau was signed in October 1946, and the following spring the computer was officially named UNIVAC, for UNIVersal Automatic Computer.

Eckert and Mauchly started operations in downtown Philadelphia, taking the upper two stories of a men's clothing store at 1215 Walnut Street. A narrow-fronted building, though running deep, it was more than sufficient for the half-dozen colleagues they had persuaded to join them from the Moore School. By the autumn of 1947, there were about twelve engineers working for the company, all engaged in the various parts of the UNIVAC.

Eckert and Mauchly had embarked upon a project whose enormousness only began to reveal itself during this first year of the company's operation. Building the UNIVAC was much more difficult than simply putting together a number of ready-made subsystems, as would be the case when building a computer a decade later. Not even the basic memory technology had been established, so that one group of engineers was working on a mercury delay-line memory—and in the process of discovering that it was one thing to develop a system for laboratory use, but quite another to produce a reliable system for fuss-free use in a commercial environment.

The most ambitious feature of the UNIVAC was the use of magnetic-tape storage to replace the millions of punched cards used by the Census Bureau and other organizations and businesses. This was a revolutionary idea, which spawned several other projects. In 1947 the only commercially available tape decks were analog ones used in sound recording studios. A special digital magnetic-tape drive had to be developed so that computer data could be put onto the tape, and high-speed servomotors had to be incorporated so that the tape could be started and stopped very rapidly. Then it turned out that ordinary commercial magnetic tape, based on a plastic substrate, stretched unacceptably.
They now had to set up a small chemistry laboratory to develop tape-coating materials, and use a metallic tape that did not stretch. Next a machine had to be developed so that data could be keyed onto the tape, and then a printer so that the contents of a tape could be listed. Later, machines would be needed to copy decks of cards onto magnetic tape, and vice versa. In many ways the magnetic-tape equipment for the UNIVAC was both the most ambitious and the least successful aspect of the project.

Eckert and Mauchly were now both working intensely hard for very long hours, as was every engineer in the company. The company was also beset by financial problems, and to keep the operation afloat Eckert and Mauchly needed more orders for UNIVACs and more advance payments. These orders were not easy to come by. However, a few months earlier, Mauchly had been hired by the Northrop Aircraft Corporation to consult on guidance computers for the Snark long-range guided missile that the company was developing. Northrop decided it needed a small airborne computer, and Eckert and Mauchly were invited to tender for the development contract for this machine—to be called the BINAC (for binary automatic computer).

The BINAC would be a very different order of machine than the UNIVAC. It would be much smaller; it would be a scientific machine, not a data processor; and it would not use magnetic tape—perhaps the biggest task in Eckert and Mauchly’s portfolio. The contract to develop the BINAC would keep the company afloat, and yet it would also detract greatly from the momentum of the UNIVAC. But there was no real choice: It was the BINAC or go out of business. In October 1947 they signed a contract to develop the BINAC for $100,000, of which $80,000 was paid in advance.

Despite the distraction of the BINAC, the UNIVAC remained central to the long-term ambition of the company, and the search for UNIVAC orders continued. The most promising prospect was the Prudential Insurance Company, which Mauchly had first approached in 1946 to no avail, but whose interest had now started to revive. The Prudential was a pioneer in the use of office machinery and had even developed its own punched-card system in the 1890s, long before IBM punched-card machines were commercially available; so it was no surprise that it would become an early adopter of the new computer technology.

The Prudential’s computer expert was a man named Edmund C. Berkeley, who was to write the first semipopular book on computers, *Giant Brains*, published in 1949. Early in 1947, Mauchly and Berkeley had tried to convince the Prudential board to order a UNIVAC, but the company was unwilling to risk several hundred thousand dollars to buy an unproved machine from an unproved
company. However, after several months of negotiation, the Prudential agreed to pay $20,000 for Mauchly's consulting services, with an option to buy a machine when it was developed. It wasn't much, but every little bit helped, and there was after all the distant prospect that the Prudential would eventually buy a machine.

By the end of 1947 the Eckert and Mauchly operation was spending money much faster than it was recovering it, and it needed further investment capital. In order to attract investors they incorporated the company as the Eckert-Mauchly Computer Corporation (EMCC). Eckert and Mauchly were desperately seeking two things, investors and contracts for the UNIVAC.

In the spring of 1948, the A. C. Nielson market research firm in Chicago agreed to buy the second UNIVAC for $150,000, and toward the end of the year the Prudential offered to buy the third for the same price. This was a ludicrously unrealistic price tag, although, as always, Eckert and Mauchly wished away the problems. Buoyed up by the prospect of firm orders, more engineers, technicians, and draftsmen were recruited, and the company moved to larger premises, taking the seventh and eighth floors of the Yellow Cab Building on the edge of central Philadelphia. Eckert and Mauchly were now employing forty people, including twenty engineers, and they needed an additional $500,000 in working capital. This financial support would shortly be offered by the American Totalisator Company of Baltimore.

It so happened that Eckert and Mauchly's patent attorney was friendly with Henry Strauss, a vice president of American Totalisator. Strauss was a remarkable inventor. In the 1920s, he had perfected and patented a totalisator machine for racetrack betting that soon dominated the market. The totalisator was, in its way, one of the most sophisticated mechanical computing systems of its era. Strauss immediately saw that the UNIVAC represented a technological breakthrough that might prove a source of future competition in the totalisator field. In August 1948 he persuaded his company to take a 40 percent shareholding in the Eckert-Mauchly Computer Corporation. Strauss, an inventor himself, had the wisdom to leave Eckert and Mauchly in full control of their company, while he would provide mature guidance by serving as chairman of the board. American Totalisator offered about $500,000 for its share of EMCC and offered further financing through loans. It was a truly generous offer, and Eckert and Mauchly grasped it thankfully.

With financial stability at last, EMCC had turned the corner. True, virtually every deadline and schedule had been missed and the future promised nothing different, but this was to some extent to be expected in a high-tech company. The important thing was that the money from American Totalisator and the
contracts with the Census Bureau, Northrop, Nielson, and Prudential ensured that the company could expand confidently. The following spring, it moved for the third time in as many years, this time to a self-contained two-story building in North Philadelphia. A former knitting factory, when emptied of its plant, the interior was so vast that it was “difficult . . . to believe that we would ever outgrow this facility.” Situated at the foot of a hill, the area was so hot in the summer that they called it Death Valley.

As soon as they moved in, there was a burst of activity to complete the BINAC. The first American stored-program computer to operate, the BINAC was never a reliable machine. In the early summer a visiting Northrop engineer reported back that it was operating about one hour a week, “but very poorly.” It was only operating a little more reliably when it was finally shipped off to Northrop in September 1949. It never really performed to expectation, but then few early computers did, and Northrop was happy enough to pay the outstanding $20,000 of the $100,000 purchase price.

With the BINAC out of the way, Eckert and Mauchly could at last focus single-mindedly on the UNIVAC, for which three more sales had now been secured. EMCC was now a bustling company in its new headquarters, with 134 employees and contracts for six UNIVAC systems totaling $1.2 million. Things had never looked brighter. A few weeks later, however, Eckert and Mauchly received the news that Henry Strauss had been killed when his privately owned twin-engine airplane crashed. Since Strauss was the prime mover behind American Totalisator’s investment in EMCC, when he died so did American Totalisator’s commitment to the company. It pulled out and required its loans to be repaid. EMCC was immediately thrown into financial disarray, and all the old uncertainties resurfaced. It was as though someone had turned out the light.

IBM: Evolution, Not Revolution

Meanwhile IBM, the company that was to become Eckert and Mauchly’s prime competitor, was beginning to respond to the computer. As mentioned at the chapter’s opening, there is a myth that IBM made a fateful decision shortly after the war not to enter the computer business, made a swift reversal of policy about 1950, and by the mid-1950s had secured a position of dominance. What is most beguiling about this myth is that it is sufficiently close to the truth that people take it at face value. Yet where it is misleading is that it portrays IBM as sleeping soundly at the start of the computer race. The truth is more complex.
IBM had several electronics and computer development projects in the laboratories in the late 1940s; what delayed them being turned into products was the uncertainty of the market.

Immediately after the war, IBM (like the other accounting-machine companies such as Remington Rand, Burroughs, and NCR) was trying to respond to three critical business challenges: product obsolescence, electronics, and the computer. The first and most critical challenge was product obsolescence. All IBM's traditional electromechanical products were in danger of becoming obsolete because during the war most of its R&D facilities had been given over to military contracts such as the development of gun aimers and bomb sights. For the very survival of IBM's business, revamping its existing products had to be the top postwar priority.

The second challenge facing the office-machine companies was the threats and opportunities presented by electronics technology. Electronics had been greatly accelerated by the war, and IBM had itself gained some expertise by constructing code-breaking machines and radio equipment. The race was now on to incorporate electronics into the existing products. The third challenge was the stored-program computer. But in 1946, when the computer was a specialized mathematical instrument of no obvious commercial importance, it had to be the lowest priority; anything else would have been irrational. IBM institutionalized its attitude to electronics and computers through the slogan "evolution not revolution." By this, it meant that it would incorporate electronics into existing products to make them faster, but they would not otherwise be any different. Other industry pundits likened the office-machine manufacturers' attitude to electronics as similar to that of aircraft manufacturers toward the jet engine: The new technology would make their products faster but would not change their function.

Thomas Watson Sr., often portrayed as an electromechanical diehard, was in fact among the first to see the future potential of electronics. As early as October 1943 he had instructed his R&D chief to "find the most outstanding Professor on electronics and get him for IBM." Although cost was no object, no suitable candidate could be found because all the electronics experts were committed to the war effort at that time. Nothing more might have happened for a few years had there not been that unpleasant incident in August 1944 when the Mark I calculator was inaugurated at Harvard University, and Howard Aiken refused to acknowledge IBM's role in inventing and building the machine.

Watson decided to slight Aiken's Mark I by building a more powerful, electronic calculator. In March 1945 IBM hired Professor Wallace Eckert (no relation
to Presper) to establish the Watson Computer Laboratory at Columbia University and develop a "supercalculator" to be known as the Selective Sequence Electronic Calculator (SSEC). Watson's objective—apart from thumbling his nose at Aiken—was to ensure that IBM had in the Watson Computation Laboratory a test bed for new ideas and devices. It was not expected that the SSEC—or any other computing machine—would develop into a salable product. The decision to build the SSEC was made a couple of months before the publication of von Neumann's *EDVAC Report*. For this reason, the SSEC was a one-of-a-kind development that never became part of the mainstream of stored-program computing.

Meanwhile, IBM's product development engineers were responding to the less glamorous challenge of incorporating electronics into the company's existing products. The first machine to receive this treatment was the Model 601 multiplying punch, first marketed in 1934. The problem with this machine was that its electromechanical multiplier could handle only about 10 numbers per minute. The heart of the machine was ripped out and replaced with electronics—giving the machine a tenfold speed improvement, and it was now able to perform about 100 multiplications per minute. Containing approximately 300 vacuum tubes, the machine was first demonstrated at the National Business Show in New York in September 1946. It was marketed as the IBM Model 603, and about 100 machines were produced before it was replaced two years later by the much more versatile Model 604 calculating punch. The latter electronic workhorse went on to sell a staggering 5,600 units over a ten-year period. With 1,400 tubes and a limited programming capability, the 604 provided "speed and flexibility of operation unmatched by any calculator in the market for some time." More than that, the 604 also provided the heart of a powerful computing setup known as the CPC—the Card Programmed Calculator.

The CPC was developed in 1947 in a cooperative effort between IBM and one of its West Coast customers, Northrop Aircraft, the same company that had commissioned the BINAC from Eckert and Mauchly. Northrop was a heavy user of IBM equipment for calculating missile trajectories and took early delivery of a Model 603 multiplier. In order to improve the flexibility of the 603, the machine was hooked up to a specially developed storage unit and other punched-card equipment. The result was a highly effective calculating setup capable of about one thousand operations per second. Very quickly, news of Northrop's installation began to spread, particularly among West Coast aerospace companies, and by the end of 1948 IBM had received a dozen requests for a similar setup. This was the first demonstration that IBM had received that there was a significant market for scientific computing equipment.
IBM product engineers set to work to develop the CPC, in which the more powerful 604 calculating punch replaced the 603 multiplier. Customer deliveries began in late 1949. The CPC was not a true stored-program computer, but it was an effective and very reliable calculating tool in 1949 and 1950, when there were no commercially available computers on the market. Moreover, even when computers did become commercially available, the low cost and superior reliability of the CPC continued to make it the most cost-effective computing system available. Some 700 systems were delivered in the first half of the 1950s, more than the world total of stored-program computers at that date.

Commentators have often failed to realize the importance of the CPC, not least because it was called a "calculator" instead of a "computer." Watson insisted on this terminology because he was concerned that the latter term, which had always referred to a human being, would raise the specter of technological unemployment. It was why he had also insisted on calling the Harvard Mark I and the SSEC calculators. But the fact remained that so far as effective scientific-computing products went, IBM had the lead from the very beginning.

Thus by 1949 IBM had built up an excellent R&D capability in computers. As well as the CPC, there was the SSEC, which was completed in early 1948. Although this was a one-of-a-kind development and not technically a stored-program computer, it was the most advanced and powerful machine available when it was completed. Watson had the machine placed on public view on the ground floor of the IBM headquarters in Manhattan. One overseas visitor wrote:

This machine was completed and put into operation by IBM at their Headquarters in New York early in 1948. It could be seen from the street by passing pedestrians who affectionately christened it "Poppa." It was a very large machine and contained 23,000 relays and 13,000 [tubes]... The machine in operation must have been the most spectacular in the world. Thousands of neon lamps flashed on and off, relays and switches buzzed away and the tape readers and punches worked continuously.

IBM courted publicity about the machine. Staff writers for The New Yorker reported that "[p]eople who just want to look at the calculator, as we did, are always welcome," and were themselves given a conducted tour by Robert Seeber Jr., a senior engineer. The magazine produced a wonderful vignette of the machine that reflected exactly the popular fascination with "electronic brains":

The principal cerebral parts of the machine are tubes and wires behind glass panels, covering three walls of the room. Two hoppers, looking rather like
oversized mailboxes, stand near the middle of the room. One is the “in” hop-
per, into which questions are inserted on punched cards or tapes; the other is
the “out” hopper, from which, if all goes well, the answer emerges. High on
one wall of the room is a large sign reading “THINK,” but this admonition
isn’t addressed to the calculator. . . . The calculator has tackled any number of
commercial problems. When we arrived, it was just warming up for one that
involved getting more oil out of oil fields. . . . As we moved along, relays be-
gan to rattle in a carefree manner and patterns of light danced across the pan-

The SSEC did a great deal to enhance IBM’s reputation as a leader in com-
puter technology. There was, however, no prospect that the SSEC could become
a product. It cost far too much ($950,000) and was technically obsolete as soon
as it was built. Its real importance to IBM, apart from publicity and image, was
to create a cadre of experienced computer engineers.

IBM also had two further full-scale computers under development in 1949:
the Magnetic Drum Calculator (MDC) and the Tape Processing Machine
(TPM). The MDC was to sell for perhaps a tenth of the price of a UNIVAC, but
would give true stored-program computing for the kinds of firms currently us-
ing the CPC, as well as for ordinary business users currently using punched-card
machines. The key money-saving technology behind it was to use a magnetic
drum for the main memory, instead of mercury delay lines or electrostatic stor-
age tubes. The drum memory consisted of a rapidly rotating magnetized cylin-
der, which made for a very economical and reliable form of memory, but also
one that was quite slow.

IBM’s Tape Processing Machine was much more on a par with the UNIVAC.
As early as 1947, IBM had begun to explore the phenomenon of magnetic-tape
recording and its potential as a replacement for punched cards in data processing,
but the project moved slowly because of the competing demands of the SSEC.
However, in mid-1949 reports of activities at the Eckert-Mauchly operation be-
gan to filter through to IBM—first, the successful completion of the BINAC, and
second, the news that several orders had been taken for UNIVACs. The latter
news convinced IBM to accelerate the TPM so that it would have a large, tape-
based data-processing computer that would be competitive with UNIVAC.

If IBM had pressed on with either or both of these computers in 1949 or
1950, it would have dominated the market for data-processing computers
much earlier than it did. In fact, these machines did not reach the market for
another five years. The delay of the MDC was due largely to conservatism in
IBM’s marketing. In 1949 the view in IBM’s “Future Demands” department was
that the MDC was too expensive to compete with ordinary punched-card ma-
chines but too slow to compete with the UNIVAC. The delay with the Tape Pro-
cessing Machine, however, had quite different causes: the start of the Korean
War and a strategic decision made by Watson’s son, Thomas J. Watson Jr.

By 1950 Watson senior was in his mid-seventies, and while he remained
president and chief executive of IBM until 1956, his thirty-five-year-old elder
son was being groomed to lead the company. Thomas J. Watson Jr. joined IBM
as a young man in 1937, learning the ropes as a salesman. After war service he
returned to IBM in 1945, and four years later was made an executive vice presi-
dent. When the Korean War broke out in June 1950, as in previous emer-
gencies, Watson senior telegraphed the White House and put IBM at the
president’s disposal. While Watson senior’s motive was “primarily patriotic,”
Watson junior “seized on the idea as an opportunity to speed the company’s
development of large-scale computers.” Market reports indicated that there
would be a potential market for at least six large-scale scientific computers with
defense contractors, so Watson junior committed the company to developing a
computer based on the machine that von Neumann was building at the Insti-
tute of Advanced Study.

This would be a very powerful machine indeed; initial estimates put the rental
at $8,000 per month—equivalent to a purchase price of $500,000—an estimate
that turned out to be just about half of the eventual cost. In order to develop the
Defense Calculator, as the machine was called, the resources devoted to the Tape
Processing Machine had to be taken away. In effect, Watson’s decision to build the
Defense Calculator in the summer of 1950, while accelerating IBM’s entry into
scientific computers, dashed its chances of an early entry into the data-processing
market. It was a business error, one that allowed Eckert and Mauchly to capture
the early market for data-processing computers with the UNIVAC.

UNIVAC Comes to Life

It will be recalled that in late 1949, Eckert and Mauchly had just learned of the
withdrawal of American Totalisator and were urgently seeking a new backer to
sustain the momentum of the UNIVAC development and fund the payroll for
their 134 employees in Philadelphia. Eckert and Mauchly were, of course, al-
ready well known to corporations with an interest in computers. Indeed, when
the BINAC had been inaugurated in August 1949, representatives from several
companies, including IBM and Remington Rand, had attended.
Early in 1950 Eckert and Mauchly decided that they would have to try to sell the company to IBM. They secured an interview—for an unexplained purpose—with the Watsons, father and son, in their New York office. Tom Watson Jr. recalled the interview:

I was curious about Mauchly, whom I'd never met. He turned out to be a lanky character who dressed sloppily and liked to flout convention. Eckert, by contrast, was very neat. When they came in, Mauchly slumped down on the couch and put his feet up on the coffee table—damned if he was going to show any respect for my father. Eckert started describing what they'd accomplished. But Dad had already guessed the reason for their visit, and our lawyers had told him that buying their company was out of the question. UNIVAC was one of the few competitors we had, and antitrust law said we couldn't take them over. So Dad told Eckert, "I shouldn't allow you to go on too far. We cannot make any kind of arrangement with you, and it would be unfair to let you think we could. Legally we've been told we can't do it."

Eckert took the point immediately and thanked the Watsons for their time, even though the interview had been unproductive, while "Mauchly never said a word; he slouched out the door after an erect Eckert." Perhaps Watson's recollection says as much about his own values and those of IBM as it does about those of Mauchly. But it was quite plain that Mauchly would never have fit in with the IBM culture. In any case the Watsons must surely have judged that Eckert and Mauchly would bring very little to IBM that it did not already have under development; by 1950 the company had well over a hundred R&D workers engaged in electronics and computer research, an effort that comfortably matched that of Eckert and Mauchly's company.

Remington Rand and NCR were also interested in making some kind of agreement with Eckert and Mauchly, and the entrepreneurs were "so desperate that they were ready to consider the first reasonable offer." Remington Rand got its bid in first.

In fact, even before the end of World War II, James Rand Jr., the charismatic president of Remington Rand, had drawn up a grand postwar expansion plan. He had been deeply impressed by the application of science to wartime activities, and he intended that after the war Remington Rand would develop a whole raft of high-technology products, many of them incorporating electronics. These would include microfilm recorders, xerographic copiers, industrial television systems, and so on. In late 1947 he recruited General Leslie R. Groves, the
famous administrative chief of the Manhattan Project, to coordinate the research effort and head Remington Rand’s development laboratories. Groves’s involvement with atomic weapons research during the war had made him aware of the ENIAC and of Eckert and Mauchly’s company; he well understood that computers would come to play an important role in the office. James Rand invited Eckert and Mauchly down to his retreat in Florida, where they were royally entertained aboard his yacht, and he made them an offer: Remington Rand would repay all of American Totalisator’s investment in the company—amounting to $438,000—would pay Eckert, Mauchly, and their employees $100,000 for the stock they owned, and would retain Eckert and Mauchly at a salary of $18,000 per year. It was not a wonderful offer, for they would now become mere employees of the company they had founded, but there was no real alternative. Eckert and Mauchly accepted, and the Eckert-Mauchly Computer Corporation became a wholly owned subsidiary of Remington Rand. Although nominally under the direction of Groves, the general wisely avoided disrupting the UNIVAC operation or relocating the engineering program. Rather, he let things roll along with the considerable momentum Eckert and Mauchly had already built up.

While Remington Rand took a relaxed view of the firm’s engineering development, it rapidly set the chronic financial condition to rights. After one of their visits to the Eckert-Mauchly operation, Rand and Groves and their financial advisers realized that the UNIVAC was being sold at perhaps a third of its true cost. First they approached the Census Bureau to try to renegotiate the price, threatening somewhat abrasively to cancel the order otherwise. The Census Bureau threatened to countersue, so the original price of $300,000 had to stand. The Prudential and Nielson machines had been offered at the giveaway price of $150,000, whereas Remington Rand now realized it could not make a profit on anything less than $500,000. In order to extricate itself from their contractual obligations, Remington Rand threatened to involve the Prudential and Nielson in court proceedings that would hold up delivery of the UNIVAC for several years, by which time it would be obsolete. Nielson and Prudential canceled their contracts and had their money returned. Eventually both bought their first computers from IBM.

While these negotiations were going on in the background, Eckert and Mauchly focused on completing the first UNIVAC. By the spring of 1950 it was at last beginning to take shape: “first, one bay was set up on the floor, then another, and another.” As ever, Eckert was the hub around which the whole project revolved. Still a young man, in his early thirties, he worked longer hours than anyone:
Each day he worked a little later and consequently was forced to arrive a little later in the morning. As the days went by, his work period slipped later and later into the day and then the evening. Finally he had to take a day off so that he could get re-phrased and come in with everyone else in the morning.

Eckert had always had a curious habit of having to work out his ideas by talking them through with someone who could act as a sounding board. In the ENIAC days it had been Mauchly who had been the sounding board, but now it was usually one of the other engineers:

Pres's nervous energy was so great he couldn't sit in a chair or stand still while he was thinking. He usually crouched on top of a desk or else paced back and forth. In many of his discussions with [one of his engineers], the pair started out at the computer test site, walked to the back of the second floor, then down a flight of steps to the first floor. After an hour or so, they would arrive back at the test site, having made a circular tour of the building, but completely oblivious to the fact that they had done so. The intensity of their discussions locked out all distractions.

By contrast, Mauchly had a laid-back, laconic style: "John was always a great morale booster for everyone. His sense of humor penetrated the black clouds. He spoke in a slow, halting way as he related one interesting anecdote after another."

By the summer of 1950 the UNIVAC subsystems were close to completion and were being tested in the baking Philadelphia heat. The equipment was located on the second floor of the UNIVAC building, beneath an uninsulated flat black roof. There was no air-conditioning, and even if there had been it could not have begun to dissipate the 120 kilowatts of heat produced by the 5,000-tube machine. First neckties and jackets were discarded; a few days later further layers of clothing were dispensed with; and finally "shorts and undershirts became the uniform of the day." One engineer recalled of another: "He had a half dozen soda bottles sitting on the edge of his desk and every once in a while, he reached for a soda bottle, placed it over the top of his head, and poured. The bottles were filled with water!"

By the beginning of 1951, UNIVAC was functioning as a computer and would soon be ready to commence its acceptance tests for the Census Bureau. Before this was possible, however, some basic software had to be developed. The programming team was initially led by Mauchly, but was later run by a programmer recruited from the Harvard Computation Laboratory, Grace Murray
Hopper, who would become the driving force behind advanced programming techniques for commercial computers and the world’s foremost female computer professional.

On 30 March 1951 UNIVAC ran its acceptance tests, performing all together some seventeen hours of rigorous computing without a fault. The machine then became the property of the Census Bureau. Over the following year, two more UNIVACs were completed and delivered to the government, and orders for a further three were taken.

In late 1952, Remington Rand achieved a spectacular publicity stunt for UNIVAC. The company persuaded the CBS television network to use UNIVAC to predict the outcome of the presidential election. Some months before the election, John Mauchly, with the help of a statistician from the University of Pennsylvania, devised a program that would use the early returns from a number of key states to predict the result, based on the corresponding voting patterns in 1944 and 1948.

On election night CBS cameras were installed in the UNIVAC building in Philadelphia with reporter Charles Collingwood as the man on the spot. At CBS headquarters, Walter Cronkite served as anchorman, while in the studio a dummy UNIVAC console was installed for dramatic effect—the drama being heightened by flickering console lights, driven by nothing more sophisticated than blinking Christmas tree lights.

The UNIVAC printed its first prediction at 8:30 P.M.:

IT'S AWFULLY EARLY, BUT I'LL GO OUT ON A LIMB
UNIVAC PREDICTS—WITH 3,398,745 VOTES IN—

<table>
<thead>
<tr>
<th>STATES</th>
<th>STEVENSON</th>
<th>EISENHOWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td></td>
<td>43</td>
</tr>
<tr>
<td>ELECTORAL</td>
<td></td>
<td>438</td>
</tr>
<tr>
<td>POPULAR</td>
<td>18,986,436</td>
<td>32,915,049</td>
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THE CHANCES ARE NOW 00 TO 1 IN FAVOR OF THE ELECTION OF EISENHOWER.

UNIVAC was forecasting a landslide for Eisenhower—in complete contrast to the Gallup and Roper opinion polls taken the previous day, which had predicted a close race. A member of the UNIVAC team recalled:

Our election officials ... looked on in disbelief. The computer called for an Eisenhower victory by an overwhelming landslide. The odds by which he would win exceeded the two digits allowed in the program; thus the printout
showed 00 to 1 instead of 100 to 1. The officials put their heads together and said “We can't let this go out. The risk is too great.” It was beyond their comprehension that with so few votes counted the machine could predict with such a degree of certainty that the odds would be greater than 100 to 1.

The UNIVAC operators quickly adjusted the parameters of the program, so that it would produce more believable results. At 9:15, the UNIVAC’s first broadcast prediction anticipated an Eisenhower win with the more modest odds of 8 to 7. But as the night wore on, it became clear that a landslide was indeed developing. A UNIVAC spokesman later appeared on television to come clean and admit to the suppression of UNIVAC’s original prediction. The final result was a win for Eisenhower against Stevenson of 442 to 89 electoral votes—within a whisker of UNIVAC’s original prediction of 438 to 93.

Of course, UNIVAC’s programmers and Remington Rand’s managers kicked themselves for holding back the initial prediction, but they could hardly have invented a more convincing demonstration of the apparent infallibility of a computer. Or, rather, of a UNIVAC—for UNIVAC was rapidly becoming the generic name for a computer. The appearance of the UNIVAC on election night was a pivotal moment in computer history. Before that date, while some people had heard about computers, very few had actually seen one; after it, the general public had been introduced to computers and had seen at least a mock-up of one. And that computer was called a UNIVAC, not an IBM.

**IBM’s Big Push**

In fact, IBM had begun to see the writing on the wall several months before UNIVAC’s election night stunt. It was the launch of the Census Bureau UNIVAC eighteen months earlier that had galvanized IBM into action. According to Watson junior, he first learned of the completion of the UNIVAC from the chief of IBM’s Washington office while they were having a routine meeting. It came to Watson as a bolt from the blue:

I thought, “My God, here we are trying to build Defense Calculators, while UNIVAC is smart enough to start taking all the civilian business away!” I was terrified.

I came back to New York in the late afternoon and called a meeting that stretched long into the night. There wasn’t a single solitary soul in IBM who grasped even a hundredth of the potential the computer had. We couldn’t
visualize it. But the one thing we could understand was that we were losing business. Some of our engineers already had a fledgling effort under way to design a computer for commercial applications. We decided to turn this into a major push to counter UNIVAC.

There was a great deal of ego at the top of IBM, and Watson junior was creating his own mythology. It was absurd to say, as Watson did, that "There wasn't a single solitary soul in IBM who grasped . . . the potential the computer had." As we have seen, IBM had, in the five or six years since the war, developed a superb organizational capability in electronics and computers, and even had two serious data-processing computers under arrested development (the Tape Processing Machine and the Magnetic Drum Calculator). It was a consequence of Watson's autocratic management style that he had—essentially on a hunch—promoted the Defense Calculator to the detriment of the two data-processing computers.

However, one advantage of Watson's autocratic style was that once he had decided that IBM had to move into data-processing computers in a big way—and had convinced his father—it could be made to happen by decree. As of the spring of 1951, IBM had three major computer projects running full steam ahead: the Defense Calculator, the Tape Processing Machine, and the low-cost Magnetic Drum Calculator. These would later emerge as Models 701, 702, and 650. Watson recalled: "People at IBM invented the term 'panic mode' to describe the way we operated: there were moments when we thought we were aboard the Titanic." The development cost of the three concurrent projects was enormous, and large numbers of R&D workers had to be recruited. A year later, 35 percent of IBM's laboratory staff was working on electronics, 150 of them on the Defense Calculator alone.

The Defense Calculator, renamed Model 701, was the farthest along of the projects. Originally expected to rent for $8,000 per month, the machine had quickly taken ten orders. In early 1952, however, it became clear that the machine would have to rent for about twice that amount—equivalent to a purchase price of about $1 million, much the same as the UNIVAC was turning out to cost. Customers who had written initial letters of intent for the machine had to be advised of the new rental, but fortunately for IBM most of the orders held up at the revised price. This ready acceptance of the new price reflected the greater maturity and knowledge of computer buyers in 1952: Large, fast scientific computers were going to cost about $1 million, regardless of who made them.

Surprisingly, many conservatives within IBM still argued against developing the Tape Processing Machine, maintaining as late as 1953 that conventional
punched-card machines would be cheaper and more cost-effective. However, this failed to take account of the fact that computers were hot news, and business magazines were buzzing with stories about electronic brains for industry and commerce. Cost-effectiveness was no longer the only reason, or even the most important reason, for a business to buy a computer. A January 1952 article in Fortune magazine titled “Office Robots” caught the mood exactly:

The longest-haired computer theorists, impatient of half measures, will not be satisfied until a maximum of the human element and paper recording is eliminated. No intervening clerical operators. No bookkeepers. No punched cards. No paper files. In the utility billing problem, for instance, meter readings would come automatically by wire into the input organs of the central office’s electronic accounting and information processing machine, which, when called on, would compare these readings with customers’ accounts in its huge memory storage, make all computations, and return the new results to storage while printing out the monthly bills.

Of course, this journalistic hyperbole was little short of science fiction, but Watson and IBM’s sales organization realized by this time that IBM had to be seen as an innovator and had to develop a data-processing computer, whether or not it made money.

The first Model 701 scientific computer came off the production line in December 1952, and IBM derived the maximum publicity it could. In a dramatic out-with-the-old-in-with-the-new gesture, designed in part to draw attention away from the UNIVAC, the 701 was installed in the IBM showroom in its New York headquarters—in the place that had been occupied by the SSEC, which was now unceremoniously dismantled.

IBM’s first real data-processing computer, the Model 702—based on the TPM—was announced in September 1953. By the following June, IBM had taken fifty orders. However, deliveries did not begin until early 1955, four years after delivery of the first UNIVAC. During the eighteen months between the announcement of the 702 and the first deliveries, it was only Remington Rand’s inability to deliver more UNIVACs that enabled IBM to protect its order book.

Although the IBM 702 Electronic Data Processing Machine (EDPM) had superficially much the same specification as the UNIVAC, in the underlying engineering there were major differences that enabled IBM’s product quickly to outdistance the UNIVAC in the marketplace. Instead of the mercury delay lines chosen for the UNIVAC, IBM decided to license the Williams Tube technology
developed for the Manchester University computer in England. Both were difficult and temperamental technologies, but the Williams Tube memory was probably more reliable and certainly twice as fast. The magnetic-tape systems on the 700 series were far superior to those of the UNIVAC, which were never completely satisfactory and required constant maintenance. Developing a successful magnetic-tape system was much more of a mechanical-engineering problem than an electronic one, and IBM’s outstanding capability in electromechanical engineering enabled it to make a system that was much faster and more reliable.

Another advantage over the UNIVAC was that IBM’s computers were modular in construction—that is, they consisted of a series of “boxes” that could be linked together on site. In addition to making shipment easier, modular construction led to greater flexibility in the size and specification of a machine. By contrast, the UNIVAC was such a monolith that just moving it from the factory to a customer’s site was a major operation. Unlike UNIVAC, IBM set sizes of components to fit into standard elevators. Indeed, the first UNIVAC for the Census Bureau spent its first several months being run in the Philadelphia plant rather than risk moving it. Finally, IBM’s greatest advantage was its reputation as a service-oriented vendor. Recognizing the importance of training from the very beginning, it organized programming courses for users and established field-engineering teams that provided a level of customer service superior to that offered by any other vendor.

In fact, neither the 701 nor the 702 proved to be quite the “UNIVAC-beater” that IBM had hoped. For both machines, the Williams Tube memories proved troublesome, making them unreliable by IBM’s normal high standards. By 1953, however, a new technology known as core memory had been identified. Several groups worked independently on core memories, but the most important development was the work of Jay Forrester at MIT (see chapter 7). Although it was still a laboratory prototype at this time, IBM mounted a crash research program to develop core memory into a reliable product. More reliable and faster core-memory versions of the 701 and 702 were announced in 1954 as the Model 704 scientific computer and the Model 705 EDPM.

According to Watson junior, 1955 was the turning point for IBM. That year, orders for IBM’s 700 series computers exceeded those for UNIVACS. As late as August 1955, UNIVACs had outsold 700s by about 30 to 24. But a year later, there were 66 IBM 700 series installations in place compared with 46 UNIVAC; and there were, respectively, 193 to 65 machines on order.

Yet it was not the large-scale 700 series that secured IBM’s leadership of the industry, but the low-cost Magnetic Drum Calculator. The machine was announced as the Model 650 in 1953 and rented for $3,250 a month (the equiva-
lent of a purchase price of about $200,000). Although only a quarter of the cost of a 701, it was still a very expensive machine—costing up to twice as much as comparable machines from other makers. However, it succeeded in the market by virtue of its superior engineering, reliability, and software. Eventually 2,000 of these machines were delivered, yielding revenues far exceeding those of the entire 700 series.

As Watson junior observed: “While our giant, million-dollar 700 series got the publicity, the 650 became computing’s ‘Model T.’” With an astute understanding of marketing, IBM placed many 650s in universities and colleges, offering machines with up to a 60 percent discount provided courses were established in computing. The effect was to create a generation of programmers and computer scientists nurtured on IBM 650s, and a trained workforce for IBM’s products. It was a good example of IBM’s mastery of marketing, which was in many ways more important than mastery of technology.

With the success of the 650, IBM rapidly began to eclipse Remington Rand’s UNIVAC division. Even so, since the launch of the first UNIVAC in 1951, Remington Rand had not been sitting idly by, but had been actively expanding its computer division. In 1952 it had acquired the small Minneapolis-based start-up, Engineering Research Associates, which developed Remington Rand’s first scientific computer, the UNIVAC 1103. In mid-1955 Remington Rand merged with Sperry Gyroscope—and was renamed Sperry Rand—to further develop its technology. But in 1954 or 1955 it had already begun to slip behind IBM. Part of the reason for this was a failure in Remington Rand’s marketing: The company had been nervous that computers might lower sales of its traditional punched-card equipment and had therefore failed to integrate its punched-card and computer sales staff, often missing sales opportunities. Other reasons for Remington Rand’s decline were infighting between its Philadelphia and Minneapolis factories and its unwillingness to invest heavily enough in computer software and marketing. While UNIVAC was still the public’s idea of a computer, corporate decision makers were beginning to favor IBM. In the memorable phrase of the computer pundit Herb Grosch, in losing its early lead to IBM, Remington Rand “snatched defeat from the jaws of victory.”

The Computer Race

Although the story of IBM versus UNIVAC is a fair metaphor for the progress of the computer industry in the 1950s, the picture was much more complicated. The scene was one of a massive shakeout toward the end of the 1950s.
In the early 1950s the electronics and control manufacturers had been able to participate in the computer business by making machines for science and engineering, if not profitably, then with tolerable losses. By the end of the decade, however, as the computer was transformed into a business machine manufactured and sold in high volumes, these companies were all faced with the same decision: Whether to exit the business or to spend the enormous sums necessary to develop peripherals and applications software, and pay for the marketing costs, to compete with IBM. Of the major firms, only three—RCA, GE, and Honeywell—chose to commit the resources to stay in the race. The remainder, including such established companies as Philco and Raytheon, fell by the wayside.

However, by far the most vulnerable firms were the small computer start-ups, of whom very few survived into the 1960s. They included firms such as the Computer Research Company (CRC—a spin-off of Northrop Aircraft Corporation), Datamatic (a joint venture of Honeywell and Raytheon), Electrodata, the Control Data Corporation (CDC), and the Digital Equipment Corporation (DEC). Of these, only two—CDC and DEC—retained their independence and developed into major firms. And of these two, only CDC had become a major player in mainframe computers by the end of the 1950s. DEC would survive, but it was not until it found a niche in minicomputers that it became a major player (see chapter 9). After old-fashioned bankruptcy, the next most common fate of the small computer firms was to be absorbed by one of the office-machine companies—just as EMCC and ERA had been absorbed by Remington Rand.

Apart from IBM, none of the office-machine firms entered the postwar world with much in the way of electronics experience, nor any interest in making computers. Like IBM, the office-machine companies had prudent doubts about the market for business computers and initially did nothing more than put electronics into their existing products in an evolutionary way. NCR, for example, devised a machine called the “Post-Tronic,” which was an electronic enhancement of its ordinary accounting machines supplied to banks. The Post-Tronic, however, was a brilliant success—bigger than almost any computer of its era. The machine created a sensation when it was announced in 1956 at the American Bankers Association meeting. It went on to do $100 million worth of business, and “became an important factor in making NCR’s heavy investment for computer development possible.” However, to make the final leap into computer production, NCR acquired CRC in 1953 and launched a series of business computers in 1956.
Burroughs also tried to develop its own computer division, and in 1948 hired Irven Travis, then research director of the Moore School, to run its Paoli, Pennsylvania, computer development laboratory. Burroughs initially spent several million dollars a year on electronics research and development, a decision that "represented courage and foresight, because in the 1946–1948 period, our revenue averaged less than $100 million a year and our net profit was as low as $1.9 million in 1946." Despite this investment, Burroughs failed to develop a successful data-processing computer, and so in 1956 acquired the Electrodata Company, a start-up that had already developed a successful business computer, the Datatron. Burroughs paid $20.5 million for Electrodata, an enormous sum at the time, but with the combination of Electrodata's technology and Burroughs's sales force and customer base, it was soon able to secure an acceptable position in the computer company league.

Several other office-machine companies tried to enter the computer race in the 1950s, by either internal development or acquisition. These included Monroe, Underwood, Friden, and Royal, but none of their computer operations survived into the 1960s. Thus, by the end of the 1950s the major players in the computer industry consisted of IBM and a handful of also-rans: Sperry Rand, Burroughs, NCR, RCA, Honeywell, GE, and CDC. Soon, journalists would call them IBM and the seven dwarves.

Despite the gains of the 1950s in establishing a computer industry, as the decade drew to a close, the computer race had scarcely begun. In 1959, IBM was still deriving 65 percent of its income from its punched-card machines in the United States, and in the rest of the world the figure was 90 percent. The 1950s had been a dramatic period of growth for IBM, with its workforce increasing from 30,000 to nearly 100,000, and its revenue growing more than fivefold, from $266 million to $1,613 million. In the next five years, IBM would come to utterly dominate the computer market. The engine that would power that growth was a new computer, the IBM 1401.
6

THE MATURING OF THE MAINFRAME:
THE RISE AND FALL OF IBM

AS LATE as 1960 IBM was still primarily a punched-card machine supplier. It
was not until 1962 that computer sales equaled those of its traditional
punched-card products. But by the end of the decade, its punched-card ma-
chine sales were essentially vestigial.

While IBM was making this transformation in its product line in the 1960s,
it was also growing at the rapid rate of 15 to 20 percent a year and soon
achieved a domination of the computer market that was historically unpar-
alleled in any other major industry. From annual sales of $1.8 billion and a head
count of 104,000 in 1960, it had rocketed to sales of $7.2 billion and 259,000
employees by the end of the decade. Its market share was over 70 percent in
1960, a position it was able to sustain and even exceed throughout the decade.

The Breakthrough Model 1401

The turning point for IBM was the announcement of the Model 1401 computer
in October 1959. The 1401 was not so much a computer as a computer system. Most of
IBM’s competitors were obsessed with designing central processing
units, or “CPUs,” and tended to neglect the system as a whole. There were plenty
of technical people in IBM similarly fixated on the architecture of computers:
“Processors were the rage,” one IBM technical manager recalled. “Processors
were getting the resources, and everybody that came into development had a
new way to design a processor.” The technocrats at IBM, however, were overrid-
den by the marketing managers, who recognized that customers were more in-
terested in the solution to business problems than in the technical merits of
competing computer designs. As a result, IBM engineers were forced into taking a total-system view of computers—that is, a holistic approach that required them to “take into account programming, customer transition, field service, training, spare parts, logistics, etc.” This was the philosophy that brought success to the IBM 650 in the 1950s and would soon bring it to the Model 1401. It is, in fact, what most differentiated IBM from its major competitors.

The origin of the 1401 was the need to create a transistorized follow-up to the tube-based Model 650 Magnetic Drum Calculator. By 1958, 800 Model 650s had been delivered—more than all the computers produced by all the other mainframe manufacturers put together. Even so, the 650 had failed to make big inroads into IBM’s several thousand traditional punched-card accounting machine installations. There were a number of sound reasons why most of IBM’s customers were still resisting the computer and continuing to cling to traditional accounting machines. Foremost was cost: For the $3,250 monthly rental of a 650, a customer could rent an impressive array of punched-card machines that did just as good a job or better. Second, although the 650 was probably the most reliable of any computer on the market, it was a tube-based machine that was fundamentally far less reliable than an electromechanical accounting machine. Third, the would-be owner of a 650 was faced with the problem of hiring programming staff to develop applications software, since IBM provided little programming support at this time. This was a luxury that only the largest and most adventurous corporations could afford. Finally, most of the “peripherals” for the 650—card readers and punches, printers, and so on—were lackluster products derived from existing punched-card machines. Hence, for most business users, the 650 was in practice little more than a glorified punched-card machine. It offered few real advantages but many disadvantages. Thus the IBM 407 accounting machine remained IBM’s most important product right up to the end of the 1950s.

During 1958 the specification of the 1401 began to take shape, and it was heavily influenced by IBM’s experience with the 650. Above all, the new machine would have to be cheaper, faster, and more reliable than the 650. This was perhaps the easiest part of the specification to achieve since it was effectively guaranteed merely by the substitution of improved electronics technology: transistors for tubes and core memory for the magnetic drum of the 650, which would produce an order-of-magnitude improvement in speed and reliability. Next, the machine needed peripherals that would give it decisive advantages over the 650 and electric accounting machines: new card readers and punches, printers, and magnetic-tape units. By far the most important new peripheral under development was a high-speed printer, capable of 600 lines per minute.
IBM also had to find a technological solution to the programming problem. The essential challenge was how to get punched-card-oriented business analysts to be able to write programs without a huge investment in retraining them and without companies having to hire a new temperamental breed of programmer. The solution that IBM offered was a new programming system called Report Program Generator (RPG). It was especially designed so that people familiar with wiring up plugboards on accounting machines could, with a day or two of training, start to write their own business applications using familiar notations and techniques. The success of RPG exceeded all expectations, and it became one of the most used programming systems in the world. However, few RPG programmers realized the origins of the language or were aware that some of its more arcane features arose from the requirement to mimic the logic of a punched-card machine.

Not every customer wanted to be involved in writing programs however, even with RPG; some preferred to have applications software developed for them by IBM—for applications such as payroll, invoicing, stock control, production planning, and other common business functions. Because of its punched-card machine heritage, IBM knew these business procedures intimately and could develop software that could be used with very little modification by any medium-sized company. IBM developed entire program suites for the industries that it served most extensively, such as insurance, banking, retailing, and manufacturing. These application programs were very expensive to develop, but because IBM had such a dominant position in the market it could afford to “give” the software away, recouping the development costs over tens or hundreds of customers. Because IBM’s office-machine rivals—Sperry Rand, Burroughs, and NCR—did not have nearly so many customers, they tended to develop software for the one or two industries in which they had traditional strengths rather than trying to compete with IBM across the board.

The IBM 1401 was announced in October 1959, and the first systems were delivered early in 1960 for upward of $2,500 per month rental (the equivalent of a purchase price of $150,000). This was not much more than the cost of a medium-sized punched-card installation. IBM had originally projected that it would deliver around 1,000 systems. This turned out to be a spectacular underestimate, for 12,000 systems were eventually produced.

How did IBM get its forecast so wrong? The 1401 was certainly an excellent computer, but the reasons for its success had very little to do with the fact that it was a computer. Instead, the decisive factor was the new type 1403 “chain” printer that IBM supplied with the system. The printer used a new technology
by which slugs of type were linked in a horizontal chain that rotated rapidly and were hit on the fly by a series of hydraulically actuated hammers. The printer achieved a speed of 600 lines per minute, compared with the 150 lines per minute of the popular 407 accounting machine that was based on a prewar printing technology. Thus, for the cost of a couple of 407s, the 1401 provided the printing capacity of four standard accounting machines; and the flexibility of a stored-program computer came, as it were, for free. It was an unanticipated motive for IBM's customers to enter the computer age, but no less real for that.

For a while, IBM was the victim of its own success, as customer after customer decided to turn in old-fashioned accounting machines and replace them with a computer. In this decision they were aided and abetted by IBM's industrial designers, who excelled themselves by echoing the modernity and appeal of the new computer age: out went the round-cornered steel-gray punched-card machines, and in came the square-cornered light-blue computer cabinets. For a firm with less sophisticated financial controls and less powerful borrowing capabilities than IBM, coping with the flood of discarded rental equipment would have been a problem. But as a reporter in Fortune noted:

[F]ew companies in U.S. business history have shown such growth in revenues and such constantly flourishing earnings. I.B.M. stock, of course, is the standard example of sensational growth sustained over many years. As everybody has heard, anyone who bought 100 shares in 1914 (cost, $2,750), and put up another $3,614 for rights along the way, would own an investment worth $2,500,000 today.

With a reputation like that, the unpredicted success of a new product was a problem that IBM's investors were willing to live with. As more and more 1401s found their way into the nation's offices in their powder-blue livery, IBM earned a sinister new name: Big Blue.

**IBM and the Seven Dwarves**

Meanwhile, IBM's success was creating a difficult environment for its competitors. By 1960 the mainframe computer industry had already been whittled down to just IBM and seven others. Of all the mainframe suppliers, Sperry Rand had suffered the biggest reverse, consolidating a decline that had begun well before the launch of the 1401. Despite being the pioneer of the industry, it
had never made a profit in computers and was gaining a reputation bordering on derision. Another Fortune writer who eulogized IBM noted:

The least threatening of I.B.M.’s seven major rivals . . . has been Sperry Rand’s Univac Division, the successor to Remington Rand’s computer activities. Few enterprises have ever turned out so excellent a product and managed it so ineptly. Univac came in too late with good models, and not at all with others; and its salesmanship and software were hardly to be mentioned in the same breath with I.B.M.’s.

As a result “the upper ranks of other computer companies are studded with ex-Univac people who left in disillusionment.” In 1962 Sperry Rand brought in an aggressive new manager from ITT, Louis T. Rader, who helped UNIVAC address its deficiencies. But despite making a technologically successful entry into computer systems for airline reservations, Rader was soon forced to admit, “It doesn’t do much good to build a better mousetrap if the other guy selling mousetraps has five times as many salesmen.”

In 1963 UNIVAC turned the corner and started to break even at last. But the machine that brought profits, the UNIVAC 1004, was not a computer at all but a transistorized accounting machine, targeted at its existing punched-card machine users. Even with the improving outlook, UNIVAC still had only a 12 percent market share and a dismal one-sixth as many customers as IBM. This was little better than the market share that Remington Rand had secured with punched-card machines in the 1930s. It seemed that the company would be forever second.

IBM’s other business-machine rivals, Burroughs and NCR, were a long way behind IBM and even UNIVAC, both having market shares of around 3 percent—only a quarter of that of UNIVAC. In both cases, their strategy was safety first: protect their existing customer base, which was predominantly in the banking and retail sectors, respectively. They provided computers to enable their existing customers to move ahead with the new technology in an evolutionary way, as they felt the need to switch from electromechanical to electronic machines.

Doing much better than any of the old-line office-machine companies, the fastest-rising star in the computer scene of the early 1960s was Control Data Corporation, the start-up founded in 1957 by the entrepreneur William Norris. Control Data had evolved a successful strategy by manufacturing mainframes with a better price performance than those of IBM—by using superior electronics technology and by selling them into the sophisticated scientific and
other markets where the IBM sales force had not so great an impact. By 1963 Control Data had risen to third place in the industry, not far behind UNIVAC.

The only other important survivors in the mainframe industry of the early 1960s were the computer divisions of the electronics and control giants—RCA, Honeywell, and General Electric. All three had decided to make the necessary investment to compete with IBM. In every case this was a realistic possibility only because they rivaled IBM in power and size. The difference, however, was that for all of them the computer was not a core business, but an attempt to enter a new and unfamiliar market. Each had plans to make major product announcements toward the end of 1963.

Honeywell was planning to launch its Model 200 computer that would be compatible with the IBM 1401 and would be able to run the same software, and therefore IBM's existing customers would be an easy target. Honeywell's technical director, a wily ex-UNIVAC engineer named J. Chuan Chu, had reasoned that IBM was sufficiently nervous of its vulnerability to antitrust litigation to be "too smart not to let us take 10 per cent of the business." Inside RCA, General David Sarnoff, its legendary chief executive officer, had committed the company to spending huge sums to develop a range of IBM-compatible computers and was in the process of making licensing agreements with overseas companies to manufacture the computers in the rest of the world. Finally, General Electric also had plans to announce a range of three computers—one small, one medium-sized, and one large—in late 1963.

Revolution, Not Evolution: System/360

Although in marketing terms the IBM 1401 had been an outstanding success, inside IBM there was a mishmash of incompatible product lines that threatened its dominance of the industry. Many IBM insiders felt that this problem could be resolved only by producing a compatible range of computers, all having the same architecture and running the same software.

In 1960 IBM was producing no less than seven different computer models—some machines for scientific users, others for data-processing customers; some large machines, some small, and some in between. In manufacturing terms IBM was getting precious little benefit from its enormous scale. By simultaneously manufacturing seven different computer models, IBM was being run almost as a federation of small companies instead of an integrated whole. Each computer model had a dedicated marketing force trained to sell into the niche that computer occupied, but these specialized sales forces were unable to move
easily from one machine or market niche to another. Each computer model required a dedicated production line and its own specialized electronic components. Indeed, IBM had an inventory of no less than 2,500 different circuit modules for its computers. Peripherals also presented a problem, since hundreds of peripheral controllers were required so that any peripheral could be attached to any processor.

All this has to be compared with IBM’s punched-card products, where a single range of machines (the 400 series accounting machines) satisfied all its customers. The resulting rationalization of production processes and standardization of components had reduced manufacturing costs to an extent that IBM had no effective competition in punched-card machines at all.

The biggest problem, however, was not in hardware but in software. Because the number of software packages IBM offered to its customers was constantly increasing, the proliferation of computer models created a nasty gearing effect: Given $m$ different computer models, each requiring $n$ different software packages, a total of $m \times n$ programs had to be developed and supported. This was a combinatorial explosion that threatened to overwhelm IBM at some point in the not-too-distant future. It was a problem rather like the one facing the Parliament of the European Community at the same time. Because the six countries of the Community used four different languages—French, German, Italian, and Dutch—it was necessary to provide twelve different translation services (French to German, Italian, and Dutch; German to French, Italian, and Dutch; and so on). As the Community grew to nine members in 1973, and eventually to twelve, the Parliament had to accept a core of three languages (English, French, and German) so that only six translation services had to be provided instead of the dozens that would otherwise be necessary. Of course, if members of the European Parliament had spoken Esperanto, then no translators would have been needed at all. For IBM, a compatible range promised to be the electronic Esperanto that would contain the software problem.

Just as great a problem was that of the software written by IBM’s customers. Because computers were so narrowly targeted at a specific market niche, it was not possible for a company to expand its computer system in size by more than a factor of about two without changing to a different computer model. If this was done, then all the user’s applications had to be reprogrammed. This often caused horrendous organizational disruption during the changeover period. Indeed, reprogramming could be more costly than the new computer itself. As IBM appreciated only too well, once a company had decided to switch computer models, it could look at computers from all manufacturers—not just those made by IBM.
All these factors suggested that IBM would sooner rather than later have to embrace the compatible-family concept. But in IBM’s case this would be particularly challenging technically because of the wide spectrum of its customers in terms of size and applications. A compatible series would have to satisfy all of IBM’s existing customers, from the very smallest to the very largest, as well as both its scientific and commercial customers. And the new machine would have to be compatible throughout the product range, so that programs written on one machine would execute on any other—more slowly on the small machines, certainly, but they would have to run without any reprogramming at all.

The decision to produce a compatible family was not so clear-cut as it appears in hindsight, and there was a great deal of agonizing at IBM. For one thing, it was by no means clear that compatibility to the extent proposed was technically feasible. And even if it were, it was feared that the cost of achieving compatibility might add so much to the cost of each machine that it would not be competitive in the marketplace. Another complication was that there were factions within IBM that favored consolidating its current success by building on its existing machines. The 1401 faction, for example, wanted to make more powerful versions of the machine. These people thought it was sheer madness for IBM to think of abandoning its most successful product ever. If IBM dropped the 1401, they argued, it would leave thousands of disaffected users open to competitors. Another faction inside IBM favored, and had partially designed, a new range, to be known as the 8000 series, to replace IBM’s large 7000 series machines.

But it was the software problem that was to determine product strategy, and by late 1960 the tide was beginning to turn toward the radical solution. Not one of IBM’s computers could run the programs of another, and if IBM was to introduce more computer models, then, as a top executive stated, “we are going to wind up with chaos, even more chaos than we have today.” For the next several months planners and engineers began to explore the technical and managerial problems of specifying the new range and of coordinating the fifteen to twenty computer development groups within IBM to achieve it. Progress was slow, not least because those involved in the discussions had other responsibilities or preferred other solutions—and the compatible-family concept was still no more than a possibility that might or might not see the light of day.

To resolve the compatible-family debate rapidly, in October 1961 T. Vincent Learson, Tom Watson Jr.’s second-in-command at IBM, established the SPREAD task group, consisting of IBM’s thirteen most senior engineering, software, and marketing managers. SPREAD was a contrived acronym that stood for Systems,
Programming, Review, Engineering, And Development, but which was really meant to connote the broad scope of the challenge in establishing an overall plan for IBM’s future data-processing products. Progress was slow and, after a month, Learson, an archetypal IBM vice president, became impatient for a year’s end decision. In early November he banished the entire task group to a motel in Connecticut, where it would not be distracted by day-to-day concerns, with “orders not to come back until they had agreed.”

The eighty-page SPREAD Report, dated 28 December 1961, was completed on virtually the last working day of the year. It recommended the creation of a so-called New Product Line that was to consist of a range of compatible computers to replace all of IBM’s existing computers. On 4 January the SPREAD Report was presented to Watson Jr., Learson, and the rest of IBM’s top management. The report was breathtaking in its scope—and in the expense of making it a reality. For example, it was estimated that software alone would cost $125 million—at a time when IBM spent just $10 million a year on all its programming activities. Learson recalled that there was little enthusiasm for the New Product Line at the meeting:

The problem was, they thought it was too grandiose. . . . The job just looked too big to the marketing people, the financial people, and the engineers. Everyone recognized it was a gigantic task that would mean all our resources were tied up in one project—and we knew that for a long time we wouldn’t be getting anything out of it.

But Watson and Learson recognized that to carry on in the same old way was even more dangerous. They closed the meeting with the words, “All right, we’ll do it.”

Implementation of the New Product Line got under way in the spring of 1962. Considerable emphasis was placed on security. For example, the project was blandly known as NPL (for New Product Line), and each of the five planned processors had a misleading code number—101, 250, 315, 400, and 501—which gave no hint of a unified product line and in some cases was identical to the model numbers of competitive machines from other manufacturers; even if the code numbers leaked, they would merely confuse the competition.

The New Product Line was one of the largest civilian R&D projects ever undertaken. Until the early 1980s, when the company began to loosen up somewhat, the story of its development was shrouded in secrecy. Only one writer succeeded in getting past the barrier of IBM’s press corps, the Fortune journalist
Tom Wise. He coined the phrase “IBM’s $5 billion gamble” and wrote “not even the Manhattan Project which produced the atomic bomb in World War II cost so much”; this sounded like hyperbole at the time, but Wise’s estimate was about right. Wise reported that one of the senior managers “was only half joking when he said: ‘We called this project “You bet your company.”’” It is said that IBM rather liked the swashbuckling image that Wise conveyed, but when his articles went on to recount in detail the chaotic and irrational decision-making processes at IBM, Watson Jr. was livid and “issued a memorandum suggesting that the appearance of the piece should serve as a lesson to everyone in the company to remain uncommunicative and present a unified front to the public, keeping internal differences behind closed doors.”

The logistics of the research program were awesome. Of the five planned computer models, the three largest were to be developed at IBM’s main design facility in Poughkeepsie, New York, the smallest in its Endicott facility in upstate New York, and the fifth machine in its Hursley Development Laboratories in England. Simply keeping the machine designs compatible between the geographically separate design groups was a major problem. Extensive telecommunications facilities were used to keep the development groups coordinated, including two permanently leased transatlantic lines—an unprecedented expense in civilian R&D projects at the time. In New York hundreds and eventually thousands of programmers worked on the software for the New Product Line.

All told, direct research costs were around $500 million. But ten times as much again was needed for development—to tool up the factories, retrain marketing staff, and re-equip field engineers. One of the major costs was to build up a capability in semiconductor manufacturing, in which IBM had previously been weak. Tom Watson Jr., who had to cajole his board of directors into sanctioning the expenditure, recalled:

Ordinary plants in those days cost about forty dollars per square foot. In the integrated circuit plant, which had to be kept dust free and looked more like a surgical ward than a factory floor, the cost was over one hundred and fifty dollars. I could hardly believe the bills that were coming through, and I wasn’t the only one who was shocked. The board gave me a terrible time about the costs. “Are you really sure you need all this?” they’d say. “Have you gotten competitive bids? We don’t want these factories to be luxurious.”

This investment put IBM into the position of being the world’s largest manufacturer of semiconductors.
By late 1963, with development at full momentum, top management began to turn its thoughts to the product launch. The compatible range had now been dubbed System/360, a name "betokening all points of the compass" and suggesting the universal applicability of the machines. The announcement strategy was fraught with difficulty. One option was to make a big splash by announcing the entire series at once, but this carried the risk that customers would cancel their orders for existing products and IBM would be left with nothing to sell until the new range came on stream. A safer and more conventional strategy would be to announce one machine at a time over a period of a couple of years. This would enable the switch from the old machines to the new to be achieved much more gently, and it was, in effect, how IBM had managed the transition from its old punched-card machines to computers in the 1950s.

However, all internal debate about the announcement strategy effectively ceased in December 1963 when Honeywell announced its Model 200 computer. The Honeywell 200 was the first machine to challenge IBM by aggressively using the concept of IBM compatibility. The Honeywell computer was compatible with IBM's Model 1401, but by using more up-to-date semiconductor technology it was able to achieve a price-performance superiority of as much as a factor of four. Because the machine was compatible with the 1401, it was possible for one of IBM's customers to return an existing rented machine to IBM and acquire a more powerful model from Honeywell for the same cost—or a machine of the same power for a lesser cost. Honeywell 200s could run IBM programs without reprogramming and, using a provocatively named "liberator" program, could speed up existing 1401 programs to make full use of the Honeywell 200's power.

It was a brilliant strategy and a spectacular success—Honeywell took 400 orders in the first week following the announcement, more than it had taken in the previous eight years of its computer operation's existence. The arrival of the Honeywell 200 produced a noticeable falloff in IBM 1401 orders, and some existing users began to return their 1401s to switch over to the new Honeywell machine. Inside IBM it was feared that as many as three-quarters of its 1401 users would be tempted by the Honeywell machine.

Despite all the planning done on System/360, IBM was still not irrevocably committed to the New Product Line, and the arrival of the Honeywell 200 caused all the marketing plans to be worked over once again. At this, the eleventh hour, there seemed to be two alternatives: To carry on with the launch of the entire System/360 range and hope that the blaze of publicity and the implied obsolescence of the 1401 would eclipse the Honeywell 200; or to abandon
System/360 and launch a souped-up version of the 1401—the 1401S—that was already under development and that would be competitive with the Honeywell machine.

On 18–19 March a final make-or-break decision was made in a protracted risk-assessment session with Watson Jr., IBM’s president Al Williams, and the thirty top IBM executives:

At the end of the risk assessment meeting, Watson seemed satisfied that all the objections to the 360 had been met. Al Williams, who had been presiding, stood up before the group, asked if there were any last dissents, and then, getting no response, dramatically intoned, “Going . . . going . . . gone!”

Activity in IBM now reached fever pitch. Three weeks later the entire System/360 product line was launched. IBM staged press conferences in sixty-three cities in the United States and fourteen foreign countries on the same day. In New York a chartered train conveyed two hundred reporters from Grand Central Station to IBM’s Poughkeepsie plant, and the visitors were shown into a large display hall where “six new computers and 44 new peripherals stretched before their eyes.” Tom Watson Jr.—gray-haired, but a youthful not-quite fifty, and somewhat Kennedyesque—took center stage to make “the most important product announcement in company history,” IBM’s third-generation computer, System/360.

The computer industry and computer users were stunned by the scale of the announcement. While an announcement from IBM had long been expected, its tight security had been extremely effective, so that outsiders were taken aback by the decision to replace the entire product line. Tom Wise, the Fortune reporter, caught the mood exactly when he wrote:

The new System/360 was intended to obsolete virtually all other existing computers. . . . It was roughly as though General Motors had decided to scrap its existing makes and models and offer in their place one new line of cars, covering the entire spectrum of demand, with a radically redesigned engine and an exotic fuel.

This “most crucial and portentous—as well as perhaps the riskiest—business judgment of recent times” paid off handsomely. Literally thousands of orders for System/360 flooded in, far exceeding IBM’s ability to deliver; in the first two years of production it was able to satisfy less than half of the 9,000 orders
on its books. To meet this burgeoning demand, IBM hired more marketing and production staff and opened new manufacturing plants. Thus in the three years following the System/360 launch, IBM’s sales and leasing revenue soared to over $5 billion, and its employee head count increased by 50 percent, taking it to nearly a quarter of a million workers.

System/360 has been called “the computer that IBM made, that made IBM.” The company did not know it at the time, but System/360 was to be its engine of growth for the next thirty years. In this respect, the new series was to be no more and no less important to IBM than the classic 400 series accounting machines that had fueled its growth from the early 1930s until the computer revolution of the early 1960s.

The Dwarves Fight Back

In the weeks that followed the System/360 announcement, IBM’s competitors began to formulate their responses. System/360 had dramatically reshaped the industry around the concept of a software compatible computer range. Although by 1964 the compatible-range concept was being explored by most manufacturers, IBM’s announcement effectively forced the issue.

Despite IBM’s dominance of the mainframe computer industry, it was still possible to compete with the computer giant simply by producing better products, which was by no means impossible. In the mythology of computer history, System/360 has often been viewed as a stunning technical achievement and “one of this country’s greatest industrial innovations”—a view that IBM naturally did all it could to foster. But in technological terms, System/360 was no more than competent. The idea of a compatible range was not revolutionary at all, but was well understood throughout the industry; and IBM’s implementation of the concept was conservative and pedestrian. For example, the proprietary electronics technology that IBM had chosen to use, known as Solid Logic Technology (SLT), was halfway between the discrete transistors used in second-generation computers and the true integrated circuits of later machines. There were good, risk-averse decisions underlying IBM’s choice, but to call System/360 the “third generation” was no more than a marketing slogan that stretched reality.

Perhaps the most serious design flaw in System/360 was its failure to support time-sharing—the fastest-growing market for computers—which enabled a machine to be used simultaneously by many users. Another problem was that
the entire software development program for System/360 was little short of a fiasco (as we shall see in chapter 8) in which thousands of programmers consumed over $100 million to produce software that had many shortcomings. IBM was not so cocooned from the real world that it was unaware of what poor value it had derived from the $500 million System/360 research costs. As he caught wind of the new computer's failings, Tom Watson Jr. personally demanded an engineering audit, which fully confirmed his suspicion that IBM's engineering was mediocre.

But as always, technology was secondary to marketing in IBM's success—and there was no question of trying to compete with IBM in marketing. Hence, to compete with IBM at all, the seven-dwarf competitors had to aim at one of IBM's technical weak spots.

The first and most confrontational response was to tackle IBM head-on by making a 360-compatible computer with superior price performance—just as Honeywell had done with its 1401-compatible Model 200. RCA, one of the few companies with sufficient financial and technical resources to make the attempt, decided on this strategy. Indeed, two years before the System/360 announcement, RCA had committed $50 million to produce a range of IBM-compatible computers. RCA had deliberately kept its plans flexible so that it would be able to copy whatever architecture and instruction code IBM finally adopted, which it believed "would become a standard code for America and probably for the rest of the world."

Right up to the launch of System/360 in April 1964, RCA product planners had no inkling either of the date of the announcement or of the eventual shape of System/360. There was no industrial espionage, and it was only on the day of the announcement that they got their first glimpse of the new range. Within a week they had decided to make the RCA range fully System/360-compatible, and working from IBM's publicly available manuals "started to copy the machine from the skin in." In order to compete with IBM, RCA needed a 10 or 15 percent advantage in price/performance; this it planned to achieve by using its world-leading capability in electronic components to produce a series that used fully integrated circuits in place of the SLT technology used by IBM. This would make the RCA machines—dollar for dollar—smaller, cheaper, and faster than IBM's. RCA announced its range as Spectra 70 in December 1964—some eight months after the System/360 launch.

RCA was the only mainframe company to go IBM-compatible in a big way. The RCA strategy was seen as very risky because it was bound to be very difficult to achieve a superior price performance to IBM, given IBM's massive
economies of scale. IBM compatibility also put the competitor in the position of having to follow slavishly every enhancement that IBM made to its computer range. Even worse, IBM might drop System/360 altogether one day.

Hence, the second and less risky strategy to compete with System/360 was product differentiation—that is, to develop a range of computers that were software compatible with one another but not compatible with System/360. This was what Honeywell did. Taking its highly successful Model 200, it extended the machine up and down the range to make a smaller machine, the Model 120, and four larger machines, the 1200, 2200, 4200, and 8200, which were announced between June 1964 and February 1965. This was a difficult decision for Honeywell, since it could be seen as nailing its flag to the mast of an obsolete architecture. However, Honeywell had the modest ambition of capturing just 10 percent of IBM's existing 1401 customer base—about 1,000 installations in all—which it comfortably did. The same strategy, of producing non-IBM-compatible ranges, was also adopted by Burroughs with its 500 series, announced in 1966, and by NCR with its Century Series in 1968.

The third strategy to compete with IBM was to aim for niche markets that were not well satisfied by IBM and in which the supplier had some particular competitive advantage. Control Data, for example, recognized that the System/360 range included no really big machines, and so decided to give up manufacturing regular mainframes altogether and make only giant number-crunching computers designed primarily for government and defense research agencies. This strategy was very successful, and soon Control Data became the world's third-largest computer maker. Similarly, General Electric recognized IBM's weakness in time-sharing, and—collaborating with computer scientists at Dartmouth College and MIT—quickly became the world leader in time-shared computer systems (see chapter 9). In other cases, manufacturers capitalized on their existing software and applications experience. Thus UNIVAC continued to compete successfully with IBM in airline reservation systems, without any major machine announcements. Again, even though their computer products were lackluster, Burroughs and NCR were able to build on their special relationship with bankers and retailers, which dated from the turn of the century, when they had been selling adding machines and cash registers. It was the old business of selling solutions, not problems. With these strategies and tactics, all seven dwarves survived into the 1970s—just.

By the end of the 1960s, IBM appeared invincible. It had about three-quarters of the market for mainframe computers around the world. Its seven mainframe competitors each had between 2 and 5 percent of the market; some were losing
money heavily, and none of them was more than marginally profitable. IBM’s extraordinarily high profits, estimated at 25 percent of its sales, enabled the other companies to shelter under its “price umbrella.” It was often said that the seven dwarves existed only by the grace of IBM, and if it were ever to fold its price umbrella, they would all get wet—or drown. This is what happened in the first computer recession of 1970–71. As the journalists put it at the time, IBM sneezed and the industry caught a cold. Both RCA and General Electric, which had problems in their core electronics and electrical businesses associated with the global economic downturn of the early 1970s, decided to give up the struggle and terminate their in-the-red computer divisions. Their customer bases were bought up by Sperry Rand and Honeywell, respectively, which helped them gain market share at relatively little cost. From then on the industry was no longer characterized as IBM and the seven dwarves, but as IBM and the BUNCH—standing for Burroughs, UNIVAC, NCR, Control Data, and Honeywell.

The Future System

Meanwhile, inside IBM, thought was being given to the future of the System/360. In the short run, it was decided to enhance the existing range by incorporating some straightforward technological advances to maintain its competitiveness. In the long run, however, it intended to replace System/360 with a completely new architecture, code-named FS for Future System.

In June 1970 the evolutionary successor to the 360 range was announced as System/370. The new series offered improved price/performance through updated electronic technology: True integrated circuits were used in place of the SLT modules of System/360, and magnetic core storage was replaced with semiconductor memory. The architecture was also enhanced to support more effectively time-sharing and communications-based on-line computing. The technique of “virtual memory” was also introduced, using a combination of software and hardware to increase the amount of working memory in the computer (and therefore permit the execution of much larger programs). IBM secured great publicity value from the “innovation” of virtual memory, although the idea had been pioneered nearly a decade earlier at Manchester University in England. As always, IBM’s publicity machine was stronger than its technology.

While the life of the 360–370 line was being extended by these modest improvements, IBM’s main R&D resources were focused on the much more challenging Future System. The new range was planned to be ready for market in the second half of the 1970s. As with System/360 a decade earlier, there was no
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unanimity within IBM about the wisdom of migrating to a new computer architecture. IBM’s top-level Corporate Technical Committee argued, however, that sooner or later the company would have to make a decision. In effect, the committee was proposing a rerun of the System/360 story:

To have competitive leadership will require bringing together new technology for logic and memory, new architecture, new programming and new input/output devices as well as CPUs. This is a major undertaking and a task equal to, if not larger than, our change to System/360.

In mid-1971, a task group was established to determine the broad capabilities of IBM’s Future System, just as ten years earlier the SPREAD task group had evolved the design of System/360.

The concepts behind FS were very advanced, as least as advanced as System/360 had been in its day. One overarching theme was the realization that only one-third of a customer’s costs were for hardware—the rest was for programming and services. Thus a primary goal of FS was to reduce software costs through a completely new design that would “displace the 370 line with a system of novel architecture, much as System/360 had displaced its predecessors.” In the spring of 1971 the task group’s recommendation to replace System/360 was accepted by management, and it planned to announce the new range in June 1975—allowing some forty-five months for research and development.

Unfortunately, the FS program had nothing like the tight focus of the System/360 program of the early 1960s. Deadline after deadline slipped by, and after three years of work the project stubbornly remained far from completion. This slippage may have been partly the result of democratic dithering in IBM following the retirement of the autocratic Tom Watson Jr. as CEO in 1971. But there were formidable technical problems too:

People involved with the project agree that it failed largely because of the vastness of the undertaking. Some suggest the organization and leadership were inadequate. Others focus on the conflicts and uncertainties surrounding the issue of direct implementation versus the three-level architecture. Many more believe the FS objectives were themselves the problem, simply too far ahead of available technologies.

FS was indeed a remarkably advanced architecture, and this entailed its own problems. Even today there is no major computer range that has the functionality of FS as it was proposed in the early 1970s.
But more than anything, it was the growing importance of the existing software investment of IBM and its users that made a new architecture less feasible by the day and sealed the fate of FS. The prospect of rewriting all that software was awesome:

In terms of sheer effort, it was estimated that all the programmers in IBM would be kept busy until 1978 implementing FS; none would be available to work on incremental improvements to System/370. This was unacceptable in the competitive marketplace in which System/370 had to survive until FS was ready.

For customers, the prospect of rewriting their code was equally unacceptable. System/360 and its successor had become an industry standard.

In February 1975, IBM pulled the plug and decided to drop FS and instead continue to evolve the 360–370 line. The design work on FS had involved thousands of staff years of effort and was estimated to have cost $100 million, making it “the most expensive development-effort failure in IBM’s history.”

IBM had been hoist with its own petard. For the decade of the 1960s, its growth had been assisted by the “software lock-in” that prevented its customers from defecting to competitors. Now IBM was locked in, too. Of course, the problem of software compatibility that forced IBM to remain wedded to its 360 architecture also forced other computer manufacturers to stay with their computer designs.

Thus by the mid-1970s, the mainframe had fully matured. Today, all of the world’s mainframe designs are about thirty to forty years old; and much of the software running on these mainframes is equally old. The maturing of the mainframe has produced one of the great technological contradictions of the twentieth century: As semiconductor components improve in size and speed by a factor of two every year or two, they are used to build fossilized computer designs and run software that is groaning with age. The world’s mainframes and the software that runs on them have become like the aging sewers beneath British city streets, laid in the Victorian era. Not a very exciting infrastructure, and largely unseen—but they work, and life would be totally different without them.

The Decline of the IBM Empire

By the mid-1970s information technology was one of the world’s major industries, ranking with automobiles and petroleum. Of every $120 of goods pro-
duced in the United States, one dollar was on computer systems. It was, of course, inevitable that IBM could not sustain a three-quarter market share indefinitely, as manufacturing globalized and the market began to fragment. For example, the advent of low-cost integrated circuits saw the arrival in the early 1970s of minicomputer manufacturers such as DEC, Data General, and Hewlett-Packard (see chapter 9). IBM competed vigorously and successfully with these new companies, but it never secured the same kind of dominance in minicomputers that it had in mainframes.

Thus by 1976, although IBM still held two-thirds of the world market for mainframes, its overall share of the global computer market had been reduced to 50 percent. By 1985 it was down to 25 percent. But this reflected only a broadening of the market. IBM’s growth and profitability scarcely faltered through the 1970s and the first half of the 1980s. It grew at an annual rate of 15 to 20 percent a year, peaking with sales of $50 billion and a workforce over 400,000 in 1985.

Yet within a period of five years IBM was to suffer the most dramatic fall from grace in corporate history, recording ever more slender profits, until in January 1993 it reported the largest loss ever by a private company. How did this happen?

For many years IBM’s domination of the computer industry was attributed to a variety of factors: its managerial competence; its technological excellence; its formidable marketing organization; its monopolistic business practices; and the leadership exerted by the Watsons. Yet when IBM fell into decline, very little had changed. Its technology and marketing were as good in the 1990s as at any time in its past; and although it had only a 20 percent market share, it exceeded its nearest competitor in size by a factor of five; and even though the Watsons were no longer at the helm of the company, IBM’s leaders were still among the most respected in the world. This suggests that there was something in the environment beyond IBM that was responsible for its rise and fall.

IBM’s malaise was frequently attributed to the rise of the personal computer, but the facts do not support this contention. The scene was set for IBM’s downfall in the mid-1970s, with the commodification of the mainframe—that is, by the mainframe becoming an article that could be produced by any competent manufacturer. This had the inevitable result of reducing the generous profit margins IBM had enjoyed for sixty years.

Today, with the hindsight of historical perspective, IBM’s early domination of the computer market can be seen as largely a fortuitous inheritance. For twenty years, from the mid-1950s to the mid-1970s, IBM was blessed with a unique combination of organizational capabilities that equipped it perfectly for
the mainframe computer market. While it fit this environmental niche, IBM prospered wonderfully; but once that niche changed, IBM’s strategies were no longer appropriate. Its dominance of the mainframe had very little to do with electronics but everything to do with the capabilities it brought from its origins as a manufacturer of punched-card accounting machines.

IBM’s key competencies were electromechanical manufacturing, marketing, and a service orientation—all geared to the delivery of integrated data-processing systems. Electromechanical manufacturing was enormously important to IBM—much more so than electronics. As we have seen, what made the Model 1401 so successful was not electronics but its path-breaking 600-lines-per-minute printer; and it was IBM’s electromechanical peripherals, such as magnetic tapes and disk drives, that consolidated this position. Again, IBM’s sales organization was second to none, and it remained as true in Thomas Watson Jr.’s time as when his father had said in the 1930s that “IBM’s products are sold, not bought.” (It is noteworthy that the only two mainframe suppliers to pull out in the early 1970s were RCA and General Electric. These were electronics and control-equipment manufacturers with no preexisting sales organization for marketing office equipment.) Customer service always had the highest priority in IBM. The firm was celebrated for responding to a malfunctioning computer system with a dedicated engineering task force until the problem was fixed.

However, it was IBM’s background as a supplier of integrated data-processing systems that provided its unique advantage. As Frank Cary, a future president of IBM, put it in June 1964, shortly after the launch of System/360, “We don’t sell a product . . . we sell solutions to problems.” This attitude was very different from that of IBM’s office-machine competitors. Before they became computer manufacturers, Sperry Rand, Burroughs, and NCR had supplied products such as typewriters, accounting machines, and cash registers. These products were generally supplied as “office appliances” that could be dropped into any office, leaving the underlying information system unchanged. Thus a secretary’s work was facilitated by a typewriter, a bookkeeper’s work was speeded up by an accounting machine, and a teller in a store was assisted by a cash register. None of these products required the office-machine supplier to have more than a superficial knowledge of the underlying business.

By contrast, when IBM sold a punched-card machine system, the business’s entire information system had to be reconfigured around the machinery. This key difference between IBM and its competitors persisted right into the computer age. Thus, when a company used equipment from one of IBM’s office-machine competitors, it was all too likely to acquire a problem rather than a
solution. Often the computer and its software were no more than a set of tools with which to fashion a solution, instead of the solution itself.

Only IBM guaranteed a complete solution to business problems, and an IBM salesman was all too likely to remind a data-processing manager that no one ever got fired for hiring equipment from IBM. This was a patronizing attitude that came close to condescension, and often resulted in a love-hate relationship between IBM and its customers. In the mid-1970s a great change began to occur in the computer industry, which was fully realized in the 1980s; 1973 marked the first year that more than 100,000 computers were in use worldwide. But the growth slowed, and in 1978 there were only 7,000 more computers in use than there had been five years earlier. The mainframe had matured and become a commodity, while IBM’s expertise in systems integration was increasingly taken over by software. As a result, computer users had far less need of IBM to hold their hand, and it was inevitable that they would begin to drift to other, less intimidating and less expensive suppliers.
THE SHAPING OF THE PERSONAL COMPUTER

NO HISTORIAN has yet written a full account of the personal computer, mainly because historians generally avoid writing about recent events on which they lack a proper perspective. But the personal computer has been of such sweeping global importance that no book on the history of the computer could properly ignore it.

There has, of course, been no shortage of published accounts of the development of the personal computer. Scores of books and hundreds of articles, written mostly by journalists, have appeared in response to a demand from the general public for an understanding of the personal computer. Much of this reportage is bad history, though some of it is good reading. Perhaps its most serious distortion is to focus on a handful of individuals, portrayed as visionaries who clearly saw the future and made it happen: Apple Computer’s Steve Jobs and Microsoft’s Bill Gates figure prominently in this genre. By contrast, IBM and the established computer firms are usually portrayed as dinosaurs: slow-moving, dim-witted, deservedly extinct. When it comes to be written, the history of the personal computer will be much more complex than this. It will be seen to be the result of a rich interplay of cultural forces and commercial interests.

Radio Days

If the idea that the personal computer was shaped by an interplay of cultural forces and commercial interests appears nebulous, it is useful to compare the development of the personal computer with the development of radio in the opening decades of the twentieth century, whose history is well understood. There are
some useful parallels in the social construction of these two technologies, and an understanding of one can deepen one’s understanding of the other.

In the 1890s the phenomenon we now call radio was a scientific novelty in search of an application. Radio broadcasting as we now know it would not emerge for a generation. The first commercial application of the new technology was in telegraphy, by which Morse signals were transmitted from one point to another—a telegraph without wires. Wireless telegraphy was demonstrated in a very public and compelling way in December 1901 when Guglielmo Marconi transmitted the letter S repeatedly in Morse across the Atlantic from Poldu in Cornwall, England, to St. John’s, Newfoundland, Canada. Banner newspaper headlines reported Marconi’s achievement, and his firm began to attract the attention of telegraph companies and private investors.

Over the next few years, wireless telegraphy was steadily perfected and incorporated into the world’s telegraph systems, and voice transmission and marine-based telegraphs were developed. The latter, particularly, captured many headlines. In 1910 a telegraph message from the SS Montrose resulted in the capture of the “acid-bath murderer” Dr. Hawley Crippen as he fled from England to Canada. Two years later the life-saving role of the telegraph in the Titanic disaster resulted in legislation mandating that all ships holding fifty or more people must carry a permanently manned wireless station. All this media attention served to reinforce the dominant mode of the technology for the point-to-point transmission of messages.

While wireless telegraphy was in the process of being institutionalized by the telegraph companies and the government, it also began to draw the attention of men and boy hobbyists. They were attracted by the glamour associated with wireless telegraphy and by the excitement of “listening in.” But mostly the amateurs were attracted by the technology itself—the sheer joy of constructing wireless “sets” and communicating their enthusiasm to like-minded individuals. By 1917 there were 13,581 licensed amateur operators in the United States, and the number of unlicensed receiving stations was estimated at 150,000.

The idea of radio broadcasting arose spontaneously in several places after World War I, although David Sarnoff (later of RCA) is often credited with the most definite proposal for a “radio music box” while he was working for the American Marconi Company in New York. Broadcasting needed an audience, and radio amateurs constituted that first audience. But for the existence of amateur operators and listeners, radio broadcasting might never have developed.

Once the first few radio stations were established, broadcasters and listeners were caught in a virtuous circle: More listeners justified better programs; and
better programs enticed more listeners. Between 1921 and 1922, 564 radio stations came into existence in the United States. The flood fueled a demand for domestic radio receivers, and the radio-set industry was born. The leading firm, RCA, led by David Sarnoff, sold $80 million worth of radio sets in the four years beginning with 1921. Existing firms such as Westinghouse and General Electric also began to make radio sets, competing fiercely with start-up firms such as Amrad, De Forest, Stromberg-Carlson, Zenith, and many more. By the mid-1920s, the structure of American radio broadcasting had been fully determined, and it has been remarkably resilient to assaults from, in turn, cinema, television, satellite broadcasting, and cable.

Three key points emerge from this thumbnail history of American radio broadcasting. First, radio came from a new enabling technology whose long-term importance was initially unrecognized. Originally promoted as a point-to-point communications technology, radio was reconstructed into something quite different: a broadcast entertainment medium for the mass consumer. Second, a crucial set of actors in this transformation were the radio amateurs. They built the first receivers when there was no radio-set industry, thus enabling broadcasting to take off. They are the unsung heroes of the radio story. Finally, once radio broadcasting was established, it was quickly dominated by a few giant firms—radio-set manufacturers and broadcasters. Some of these firms were the creations of individual entrepreneurs, while others came from the established electrical engineering industry. Within a decade, the firms were virtually indistinguishable.

As we shall see, the personal computer followed a similar path of development. There was an enabling technology, the microprocessor, which took several years to be used in a product that the mass consumer wanted. The computer amateur played an important but underappreciated role in this transformation, not least by being a consumer for the first software companies—whose role was analogous to that of the radio broadcasters. And the personal computer spawned a major industry—with entrants coming from both entrepreneurial start-ups and established computer firms such as IBM.

Microprocessors

The enabling technology for the personal computer, the microprocessor, was developed during 1969 to 1971 in the semiconductor firm Intel. (Like many of the later developments in computer history, the microprocessor was independently
invented in more than one place—but Intel was undoubtedly the most important locus.) Intel was founded in 1968 by Robert Noyce and Gordon Moore, both vice presidents of Fairchild Semiconductor and two of the original Shockley Eight. Today, Intel has annual revenues of several billion dollars and Noyce and Moore are legends of the American electronics industry. The microprocessor itself, however, was suggested not by them but by an Intel engineer Ted Hoff, then in his early thirties.

When Intel first began operations in 1968, it specialized in the manufacture of semiconductor memory and custom-designed chips. Intel's custom-chip sets were typically used in calculators, video games, electronic test gear, and control equipment. In 1969 Intel was approached by the Japanese calculator manufacturer Busicom to develop a chip set for a new scientific calculator—a fairly up-market model that would include trigonometrical and other advanced mathematical functions. The job of designing the chip set was assigned to Ted Hoff and his coworkers.

Hoff decided that instead of specially designed logic chips for the calculator, a better approach would be to design a general-purpose chip that could be programmed with the specific calculator functions. Such a chip would of course be a rudimentary computer in its own right, although it was some time before the significance of this dawned inside Intel.

The new calculator chip, known as the 4004, was delivered to Busicom in early 1971. Unfortunately, Busicom soon found itself a victim of the calculator price wars of the early 1970s and went into receivership. Before it did so, however, it negotiated the price of the 4004 downward in exchange for Intel acquiring the rights to market the new chip on its own account. Intel did this in November 1971, placing an advertisement in Electronics News that read: “Announcing a new era of integrated electronics: A microprogrammable computer on a chip.” This first microprocessor sold for about $1,000.

The phrase “computer on a chip” was really copywriter's license; in any real application several other memory and controller chips would need to be attached to the 4004. But it was a potent metaphor that helped reshape the microelectronics industry over the next two years. During this period Intel replaced the 4004, a relatively low-powered device that processed only four bits of information at a time, with an eight-bit version, the 8008. A still more powerful chip, the 8080, which became the basis for several personal-computer designs, appeared in April 1974. By this time other semiconductor manufacturers were starting to produce their own microprocessors—such as the Motorola 6800, the Zilog Z80, and the MOS Technology 6502. With this competition, the price of microprocessors soon fell to around $100.
It would not be for another three years, however, that a real personal computer emerged, in the shape of the Apple II. The long gestation of the personal computer contradicts the received wisdom of its having arrived almost overnight. It was rather like the transition from wireless telegraphy to radio broadcasting, which the newspapers in 1921 saw as a “fad” that “seemed to come from nowhere”; in fact, it took several years, and the role of the hobbyist was crucial.

Computer Hobbyists and “Computer Liberation”

The computer hobbyist was typically a young male technophile. Most hobbyists had some professional competence. If not working with computers directly, they were often employed as technicians or engineers in the electronics industry. The typical hobbyist had cut his teeth in his early teens on electronic construction kits, bought through mail-order advertisements in one of the popular electronics magazines. Many of the hobbyists were active radio amateurs. But even those who were not radio amateurs owed much to the “ham” culture, which descended in an unbroken line from the early days of radio. After World War II, radio amateurs and electronic hobbyists moved on to building television sets and hi-fi kits advertised in magazines such as *Popular Electronics* and *Radio Electronics*. In the 1970s, the hobbyists lighted on the computer as the next electronic bandwagon.

Their enthusiasm for computing had often been produced by the hands-on experience of using a minicomputer at work or in college. The dedicated hobbyist hungered for a computer at home for recreational use, so that he could explore its inner complexity, experiment with computer games, and hook it up to other electronic gadgets. However, the cost of a minicomputer—typically $20,000 for a complete installation—was way beyond the pocket of the average hobbyist. To the nonhobbyist, why anyone would have wanted his own computer was a mystery: It was sheer techno-enthusiasm, and one can no more explain it than one can explain why people wanted to build radio sets sixty years earlier when there were no broadcasting stations.

It is important to understand that the hobbyist could conceive of hobby computing only in terms of the technology with which he was familiar. This was not the personal computer as we know it today; rather, the computing that the hobbyist had in mind in the early 1970s was a minicomputer hooked up to a teletype equipped with a paper-tape reader and punch for getting programs
and data in and out of the machine. While teletypes were readily available in
government-surplus shops, the most expensive part of the minicomputer—the
central processing unit—remained much too costly for the amateur. The allure
of the microprocessor was that it would reduce the price of the central proces-
sor by vastly reducing the chip count in the conventional computer.

The amateur computer culture was widespread. While it was particularly
strong in Silicon Valley and around Route 128, computer hobbyists were to be
found all over the country. The computer hobbyist was primarily interested in
tinkering with computer hardware; software and applications were very much
secondary issues.

Fortunately, the somewhat technologically fixated vision of the computer
hobbyists was leavened by a second group of actors: the advocates of "computer
liberation." It would, perhaps, be overstating the case to describe computer lib-
eration as a movement, but there was unquestionably a widely held desire to
bring computing to ordinary people. Computer liberation was particularly
strong in California, and this perhaps explains why the personal computer was
developed in California rather than (say) around Route 128.

Computer liberation sprang from a general malaise in the under-thirty
crowd in the post-Beatles, post-Vietnam War period of the early 1970s. There
was still a strong anti-establishment culture that expressed itself through the
phenomena of college dropouts and campus riots, communal living, hippie
culture, and alternative lifestyles sometimes associated with drugs. Such a
movement for liberation would typically want to wrest communications tech-
nologies from vested corporate interests. In an earlier generation the liberators
might have wanted to appropriate the press, but in fact the technology of print-
ing and distribution channels were freely available, so that the young, liberal-
minded community was readily able to communicate through magazines such
as Rolling Stone as well as a vast underground press. On the other hand, com-
puter technology was unquestionably not freely available; it was mostly rigidly
controlled in government bureaucracies or private corporations. The much
vaunted computer utility was, at $10 to $20 per hour, beyond the reach of ordi-
nary users.

The most articulate spokesperson for the computer-liberation idea was Ted
Nelson, the financially independent son of the Hollywood actress Celeste
Holm. Among Nelson's radical visions of computing was an idea called hypertext,
which he first described in the mid-1960s. Hypertext was a system by
which an untrained person could navigate through a universe of information
held on computers. Before such an idea could become a reality, however, it was
necessary to “liberate” computing: to make it accessible to ordinary people at a trivial cost. In the 1970s Nelson promoted computer liberation as a regular speaker at computer hobbyist gatherings. He took the idea further in his self-published books *Computer Lib* and *Dream Machines*, which appeared in 1974. While Nelson’s uncompromising views and his unwillingness to publish his books through conventional channels perhaps added to his anti-establishment appeal, this created a barrier between himself and the academic and commercial establishments.

It is not possible at this distance in time to properly evaluate Nelson’s impact on the development of personal computing. In many ways his influence was similar, though certainly less important, to that of Marshall McLuhan, whose book *Understanding Media* provided such resonant late-twentieth-century ideas as “the medium is the message” and “the global village.” In both cases their influence has been largely intangible, but it seems likely that cultural historians one day will see them as having changed the intellectual climate—in the case of McLuhan, who was well integrated in the academic and cultural establishment, on a global scale, while Nelson influenced mainly the young, predominantly male, local Californian technical community.

Personal computing in 1974, whether it was the vision of computer liberation or that of the computer hobbyist, bore little resemblance to the personal computer that emerged three years later—that is, the configuration of a self-contained machine, somewhat like a typewriter, with a keyboard and screen, an internal microprocessor-based computing engine, and a floppy disk for long-term data storage. In 1974 the computer-liberation vision of personal computing was a terminal attached to a large, information-rich computer utility at very low cost, while the computer hobbyist’s vision was that of a traditional minicomputer. What brought together these two groups, with such different perspectives, was the arrival of the first hobby computer, the Altair 8800.

**The Altair 8800 and Bill Gates**

In January 1975 the first microprocessor-based computer, the Altair 8800, was announced on the front cover of *Popular Electronics*. The Altair 8800 is often described as the first personal computer. This was true only in the sense that its price was so low that it could be realistically bought by an individual. In every other sense the Altair 8800 was a traditional minicomputer. Indeed, the blurb on the front cover of *Popular Electronics* described it as exactly that: “Exclusive!
Altair 8800. The most powerful minicomputer project ever presented—can be built for under $400."

The Altair 8800 closely followed the marketing model of the electronic hobbyist kit: It was inexpensive ($397) and was sold by mail order as a kit that the enthusiast had to assemble himself. In the tradition of the electronics hobbyist kit, the Altair 8800 often did not work when the enthusiast had constructed it; and even if it did work, it did not do anything very useful. The computer consisted of a single box containing the central processor, with a panel of switches and lights on the front; it had no display, no keyboard, and not enough memory to do anything useful. Moreover, there was no way to attach a device such as a teletype to the machine to turn it into a useful computer system.

The only way the Altair 8800 could be programmed was by entering programs in pure binary code by flicking the hand switches on the front. When loaded, the program would run; but the only evidence of its execution was the change in the shifting pattern of the lights on the front. This limited the Altair 8800 to programs that only a dedicated computer hobbyist would ever be able to appreciate. Entering the program was extraordinarily tedious, taking several minutes—but as there were only 256 bytes of memory, there was a limit to the complexity of programs that could be attempted.

The Altair 8800 was produced by a tiny Albuquerque, New Mexico, electronics kit supplier, Micro Instrumentation Telemetry Systems (MITS). The firm had originally been set up by an electronics hobbyist, Ed Roberts, to produce radio kits for model airplanes. In the early 1970s Roberts began to sell kits for building electronic calculators, but that market dried up in 1974 during the calculator wars. Although he had toyed with the idea of a general-purpose computer for some time, it was only when the more obvious calculator market faded away that he decided to take the gamble.

The Altair 8800 was unprecedented and in no sense a "rational" product—it would appeal only to an electronics hobbyist of the most dedicated kind, and even that was not guaranteed. Despite its many shortcomings, the Altair 8800 was the grit around which the pearl of the personal-computer industry grew during the next two years. The limitations of the Altair 8800 created the opportunity for small-time entrepreneurs to develop "add-on" boards so that extra memory, conventional teletypes, and audiocassette recorders (for permanent data storage) could be added to the basic machine. Almost all of these start-up companies consisted of two or three people—mostly computer hobbyists hoping to turn their pastime to profit. A few other entrepreneurs developed software for the Altair 8800.
In retrospect, the most important of the early software entrepreneurs was Bill Gates, the co-founder of Microsoft. Although his ultimate financial success has been almost without parallel, his background was quite typical of a 1970s software nerd—a term that conjures up an image of a pale, male adolescent, lacking in social skills, programming by night and sleeping by day, oblivious to the wider world and the need to gain qualifications and build a career. This stereotype, though exaggerated, contains an essential truth; nor was it a new phenomenon—the programmer-by-night has existed since the 1950s. Indeed, programming the first personal computers had many similarities to programming a 1950s mainframe: There were no advanced software tools, and programs had to be hand-crafted in the machine’s own binary codes so that every byte of the tiny memory could be used to its best advantage.

Gates, born in 1955 in Seattle to upper-middle-class parents, was first exposed to computers in 1969, when he learned to program in BASIC using a commercial time-sharing system on which his high school rented time. He and his close friend, Paul Allen, two years his senior, discovered a mutual passion for programming. They also shared a strong entrepreneurial flair from the very beginning: When Gates was only sixteen, long before the personal-computer revolution, the two organized a small firm for the computer analysis of traffic data, which they named Traf-O-Data. While Allen went on to study computer science at Washington State University, Gates decided—under the influence of his lawyer father—to prepare for a legal career at Harvard University, where he enrolled in the fall of 1973. However, he soon found that his studies did not engage his interest, and he continued to program by night.

The launch of the Altair 8800 in 1975 transformed Gates’s and Allen’s lives. Almost as soon as they heard of the machine, they recognized the software opportunity it represented and proposed to MITS’ Ed Roberts that they should develop a BASIC programming system for the new machine. Besides being easy to develop, BASIC was the language favored by the commercial time-sharing systems and minicomputers that most computer hobbyists had encountered, and would therefore be the ideal vehicle for the personal-computer market. Roberts was enthusiastic, not least because BASIC would need a lot more memory to run than was normally provided with the Altair 8800; he expected to be able to sell extra memory with a high margin of profit.

Gates and Allen formed a partnership they named Micro-Soft (the hyphen was later dropped), and after six weeks of intense programming effort they delivered a BASIC programming system to MITS in February 1975. Now graduated, Allen became software director at MITS—a somewhat overblown job title
for what was still a tiny firm located in a retail park. Gates remained at Harvard for a few more months, more from inertia than vocation; by the end of the academic year the direction of the booming microcomputing business was clear, and Gates abandoned his formal education. During the next two years, literally hundreds of small firms entered the microcomputer software business, and Microsoft was by no means the most prominent.

The Altair 8800, and the add-on boards and software that were soon available for it, transformed hobby electronics in a way not seen since the heyday of radio. In the spring of 1975, for example, the “Homebrew Computer Club” was established in Menlo Park, on the edge of Silicon Valley. Besides acting as a swap shop for computer components and programming tips, it also provided a forum for the computer-hobbyist and computer-liberation cultures to meld.

During the first quarter of 1975, MITS received orders worth over $1 million for the Altair 8800 and launched its first “world-wide” conference. Speakers at the conference included Ed Roberts, Gates and Allen as the developers of Altair BASIC, and the computer-liberation guru Ted Nelson. At the meeting Gates launched a personal diatribe against hobbyists who pirated software. This was a dramatic position: He was advocating a shift in culture from the friendly sharing of free software among hobbyists to that of an embryonic branch of the packaged-software industry. Gates encountered immense hostility—his speech was, after all, the very antithesis of computer liberation. But his position was eventually accepted by producers and consumers, and over the next two years it was instrumental in transforming the personal computer from a utopian ideal to an economic artifact.

The period 1975–77 was a dramatic and fast-moving one in which the microcomputer was transformed from a hobby machine to a consumer product. The outpouring of newly launched computer magazines remains the most permanent record of this frenzy. Some of them, such as *Byte* and *Popular Computing*, followed in the tradition of the electronics hobby magazines, while others, such as the whimsically titled *Dr. Dobb’s Journal of Computer Calisthenics and Orthodontia*, responded more to the computer-liberation culture. The magazines were important vehicles for selling computers by mail order, in the tradition of hobby electronics. Mail order was soon supplanted, however, by computer shops such as the Byte Shop and ComputerLand, which initially had the ambiance of an electronics hobby shop: full of dusty, government-surplus hardware, and electronic gadgets. Within two years, ComputerLand would be transformed into a nationwide chain, stocking shrink-wrapped software and computers in colorful boxes.
While it had taken the mainframe a decade to be transformed from laboratory instrument to business machine, the personal computer was transformed in just two years. The reason for this rapid development was that most of the subsystems required to create a personal computer already existed: keyboards, screens, disk drives, and printers. It was just a matter of putting the pieces together. Hundreds of firms—not just on the West Coast, but all over the country—sprang up over this two-year period. They were mostly tiny start-ups, consisting of a few computer hobbyists or young computer professionals; they supplied complete computers, add-on boards, peripherals, or software. Within months of its initial launch at the beginning of 1975, the Altair 8800 had itself been eclipsed by dozens of new models produced by firms such as Applied Computer Technology, IMSAI, North Star, Cromemco, and Vector.

The Rise of Apple Computer

Most of the new computer firms fell almost as quickly as they rose, and only a few survived beyond the mid-1980s. Apple Computer was the rare exception in that it made it into the Fortune 500 and achieved long-term global success. Its initial trajectory, however, was quite typical of the early hobbyist start-ups.

Apple was founded by two young computer hobbyists, Stephen Wozniak and Steve Jobs. Wozniak grew up in Cupertino, California, in the heart of the booming West Coast electronics industry. Like many of the children in the area, electronics was in the air they breathed. Wozniak took to electronics almost as soon as he could think abstractly; he was a talented hands-on engineer, lacking any desire for a deeper, academic understanding. He obtained a radio amateur operating license while in sixth grade, graduated to digital electronics as soon as integrated circuits became available in the mid-1960s, and achieved a little local celebrity by winning an interschools science prize with the design of a simple adding circuit. Unmotivated by academic studies, he drifted in and out of college without gaining significant qualifications, although he gained a good working knowledge of minicomputers.

Like many electronics hobbyists, Wozniak dreamed of owning his own minicomputer, and in 1971 he and a friend went so far as to construct a rudimentary machine from parts rejected by local companies. It was around this time that he teamed up with Steve Jobs, five years his junior, and together they went into business making “blue boxes”—gadgets that mimicked dial tones, enabling telephone calls to be made for free. While not illegal to make and sell, using a
blue box was illegal, as it defrauded the phone companies of revenues; but many of these hobbyists regarded it as a victimless crime, and in the moral climate of the West Coast computer hobbyist it was pretty much on a par with pirating software. This in itself is revealing of how far cultural attitudes would shift as the personal computer made the transition from hobby to industry.

Despite his lack of formal qualifications, Wozniak’s engineering talent was recognized and he found employment in the calculator division of Hewlett-Packard in 1973; but for what amounted to a late-twentieth-century form of patronage that prevailed in the California electronics industry, Wozniak might have found his career confined to that of a low-grade technician or repairman.

While Wozniak was a typical, if unusually gifted, hobbyist, Steve Jobs bridged the cultural divide between computer hobbyism and computer liberation. That Apple Computer ultimately became a global player in the computer industry is largely due to Jobs’s evangelizing of the personal computer, his ability to harness Wozniak’s engineering talent, and his willingness to seek out the organizational capabilities needed to build a business.

Born in 1955, Jobs was brought up by adoptive blue-collar parents. Although not a child of the professional electronics engineering classes, Jobs took to the electronic hobbyism that he saw all around him. While a capable enough engineer, he was not in the same league as Wozniak. There are many stories of Jobs’s astounding, and sometimes overbearing, self-confidence, which had a charm when he was young but was seen as autocratic and immature when he became the head of a major corporation. One of the more celebrated stories is that, at the age of thirteen, when he needed some electronic components for a school project, he telephoned William Hewlett, the multimillionaire co-founder of Hewlett-Packard. Hewlett, won over by Jobs’s chutzpah, not only gave him the parts but offered him a part-time job with the company.

Something of a loner, and not academically motivated, Jobs drifted in and out of college in the early 1970s before finding a well-paid niche as a games designer for Atari. An admirer of the Beatles, like them Jobs spent a year pursuing transcendental meditation in India and turned vegetarian. Jobs and Wozniak made a startling contrast: Wozniak was the archetypal electronic hobbyist with social skills to match, while Jobs affected an aura of inner wisdom, wore open-toed sandals, had long, lank hair, and sported a Ho Chi Minh beard.

The turning point for both Jobs and Wozniak was attending the Homebrew Computer Club in early 1975. Although Wozniak knew about microprocessors from his familiarity with the calculator industry, he had not up to that point realized that they could be used to build general-purpose computers and had
not heard of the Altair 8800. But he had actually built a computer, which was more than could be said of most Homebrew members at that date, and he found himself among an appreciative audience. He quickly took up the new microprocessor technology, and within a few weeks had thrown together a computer based on the MOS Technology 6502 chip. He and Jobs called it the "Apple," for reasons that are now lost in time, but possibly for the Beatles' record label.

While Jobs never cared for the "nit-picking technical debates" of the Homebrew computer enthusiasts, he did recognize the latent market they represented. He therefore coaxed Wozniak into developing the Apple computer and marketing it, initially through the Byte Shop. The Apple was a very crude machine, consisting basically of a naked circuit board, lacking a case, a keyboard, or screen, or even a power supply. Eventually about two hundred were sold, each hand-assembled by Jobs and Wozniak in the garage of Jobs's parents.

In 1976 Apple was just one of dozens of computer firms competing for the dollars of the computer hobbyist. Jobs recognized before most, however, that the microcomputer had the potential to be a consumer product for a much broader market if it were appropriately packaged. To be a success as a product, the microcomputer would have to be presented as a self-contained unit in a plastic case, able to be plugged into a standard household outlet just like any other appliance; it would need a keyboard to enter data, a screen to view the results of a computation, and some form of long-term storage to hold data and programs. Most important, the machine would need software to appeal to anyone other than an enthusiast. First this would be BASIC, but eventually a much wider range of software would be required. This, in a nutshell, was the specification for the Apple II that Jobs passed down to Wozniak to create.

For all his naivety as an entrepreneur Jobs understood, where few of his contemporaries did, that if Apple was to become a successful company, it would need access to capital, professional management, public relations, and distribution channels. None of these was easy to find at a time when the personal computer was unknown outside hobbyist circles. Jobs's evangelizing was called on in full measure to acquire these capabilities. During 1976, while Wozniak designed the Apple II, Jobs secured venture capital from Mike Markkula, to whom he had been introduced by his former employer at Atari, Nolan Bushnell. Markkula was a thirty-four-year-old former Intel executive who had become independently wealthy from stock options. Through Markkula's contacts, Jobs located an experienced young professional manager from the semiconductor industry, Mike Scott, who agreed to serve as president of the company. Scott would take care of
operational management, leaving Jobs free to evangelize and determine the strategic direction of Apple. The last piece of Jobs's plan fell into place when he persuaded the prominent public relations company Regis McKenna to take on Apple as a client.

Throughout 1976 and early 1977, while the Apple II was perfected, Apple Computer remained a tiny company with fewer than a dozen employees occupying 2,000 square feet of space in Cupertino, California.

**VisiCalc**

During 1977 three distinct paradigms for the personal computer emerged, represented by three leading manufacturers: Apple, Commodore Business Machines, and Tandy, each of which defined the personal computer in terms of its own existing culture and corporate outlooks.

If there can be said to be a single moment when the personal computer arrived in the public consciousness, then it was at the West Coast Computer Faire in April 1977, when the first two machines for the mass consumer, the Apple II and the Commodore PET, were launched. Both machines were instant hits, and for a while they vied for market leadership. At first glance the Commodore PET looked very much like the Apple II in that it was a self-contained appliance with a keyboard, a screen, a means of program storage, and with BASIC ready-loaded so that users could write programs.

The Commodore PET, however, coming from Commodore Business Machines—a firm that had originally made electronic calculators—was not so much a computer as a calculator writ large. For example, the keyboard had the tiny buttons of a calculator keypad rather than the keyboard of a standard computer terminal. Moreover, like a calculator, the PET was a closed system, with no potential for add-ons such as printers or floppy disks. Nevertheless, this narrow specification and the machine's low price appealed to the educational market, where it found a niche supporting elementary computer studies and BASIC programming; eventually several hundred thousand machines were sold.

By contrast, the Apple II, although more expensive than the PET (it cost $1,298, excluding a screen), was a true computer system with the full potential for adding extra boards and peripherals. The Apple II was therefore far more appealing to the computer hobbyist because it offered the opportunity to engage with the machine by customizing it and using it for novel applications that the inventors could not envisage.
In August 1977 the third major computer vendor, Tandy, entered the market, when it announced its TRS-80 computer for $399. Produced by Tandy's subsidiary, Radio Shack, the TRS-80 was aimed at the retailer's existing customers, who consisted mainly of electronic hobbyists and buyers of video games. The low price was achieved by the user having to use a television set for a screen and an audiocassette recorder for program storage. The resulting hook-up was no hardship to the typical Tandy customer, although it would have been out of place in an office.

Thus, by the fall of 1977, although the personal computer had been defined physically as an artifact, a single constituency had not yet been established. For Commodore the personal computer was seen as a natural evolution of its existing calculator line. For Tandy it was an extension of its existing electronic-hobbyist and video games business. For Apple the machine was initially aimed at the computer hobbyist.

Jobs's ambition and vision went beyond the hobby market, and he envisioned the machine also being used as an appliance in the home—perhaps the result of his experience as a designer of domestic video games. This ambiguity was revealed by the official description of the Apple II as a "home/personal computer." The advertisement that Regis McKenna produced to launch the Apple II showed a housewife doing kitchen chores, while in the background her husband sat at the kitchen table hunched over an Apple II, seemingly managing the household's information. The copy read:

The home computer that's ready to work, play and grow with you. . . . You'll be able to organize, index and store data on household finances, income taxes, recipes, your biorhythms, balance your checking account, even control your home environment.

These domestic projections for the personal computer were reminiscent of those for the computer utility in the 1960s, and were equally misguided. Moreover, the advertisement did not point out that these domestic applications were pure fantasy—there was no software available for "biorhythms," accounts, or anything else.

The constituency for the personal computer would be defined by the software that was eventually created for it.

At that time it was very easy to set up as a personal-computer software entrepreneur: All one needed was a machine on which to develop the software and the kind of programming know-how possessed by any talented first-year
computer science student, which many hobbyists had already picked up in their teenage years. The barriers to entry into personal-computer software were so low that literally thousands of firms were established—and their mortality rate was phenomenal.

Up to 1976 there were only a handful of personal-computer software firms, mainly producing “system” software. The most popular products included Microsoft’s BASIC programming language and Digital Research’s CP/M operating system, which were each used in many different makes of computer. This software was usually bundled with the machine, and the firm was paid a royalty included in the overall price of the computer. In 1977 personal-computer software was still quite a small business: Microsoft had just five employees and annual sales of only $500,000.

With the arrival of consumer-oriented machines such as the Apple II, the Commodore PET, and the Tandy TRS-80, however, the market for “applications” software took off. Applications software enabled a computer to perform useful tasks without the owner having to program the machine directly. There were three main markets for applications software: games, education, and business.

The biggest market, initially, was for games software, which reflected the existing hobbyist customer base:

When customers walked into computer stores in 1979, they saw racks of software, wall displays of software, and glass display cases of software. Most of it was games. Many of these were outer space games—Space, Space II, Star Trek. Many games appeared for the Apple, including Programma’s simulation of a video game called Apple Invaders. Companies such as Muse, Sirius, Broderbund, and On-Line Systems reaped great profits from games.

Computer games are often overlooked in discussions of the personal-computer software industry, but they played an important role in its early development. Programming computer games created a corps of young programmers who were very sensitive to what we now call human-computer interaction. The most successful games were ones that needed no manuals and gave instant feedback. The most successful business software had similar, user-friendly characteristics. As for the games software companies themselves, the great majority of them faded away. While a handful of firms became major players, the market for recreational software never grew as large as that for business applications, and so none of the firms became Fortune 500 companies.
The second software market was for educational programs. Schools and colleges were the first organizations to buy personal computers on a large scale: Software was needed to learn mathematics; simulation programs were needed for science teaching; and programs were needed for business games, language learning, and music. Much of this early software was developed by teachers and students in their own time and was of rather poor quality. Some major programs were developed through research grants, but because of charitable status, the software was either free or sold on a nonprofit basis. As a result the market for educational software did not develop for a decade, and even today it is a poorly developed sector of personal-computer software.

The market of packaged software for business applications developed between 1978 and 1980, when three generic applications enabled the personal computer to become an effective business machine: the spreadsheet, the word processor, and the database. All these types of software already existed in the ordinary mainframe computer context, typically using a time-sharing terminal, so it was not obvious at the outset that the personal computer offered any advantage as a business machine.

The first application to receive wide acceptance was the VisiCalc spreadsheet. The originator of VisiCalc was a twenty-six-year-old Harvard MBA student, Daniel Bricklin, who thought of the idea of using a personal computer as a financial analysis tool, as an alternative to using a conventional mainframe computer or a time-sharing terminal. Bricklin sought the advice of a number of people, including his Harvard professor-supervisor, but they were somewhat discouraging because his idea seemed to offer no obvious advantage over a conventional computer. Bricklin was not dissuaded, however, and during 1977–78 he went into partnership with a programmer friend, Bob Frankson. In their spare time they developed a program for the Apple II computer. To market the program, Bricklin approached a former student from his MBA course, who was then running a company called Personal Software, which specialized in selling games software. They decided to call the program VisiCalc, for Visible Calculator.

Bricklin’s program used about 25,000 bytes of memory, which was about as big as a personal computer of the period could hold, but was decidedly modest by mainframe standards. The personal computer, however, offered some significant advantages that were not obvious at the outset. Because the personal computer was a stand-alone, self-contained system, changes to a financial model were displayed almost instantaneously compared with the minute or so it would have taken on a conventional computer. This fast response enabled a manager to
explore a financial model with great flexibility, asking what were known as “what if?” questions. It was almost like a computer game for executives.

When it was launched in December 1979, VisiCalc was a word-of-mouth success. Not only was the program a breakthrough as a financial tool but its users experienced for the first time the psychological freedom of having a machine of one’s own, on one’s desk, instead of having to accept the often mediocre take-it-or-leave-it services of a computer center. Moreover, at $3,000, including software, it was possible to buy an Apple II and VisiCalc out of a departmental, or even a personal, budget.

The success of VisiCalc has become one of the great heroic episodes of the personal-computer revolution and is often, alone, credited with transforming the industry. As described in Robert Slater’s Portraits in Silicon:

Suddenly it became obvious to businessmen that they had to have a personal computer: VisiCalc made it feasible to use one. No prior technical training was needed to use the spreadsheet program. Once, both hardware and software were for hobbyists, the personal computer a mysterious toy, used if anything for playing games. But after VisiCalc the computer was recognized as a crucial tool.

One can find a similar passage in virtually every history of the personal computer. On the whole, the role of VisiCalc has been exaggerated. Apple itself estimated that only 25,000 of the 130,000 computers it sold before September 1980 were bought on the strength of VisiCalc. Important as VisiCalc was, it seems highly likely that if it had not existed, then a word-processor or database application would have brought the personal computer into corporate use by the early 1980s.

Word processing on personal computers did not develop until about 1980. One reason for this was that the first generation of personal computers displayed only forty uppercase letters across the screen, and good-quality printers were expensive. This did not matter much when using a spreadsheet, but it made a personal computer much less attractive for word processing than an electric typewriter or a dedicated word-processing system. By 1980, however, new computers were coming onto the market capable of displaying eighty letters across the screen, including both upper and lower cases. The new computers could display text on the screen that was identical to the layout of the printed page—known as “what you see is what you get,” or WYSIWYG. Previously, this facility had been available only in a top-of-the-line word processor
costing several thousand dollars. The availability of low-cost printers that produced reasonable quality output, primarily from Japanese manufacturers, also greatly helped the word-processing market.

The first successful firm to produce word-processing software was MicroPro, founded by the entrepreneur Seymour Rubinstein in 1978. Rubinstein, then in his early forties, was formerly a mainframe software developer. He had a hobbyist interest in amateur radio and electronics, however, and when the first microcomputer kits became available, he bought one. He recognized very early on the personal computer’s potential as a word processor, and he produced a program called WordMaster in 1978. This was replaced in mid-1979 with a full WYSIWYG system called WordStar, which quickly gained a two-thirds market share. WordStar sold hundreds of copies a month, at $450 a copy. During the next five years MicroPro sold nearly a million copies of its processing software and became a $100-million-a-year business.

During 1980, with dozens of spreadsheet and word-processing packages on the market and the launch of the first database products, the potential of the personal computer as an office machine became clearly recognizable. At this point the traditional business-machine manufacturers, such as IBM, began to take an interest.

The Reemergence of IBM

IBM was not, in fact, the giant that slept soundly during the personal-computer revolution. IBM had a sophisticated market research organization that attempted to predict market trends. The company was well aware of microprocessors and personal computers. Indeed, in 1975 it had developed a desktop computer for the scientific market (the model 5100), but it did not sell well. By 1980 IBM was selling a dedicated word processor based on microprocessor technology. But its sales came a poor second to its traditional electric typewriters, of which IBM was still selling a million a year.

Once the personal computer became clearly defined as a business machine in 1980, IBM reacted with surprising speed. The proposal that IBM should enter the personal-computer business came from William C. Lowe, a senior manager who headed the company’s “entry-level systems” division in Boca Raton, Florida. In July 1980 Lowe made a presentation to IBM’s senior management in Armonk, New York, with a radical plan: Not only should IBM enter the personal-computer market but it should also abandon its traditional development
processes in order to match the dynamism of the booming personal-computer industry.

For nearly a century IBM had operated a bureaucratic development process by which it typically took three years for a new product to reach the market. Part of the delay was due to IBM's century-old vertical integration practice, by which it maximized profits by manufacturing in-house all the components used in its products: semiconductors, switches, plastic cases, and so on. Lowe argued that IBM should instead adopt the practice of the rest of the industry by outsourcing all the components it did not already have in production, including software. Lowe proposed yet another break with tradition—that IBM should not use its direct sales force to sell the personal computer but should instead use regular retail channels.

Surprisingly, in light of its stuffy image, IBM's top management agreed to all that Lowe recommended, and within two weeks of his presentation he was authorized to go ahead and build a prototype, which had to be ready for the market within twelve months. The development of the personal computer would be known internally as Project Chess.

IBM's relatively late entry into the personal-computer market gave it some significant advantages. First, it could make use of the second generation of microprocessors (which processed sixteen bits of data at a time instead of eight); this would make the IBM personal computer significantly faster than any other machine on the market. IBM chose to use the Intel 8088 chip, thereby guaranteeing Intel's future prosperity.

Although IBM was the world's largest software developer, paradoxically it did not have the skills to develop software for personal computers. Its bureaucratic software development procedures were slow and methodical, and geared to large software artifacts; the company lacked the critical skills needed to develop the "quick-and-dirty" software needed for personal computers.

IBM initially approached Gary Kildall of Digital Research—the developer of the CP/M operating system—for operating software for the new computer, and herein lies one of the more poignant stories in the history of the personal computer. For reasons now muddied, Kildall blew the opportunity. One version of the story has it that he refused to sign IBM's nondisclosure agreement, while another version has him doing some recreational flying while the dark-suited IBMers cooled their heels below. In any event, the opportunity passed Digital Research by and moved on to Microsoft. Over the next decade, buoyed by the revenues from its operating system for the IBM personal computer, Microsoft became the quintessential business success story of the late twentieth century, and Gates became a billionaire at the age of thirty-one. Hence, for all of Gates's
self-confidence and remarkable business acumen, he owed almost everything to being in the right place at the right time.

The IBM entourage arrived at Bill Gates and Paul Allen's Microsoft headquarters in July 1980. It was then a tiny (thirty-two-person) company located in rented offices in downtown Seattle. It is said that Gates and Allen were so keen to win the IBM contract that they actually wore business suits and ties. Although Gates may have appeared a somewhat nerdish twenty-five-year-old who looked fifteen, he came from an impeccable background, was palpably serious, and showed a positive eagerness to accommodate the IBM culture. For IBM, he represented as low a risk as any of the personal-computer software firms, almost all of which were noted for their studied contempt for Big Blue. It is said that when John Opel, IBM's president, heard about the Microsoft deal, he said, "Is he Mary Gates's son?" He was. Opel and Gates's mother both served on the board of the United Way.

At the time that Microsoft made its agreement with IBM for an operating system, it did not have an actual product, nor did it have the resources to develop one in IBM's time scale. However, Gates obtained a suitable piece of software from a local software firm, Seattle Computer Products, for $30,000 cash and improved it. Eventually, the operating system, known as MS-DOS, would be bundled with almost every IBM personal computer and compatible machine, earning Microsoft a royalty of between $10 and $50 on every copy sold.

By the fall of 1980 the prototype personal computer, known internally as the Acorn, was complete; IBM's top management gave final authorization to go into production. Up to this point the Acorn had been only a development project like any other—now serious money was involved. Lowe, his mission essentially accomplished, moved up into the higher echelons of IBM, leaving his second-in-command, Don Estridge, in overall charge. Estridge was an unassuming forty-two-year-old. Although, as the corporate spokesman for the IBM personal computer, he later became as well known as any IBMer apart from the company's president, he never attracted as much media attention as the Young Turks such as Gates and Jobs.

The development team under Estridge was now increased to more than a hundred, and factory arrangements were made for IBM to assemble computers using largely outsourced components. Contracts for the bulk supply of subsystems were finalized with Intel for the 8088 microprocessor, with Tandon for floppy disk drives, with Zenith for power supplies, and with the Japanese company Epson for printers. Contracts were also firmed up for software. Besides Microsoft for its operating system and BASIC, arrangements were made to develop a version of the VisiCalc spreadsheet, a word processor, and a suite of
business programs. A games program, Adventure, was also included with the machine, suggesting that even at this late date it was not absolutely clear whether the personal computer was a domestic machine, a business machine, or both.

Not everyone in IBM was happy to see the personal computer—whether for home or business—in the company’s product line. One insider was reported as saying:

Why on earth would you care about the personal computer? It has nothing at all to do with office automation. It isn’t a product for big companies that use “real” computers. Besides, nothing much may come of this and all it can do is cause embarrassment to IBM, because, in my opinion, we don’t belong in the personal computer business to begin with.

Overridding these pockets of resistance inside the company, IBM began to actively consider marketing. The economics of the personal computer determined that it could not be sold by IBM’s direct sales force because the profit margins would be too slender. The company negotiated with the Chicago-based Sears Company to sell the machine at its Business Centers and contracted with ComputerLand to retail the machine in its stores. For its traditional business customers, IBM would also sell the machines in its regular sales offices, alongside office products such as electric typewriters and word processors.

Early in 1981, only six months after the inception of Project Chess, IBM appointed the West Coast–based Chiat Day advertising agency to develop an advertising campaign. Market research suggested that the personal computer still lay in the gray area between regular business equipment and a home machine. The advertising campaign was therefore ambiguously aimed at both the business and home user. The machine was astutely named the IBM Personal Computer, suggesting that the IBM machine and the personal computer were synonymous. For the business user, the fact that the machine bore the IBM logo was sufficient to legitimate it inside the corporation. For the home user, however, market research revealed that although the personal computer was perceived as a good thing, it was also seen as intimidating—and IBM itself was seen as “cold and aloof.” The Chiat Day campaign attempted to allay these fears by featuring in its advertisements a Charlie Chaplin lookalike and alluding to Chaplin’s famous movie *Modern Times*. Set in a futuristic automated factory, *Modern Times* showed the “little man” caught up in a world of hostile technology, confronting it, and eventually overcoming it. The Charlie Chaplin figure reduced the intimidation factor and gave IBM “a human face.”
During the summer of 1981 the first machines began to come off the IBM assembly plant in Boca Raton, and by early August initial shipments totaling 1,700 machines had been delivered to Sears Business Centers and ComputerLand stores ready for the launch. A fully equipped IBM Personal Computer, with 64 Kbytes of memory and a floppy disk, cost $2,880.

The IBM Personal Computer was given its press launch in New York on 12 August. There was intense media interest, which generated many headlines in the computer and business press. In the next few weeks the IBM Personal Computer became a runaway success that exceeded almost everyone's expectations, inside and outside the company. While many business users had hesitated over whether to buy an Apple or a Commodore or a Tandy machine, the presence of the IBM logo convinced them that the technology was for real: IBM had legitimized the personal computer. There was such a demand for the machine that production could not keep pace, and retailers could do no more than placate their customers by placing their names on a waiting list. Within days of the launch, IBM decided to quadruple production.

During 1982–83 the IBM Personal Computer became an industry standard. Most of the popular software packages were converted to run on the machine, and the existence of this software reinforced its popularity. This encouraged other manufacturers to produce "clone" machines, which ran the same software. This was very easy to do because the Intel 8088 microprocessor used by IBM and almost all the other subsystems were readily available on the open market. Among the most successful of the clone manufacturers was Houston-based Compaq, which produced its first machine in 1982. In its first full year of business, it achieved sales of $110 million. Adroitly swimming with the tide, several of the leading manufacturers such as Tandy, Commodore, Victor, and Zenith switched into making IBM-compatible products. Alongside the clone manufacturers, a huge subindustry developed to manufacture peripherals, memory boards, and add-ons. The software industry published thousands of programs for the IBM-compatible personal computer—or the IBM PC, as the machine soon became known. In 1983 it was estimated that there were a dozen monthly magazines and a score of weekly newspapers for users of the machine. Most famously, in January 1983, the editors of Time magazine nominated as their Man of the Year not a person but a machine: the PC.

Almost all the companies that resisted the switch to the IBM standard soon went out of existence or were belatedly forced into conforming. The only important exception was Apple Computer, whose founder, Steve Jobs, had seen another way to compete with the IBM standard: not by making cheaper hardware but by making better software.