Appendix A. Electronic Book Technology

> The evolution of the personal computer has followed a path similar to that of the printed book, but in 40 years instead of 600. Alan Kay. [36]

To understand the long-term threat to publishing paper books, we need to understand some technology: computer memory, optical discs, memory cards, geosynchronous satellites, cellular radio, radio frequency modems, fiber optic cable, electronic networks, flat-panel displays, portable computers, and desktop computers.

This appendix also supports claims made in the report that some apparently radical technology will not only be possible, it is almost inevitable. By sketching the demand and market for each piece of technology, it also shows the computer industry's commitment to rapid change and it shows why this pace of change is inevitable. Personal computers are not yet as common as dishwashers, but that is only a few years away.

It is hard to grasp just how much computers have improved. Unlike any other technology ever, computers have improved 10 millionfold in the past 50 years; [37] in that time computers have gone from the lab to the lap. In 30 years, computers shrank from houses, to cars, to refrigerators, to ovens, to microwave ovens, to record players, to large books, to magazines, to wallets. They have stopped at wallet size only because if they were any smaller humans could not use them; eventually they will accept voice input and could display output on the inside of a pair of sunglasses. In the far future, they may move inside the human body.

Since 1971, the number of components on a chip has doubled every 16 to 18 months, and computers as a whole are now halving in price every two or three years. The present pace is expected to continue for at least two more decades, which means a further 10 millionfold improvement. And because computer technology is self-synergistic (better computers help us design and build better computers) the computers ten years from now can be used to keep the self-improvement ball rolling.

The industry's watchwords are: smaller, lighter, faster, denser, stronger, cheaper. Unless something drastic happens, in 10 years powerful computers will be as easy to use as toasters, in 20 years they will be as common as pens, and in 30 years they will be as cheap as paper-clips.

A.1.0 Computer Memory

A bit (binary digit) is a one or zero (off or on), and eight bits is a byte. The number of bytes a device can store is its memory, or storage. In 1986, memory was measured in the thousands or tens of thousands (1 kilobyte is roughly 1,000 bytes). In 1991, memory is measured in the millions (1 megabyte is roughly 1 million bytes), or billions (1 gigabyte is roughly 1 billion bytes). By 1996, it will be measured in the trillions (1 terabyte is roughly 1 trillion bytes), or quadrillions (1 petabyte is roughly 1 quadrillion bytes).

One byte usually corresponds to one character: a letter, number, or punctuation mark. On average an English word is about

5 or 6 bytes and a novel is anywhere from 60,000 to 100,000 words. So roughly, a novel is about 1/2 megabyte, a 500-page textbook is about 1 megabyte, and, at VHS (Video Home System) quality, a 1 hour movie is about 3/4 gigabytes. And these sizes halve when files are compressed. This report contains about 21,500 words and is about 135 kilobytes.

Memory cost is dropping fast. In 1964, 128 kilobytes cost a million dollars. Today that much memory is cheaper than the small amount of plastic used on the chip surrounding it. In 1984, 1 megabyte was a lot of memory; few people could afford that much memory, and they all worked at large institutions. By 1991, hundreds of thousands of personal computer users had over 8 megabytes of computer storage and 1 or 2 gigabytes of tape or disc storage.

The Panasonic LM-D501W is a rewriteable optical disc that holds 940 megabytes (roughly 1,800 novels); it is about the size of a compact disc and it costs $140. The 3M 8mm D8-112M is a rewritable digital tape that holds 2.3 gigabytes (roughly 4,600 novels); it is about the size of a cassette tape and it costs $18.

In 1990, IBM succeeded in storing 1/8 gigabyte on a 1 inch square magnetic disc. Just six years separate the first IBM 1/8-megabyte chip from the first Hitachi 8-megabyte chip; a 64-fold increase--the equivalent of a doubling every year. Some expect terabyte memories within ten years. Five such memories would hold more text than the human race has ever produced.

A.1.1 Optical Discs

An optical disc is a metal-coated polycarbonate disc covered by protective clear plastic with a 20 kilometer long (or longer) spiral, with pits inscribed along the spiral. Each pit is between 1.3 and 4 micrometers (millionths of a meter) long, so a laser is necessary to focus light on such tiny pits in the disc. A human hair is about 75 micrometers wide; a phonograph groove is about 100 micrometers wide.

On a music disc, the length and frequency of occurrence of the pits matches the sound's pitch and loudness. Unlike a phonograph record, reading speed is high, scratches will not harm it, the disc lasts longer than a human does, and there is no degradation of the reading surface over repeated readings. Human mouths produce sounds that are vibrations in the air, these vibrate from the lowest bass of about 73 hertz (73 cycles a second) to the highest soprano of about 1.5 kilohertz (1,500 cycles per second). Because we can hear only up to about 20 kilohertz, once we sample a sound at twice that speed or higher we capture all that any human can hear.

A compact disc (CD) is just a small optical disc; instead of music it can just as easily store any sequence of pits. For example, digital cameras and scanners can convert any scene into a series of bits, and we can store these bits as pits in an optical disc.

An optical disc can hold from 550 to over 1,000 megabytes (one gigabyte). So one small light disc can store up to 1,000 textbooks or 2,000 novels. Sony chose the size of compact discs (72 minutes) so that one would contain all 66 minutes of Beethoven's Ninth Symphony; beside convenience, there is no other reason for them to be so small. Further, because they are

circular, their area grows as the square of their radius, so a disc of double the width would hold four times as much information. Larger discs can hold 5,000 books--a truckload. A few dozen can hold a trainload. A few thousand can hold all 20 million books in the Library of Congress.

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A.1.2 Fast Memory and Memory Cards

Late in 1990, Hitachi surprised the world with the first 8-megabyte dynamic random access memory (DRAM) on a single chip. The chip is 10 millimeters by 20 millimeters--the size of a fingernail--and it contains 140 million electronic components, each over 100 times smaller than the diameter of a human hair. Dynamic means that the chip loses its memory unless it is continually powered. Random access means that any part of the memory can be fetched or written to in the same time as any other part. With an access time of 50 nanoseconds (billionths of a second), the chip can output its entire memory, roughly 16 novels' worth of data, in roughly 3.2 seconds. An eye blink is about 1/10th of a second.

Memory cards are credit card sized random access memories that hold their data without external power. They are low power and they will make disc drives obsolete within seven years. At present they are expensive, but the price is expected to drop rapidly as technology improves and demand drives their development. [38] Fujitsu, the second largest computer company in the world, and Intel are now working on a 64-megabyte memory card.

A.2.0 Computer Communications

Most of the world's major computers are linked together into gigantic electronic networks. The Internet, the largest computer network in the world, links over 350,000 computer installations, most with thousands of users, in 26 countries. Because of its strategic importance, in the U.S. the Internet is supported by the Defense Advanced Research Projects Agency, the National Science Foundation, the National Aeronautics and Space Administration, and the Department of Energy. This subsection discusses the technology used to connect computers.

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A.2.1 Geosynchronous Satellites

A geosynchronous satellite remains above the same spot on the earth by orbiting at roughly 36,000 kilometers up; it allows communication between any two points in its footprint (all the places it can broadcast to). For example, the recently launched AsiaSat-1 has a footprint extending over China, Japan, and most of the Pacific Rim countries. Earth stations beam (uplink) microwaves to the satellite and the satellite beams (downlinks) them back to earth. (Microwaves are poorly named; they are so named because they are the shortest radio waves, but radio waves are longer than most other electromagnetic waves, as for example, light.) Microwaves allow a communications capacity of about 1/4 megabyte per second, but with 1/4 second round trip time lag because they must travel to space and back.

As the technology has improved, receivers have shrunk;

currently receivers can be less than 1 meter wide (an arm's length) and are expected to shrink further. These receivers are affordable by individuals and are growing ever cheaper. There are now 1,400 satellites of all types in orbit. [39]

A.2.2 Cellular Radio

Unlike citizens-band radios (CBs) that require mobile users to be close to each other, a car phone works by cellular radio. It is a phone that keeps its connection while the user is mobile by continuously checking its immediate neighborhood for repeater stations and rapidly switching to a new station when out of range of the last one. The switching takes place so rapidly (0.3 seconds) that human conversations are not interrupted.

In February 1991, the U.S. Federal Communications Commission (FCC) approved three experimental pocket phone systems in Atlanta, Boston, and Long Island by three different U.S. cable companies. These phones fit in a shirt pocket and do not require any other equipment; low-power radio towers throughout each city pick up their weak broadcasts and computers route the traffic to the appropriate person. These phones can be used anywhere in the city. In September 1991, the British-based satellite consortium Inmarsat announced plans to launch 30 to 40 satellites to do the same for pocket phones, but worldwide. And Motorola is petitioning the FCC to approve its Iridium Project: a plan to launch dozens of low-power microsatellites that would do the same for portable computers--again worldwide.

There are now almost 7 million cellular phone users in the U.S., and the number of cellular phones is doubling every year. [40]

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A.2.3 Radio Frequency Modems

A modem (modulator/demodulator) is a device that transforms signals from one form to another. Modems are usually used over phone lines, but an RF (radio frequency) modem converts radio signals to other forms.

In August 1991, CUE, a paging company, announced the CUE LapCom RF modem. This modem lets senders transmit data without knowing where the intended recipient is, and it lets intended recipients accept data without dialing a special number. The sender dials an 800 number and uploads the data with the intended recipient's ID. CUE's computer uplinks the data to a satellite and the satellite downlinks it to 270 FM radio stations in its footprint. The radio stations then broadcast the data on their FM subcarriers.

A few seconds after the sender transmitted the data, the intended recipient's LapCom picks up the FM signal and receives the data. This system reaches over ninety percent of the U.S. and Canadian population. CUE currently supports 70,000 subscribers and is planning to offer the LapCom service at $60 to $75 per month. CUE is pricing the LapCom itself to be competitive with normal modems.

A.2.4 Fiber Optic Cable

Fiber optic cables use lasers to send information down glass fibers. Fiber optic cables are light, small, energy-efficient, non-rusting, not easily wire-tapped, and long-lasting. They let

us send a huge amount of information (that is they are high-bandwidth), and at near the speed of light. A single cable can carry up to 1 million simultaneous phone conversations.

In the past decade, the bandwidth of fiber optic cable has increased 100 times while the cost of fiber fell from $3 a meter to 15 cents a meter. [41] Currently every developed nation is laying millions of kilometers of fiber optic cable a year. Hong Kong's telephone network will be all digital by 1994, Singapore's by 1995, and Japan's by 1996.

A.2.5 Electronic Networks

Today's fiber optic local-area networks (LANs) have bandwidths of 6.25 to 18.75 megabytes per second, [42] which lets us send a 500-page book in under 1/6 of a second. Nippon Telegraph and Telephone, the largest company in the world, has already built an experimental fiber system transmitting almost 1/3 gigabytes a second over 2,200 kilometers. [43] In 1989, LAN sales (hardware, software, and cabling) exceeded $5.68 billion in the U.S. alone. [44]

In September 1991, the U.S. Senate approved a $1 billion expenditure over five years to develop high-speed supercomputing networks linking Federal, university, and corporate research centers. This network will be 100 times faster than current high-speed networks. In ten years, networks that are citywide (metropolitan-area networks, or MANs) and nationwide (wide-area networks, or WANs) with bandwidths of 1/8 to 1/4 gigabytes will be the standard. [45] These bandwidths let us send a 500-page book in under 4 milliseconds.

A.3.0 Flat-Panel Displays

Unlike the cathode-ray tubes (CRTs) used as the display devices of most computers and televisions, a flat-panel display is flat, light, thin, and uses little power. They are rapidly replacing CRTs. [46] A liquid-crystal display (LCD) is one particular kind of flat-panel display; it is a sandwich of glass containing crystals of amorphous silicon or other materials that change the way they polarize light in response to electricity. Electrodes on the back of the screen can be used to display information by polarizing light in different parts of the display.

In 1990, Japan's Ministry of International Trade and Industry sponsored a $100-million project to develop a 40-inch flat-panel display by 1996. [47] In 1990 and 1991 alone, Sharp, Sanyo, Matsushita, Hitachi, Hoshiden, Toshiba-IBM, Mitsubishi, and NEC together committed almost $2.25 billion to develop active-matrix liquid-crystal displays. [48] Worldwide annual sales of flat screens now exceed $2 billion. [49]

A.4.0 Portable Computers

Portable computers are the newest and fastest growing segment of the computer market. Toshiba alone sells 25,000 a month in the U.S.; the total U.S. market is about 120,000 a month. Worldwide, Toshiba alone has sold almost 2 million units. [50]

Portables are divided by size into palmtops, handhelds, notebooks, and laptops, and they are further divided by whether

they have a keyboard. Notebooks are three-ring notebook-sized (21 centimeters by 30 centimeters and 5 centimeters thick) or smaller. Today, they weigh between 2.5 and 4 kilograms, but that is dropping rapidly. [51]

The new pen-based notebooks are about 2.5 kilograms. They are about the size of a thick magazine and dispense with a keyboard by reading the user's handwriting. In 1991, the second year of pen-based computers, there are already 33 companies producing pen-based computers.

Notebooks were introduced two years ago and already are beginning to extinguish laptops; the notebook market is growing by 20 percent a year. There are now 125 different portables and every month brings a new model, with new features, and lower prices. Notebooks will quickly drop to 1 kilogram--lighter than 8 millimeter camcorders--then, along with camcorders, they will drop even lower.

Many portables have the same computational power as a desktop computer, and prices are high, typically in the range $2,000 to $6,000, but that is dropping rapidly. By 1994, notebooks may weigh under 1 kilogram and cost $2,000. By 1996, they may weigh less than a paperback and cost $1,000.

The big problem with portables is the batteries needed to run the disc player. As with camcorders (and for the same reason, except in camcorders the power drain is caused by the tape transport), currently batteries last only two to three hours. But that time will increase when memory cards become cheap enough. And the same will be true of camcorders; it is not necessary to produce an analog recording, and on tape to boot. Two AA batteries, the same power used today to run a television remote control, can run a portable with a memory card instead of a power-hungry disc drive for a week.

In July 1991, the Zenith MastersPort 386SL, priced at $5,000, improved enough to extend battery life to eight hours. The U.S. Army immediately placed a $50 million order. The MicroSlate Datellite 300S is touch-sensitive and keyboardless and runs for eight hours, but it needs two 12-volt batteries to do so. It costs $6,000. The Dataworld NB320SX has a smaller screen and only two hours of battery life. It costs $2,300.

A.5.0 Desktop Computers

The desktop computer market is even larger than the portable market; worldwide sales of high-end desktops exceeded $7.3 billion in 1990 alone, more than a seven-fold increase in only five years. [52] Like every other part of the market, the huge demand drives unrelenting improvement and enormous price cutting, which increases the market and further drives improvement. For example, in October 1991, IBM cut prices on the PS/2, its personal computer, by 20 percent; in November 1991, Toshiba and Compaq cut prices on several of their computers 25 percent; and in 1990 Apple halved the prices of all its computers. These are common occurrences in the computer industry over the last ten years.

Introduced three years ago, the NeXT desktop computer came with Webster's Ninth Collegiate Dictionary and Shakespeare's corpus, ready for instant display of any page or part of page, with its accompanying high-resolution illustrations. Among many other then amazing advances, the NeXT let readers search for any phrase or part of phrase, or any other simple pattern, and in

milliseconds it displayed all pattern occurrences anywhere in Shakespeare's works.

After only three years that computer is already obsolete; the current best high-end personal computer is the just introduced Silicon Graphics IRIS Indigo. The Indigo operates at 30 MIPS (million instructions per second), and combines compact disc quality sound with real-time three-dimensional animation. It can display color images as fast as it can read them off of its disc. It costs $8,000.

Three years ago the original NeXT cost $10,000 to students and academics; in 1991 it costs $5,000 to the general public and $3,000 to students and academics. By 1995, it may cost as little as $1,500. By 1997, equivalent power will be available for $500.

Appendix B. Electronic Book Players

> Every great advance in science has issued from a new audacity of imagination. John Dewey, The Quest for Certainty.

Besides portable and home computers electronic books can be displayed on special-purpose electronic book players. These may bring the most long-lasting changes in the publishing industry.

B.1.0 Readman

The Sony Data Discman, called the Readman here, is a modification of the Sony Discman, their portable disc player. The Readman is 10 centimeters by 17 centimeters and weighs 1/2 kilogram--about the size of a paperback and the weight of a hardback--with a keypad and small pop-up liquid-crystal display. Users tap in queries on the keypad and information is displayed on the liquid-crystal display. It stores information on a compact disc holding roughly 200,000 pages of text. [53] It also plays music compact discs.

Sony initially offered 17 titles, and by April 1991 offered over 30. They sold 200,000 titles in five months at a list price ranging from $25 to $155 a title. As with music discs, a title costs $2 to make and the cost drops with volume. Since there will be little or no retooling involved in switching a music disc factory to a book disc factory, there will be almost zero transition cost to produce the discs.

From its introduction in July 1990 to February 1991, Sony sold 100,000 Readmen in Japan at a list price of $450. Sony is making 20,000 Readmen a month, and introduced them in the U.S. on November 1, 1991. For its U.S. debut, Sony changed its name to the Electronic Book Player, upgraded its screen from two inches to three inches, bundled Compton's Multimedia Encyclopedia with it, improved screen backlighting, added graphics ability, increased the unit's price to $550, and decreased title prices to between $20 and $69.

To estimate how many Readmen may be sold in English-speaking countries, in 1990 alone Japan sold 3,188,600 camcorders in the U.S. at prices ranging from $800 to $3,000. Worldwide in 1990, Japan exported 7 million camcorders, 11 million compact disc players, and 26 million videocassette recorders. Once there are a few million English-speaking Readman-equivalent units in existence, Sony, or other suitably positioned companies, will have the reader base to begin taking over at least the reference

part of the reading market (encyclopedias, dictionaries, and so on). It should start happening within two years.

B.1.1 Problems with the Readman

Readman discs are read-only memory (ROM), that is, they can be read but not changed, its screen is too tiny and too low-resolution, and it deliberately has no provision for computer attachment. The last was a foolish decision on Sony's part, caused perhaps by fear of reaction from the publishing industry. (In the late seventies, the movie industry tried to obstruct videocassettes by suing Sony for contributory copyright infringement; they lost.) [54]

But making the Readman's memory rewriteable (so that users can change it) and connecting it to a computer should take under a year. If Sony does not do it someone else will. Commodore already has a compact disc player out for $1,000 that sports an advanced microprocessor (the Motorola 68020). [55]

In September 1991, Philips introduced the Magnavox 461; a computer that plays music discs and comes packaged with WordPerfect and Grolier's Electronic Encyclopedia. In October 1991, both Tandy and CompuAdd unveiled their CD-ROM computers; they are the first to introduce multimedia personal computers (MPCs). These computers add sound, animation, and near photo-quality images to normal personal computers. Users can upgrade their personal computers to become MPCs for about $1,000.

It cannot be coincidental that in March 1991 Philips, Matsushita, and Sony formed a consortium of over 180 Japanese companies to develop and market interactive compact discs (CD-I or compact disc interactive). These discs allow interaction by users and they combine sound, pictures, text, graphics, and data on a single compact disc (for technical information, see Philips International, [56] and for an overview see Herther). [57]

By Christmas 1993, Readmen or Readmen-equivalent systems may cost $200. Parents may buy them by the hundreds of thousands to give their children access to the information readable on the new media. If Sony, or any of the other suitably positioned companies, is as astute in 1994 as Apple was in 1984, then they will drop prices even further and sell in quantity to high schools and universities. By 1995, high schools may incorporate them into their classes and curricula, as happened with the more expensive personal computers in 1984. If Sony is clever they could also rent their units instead of selling them, just as AT&T rented its phones until deregulation in 1984. If Sony does not do it then a third-party company could do so.

The problem with introducing new technology is a classic chicken-and-egg: being unable to sell hardware unless there is software to run on it, and being unable to sell software unless there is hardware to run it on. Unlike many U.S. companies that just sit on their hands and bemoan the problem, the Readman-equivalent companies solved the problem by buying the chicken. They started in 1988.

Sony lined up 63 Japanese publishers and other companies to produce the books that will be read on the Readman. And just as Sony, Fujisankei, and Matsushita bought major U.S. film, music, and entertainment companies (in 1990 Sony paid almost $5 billion

for Columbia Pictures), Sony, and other capital-heavy Readman-positioned companies like Toshiba, Philips, and Matsushita, will surely continue to buy or co-opt western publishing companies, to use their stock as software for the product.

All six of the world's largest music companies are now owned by international corporations; the only remaining independent music company is the seventh largest, Virgin Records--and it is British. Bertelsmann Group, A.G. already owns similar properties in 20 countries. [58] Of the major U.S. entertainment companies all but one, Warner Brothers, are now foreign-owned. And in October 1991 Toshiba and C. Itoh paid $1 billion for 12.5 percent of Time Warner.

B.2.0 Dynabooks

Readmen are only the near-future electronic threat; turning paper books into aluminum-coated polycarbonate discs will not remove all the problems inherent in producing many copies of each title on a fixed medium. The long-term threat to paper publishing comes from dynabooks.

In 1971, Alan Kay at Xerox PARC (Palo Alto Research Center) had an idea for a computational notebook that he called a dynabook. [59] For the purposes of this report, a dynabook is a notebook-sized keyboardless portable computer, with a large high-resolution touch-sensitive color display and an electronic pen. It communicates with the world through radio. The screen is large enough to display two document pages at a time, in 11 point font and at paper resolution, and the pen can be used to annotate electronic documents. The dynabook must be a carry-anywhere device; it must be waterproof and robust enough to survive a two meter fall.

It could function as: computer, phone, and credit card; body health sensor, proximity sensor, and police whistle radio; clock, calendar, agenda, reminder, alarm, and diary; notepad, drawing-pad, and music synthesizer; mailbox, typewriter, and voicewriter; spelling, grammar, style, pronunciation, and word frequency checker; dictionary, encyclopedia, foreign phrase translator, global map, location finder, and restaurant guide; video camera, news viewer, video game display, and movie viewer; library, and of course, book reader.

Dynabooks have yet to be realized cheaply but the technology is almost here.

B.2.1 Realizing the Dynabook

The next step to the dynabook will be cellular or RF portables. Researchers at Columbia University have already built three different portables called PIPs (Personal Information Portals) that communicate using cellular radio. [60] Since April 1991, they have achieved bandwidths of 2 megabytes per second over spread-spectrum radios.

The only two remaining technical advances needed to make dynabooks a reality are improved screen resolution and computer power. Current liquid-crystal displays are too low resolution for comfortable reading over extended periods and in strong sunlight, and portables are not yet powerful enough to accomplish all the above dynabook functions.

But both obstacles will be overcome by 1996. Computer power

will not be a problem, but high resolution could remain an issue for several years, perhaps as many as five. There already are CRT screens of high enough resolution to rival paper (300 dpi or higher), but they are expensive. After packing enough computer power into a portable and improving its screen resolution enough to rival paper, it only remains to bring its price within reach of the general population. That should take another five years.

B.3.0 Grave New World

Cheap computing power, cheap storage, high-resolution flat screens, cellular radio, radio frequency modems, satellites, fiber optics, and networks equals the dynabook. And the dynabook means that you can be anywhere and create, access, modify, or transmit highly structured information anywhere else--in seconds. By the turn of the century, information production and exchange may be unrecognizable. As we hurtle into the future, technology will make possible changes so drastic that they will be considered discontinuities; changes both for the better and for the worse.

Imagine a world of little or no privacy, of even greater earning power for the technologically-literate, of even larger disparities between the haves and the have-nots, of wholesale social disruption as the technology percolates through society. Imagine a world where mail is delivered in four milliseconds instead of four days and many postal workers are jobless. Imagine a world where the proportion of the work force in manufacturing, now 25 percent, drops to 16 percent--only eight times the proportion of the work force in agriculture; postal workers may have lots of company.

Imagine a world where suing a doctor means suing the diagnostic program that the doctor used. Imagine a world of greater financial instability and even shorter boom-bust cycles as governmental regulatory agencies, designed for a slower era, utterly fail to keep up with the speed of international electronic money transfers. As you read this, all the money you own is chasing other money around the world, 24 hours a day.

Imagine a world where anyone threatened with assault can instantly alert the police and supply their exact location together with video of their potential attacker; not even masks or darkness may help attackers if the dynabook has an infrared camera. Imagine a world where no news service is trustworthy since any sound, any image, any scene, any movie--including those with apparently live-action famous personages--can be complete fiction.

These predictions are simple extrapolations from current technology. Developments 20 years into the future require unproven technology (nanotechnology, holographic memories, biocomputers, optical computers, and atomic-scale computers), artificial intelligence, or deeper changes in society. Just 35 years separate the decryption of DNA from the first patented artificial animal life. Just 20 years separate Yuri Gagarin's Vostok 1 flight from the first shuttle Columbia launch. Just 14 years separate the first successful personal computers from the Silicon Graphics Indigo.

We are now in the curious position that facts learned in childhood are obsolete by the time we become adults 18 years later. And it will only grow worse since the pace of

technological change is accelerating, and will continue to accelerate. Given the enormous rate of technological change, it is almost senseless to extrapolate 20 years into the future. The world of 60 years from now may be as different from us as we are from preindustrial societies.

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Acknowledgements

If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea, which an individual may

exclusively possess as long as he keeps it to himself . . . . That ideas should be spread from one to another over the globe, for the moral and mutual instruction of man, and improvement of his condition, seems to have been peculiarly and benevolently designed by nature. Thomas Jefferson.

One of the best ways to get yourself a reputation as a dangerous citizen these days is to go about repeating the very phrases which our founding fathers used. Charles A. Beard.

Article 5 of the ACM Code of Professional Conduct states that an ACM member shall use the member's special knowledge and skills for the advancement of human welfare. Although I have no special knowledge of publishing or economics, I wrote this report because I believe that marketable information should be cheap, unprotected, and electronic--a belief I recognize as idealistic, unrealistic, and perhaps even fatuous.

This report tries to show why it would benefit everyone to make marketable information a little cheaper, a little freer, and more electronically available. And since I do not see how something like it could be perpetually avoided, I hope this report helps to reduce avoidable near-future confusion, disruption, and conflict.

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