Chronologically Incorrect

by Edward Tenner

Seventy years ago, W. I. Thomas and Dorothy Swaine Thomas proclaimed one of sociology's most influential ideas: "If men define situations as real, they are real in their consequences." Their case in point was a prisoner who attacked people he heard mumbling absent-mindedly to themselves. To the deranged inmate, these lip movements were curses or insults. No matter that they weren't; the results were the same.

The Thomas Theorem, as it is called, now has a corollary. In a microprocessor-controlled society, if machines register a disordered state, they are likely to create it. For example, if an automatic railroad switching system mistakenly detects another train stalled on the tracks ahead and halts the engine, there really will be a train stalled on the tracks.

Today, the corollary threatens billions of lines of computer code and millions of pieces of hardware. Because they were written with years encoded as two digits (treating 1998 as 98), many of world's software programs and microchips will treat January 1, 2000, as the first day of the year 1900. Like the insane convict, they will act on an absurd inference. For purposes of payment, a person with a negative age may cease

to exist. An elevator or an automobile engine judged by an embedded microprocessor to be overdue for inspection may be shut down. All of our vital technological and social systems are vulnerable to crippling errors. Correcting programs requires time-consuming close inspection by skilled programmers, custom-crafted solutions for virtually every computer system, and arduous testing—and time is running out.

Nobody denies the hazards. And as we will see, if only because of the original Thomas Theorem, the Year 2000 Problem is already upon us. The unsettling question is just how serious it will remain after more billions of dollars are spent between now and then correcting and testing affected systems—fully 1,898 in the U.S. Department of Defense alone, and hundreds of thousands of smaller computer networks if those of small businesses are included. Will the first days of the year 2000 be just a spike in the already substantial baseline of system failures recorded in professional forums such as the Risks site on the Internet? That might be called the fine mess scenario. Or will it be a chain reaction of self-amplifying failures—the deluge scenario?

Warning, diagnosing, correcting, testing, certifying, and testifying about the Year 2000 Problem, increasingly abbreviated as Y2K, is the mission of a new computer specialty that might be called Y2Kology. Few of today's Y2Kologists were familiar to readers of the consumer computer press even five years ago, though Edward Yourdon had written influential books on programming and Capers Jones was a leading network management consultant. Few teach in the largest and oldest academic computer science departments or business schools. The hardware and software establishments regarded the problem as tedious housekeeping in the emerging frictionless networked economy. All that is changing as Y2Kologists begin to make headlines.

Because Y2Kology mixes evangelism, prophecy, and entrepreneurship, its message has not won easy acceptance. The financial news magnate Michael Bloomberg called the Year 2000 Problem "one of the greatest frauds of all time" at a meeting of securities traders last year. As late as last spring, the Bank of Montreal predicted only a "mild blip," and a mid-1998 survey of chief financial officers of companies with more than 20 employees revealed that only 17 percent were very concerned, and 48 percent were unconcerned.

Read closely, Y2Kologists share no consensus on how severe the Y2K dislocations are likely to be. Edward Yardeni, chief economist of the Deutsche Morgan Grenfell investment bank, now estimates that the odds are strongly in favor of an economic recession as serious as the one triggered by the 1973–74 oil shock. But an acknowledged aim of alarming predictions, as in George Orwell's *1984*, is to galvanize people into action that will prevent the worst. As of mid-1998, many leading

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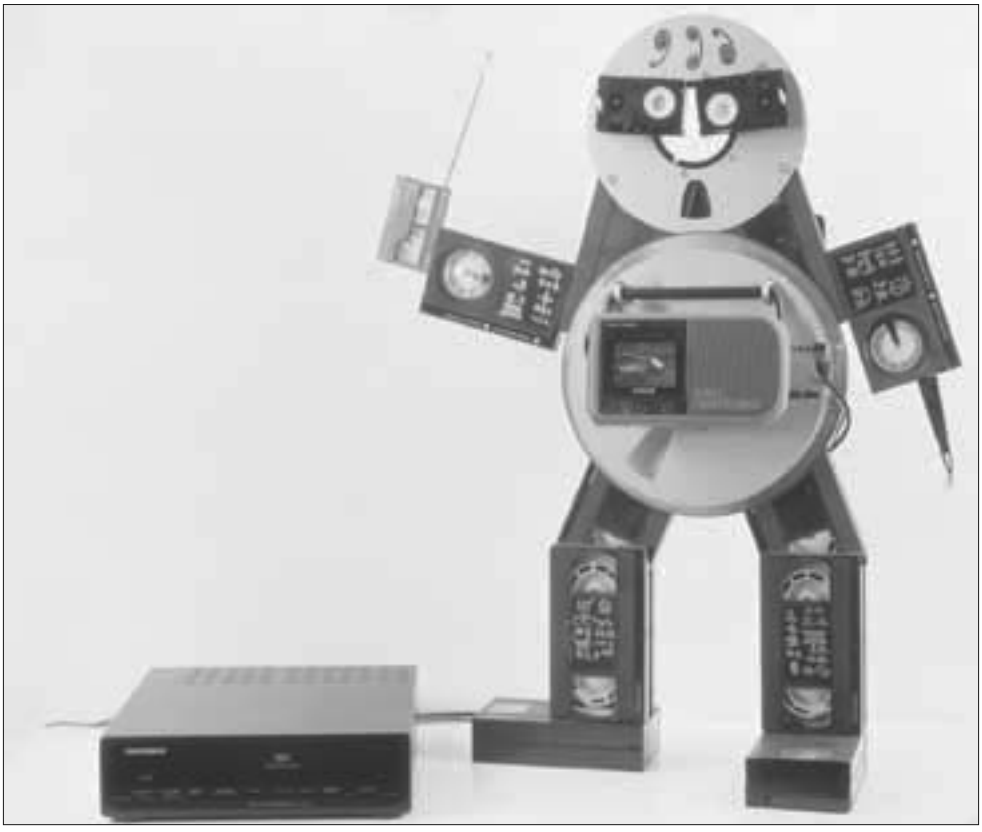

Fin de Siècle Man *(1992), by Nam June Paik*

Y2Kologists, including the Canadian consultant Peter de Jager and the American academic Leon Kappelman, were arguing that if organizations concentrated on their essential systems and deferred other work, massive failure could still be averted. Edward Yourdon and his daughter Jennifer Yourdon have written a guide for coping with a variety of plausible scenarios, which in their view range from a two-to-three-day disruption to a 10-year depression. And a few panicky Y2K programmers are retreating to the western deserts—the very area most dependent on electronically controlled federal water distribution systems.

One thing is certain: the apprehension is real, and will have real consequences. Just as the fear of nuclear war and terrorism has transformed the world over the last two generations, so the mere possibility of massive system failure will cast a shadow over its political, military, business, and scientific rulers for years to come. Year 2000 is less a crisis of technology than a crisis of authority.

For at least a century the West has expected, and received, orderly technological transitions. Our vital systems have grown faster, safer, and more flexible. Boiler explosions, for example, killed as many as 30,000 Americans a year around 1900; today, only a handful die in such accidents. The reduction was the result of cooperation among engineers, state legislators, and industries to establish uniform codes and inspection procedures in

place of patchwork regulations and spotty supervision. Well before the sinking of the *Titanic* in 1912, national and international bodies had made transatlantic travel much safer than it had been in the age of sail. Railroads long ago arrived at standards for compatible air brake systems that allowed passenger and freight cars to be safely interchanged. And evolving engineering standards have helped reduce accident levels on the nation's interstate highways. But no comparable effort has been made to cope with the Y2K problem.

Most consumers pay little attention to the hundreds of national and international standards-setting bodies. Only when major commercial interests are at stake, as when specifications are established for high-definition television or for sound and video recording, do the news media report on debates. Laypeople are rarely present at standards-setting deliberations. Before the early 1980s, many conventions were handled mainly as internal corporate matters. AT&T established exchange numbers and area codes, and IBM and a handful of other manufacturers upgraded operating systems of their mainframe computers. And why should people worry? The record of these organizations was unmatched in the world. A Henry Dreyfuss-designed, Western Electric-manufactured rotary telephone could work for a generation without repair. The future seemed to be in good hands.

The breakup of AT&T, the explosion of utilities competition, the globalization of manufacturing, and the rise of personal computing have all helped diffuse authority over standards. And freedom from regulatory entanglement has brought immense benefits to manufacturers, consumers, and the economy. But it has had an unintended consequence. The diversity of systems and the fierceness of business rivalries discourage public and private technological authorities—from the Defense Department to Microsoft—from taking firm and early action to cope with emerging problems. (A fear of antitrust prosecutions has also inhibited Year 2000 cooperation among corporations, enough so that President Bill Clinton felt compelled in July to propose special legislation to clear the way.) Governments have avoided interference in commercial decisions, and businesses have succeeded more by following market shifts than by staking out ambitious new standards. As the Thomas Theorem implies, if people do not believe they can exert power or influence, then they cannot. Which brings us to "the millennium bug," which is no bug at all.

Over the last four decades, the Year 2000 Problem has passed through three phases, each bringing its own challenges for authorities. The first age, the Time of Constraint, lasted from the origins of electronic computing to the early 1980s. The managers and programmers of the time knew that programs using only two-digit years had limits. Many must have been aware of the master programmer Robert Bemer's early-1970s article in the industry journal *Datamation*, describing the Year 2000 Problem in the COBOL programming language he had codeveloped. These electronic pioneers could have used four-digit dates, but there was a strong economic case for two. In fact, the U.S. Air Force

used single-digit dates in some 1970s programs and had to have them rewritten in 1979.

Leon Kappelman and the consultant Phil Scott have pointed out that the high price of memory in the decades before personal computing made early compliance a poor choice. In the early days of computing, memory was luxury real estate. A megabyte of mainframe hard disk storage (usually rented) cost $36 a month in 1972, as compared with 10 cents in 1996. For typical business applications, using four digits for dates would have raised storage costs by only one percent, but the cumulative costs would have been enormous. Kappelman and Scott calculate that the two-digit approach saved business at least $16–$24 million (in 1995 dollars) for every 1,000 megabytes of storage it used between 1973 and '92. The total savings are impossible to calculate, but they surely dwarf most estimated costs of correcting the Year 2000 problem. (One leading research group, the International Data Corporation, estimates a correction cost of $122 billion out of more than $2 trillion in total information technology spending in the six years from 1995 through 2000.)

Sometimes linked to apocalyptic anxieties about the millennium, the Y2K problem is beginning to produce a crop of alarmist pop-culture products.

Even where Year 2000 compliance was feasible and economical, it wasn't always in demand. In the 1980s, a number of applications programs were available with four-digit dates, such as the statistical programs and other software systems produced by the SAS Institute, one of computing's most respected corporations. SAS does not appear to have promoted it competitively as a major feature. The UNIX operating system, originally developed at Bell Laboratories, does not face a rollover problem until 2038, yet this too did not seem to be a selling point. Even Apple Computer did not promote its delayed rollover date of 2019. The year 2000 still seemed too far away.

By the mid-1980s, the Time of Choice was beginning. The economic balance—initially higher storage and processing costs versus long-term savings in possible century-end conversion costs—would have still been an open question, had it been openly raised. The great majority of

crucial government and business applications were still running on mainframe computers and facing memory shortages. But the trend to cheaper memory was unmistakable. The introduction of the IBM PC XT in 1983, with up to 640 kilobytes of random access memory (RAM) and its then-vast fixed hard drive of 10 megabytes, was already signaling a new age in information processing.

Yet the possibilities presented by the new age remained an abstraction to most computer systems managers and corporate and government executives. Then as now, most of their software expenses went not to create new code but to repair, enhance, and expand existing custom programs—what are now called "legacy systems." A date change standard would initially increase errors, delay vital projects, and above all inflate budgets. And it was not a propitious time to face this kind of long-term problem. The American industrial and commercial landscape during the 1980s was in the midst of a painful transformation, and investors appeared to regard most management teams as only as good as their last quarter's results. Only the mortgage industry, working as it did on 30-year cycles, had recognized the problem (in the 1970s) and begun to work on it.

In 1983, a Detroit COBOL programmer named William Schoen tried to market a Year 2000 conversion program he had created. A sympathetic column about his warnings in a leading trade weekly, *Computer World*, went unheeded. Schoen went out of business after selling two copies.

Not that government was much more prescient. The Federal Information Processing Standard of the National Institute of Standards and Technology (NIST) for interchange of information among units of the federal government specified a six-digit (YYMMDD) format in 1968 and did not fully change to an eight-digit (YYYYMMDD) format until 1996. The Social Security Administration was the first major agency to begin Year 2000 conversion, in 1990. Despite the impressive military budget increases of the 1980s and the Pentagon's tradition of meticulous technical specifications for hardware, many vital Defense Department systems still require extensive work today.

The computing world of the 1990s recalls a multimedia trade show display decorated at great expense and stocked with the best equipment money can buy, yet still dependent on a hideous, half-concealed tangle of cables and power lines, with chunky transformer blocks jutting awkwardly from maxed-out surge protectors. Our apparently seamless electronic systems turn out to be patched together from old and new code in a variety of programming languages of different vintages. The original source code has not always survived. Year 2000 projects can turn into organizational archaeology.

The German philosopher Ernst Bloch popularized the phrase *Gleichzeitigkeit des Ungleichzeitigen*, literally "simultaneity of the nonsimultaneous," to express the coexistence of old and new values. Far from being dead, the past (in William Faulkner's even more celebrated words) sometimes is not even past. Indeed, in Faulkner's native South, much of the

cotton trade is said to rely on ancient IBM punch card systems now maintained by arcane specialty vendors. In the United Kingdom, the Royal Air Force's supersonic Tornado fighters, costing £20 million each, are still equipped with 256 kilobytes of core memory, with processing data recorded on standard audiocassettes. This seemingly obsolete system not only performed magnificently in the Persian Gulf War but is considered impervious to conventional electronic jamming techniques. Year 2000 repair confronts us with many such examples of coexistence.

The Time of Choice ended in the early 1990s, when leading computer industry publications prominently recognized Year 2000 conversion as a problem and warned of the consequences of neglecting it. Peter de Jager's September 1993 *Computerworld* article, "Doomsday 2000," may not have been the *Silent Spring* of Y2Kology, but it was fair warning. Writing in *Forbes* in July 1996, Caspar W. Weinberger, chairman of Forbes, was probably the first prominent business figure to underscore the seriousness of the problem (though, curiously, the former secretary of defense said nothing about the Y2K dilemmas confronting the public sector).

The Time of Trial began in the mid-1990s, as conversion programs began in earnest and Y2K issues were increasingly aired in the computer press. It will probably last until around 2005. A few annoyances are already apparent. Credit cards with 2000 expiration dates, for example, have been rejected by some authorization systems. Many critical points will arrive in 1999, with the need to reset some older Global Positioning System (GPS) equipment, for example, and especially with the beginning of fiscal year 2000 for many governments and private-sector organizations.

During the Time of Choice, the problem was recognized but deferred for two reasons. First, there was the chance that entire computer systems would be replaced before 2000. Second, future software tools might reduce conversion costs sharply. In 1988, a senior Defense Department computer systems official told the *Chicago Tribune*: "Our projections for the development of artificial intelligence systems suggest that by 1994 and 1995, they may be able to handle most of this relatively easily." Yet 10 years later, a congressional committee heard one expert give the Pentagon an "F" for its Year 2000 readiness. In the civilian sector, too, older hardware and software is far more pervasive than many experts anticipated. It may also be too late for most businesses to replace their vulnerable systems; programmers are scarce and expensive, and conversion can take years to complete.

Speaker of the House Newt Gingrich (R.-Ga.), publisher and likely Republican presidential contender Steve Forbes, and other prominent Republicans are exploiting the Clinton administration's failure to address the problem earlier. How could self-styled technology advocates such as Vice President Al Gore have turned a blind eye to a threat of such magnitude? Embarrassed as Gore might turn out to be by a series of government computer failures in early 2000, and shy of the Year 2000 issue as he has lately appeared, congressional Republicans have no better track record. For example, during hearings about the Internal Revenue Service's computer

system woes in 1996, Senator Ted Stevens (R.-Alaska) cited "advice from a very distinguished thinker" to the effect that problematic computer systems would be replaced by 2000. Only in early 1997 did the Republican-controlled Congress's own auditing arm, the General Accounting Office, upgrade Year 2000 to its most serious category of issues. The other organization that might have dealt with the issue, the Office of Technology Assessment, was abolished by Congress in 1995. In fact, the legislators with an interest in the problem are a small group that includes members of both parties, among them senators Robert Bennett (R.-Utah) and Daniel Patrick Moynihan (D.-New York).

Computer industry executives, from Microsoft's William Gates on down, also missed opportunities. When Microsoft introduced Windows 95—a two-digit name—in the summer of that year, it required developers to meet a variety of compatibility standards before they could display the Win95 logo. (For example, the procedures for removing a program and its associated files from a hard drive had to be simplified.) Continued functionality after four and a half years was not one of these requirements. Even in mid-1998, some of Microsoft's own software products may have at least minor problems associated with the date change. Microsoft has been at least as responsible as most other companies, probably more so. Yet Gates published his book *The Road Ahead* (1996) without a discussion of the Year 2000 Problem; in a July 1996 column, he appeared unaware that a number of popular current personal computer programs were affected. (Most problems with programs on non-networked personal computers can be solved relatively easily, often with a simple upgrade.)

If the coexistence of past, present, and future was the discovery of the Time of Choice, *triage* is becoming the watchword of the Time of Trial. Fortunately, information technologies are not created equal. Some organizations have hundreds or even thousands of computer systems, but only a minority are vital and only a few may be critical. In 1998 it is too late to fix everything, even with emergency budgets and the mobilization of computer-skilled employees from other departments. As the project management guru Frederick P. Brooks pointed out in his classic *Mythical Man Month* (1982), adding programmers to a late project can actually delay it further. In a complex interconnected system, more things can go wrong.

In the Time of Trial, triage will not be the only military metaphor. Many other information technology projects will be suspended or canceled as programmers are called up for the front. Careers will be damaged and entire organizations will be set back. Well-prepared companies will gain strategic advantages. Yet so far, financial markets have not been able to identify Year 2000 winners and losers. A study by Triaxys Research showed that as of June 1998 many companies had not completed Year 2000 assessments, much less undertaken efforts to correct their problems. Investors still do not have adequate information.

Despite these gaps, there is reason to hope for a fine mess rather than a deluge. Some banks and investment houses have reported mak-

Moon, Antares, Earth, Sun *(1990), by Nam June Paik*

ing good progress on their systems. A Wall Street dry run of Year 2000 trading last July seemed to go well. Improvements of Year 2000 software tools may shorten the time needed to make repairs. Indeed, the military metaphor provides a measure of reassurance. For all the shortcomings of British and American policy and planning during the years between the world wars, for example, Allied scientists and engineers performed miracles once war broke out.

Some dangers will persist despite the efforts of even the most resourceful managers. Realization of any one of the five most ominous threats could validate the doomsayers' predictions. These risks might be abbreviated as SMILE: second-order effects, malicious code, interdependencies, litigation, and embedded processors.

Thomas's Theorem suggests that the expectation of a Year 2000 crisis may be enough to create a real one no matter how effective the efforts to repair the underlying code. Our social and technological systems are more efficient than ever, but because, for example, information technologies now allow vendors and manufacturers to maintain lean warehouse inventories, slight disruptions can have more serious repercussions. Running the gamut from shifts of investment funds based on Internet-transmitted rumors about the Year 2000 readiness of particular companies, to depletion of bank and automatic teller machine currency supplies, to runs on bread and toilet paper, a late 1999 panic might be comical but also potentially deadly.

Add potential sabotage to the equation. The Pentagon already wor-

ries about information warfare and terrorism. Hostile states, criminal organizations, and domestic and foreign radical movements can already attack vital networks. The beginning of the year 2000 is a perfect cover. Do not forget embezzlers and vengeful staff. An apparently Year 2000-related incident could mask electronic robbery, and a continuing shortage of skilled personnel could delay diagnoses for priceless months. Computer security experts also fear fly-by-night Y2K consultants who may collude with corrupt managers to offer bogus certification, or plant Trojan horse programs in the systems of honest but desperate ones.

Thanks to decades of global thinking, North America and Europe are also linked to nations whose Year 2000 readiness makes many Western nations look like paragons. The Asian financial crisis that began last year has surely delayed the compliance programs of some major trading partners of the United States and Europe. International interchange of data may send a failure in one country rippling through the most rigorously Year 2000-ready systems: the sociologist Charles Perrow calls this "tight coupling." Major corporations are already pressing their trading partners for certification of their Year 2000 compliance. Domestically, this may make or break some firms, but it will not bring down the economy. Internationally, it may trigger local crises that might lead to mass migrations or insurrections.

The courts have only begun to consider legal liability for Year 2000 failures. The cases already on the docket will test one of the law's principles: to decree retroactively but to create predictability. Because Year 2000 cases will raise new questions and provoke immense claims, the litigation will be prolonged and sometimes ruinous.

The most serious wild card of all, though, is a hardware issue. Most discussions of the Year 2000 Problem focus on the difficulty of repairing and testing software, but that is a cinch compared to dealing with the thousands of embedded microchips that control critical systems. The Gartner Group estimates that 50 million embedded devices may malfunction. Traffic signals and freeway entrance metering lights will fail. Elevators will shut down if their electronic hardware tells them they have not been inspected for nearly a hundred years. (The largest elevator manufacturers deny their products are vulnerable to Y2K failure.) Electric power distribution switches and pipeline controls will interrupt energy flow. Medical x-ray machines will not turn on—or far worse, off—at the proper times.

(There is an alternative final E in SMILE: the euro, the new European currency scheduled for introduction in 1999. Conversion of existing financial programs and historical data for euro compatibility competes for scarce programming time with Year 2000 conversion projects, and bugs in new and revised financial software may compound Year 2000 errors.)

No matter what its outcome, the Year 2000 Problem will stamp a cohort of managers, private and public, as it will put some of their predecessors on trial. Generation X will become Generation YY. Like other powerful events, Year 2000 will alter culture. But we don't know how, because it will have many surprises, positive and negative, for even today's most informed analysts.

The Year 2000 Problem shows that neither military nor civilian authority, neither social democracies nor authoritarian regimes nor market economies, neither big business nor small business, took fully adequate steps in planning for the future. And now, those seeking to discredit all established elites are coming into their own. Gary North, a Ph.D. historian and founder of the Institute for Christian Economics, not long ago was a prolific but obscure lay theologian criticized by some mainstream evangelical conservatives for his mix of radical theocracy and financial doomsaying. Now enjoying the survivalist good life on an Arkansas property with a private natural-gas well, he runs the Internet's scariest Y2K Web site, deftly collating the most frightening speculation available from establishment sources.

The future prestige of technological leaders is as problematic as the fate of political elites. Bill Gates apparently has never responded publicly to Peter de Jager's impassioned plea in the August 1997 issue of *Datamation* for a formal declaration of the urgency of action on Year 2000. A surprising number of nontechnical people still expect that Gates will find a way to fix the problem. Paradoxically, surveys of public opinion, independent of the millennium issue, have shown least public confidence in the insurance industry and greatest confidence in executives in the technology industries, yet insurers may well emerge less damaged in the early 2000s than some of the software producers. Prudential is often cited as an exemplary pioneer of conversion management.

Supposedly insulated from market pressures and encouraged to take the long view, universities seem to be as badly exposed to Year 2000 troubles as other organizations. Nor did any of the leading engineering, scientific, or business associations, or the best-funded think tanks, sound any early warning that I have been able to find. A few journalists did bring the issue to their readers' attention as early as the 1980s.

If centralized technological planning is discredited, if the discipline of markets (such as securities analysts' reports and insurance underwriters' risk assessments) has failed to give timely warning that cannot be ignored, what is left? Perhaps it is the realization that technology is not just a radiant future but a messy present, that the age of transition never ends, and that rapid novelty and massive legacy can interact to create lethal assumptions. The first of January 2000 will not be the first danger point, and it will be far from the last. Nobody can predict just what lessons will be learned, what concepts introduced, which individuals acclaimed. The outcome of Y2K will change everything, but if we already knew what will be changed, there would have been no Year 2000 crisis, only a problem.
