The New Publishing

Technology's impact on the publishing industry over the next decade

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Abstract

This report discusses technology's impact on the products, revenue sources, and distribution channels of the publishing industry over the next decade.

It examines the threats and opportunities facing the book publishing industry, and presents a strategy for publishers to meet the threats and to use the opportunities to decrease risk and increase profit.

The strategy also benefits education, science, and technology by making books cheaper, more flexible, and more easily and quickly available.

A book is a machine to think with.
I. A. Richards, Principles of Literary Criticism

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1 Overview

You can count how many seeds are in the apple, but not how many apples are in the seed.
Ken Kesey

Over the past 2 decades printing, paper, and transportation costs rose while their electronic counterparts: computing, electronic storage, and communication costs, halved roughly every 4 years. Both trends are expected to continue for at least 2 more decades.

The last time something this radical happened was in the 15th century when the printing press used the newly available cheap paper to take over the manuscript market, throw scribes out of work, and explosively increase the number of available books.

Print led to pagination, indices, and bibliographies since they were now possible and they made searching easier. And that forced people to learn the alphabet so that they could use the new indices. Print increased literacy, democratized knowledge, increased accuracy, made fiction possible, made propaganda possible, created public libraries, and created the idea of authorship.

Print also decreased the importance of memories—and their main possessors, the elders; loosened the hold of the Church and led to the Reformation; added fuel to the Humanist movement and led to the Renaissance by putting classical authors back in print; increased education, science, and technology transfer; and created publishers.

Electronic books may bring changes of similar magnitude.

1.1 Electronic Books and Copy Protection

Today we can scan a printed book into electronic form, then distribute it over the phone in minutes to hundreds of people at pennies a copy. Further, we can produce books electronically without ever committing them to paper. Finally, we can augment electronic books to include sound and motion pictures, and automatic cross-referencing. Electronic books can be easier to distribute, less expensive, less risky, more powerful, more flexible, more immediate, and easier to search and collate. They can also be interactive, changeable, and adaptive.

For these reasons, and others detailed in this report, electronic books will become a large part of the book market within the decade. And that will make it harder for publishers to ensure that their increasingly expensive books are not illegally copied.

Traditionally, publishers and authors have used copyright and the courts to protect their investment. So the natural way for publishers to adapt to the new technology is to copy protect their books, as software publishers and video producers first tried, and recording artists are still trying, to protect their products. Copy protection is like putting a lock on each copy then selling a key with each locked book.

Protections on marketable intellectual properties try to equate intellectual properties, like this report, with tangible properties, like ham sandwiches, or rights on tangible properties, like franchises, licenses, water rights, stock futures, or airline routes. Because of their artificiality, some would say that copy protection is a way to feed lawyers and annoy legitimate users. Whether or not that position is defensible, copy protection adds expense and works against easy searching and collating. So from the point of view of educators, scientists, and technologists, it would be desirable to avoid it, if possible.

The information in books is freely accessible; this ease of information exchange makes civilization go. But paper books are not easy to search, cross-reference, index, collate by multiple subjects, or carry in bulk. It will increase information distribution, and benefit education, science, and technology, if there was some way for publishers to make their books cheap, electronic, and not copy protected. That would keep the freedom of paper while adding easy searchability and wider availability.

1.2 Subscription Service Publishers

Publishers can accomplish all of the above aims by becoming subscription services, charging subscribers a small monthly fee for the ability to get any of their books electronically over the phone, at a small cost per book. Among other business advantages detailed later in this report, such publishers are immune from pirates.

These publishers will also benefit education and science. Further, they may speed up technology transfer from the research lab to the factory floor. Both education and science flourish when information is easily and widely available, and easy to distribute, compare, refine, search, and collate. The subscription scheme will make marketable information cheap, easily available electronically, and easily translatable from one electronic medium to another.

And publishing will cost less, so more people can become publishers, which will increase title diversity. More diversity seems necessary when 2 percent of all publishers produce about 75 percent of all U.S. book titles, and when the 3 largest bookstore chains generate about 40 percent of all retail bookstore revenue [33]. The U.S. now has about 6,500 independent bookstores and the top 3 chains own about 2,750 outlets.

More publishers would increase title diversity and the market would decide what is good and what is not—as is true on the electronic network, but not in print. When everything is committed to paper the few can control what the many can read by controlling the bottleneck—the printer. That is like letting Kodak control the movie industry since it produces the most film.

The electronic network is the equivalent of the road system today. Instead of killing trees, printing books, loading a truck, train, plane, or ship with crates of books, expending oil and human labor to transport them to various retailers, polluting the environment, and taking days to do so, any book can be sent on demand directly from the publisher to any reader in the world in seconds. This is also true for any other information—movies, software, music, television shows, or radio shows.

Books can be more easily distributed if they were electronic, and publishers can make a profit without copy protecting their books. The scheme makes books cheaper both to publishers and to readers, reduces the risks of publishing, and increases publisher profit. It works by shifting the publishing emphasis from betting that one particular title will be a bestseller to maintaining a large number of readers of at least one title.

In a decade, publishers will be back to doing what they do today. Once the novelty of electronic books wears off, publishers will again compete to ensure that their product is better designed, better packaged, and better promoted than that of their competitors. But because of the coming economic dislocation, in the intervening decade unprepared publishers may fail.

This report examines the threats to contemporary publishing, describes the advantages that are forcing it into existence, and presents a way for publishers to succeed in the new publishing. It concentrates on possible electronic formats, revenue sources, and distribution channels of the publishing industry. And it briefly mentions changes in the publishing process itself, and governmental, geopolitical, economic, legal, and social changes brought on by the new milieu. It is biased toward the interests of scientists, technologists, and educators.

2 Threats to Contemporary Publishing

The race is not always to the swift, nor the battle to the strong, but that's the way to bet.
Damon Runyon

Because of the costs of paper publishing and publisher assumptions about how to make books return a profit, a 500-page textbook typically costs $50 retail, or 10 cents a page.[1] Second-hand it costs $25, or 5 cents a page. On a large copier it costs $18, or 3 cents a page. On a large printer it costs $6, or 1 cent a page. If it were distributed electronically, it would cost about $1 to send it to any phone in the world, at a cost of 1/6 cent a page. And whether it is an excellent or a terrible book does not change these cost differences.

2.1 Paper Copying

The short-term threat is that fast high-resolution color copying technology is now so cheap that enforceable copyright is becoming a thing of the past. Publishers will not face threats from large copy stores because they are a large enough target that they can be sued, but now individuals can afford personal copiers. For example, the Canon PC-311 costs $400. And this is not an industry that is about to disappear; worldwide, the copying industry now sells $14 billion worth of equipment, of which Canon alone accounts for $3.5 billion [10].

Worse, copiers are going to get smaller and cheaper. The cost of electronic storage has dropped so low relative to printing costs, that a copier can be merely a scanner with a capacious memory. Such a copier could be palm-sized—it would be attachable to a separate computer or printer. Because memory is now so cheap, it is no longer necessary to print pages as soon as the original is scanned.

It is not that paper has become an unsupportably expensive medium overnight, but because electronic storage cost has plummeted so drastically, paper's cost has relatively skyrocketed.

Imagine a world of small cheap personal copiers, where you can rent, then copy, expensive paper books just as you can rent music, software, or movies today. Imagine a world where one student in a class buys a copy of a

[1] All prices are in U.S. currrency and a billion is a thousand million.

textbook, then copies it for all the others. Imagine a world where publishers in Pacific Rim and Middle Eastern countries buy one copy of a book then sell duplicates just above the duplicating cost.

2.2 Electronic Copying

The copying problem will grow even worse as books become electronic because copying electronic information is even easier than paper copying, and it can be done without human labor. Once books are electronic then at some point the book must be decoded for the user to read. At this point it can be copied. Perfectly. Further, this copy's cost, being equivalent to the cost of the memory needed to hold the copy, is effectively zero. Finally, once a copy is made both copies can be used at the same time; where there was once one copy there are now two separate and perfect copies. Even if publishers try to avoid electronic copying by staying with paper, readers could scan their paper books into electronic form.

There are ways to copy protect electronic media in the short term (a year or so at a time), but they are soon broken by pirates. So there is an escalating copy protection cost. Further, copy protection is odious to some and may not gain wide acceptance for something as fundamental as a book. Finally, if books continue to cost more than it costs to copy them, then publishers and authors will always lose money to pirates.

Authors and publishers use copyright to protect their investment of time, creativity, and capital, but the mechanisms of that protection are rapidly eroding. There is no long-term copy protection scheme suitable for marketable electronic books; the user can always scan the book and make a perfect electronic copy. It will merely take longer to make the first copy.

Some publishers may price their books so high that they will make a profit even if only a few copies are sold. Today, some publishers charge libraries high prices on the principle that many people use a book at a library. But if publishers try either copy protection or high prices, or worse, copy protection to enforce high prices, a breed of intellectual terrorists may arise, who will break their copy protection and anonymously distribute unprotected copies for free along the electronic networks (for example, see the NuPrometheus league discussed in [8]). And millions of people are reachable electronically. Of course, such a market also encourages pirates.

The problems facing the publishing industry seem insurmountable, if publishing proceeds as it does today with the sole change being that books are electronic instead of on paper. But with a new view of the publishing effort, the apparently severe problems become opportunities. The only viable long-term solution is for publishers to make book buying cheaper or more convenient than book copying, as it used to be 5 years ago. Publishers can do so if they keep a stable number of captive readers and amortize costs over their entire list.

2.3 The Future of Copyright

As happened in the music industry, the software industry, the television industry, and the movie industry, publishers will have to accommodate themselves to the new technology. Like every other business, it is natural for publishers to want to continue to operate as they have done in the past. But they may not be able to. Once a few publishers take advantage of the technology other publishers may be forced to comply. As has happened in the most staid of all industries—banking.

In 1977, Citibank's share of retail deposits was 4.7 percent. Citibank realized that it could increase market share by reducing its unit costs; revenues would increase if it could attract many more low-balance customers. Citibank invested at least $250 million to deploy roughly 500 automatic teller machines (ATMs). By 1982, it had more than doubled its market share, and its share continued to rise by about 1 percent a year since 1983. By 1990, its share of the retail market was 14.7 percent—triple its 1977 share [15].

In 1983, eight other banks banded together to meet the threat and formed NYCE (New York Cash Exchange). By 1988, NYCE was the second largest shared ATM network in the world, trailing only France's Carte Bleue. Today it alone provides instant 24-hour service to over 11 million cardholders, who have access to over 6,000 ATMs owned by 360 banks in 22 states. Many new bank branches are merely a series of ATMs set into a wall, with no tellers at all. Today a bank's ATM network is not a competitive advantage, it is an economic necessity.

Information is not the same as tangible goods; it can be copied almost instantly over enormous distances, with no trace, no loss in fidelity, and, potentially, no loss in value. This is true for pictures, designs, music, movies, software, and books. In the information economy, the ability to read something is inextricably bound up with the ability to copy it. When a few million people have the means of duplication in their hands copyright may exist as an idea, but it will be unenforceable between publishers and the public. Illegal drug use could be controlled easily if all drugs had to enter the country through a few large depots. Today no one is arrested for making personal copies of audiotapes or videotapes, even though that principle has never been tested in court [55].

But avoiding copy protection does not mean giving up copyright, particularly since the new technology allows abuses of copyright between authors and publishers and between publishers and retailers. That was not possible when production and distribution were so expensive that they were solely in the hands of publishers, and publishers had to be large companies just to be publishers. In those days, authors could always sue their publishers, and authors could not cheaply distribute their own works. But now that production and distribution are affordable by individuals, and growing ever cheaper, cases will eventually arise of publishers not properly crediting all sales to their authors, of retailers not properly crediting all sales to their publishers, of publishers distributing copies of their titles independent of their retailers, and of authors distributing copies of their works independent of their contracted publishers.

However, the subscription scheme is immune from attack because it makes book buying cheaper and more convenient than book copying. To see why it can work, imagine that someone invents a programmable matter transformer that can produce food from sand. Now imagine that the technology is so cheap that everyone can own one. It would then be foolish to try to sell food. But you still can sell recipes. (The same conclusions would be true of pharmaceuticals, jet engines, or microprocessors, only the producers and consumers change.) What will make consumers come back for more? The promise of more delicious recipes. The next section discusses what will make those recipes delicious.

3 Electronic Book Advantages

To describe the evolutions in the dance of the gods... without visual models would be labor spent in vain.
Plato, The Timaeus

The advantages of printed books as a medium of information storage and exchange are that they are robust, they need zero power, several can be open at once, they have been around for 550 years, all literate people know how to use them, and they are readable in strong sunlight.

Their disadvantages are that illiterate people cannot use them, it is easier to print an electronic book than it is to digitize a printed book, and it is hard to collate non-sequential but related parts of one book, or many books by several subjects. Further, they do not talk, adapt to their readers, or have animated illustrations or music. They do not let readers zoom or pan illustrations, or increase or decrease their font size, nor do they recognize voice commands or visual cues. Finally, they are not cheap, long lasting, easily copied, quickly acquired, easily searched, or portable in bulk.

Paper will be with us for decades to come because of the hundreds of years of technological development behind simple, cheap, light, detachable pieces of paper, and the complementary use of hand and eye to arrange, read, or write them. It will be many decades before another piece of technology called virtual reality (not discussed in this report) eclipses paper. But because of their strong advantages to readers, libraries, educators, publishers, and retailers, in a decade electronic books will be a significant part of the market. About all that can be said of paper books is that they are lighter than clay tablets, less awkward than papyrus rolls, and cheaper than parchment codices.

3.1 Reader Advantages

When books are electronic, readers have instant and unsleeping access, as has happened in banking. Also, readers can have instant updates and revisions, and electronic contact with all other readers of each book, thereby sharing ideas and reactions more rapidly and with more people. For publishers this means that word of mouth can sell more books more quickly. Further, electronic books need never go out of print. And electronic books are cheaper and less bulky than paper books. Instead of several expensive books, where although each one is portable, large numbers are not, thousands of books can be stored on one small light disc, at 8 cents per book.

Making books electronic makes them computer accessible, so books can contain electronic bookmarks and cross-referencing. Cross-referencing can be either reader controlled or computer generated. And all the advantages of paper books—handwritten annotation, highlighting with colored markers, underlining, post-it notes, bookmarks—can be allowed through software on small portable pen-based computers (for example, see [40]).

Also, books can be customizable by, or for, their readers; a copy of a book need no longer be an exact copy—as has already happened in consumer-targeted advertising. Because the information economy is computer-based and global, with concomitant increased knowledge of consumer tastes and increased competition, more and more of it will be lifestyle-targeted.

Unlike paper books, electronic books can be multimedia: letting us mix voice, music, color, motion pictures, data, and text, and leading to animated talking books. For example, the Xerox/Kurzweil Personal Reader can read the text of any book out loud—an invaluable aid to the blind, sight-impaired, illiterate, or busy—it is unnecessary to first record an actor reading the book [59]. The Personal Reader trains itself on any printed text and gets better as it progresses down the first page. It can read 6 languages.

A program called NETtalk, [45], can be used to produce a children's book that is really a whole library of children's books. The book listens to the child (or parent) reading aloud for a few hours until it can read any of its repertoire of books in that voice.

Imagine children's books that read themselves to a child at bedtime. By listening to the child's breathing, the book can reduce its volume, dim the lights, and slow its cadence as the child drops off to sleep. This can be done today.

3.2 Library Advantages

Electronic books mean that libraries need not keep large and expensive stores of bulky and decaying paper. And catalogs can be electronic, electronically updatable, and computer generatable, making them easier, faster, and cheaper to search, produce, and update. And libraries will not need to buy multiple copies to allow for book scuffing, or to place one book in several categories. Nor will they need binderies to bind journals into books, or to rebind old books. Nor will they need to hire reshelvers. Also, the library can more easily refer readers to other books with similar subjects, tastes, or interests.

Libraries will not need to chemically treat their decaying books, microfilm them, or transcribe them to Braille, large-print, or audio. All transformations are easier with electronic books. Currently, the Library of Congress can afford to transcribe only 2,000 new books and 1,000 new periodicals a year. Out of its 20 million books, it carries only 30,000 in alternate formats.

3.3 Educator Advantages

It is curious that in a supposedly highly literate society a U.S. hardcover is one of the top 25 bestsellers for the year if it manages to sell only 115,000 copies—about 1/20th of 1 percent of the population. *Gone With the Wind* sold 21 million copies over 40 years, but 55 million people saw the first half of the television movie [35]. *Roots* sold 5 million copies over 8 years, but 130 million people watched 8 episodes of the television version. The television shows *A-Team* and *Dallas* drew 40 and 37 million viewers per episode.

The U.S. has an estimated 27 million illiterate adults. Since talking books deemphasize literacy, they may move us closer to preliterate societies and help to enfranchise the illiterate, the dyslexic, the blind, the sight-impaired, the disabled, the elderly, and the young. For publishers this means that sales could be higher.

Many believe that the U.S. is facing serious education problems. Every year 700,000 high-school students drop out, while another 700,000 graduate unable to read; the percentage of graduating high-school students has dropped every year since 1984 [13]. The social problems causing the drop out are serious and severe and most are unrelated to books, so electronic books are no cure-all, but they may help reverse the trend.

Eventually all books will become animated, vocal, and interactive. Imagine learning orbital mechanics like a video game where you may choose burn rate and burn time, then have the book show you what happens to the rocket. Imagine a chemistry book that lets you bring together different molecules and watch what the van der Waals forces do to them, following through until the molecules reach a stable state.

Imagine a physics book where an apparently alive Galileo, Newton, or Einstein propounds their various theories then guides you through developments and consequences, letting you ask questions or suggest alternatives. As technology improves, you will be able to change Galileo, Newton, or Einstein to whomever you wish: perhaps a favorite aunt, a teacher, Bugs Bunny, or Walter Cronkite.

Imagine a book that lets you tour a computer chip. The book first displays a chip as seen by humans normally—a black fingernail-sized sliver of shiny silicon. The book has two controls: a joystick and a light-dimmer switch. As you move the joystick the book displays the image you would see if you were at that distance and point of view.

Pressing down on the joystick brings up a quarter-scale display in the lower right hand corner with text, voice, or video of the author explaining what you are seeing, and telling you about other things that you might like to see if the current view interests you. Touching any portion of the screen also pops up a little window to explain whatever is being displayed at that place on the screen. The dimmer switch controls the timescale; twisting it changes the speed at which things happen.

As your viewpoint gets nearer to the surface of the chip the chip expands to cover the entire display, then the horizon disappears off the screen. As you get closer to the surface you begin to see pulsating rivers of light, representing electron flows, and you hear a susurrus of sound, representing thermal noise, which later grows to a keening roar as you approach a river of light. Getting closer to the chip surface and reducing the timescale you can see individual clumps of electrons switching through individual gates. The sound has also slowed, so you can hear each electron whizzing by. Getting even closer and further slowing the timescale shows a single electron about to tunnel out of a channel.

This tourbook idea works for any physical construct, natural or artificial. We could have tourbooks for trees, fire extinguishers, DNA, motor boats, lungs, car engines, eyes, televisions, humming birds, space shuttles, whales, or cyclotrons. More expensive versions of these books can dispense with the joystick and dimmer switch and instead accept simple vocal commands: stop, go, faster, slower, zoom here, pan, undo, reverse, put this there, what is this, show me more, tell me why.

By 2000 the U.S. Geological Survey expects to complete its national digital cartographic database. This database will include all the information on the agency's maps, and the agency is working with the U.S. Census Bureau to integrate demographic data [5]. Meanwhile Geovision is selling a U.S. atlas on disc for $600; on this disc users can zoom down to a city block. And SilverPlatter is selling a 3-disc set for $2,000; the discs list over 115 million people living in 80 million residences in the U.S. (Earlier this year a similar set promoted by Lotus was withdrawn after a blizzard of protest.)

Imagine an atlas that opens with a rotating globe. (Or an atlas that begins with a rotating human, library, computer, solar system, house, car, scanning tunneling microscope, or nuclear power plant.) You learn about different parts of the globe by touching it. You can then find out about the geography, history, geology, climatology, politics, culture, demographics, or economics of each area. Touching economics might bring up overlays showing trading partners, trade routes, and goods. Touching one of the trade goods, from tractors to camcorders, leads to overlays giving the source of all the raw materials used to make the good.

Touching a portion of the display gives the history of the region, its geological background, its demographics, its transportation system, its climatology, its political allies, its nearness to major fault lines, its chlorofluorocarbon emission rate, its projected development over the next 5 years, its skin cancer rate over the past 10 years and projections for the next 10 assuming various levels of ozone depletion.

Touching another portion lets you extrapolate land use and deforestation over time to examine the effect of tariffs, or the effect of waste heat from cities on fish populations, or the effect of power lines on bird migratory paths, or the effect of global warming on coastlines and industries. Touching yet another portion gives pictures of the region's Nobel prize winners, with their accomplishments and acceptance speeches. Or pictures of the region's politicians. Or a breakdown of the region's gross national product decomposed into budgetary expenditures. Or the effect of solar wind on the region's satellite reconnaissance. Or the region's offshore natural gas deposits. Or the epidemiology of retroviral disease. All portions of the display could be accompanied by movie snippets, stills, and music.

Such an atlas would be more accurate, more powerful, more flexible, more informative, more usable, more timely, more sophisticated, and more adaptable to its user than any number of paper atlases. Today an author has to first think of the questions, research the answers, and find a way to summarize them in print. With these books the user poses the questions—questions perhaps even the author did not think of—the book researches the answers—research perhaps almost as good as the author's own—and the user decides how the information is to be displayed.

And the same observations hold for books on music, politics, painting, craftwork, foreign languages, history, zoology, architecture, geography, design, cooking, hairstyling, self defense, travel, health, environmental studies, or any other subject. These books could increase comprehension, retention, and emotional response without sacrificing convenience, adjustability, repeatability, searchability, generality, and abstractability the way that broadcast television does. And because they are built on top of computers with their great power for simulation they also add interactivity, testability, convertability, and projectability.

These books can combine the best aspects of human visual and auditory presentations, the best aspects of broadcast television, the best aspects of computers, and the best aspects of print. Compared to such books, present books are pitiful.

Of course, not all electronic books will be well written; there will still be poor books and good books, and perhaps in the same proportion. But even the worst electronic book could be better than even the best paper book, if only because it may be more easily searched to see if it has anything useful. But, as always, the sharper the tool, the deeper the cut. Because these books are more immediate they can shape our unconscious more deeply; so bad books could be more dangerous, just as a demagogue's speech is more compelling than the text of the speech.

Reading is work, but before writing there was speech, sounds, and sights. We have had only 5,300 years to get used to writing, but we have had millions of years to hone our audiovisual response. Humans are good at interpreting and relating to audiovisual cues—particularly if they are in control and can stop, replay, or interact with the action at any time. Such books will change the way we think, the way we work, and the way we see ourselves, our artifacts, our governments, and our world. Every business, every industry, every vocation, every profession, every educational institution, and every entertainment group, can use these books to advantage.

Students with books like these are exploring, not reading. Curiosity motivates them to explore and develop intuition. They are not intimidated by premature formalism, nor by the artificial linearity authors are forced to place on a subject just to fit it into the unnatural format of a paper book. The difference between these books and paper books is the difference between behavior and the description of behavior.

Textbooks can move toward this ideal even within the confines of paper. They can try to: involve the student through a large number of questions; deformalize the subject until absolutely necessary through an informal style, cartoons, and a large number of pictures; show links among different parts of the book through continuous and exact page referencing; show links among different parts of the subject through a large number of annotated references; humanize the author, the book, and the subject through a large number of quotes, quips, and jokes; and encourage reader exploration.

3.4 Publisher Advantages

Contemporary publishing is risky business. Because of the economics of paper printing and distribution, titles have to be produced in large print runs to make it profitable to sell them. But there is no guarantee that a book will sell its print run.

Large print runs mean that a lot of capital is tied up in product for a long time. So less capital is available to buy new titles or to promote current ones. It further means large transportation, warehousing, security, insurance, and distribution costs. And all the people who do this have to be paid salaries, workers compensation, and pensions.

But small print runs mean risking running out of stock and losing customers to a competing title because of delay. Further, because printing costs drops sharply with volume, a large number of small print runs is not profitable.

Even if demand could be predicted exactly and even if titles could reach readers as soon as they are printed, printing alone adds 4 to 6 weeks to product delivery. And unless product is mailed express at greater cost, the post office adds a further 2 to 3 weeks. Finally, even if warehousing and capital costs are zero, product cannot be kept awaiting demand indefinitely since it is bulky and it physically decays in a few years.

Because of these constraints imposed by committing books to a fixed medium (in this case paper, but similar things would be true of discs), publishing proceeds by guess and by gosh.

Publishers let retailers return unsold copies to increase the chance that retailers can afford to carry their titles. Sometimes as much as half of a mass-market fiction print run of 500,000 copies is returned. But with electronic distribution, outlets will not have to keep as many copies of each title as they think they can sell; they need only one for promotional use. And that will increase the diversity of titles outlets can offer. Eventually, distribution costs to publishers may drop to zero since readers could acquire product rather than publishers supplying it.

Further, when distribution is electronic used-textbook stores go out of business. Currently, a textbook may sell 10,000 copies in the first year, 5,000 copies in the second year, then 2,000 in the third year. The original 10,000 market is still there, but it is being serviced by used copies. The used bookstores are piggybacking on the publisher's and author's investment of time, capital, and creativity. Electronic distribution eliminates that opportunity since the most recent version is available instantly and cheaply.

Going to electronic books and electronic distribution of them on demand means no printing and its costly consequences: warehousing, transportation, delay, backordering; competing for scarce outlet shelf space; overestimating demand and having to remainder or destroy books; underestimating demand and having to lose business or annoy customers; and sinking large amounts of capital into paper copies that take time to sell, that take up shelf space, that decay on the shelf, that may be returned even after sale, and which if sold then fuel the used book market.

Production will become editing, reviewing, and developing acceptable projects. Printing and distribution will cost little. And there will be more resources available for acquisition and marketing. Finally, in the subscription scheme publishers will have large stable incomes over a period of years, thereby making it easier to attract venture capital for startup or expansion, making planning easier, and reducing risk.

3.5 Retailer Advantages

Today, retailers must risk almost as much as publishers. Most bookstores carry anywhere from 1 to 1,000 copies of each title, depending on expected demand. All but one of these copies are redundant. Electronic media let retailers choose a melange of distribution schemes to reduce their risk and increase profit. For example, in 7 years some bookstores will become half compact disc stores, thereby quadrupling the number of titles per meter of shelf space, but otherwise keeping many of the ills of paper publishing since retailers will still have to order as many copies of each title as they think they can sell.

This will take 7 years or more to allow for the time needed to scan most of the books that exist on paper only and to allow for cultural inertia and technophobia; some people will dislike the idea of electronic books. But once a book exists in at least one electronic form, it is easy to print it if necessary, convert it to another electronic form, or distribute it electronically. Electronic books contain paper books as a special case.

From a standing start in 1984 compact discs overtook phonograph records in 5 years. Paper books will put up more of a fight because of inertia and because it will take time for adequate display technology to reach a large number of people. But it is inevitable.

In 7 to 10 years, some bookstores will literally disappear into the woodwork. These bookstores may become just wall-sized display screens electronically displaying an array of titles, with pictures. Each title may be in its own book-sized rectangle of the display. Customers can use their electronic pens to wand the appropriate title(s) and have it automatically delivered to their portable or home computer and their credit card automatically charged. To allow browsing, perhaps a part of the book is downloaded to the portable first (reviews, description, sample pages, list of previous books written), and the sale goes through if the customer does not discard the preview after half an hour.

Major book chains like Waldenbooks, B. Dalton Booksellers/Barnes & Noble, Crown, Coles, Waterstones, and W.H. Smith's would love such a system. They would love it so much that they may become publishers themselves. They would have little space to rent, no staff salaries, no stock, no warehousing, no transportation, no remainders, no returns, no overhead, no need to reshelve books disturbed by customers, no need to discard books scuffed by customer handling, and no need for insurance against fire, theft, or water damage. Further, it is easy to reorganize the display, and the display operates continuously.

Essentially, these bookstores would be interactive billboards. Retailers could put them anywhere people congregate (bus stops, church yards, playgrounds) and even on vehicles (buses, trains, planes, ships).

When books are electronically distributed, a publisher (or retailer) can produce catalogs that are really databases with a front-end program to help customers query the catalog. The top level display might be a menu of all the subjects the publisher (or retailer) groups their books by. Customers move through the catalog searching for books they want, and can immediately receive them (and pay for them).

Such a catalog would also be cheaper than print. A typical 64-page print catalog destroys trees and costs over $2 per catalog, a disc version for several apparel companies costs $1.28 per disc, including production and mailing [57].

The catalog can instantly reflect demand for each title. The Italian apparel company Benetton uses its worldwide system to determine the demand for each fabric, and what color it should be dyed for the next week's fashions. Benetton's system lets it drastically reduce inventory and lost sales. The publisher (or licensed retailer) can print some fraction of the demand for each title to service the paper trade. The electronic service acts as a market sample, giving a more accurate estimate of demand than today's print run system.

For readers not comfortable with such systems, there will still exist bookstores similar to those existing today, but these bookstores can carry hundreds more titles than they can carry today because they need only one copy of each. Customers can browse through this copy as they do today, then have an electronic copy delivered to them if they decide to buy.

Electronic books are more flexible than paper books. For example, to cater to those customers who dislike electronic distribution or lack adequate display technology, publishers can license their list to retailers and have them produce paper books in the retail outlet on demand. The Kodak Lionheart 1392 costs $199,000 and prints 92 two-sided 300 dots per inch (dpi) pages a minute; the Xerox DocuTech Production Publisher costs $220,000 and prints 135 two-sided 600 dpi pages a minute—it can also collate, saddle stitch, and cover the documents [54].

If these prices are too high for one publisher or retailer a consortium of publishers can buy (or lease) the printers with each retailer. These on-demand retailers will save on most of the costs of contemporary retailers, so publishers may be justified in charging high licensing fees.

This practice may persist, but since electronic books will quickly grow out of the linear text-and-pictures format (it is restrictive and no longer necessary), these customers will be getting only the flat form of the book. Further, licensing could also work if the retailer is producing books on disc, not paper. So another possible distribution scheme is book dispenser machines like movie dispenser machines or ATMs, where the user inserts a disc, has books downloaded to it, and pays for the downloaded books with a credit card [31].

Another way to distribute electronic books is for publishers to put their entire list on a single disc. Publishers can encrypt each title separately so knowing the decrypt key for a title gives access only to that title. Encryption is different from copy protection; copy protection tries to ensure that information cannot be physically copied, encryption tries to ensure that information is unintelligible without a key. One tries to lock the hardware, the other tries to lock the software. Both try to deny general access.

These discs can be produced in runs of several hundred thousand at $1 per disc and could be sold for $5 each. As in the subscription scheme, publishers could bypass retailers entirely and sell these discs by mail order. After buying a disc, a reader who wants a particular title phones the publisher and the publisher gives the title's decrypt key and charges the reader's credit card. Such a scheme is already being tried by font and clip-art companies [38].

Of course, once one reader is given the decrypt key for a particular title that reader could tell the rest of the world. So publishers may divide the print run into lots of 100, number the discs, and change all encrypt keys from one run to the next. This will increase disc production costs and when ordering, users would have to supply the disc lot number. As with any protection scheme, cost increases and usability decreases.

Many publishers may choose this scheme since it is most like their present system, but better. Further, each title is copy protected so publishers could increase prices if they choose. But this scheme, and every other scheme that distributes books on fixed media, has the problems discussed in the overview and in the previous subsection.

In the short term, publishers and retailers may promote their wares direct to readers through media like cable television, the postal service, and online services, and later, the reader's portable or home computer. But the need to announce new books will eventually fade as readers are empowered to do their own searching for books that they may be interested in. Eventually their portable or home computer will do the searching for them—continuously, perhaps storing a backlog of books to be considered.

Electronic books are inherently more plastic than paper books. A decade hence many distribution schemes may coexist: normal paper publishers, unlocked single-title disc publishers, locked single-title disc publishers, on-demand paper publishers, on-demand disc publishers, prerecorded full-list locked-disc publishers, and subscription publishers.

From now on this report focusses on the last type of publisher: publishers who charge a monthly fee and who distribute their titles on demand over the phone.

4 The New Publishing

Lead us, Evolution, lead us,
Up the future's endless stair;
Chop us, change us, prod us, weed us.
For stagnation is despair.
C.S. Lewis, "Evolutionary Hymn"

The criteria for judging among the new subscription services will be capital, reputation, and performance. Capital acquires new product and its amount and liquidity determines credit, which determines how much expansion there can be, and how fast it can take place. Reputation and performance assure subscribers of quality and selection, and attract and retain new authors and subscribers.

Marketing will also be important. At 3,500 new books a month and climbing, major book chains and convenience outlets (convenience stores, drugstores, supermarkets) now keep new fiction less than 6 weeks. Soon paperback fiction will be monthly—the equivalent of one-shot magazines; eventually turnover will be weekly.

To pervert Toffler's prediction in *Future Shock* [48], in a decade we will be living in a world of future schlock; 1,000 new books a day is possible, that is only a factor of 8 from today. Counting all languages, we already produce 1,000 new books a day.

4.1 Mapmakers, Ferrets, and Filters

As the number of books published per day mushrooms, the value of the publisher's editors and their reputation will increase. The publisher functions as a stamp of approval, a selector, and a collator. Soon there will be a whole new profession—people who find things, or know who to ask—perhaps they will be called ferrets. For those who want to rummage for themselves there will be another new profession—people who arrange things—perhaps they will be called mapmakers. And everyone will need people who select things—perhaps they will be called filters.

These three professions mirror the three basic aids in non-fiction books: indices (ferreting), tables of contents (mapmaking), and bibliographies (filtering); and the three basic uses of computers: searching (ferreting), sorting (mapmaking), and selecting (filtering). All three are marketable services.

Publishers may try to enter all three markets, but unless they enter them understanding their importance they may be shut out by more aggressive third-party companies. Eventually they will also have to compete with computer programs. Word processors like *WordPerfect,* spreadsheets like *Lotus 1-2-3,* and database programs like *dBase* are the three biggest reasons the business community adopted personal computers. In 10 years, ferrets, mapmakers, and filters may be the equivalent of these programs today.

As computer power becomes more widespread each user's computer may run hundreds of ferret programs continuously, all separately exploring the world's data for useful information. When a ferret returns it may have to face dozens of filters who try to prevent them from adding the data found to the user's personal information base. Data that enough filters judge to be important is passed to the mapmaker to be linked into the user's personal map of what's important, where it is, and how it relates to other information in the personal map.

Human beings often use different archival schemes than print. Librarians are fond of telling horror stories of naive library users who ask for the large green book on cartoons they flipped through a month before. The weight, size, smell, and color of a book are easily apprehended, while title, author, International Standard Book Number, Dewey decimal number, and Library of Congress number are artificially imposed because they make easier search keys in traditional databases. The ferret, filter, and mapmaker programs will benefit those who want to recall the blue book with the funny picture of President Bush that Joe lent them.

To most Americans, the 20 million books in the Library of Congress, perhaps the nation's greatest intellectual resource, are less useful than a home encyclopedia, because the information retrieval problem bars access. As books become electronic, indices, commentaries, databases, annotations, bibliographies, reviews, concordances, compendia, and selections will be in high demand. The more data there is, the less information there is; the more information there is, the less knowledge there is.

To take a household example, partly because they are on paper the Yellow Pages function poorly. To get the most from them the user must understand exactly how the phone company organized them. The user must also have a detailed map, a subway guide, bus routes, *Consumer Reports,* the local Better Business Bureau Report, and plenty of time.

In addition to an alphabetical listing by type of business Yellow Pages should list all businesses on each street, in each neighborhood, and in each mall; by the time needed to get to them from the user's current location; by their relation to various landmarks; by whether they are currently having a sale; by whether they accept checks, cash, or credit; by their hours of operation; by their nearness to restaurants, gas stations, public restrooms, or other stores of interest to the user; and by their expensiveness, reliability, revenue, experience, and returns policy.

All of these ways of organization are possible with electronic Yellow Pages, and that applies to every other kind of information. And businesses would pay the mapmaker to be included, just as they pay credit card companies today, since it means more business for them. Only 5 percent of the roughly 6.5 million U.S. businesses advertise outside of the Yellow Pages.

4.2 Stage I Penetration

The new technology will first take over technical, professional, and business knowledge databases, and technical, scientific, and academic journals for doctors, lawyers, executives, financial analysts, dentists, scientists, engineers, technicians, and the professoriat. These people have the need, the money, the expertise, and the technical infrastructure to support the technological thrust in the early days.

Already *MathReviews* exists on disc and it is an enormous improvement over paper. A year ago, researchers had to wade through several heavy 1,000-page books full of fine print, imperfectly indexed and cross-referenced by humans, and out of date because of the delay. Today, these same researchers can search the entire corpus of published papers—including abstracts, reviews, comments, and other information not previously included in *MathReviews* because of bulk—for arbitrary patterns in seconds.

They no longer even have to go to the library, they can access it remotely from their home computers. And they no longer have to use the service during library hours; they can access it at any time. Further, the library no longer has to find space for many years worth of 1,000-page *MathReviews;* they have to keep only one or two small discs. Finally, the discs are cheaper than the books they replace. Eventually libraries will not even have to buy the discs since a few cheap computers can supply the same information over the phone to the entire world.

Soon universities will start publishing their own electronic journals. Already publications of the American Chemical Society, the American Mathematical Society, the American Psychological Association, the Association for Computing Machinery, the Institute of Electrical and Electronics Engineers, McGraw-Hill, and Elsevier Science Publishers, are available electronically [42, 50]. The European Economic Community and the U.S. Office of Technology Assessment are sponsoring future projects [32].

Already the *Harvard Business Review* is available electronically (there is still a paper version), and the American Association for the Advancement of Science is publishing the *Online Journal of Current Clinical Trials* to be released April, 1992 [56] (there is no paper version). Academic libraries will inevitably start clamoring for electronic versions of all journals, even if publishers also produce paper versions. Currently, university libraries have to devote over half their budgets to journals. The number of academic journals is doubling every 5 years, and subscription costs, already high, continue to rise by 10 percent every year.

Full-color professional magazines charge advertisers to pay authors, publish 10 to 12 times a year, and cost consumers $4 to $6 per issue. Black-and-white academic journals charge authors to pay printers, publish 4 to 6 times a year, and cost libraries $25 to $400 per issue. Electronic journals would be cheaper for everyone: publishers, libraries, and readers. They would also be easier to archive, catalog, and search, less bulky, more flexible, more expandable, timelier, and larger than paper journals.

The business community is even more ready to pay a lot for precious information. In most corporations middle management plays the part of ferrets, mapmakers, and filters for senior management. But paper reports are hard to search, index, compare, and collate. Further, once a fact, a table, a report, is committed to paper it is fixed; it cannot be displayed in alternate and perhaps more accessible forms, like histograms, pie charts, and graphs.

In 1986 GTE executives could not easily find information in their own 200-page financial reports. GTE spent 6 weeks and $14,000 to create an Apple HyperCard system that let executives keep informed about their own business [22]. Hypertext lets users chart their own course through the data; text versus hypertext is like taking a train versus driving a car. Soon after GTE adopted the system its president demanded all his reports this way instead of formal presentations from middle management.

Dow Jones charges $19,600 a year for its CD/Newsline subscription service: monthly mailings of discs containing public information about the financial performance of various companies [7]. Dow Vision delivers news and market information direct to users' computers for $1,000 a month [27]. Perhaps they get away with these prices because of the business community's ignorance of what is possible and what it costs to attain, and the publishing industry's ignorance of the demand for timely, high-quality, and electronically-accessible product.

4.3 Stage II Penetration

The new technology will then take over general information sources: dictionaries, multilingual dictionaries, dictionaries of quotations, encyclopedias, atlases, almanacs, thesauri, concordances, phrase books, tourist guides, repair manuals, phone books, cookbooks, collections of statistics, stock prices, speeches, operas, paintings, sculptures, magazines, census information, and library and museum catalogs.

Already the catalog of the Library of Congress, *The Readers' Guide to Periodical Literature, The Oxford English Dictionary,* and *Books in Print* (at $1,000 a year; with book reviews—something unthinkable with paper—it is $1,400 a year), are all available on disc. There are now 1,400 titles available on compact disc.

The Voyager Company, ABC News Interactive, and Warner New Media, Incorporated, are all producing titles solely for the new media. For example, in August the top 10 bestsellers (with some prices) were: *Grolier's Electronic Encyclopedia ($400), The Magazine Rack, The Multimedia World Fact Book, The Microsoft Bookshelf ($300), U.S. History on CD-ROM, National Geographic's Mammals, The PC-SIG Library ($500), The Reference Library, McGraw-Hill's Encyclopedia of Science and Technology,* and *Compton's Multimedia Encyclopedia ($900).*

Grolier's Encyclopedia contains 10 million words and 1,500 pictures; what used to take 21 large books now takes just 1/5th of one disc. Compton's Encyclopedia contains 8,784,000 words, 5,200 articles, 15,800 photos, maps, and diagrams, 60 minutes of recorded voices and sounds, 45 animated sequences, *Webster's Intermediate Dictionary* (which itself has 65,000 entries), and a word processing program.

Then the new technology will take over textbooks and all other technical and professional books. Electronically distributing textbooks could eliminate printing, packaging, distribution, transportation, postal delay, possible returns, warehousing costs, and the used textbook industry. And it reduces both the risk and span of time of having capital tied up during the distribution process.

4.4 Stage III Penetration

Finally, since electronic books can be interactive, animated, and vocal they could make serious inroads on fiction. Software publishers like Brøderbund, Voyager, Discis, and Software Mart and computer/entertainment companies like Sony, Philips-PolyGram, Britannica Software, Rand-McNally, and Time-Life are seizing the high ground here, perhaps because traditional publishers lack the expertise, or are not aware of the market.

At the end of October Voyager introduced interactive versions of Douglas Adams' *Hitchhiker's Guide to the Galaxy,* Michael Crichton's *Jurassic Park,* and *The Annotated Alice in Wonderland,* at $19.95 each. These are the first 3 of Voyager's planned 20 Expanded Book series. Brøderbund's Living Books series are animated children's books scheduled for early 1992 release, the first 3 are: Mercer Meyer's *Just Grandma and Me,* Jack Perlutski's *New Kid on the Block,* and Marc Brown's *Arthur's Teacher Troubles,* at $49.95 each.

It may take 5 years for these kinds of fiction books to make a serious impact, but if they do then that will be the beginning of the end of paper books.

5 Getting There from Here

Even technologies with enormous potential can lie dormant unless there are significant payoffs along the way to reward those who pioneer them.
John Walker, in [16]

Some publishers may fight rather than switch. They may protest the new technology and push for laws against copying, or for an electronic book standard that tries to keep book production or book copying out of the hands of the average person. That is what happened in the music, software, television, and movie industries. 15th century scribes and 18th century weavers tried the same tactics. But just as happened in those other industries, such publishers will eventually fail. Should it bother us that pocket calculators wiped out slide-rules? Should we weep because polio vaccines destroyed iron-lungs?

In 2 decades, paper technical books will be the equivalent of phonograph records today; they will exist for historical, sentimental, or ceremonial reasons. Eventually they will go the way of the vacuum tube, which, legend tells us, existed in the forties and fifties. Of course, after skimming parts of an electronic book readers may make their own paper copy if they wish. (A decade ago a high-quality laser printer cost $25,000; today a good PostScript laser printer costs $1,500.) And for the wealthy, paper books will still make good furniture.

Those who are 12 and under have no vested interest and no prior investment in paper technology. The U.S. alone has 30 million electronic game machines; 70 percent of all U.S. homes with a child aged between 8 and 12 have a Nintendo game machine [37]. And in 1990, Nintendo's net income was $488 million on revenues of $3.34 billion [53]. Revenues exceeding that of the entire U.S. robotics industry. Almost 46 percent of all U.S. children use a personal computer at home or school. Almost 14 million homes have a computer—double the figure for 1984. On the other hand, although the U.S. produces 3.5 billion books a year, an American adult reads an average of 3 books a year.

Those who are 25 and under are more familiar with television and computer screens than they are with print. They have had Pac-Man for 10 years, Apple computers for 14 years, and *Sesame Street* for 21 years. In a decade paper technical books will still be published—it will take perhaps another decade for them to completely vanish—but the bulk of technical information production and exchange that today we conduct by printing and distributing paper books will by then be electronic.

There will be more books, and they will be always in print. They will be larger, less expensive, easier to get, search, filter, and collate, and updates will be monthly—or perhaps continuous.

5.1 Gearing Up

Publishers who are wondering how they can keep things the same are asking the wrong question. In a rapidly changing environment the most important asset is not the present inventory of skills, but how fast it is improving. Education and flexibility are essential when what you sell, how you sell it, who you sell it to, and what they want, are all changing.

Classical economic theory is largely irrelevant to the early stages of a new information industry [2]. Economics assumes that resources are finite and that there is sufficient time for markets to reach stability. Three things are wrong about this picture: information is not finite, there is no single stable point—there are many, and there is little time to reach stability before there is another major change.

Standard economics applies to finite-resource markets like agriculture, mining, and bulk-goods. Economics presently has little to say about information markets like communications, computers, pharmaceuticals, and bioengineering. These markets require a large initial investment for design and tooling, but enormous price reductions with increasing market growth. This growth is further compounded by positive feedback: with increasing market growth the production process gets more efficient, therefore returns increase.

And that growth increases both the number of people attracted to work on the remaining problems, and the number of people desiring the better-designed products. Which in turn fuels the development of better products. For example, the more people with facsimilie (fax) machines, the more people who wanted fax machines to talk to those who already had them, and the more people who had them, the more people who worked to improve them.

Finally, this exponential improvement is being applied to a group of synergistic technologies; each improvement in one technology improves other technologies in the group, which in turn help improve the original technology. For example, better computers help make better communications, which help make better science and engineering, which helps make better instruments, which help make better computers.

Most U.S. firms seem to see the world in the order: shareholder, supplier, shopper, staff, society. This order reflects a world where capital is the most important thing. This order works well in a stable industrial economy, but in a rapidly changing industry placing investors first often leads to short-sighted financial cannibalism. Instead, in a fast-changing market the priorities should be: shopper, staff, society, supplier, shareholder. The two stock market debacles in October 1987 and October 1989 show what happens when short-term gain is valued more than long-term development. Fortunately the financial markets matter less and less to the economy; capital will remain important as a risk softener, but the thing that has become more important is knowledge.

Anyone in an information industry who clings to 19th century techniques is unlikely to survive long. Today, above all else, it is necessary to be able to cope with change. Achieving this will take great care since, contrary to technologists' desires, most people are afraid of computers and of change.

In light of these observations, publishers should acclimate their staff using internal training programs, salary incentives for mastering technology, and an internal electronic communications network. The biggest asset today is a computer-literate and interacting staff; such a staff is the best source of ideas on ways to navigate changes. And while other firms can quickly reverse-engineer and copy systems, technology, and products, they cannot quickly copy a well-coordinated, committed, intellectually stimulated, and productive staff.

Equipment is now less important than almost anything else because of plummeting prices and increasing power, flexibility, robustness, and reliability. Even though the equipment will be obsolete in 3 years, spending $3,000 per employee to buy computers and an interoffice network is money well spent. If everyone gets one and it is presented as a natural change it is likely that staff members can help each other over the initial humps—and there will be many. Once employees start using their machines for things as approachable as personal electronic mail to each other their resistance should decrease.

Publishers should also develop a subdivision of one or two technical people who gather information about and experiment with different ways of packaging and distributing electronic books. The subdivision can also function as a source of technical help for the rest of the company during the transition period, thereby partly defraying their salary cost.

5.2 Why It Will Work

The subscription scheme will work because many professionals pay over $100 a year for each of several subscriptions to professional or academic organizations. For this money they get quarterly journals and mild discounts on publications that the organization carries (plus incidental benefits at conferences, and so on). Many professionals pay lawyers and financial advisors annual retainers for the ability to call on them whenever they wish.

Many people pay over $100 a month in phone bills, and phone companies charge $30 or more merely to remain connected. Similarly, millions of people pay $25 or more a month for the opportunity to watch movies that a cable company chooses, at times the cable company chooses. Of course they offer a huge stock. Publishers can provide better service by letting readers choose what they read and when, provide a more long-term benefit to society by benefitting education, science, and technology, charge each household less per year to do so, and still make money.

Further, there are now thousands of bulletin boards and hundreds of online services, of which 10 are major companies: BIX, Dialog, Prodigy, CompuServe, Delphi, Reuters, Dow Jones News Retrieval, GEnie, SprintMail, and Data-Star. In 1990 online service sales reached nearly $9 billion, almost double 1986 sales.

BIX, the Byte Information Exchange, offers each month's *Byte* magazine and other services; its subscription rate is $39 a quarter, exclusive of phone connect charges. Dialog gives access to 390 databases, with over 270 million references to over 100,000 publications, including the complete texts of over 1,000 periodicals. Dialog charges anywhere from $45 to $150 for signup and connect charges. Prodigy (run by IBM and Sears) has almost 1 million subscribers, and charges a $50 signup cost and $13 per month. CompuServe has 3/4 million subscribers, and charges a $40 signup cost and $6 to $22.50 per hour for connections. Delphi has 100,000 subscribers, and charges $6 a month and $20 for 20 connect hours.

Finally, after only 2 1/2 years Waldenbooks has 4.4 million U.S. readers in their Preferred Reader Program. Waldenbooks and B. Dalton Booksellers use their programs to keep track of book buying, title performance, and reader habits, and they use the names for their mail order programs. But more can be done by changing the one-time cost of the card to a yearly fee and offering larger discounts—in other words, making it a subscription program.

5.3 A New View of Publishing

Perhaps a publishing by subscription scheme has not occurred before because a single title can take a long time to develop; so there is a tendency to think book by book. Only the most prolific authors could sell their works to the public by subscription, as Dickens did. But publishers have many authors; 20 or so should be enough to generate a constant supply of new product. And that makes it worthwhile for the public to subscribe.

Publishers are more like movie producers than movie directors. The mistake many early software companies made was to employ large numbers of programmers. Having to find money for a large monthly payroll (and sometimes just greed) forced them to charge high prices for each copy of their software. Which led to piracy. Which led to copy protection and higher prices to make up for revenue lost to pirates. Which led to more piracy [39]. (Software publishers eventually broke this cycle by dispensing with copy protection and turning to a form of subscription publishing; successful publishers hooked their audience with a promise of continuous updates for a fee.)

Instead of employing authors, the book publishing model is to encourage free-lance authors to write books, then help develop the projects, and promote and sell them. But publishers are more than mere intermediaries; the book industry would not exist at all without someone amortizing supply on one end and demand on the other, providing the capital and expertise to develop and edit products, and getting products from supply to demand. In many ways subscription publishing is the natural way to be a publisher—low unit margin but stable high volume instead of high unit margin but low, and unpredictable, volume.

A large stable number of subscribers each paying a tiny amount per book is more important than a small number of incidental purchasers of expensive single copies. That uncertainty and the emphasis on single copies is what is wrong with publishing as a business today. To those who argue that publishing should not be a business, the answer is that a large stable income frees publishers to produce quality books.

5.4 The Short Term

In the short term (1 to 3 years), the subdivision should first target executives, professionals, and technicians. They have the money and the motivation to support expensive early experiments. This phase will not generate much capital since the experiments and the learning process will be expensive.

During this first phase publishers should start trying to put their authors under long-term contract, just as Hollywood studios kept their actors in the thirties to fifties. Failing that, it is essential for publishers to attract and maintain a stable source of new product—which means more emphasis on new product acquisition. Only with constant title turnover will they keep their readership.

Publishers should also renegotiate their author contracts to allow for electronic distribution. Putnam and Berkley have already adapted their contracts to keep electronic display rights [12]. Through ignorance of the market and the technology Random House sold the electronic display rights for its dictionary and other references for a mere $10,000 plus 10 percent of the royalties [52]. Random House expected to make $40,000 (this was the lower cap in the contract). They made over a million dollars.

5.5 The Mid Term

In the mid term (3 to 5 years), the electronic subdivision should target schools, universities, corporations, states, and other large organizations to accept subsets of their electronic catalog at small cost per book, but at large cost per catalog. These organizations will serve as suitable testing grounds for the new techniques on a large scale. This stage will also make for word-of-mouth advertising.

Large organizations will not allow wholesale copying for fear of lawsuits and public embarrassment. It is easy to ensure that by inserting hard to find identifying tags in the particular version of the books they receive; so if excessive copying is suspected there is a way to prove that a particular copy was made from the files the publisher supplied to the organization. To be able to insert these tags the subdivision needs to develop, or at least have a say in, the software used to display books; and that will happen only if the publisher is one of the first of the new publishers. This phase should generate a fair amount of capital that can then be plowed into development for the final phase.

At this stage publishers can work out ways to divide the income; the royalty system may have to change. With such a large number of dollars coming in every year (or quarter, month, or day, depending on which is the better business policy), non-fiction publishers can afford to pay authors an advance the same way fiction houses do now, then keep track of demand for their work crediting them for any accesses of their work by any subscriber. Or publishers can buy titles on consignment. Or capital-heavy publishers can buy a work outright.

Other arrangements are possible, for example, capital-light publishers can ask authors to pay for the privilege of being put on their list, as vanity presses do today. In this scheme, authors bet that the demand for their work, once it is widely available, will outweigh their capital outlay; a better system than the present one if the author has the capital. Since the publisher's marginal distribution cost is near zero the publisher risks little. To avoid simple frauds later on when an author can also be a subscriber, each subscriber's electronic connection can be recorded and publishers can require them to identify themselves to gain access.

5.6 The Long Term

In the long term (5 to 10 years), publishers should get out of anything to do with milling, producing, printing, transporting, warehousing, or distributing paper. Which fits in well with the growing antagonism to deforestation. Publishers with heavy investments in paper and printing will be hit hard. Publishers should develop computer expertise within their electronic subdivision, or form an alliance with a computer firm. Then they should gradually grow their subdivision to take over the backlist of the rest of the company.

6 Pricing, Positioning, and Profits

What we must decide is perhaps how we are valuable, rather than how valuable we are.
F. Scott Fitzgerald, The Crack-Up

At this point such publishers have become general subscription services acquiring, developing, packaging, and distributing intellectual property just as publishers do now, but with higher profit margins and less risk. With a captive reader base of 50,000, such a publisher can charge subscribers only $10 to $20 a month, and still gross $6 to $12 million a year. And, except for salaries and royalties, every cost and risk of contemporary publishing will be near zero.

These all-you-can-read publishers charge $120 a year, but the subscriber can then get any number of books, each for $1. The $10 subscription rate and $1 book rate are not based on market surveys or sensitivity analyses. Prestige, niche, and designer-label publishers may be able to get away with more than $20 a month. Or perhaps they should leave the subscription rate at $10 a month, but charge $5 per book.

As fear of scientific and economic non-competitiveness grows in the U.S. the fastest growing domestic book market may be electronic educational books for the 5–20 age group. This market may easily bear $20 a month subscription charges.

Publishers should split their list into subgroups based on expected readership for each grouping. That will let them charge different amounts for each sublist. They should also offer packages of the whole list for those willing to pay more for the full service. Finally, they should offer the general public a per use cost that is higher per book than the subscription price per book, so that there is incentive to become, and remain, a subscriber either to the whole list or to some subset of it. That encourages subscription and lets people who do not want the whole service get just one or a few books.

As long as publishers charge roughly as much as it costs to copy a book they will not have serious piracy loss. It is even permissible to charge triple the copying costs, since they still can be more convenient suppliers than pirates, but more than quintuple the copying cost may lead to serious piracy. Publishers should resist the temptation to charge a lot per book; they should not try to make each book necessarily pay for itself immediately. They should resist the lure of historical precedent and avoid charging subscribers by the book.

It is better if they charge a flat rate for access to their entire list. If the flat rate is low, subscribers will not ask themselves which titles they should get. In the subscription scheme, publishers' attractiveness to subscribers is their list—how many good books they carry, not what proportion of good books they carry. When their lists are fully electronic, with the concomitant near-zero marginal cost to distribute a copy of any title, it is not relevant if some of their titles are not big sellers—they cost nothing to keep, they can be kept forever, and they cost almost nothing to distribute if demand ever rises.

6.1 Lures to Subscribe

Each title is valuable if it is eventually responsible for gaining its publisher more subscribers; even difficult books that no one ever reads are useful, if they add luster to the list. In general, publishers will be able to support more authors and a wider variety of specialty topics.

Publishers can encourage more people to subscribe by reducing subscription rates as people subscribe. Since computers will be doing the distribution and billing, there is no reason for a fixed rate per subscriber. Since overhead is now largely fixed and marginal costs are near zero, publishers could let subscription rates drop as enrollments rise.

Unfortunately if enrollments drop, rates rise, which could lead to more dropping enrollments, and so on. Perhaps subscription rates should start higher than that necessary to make a comfortable profit, then drop to the precalculated floor level as enrollments rise. Even if that idea is ruled out, publishers should let heavy readers pay less per book on the principle that subscribers who buy many books will remain subscribers longer than those who do not buy heavily. Today publishers have no way to give preference to the very people they should be targeting most.

The point is for publishers to keep subscription costs low and to increase readership as much as possible, but only to a level that can be maintained indefinitely. After startup, their marginal cost to add a new subscriber will be effectively zero, yet each new subscriber pays the same.

6.2 Global Publishers

Electronic publishers can become international without having to develop overseas bases. It is trivial to transport information cheaply and distance does not matter; geography is irrelevant in the information economy and only language differences still separate us.

At this point governments will start worrying about taxation, export controls, and tariffs—but these are irrelevant since unenforceable. The state can no longer control its population by controlling access. Cutting off international calls would have drastic economic and social consequences. Even if the state were to disallow international calls there would still be satellites and radio. We are already irrevocably committed to the information economy.

Publishers can reduce the risk of ten thousand simultaneous requests by increasing the number of distribution sites and by charging different amounts to service requests at different times of day (local time), thereby evening out the number of calls per hour. Further, each distribution site is merely a phone line and a small special-purpose computer—at most a few thousand dollars of equipment—which easily pays for itself if it supports a few dozen subscribers.

The technology supporting the system would already have been deployed and paid for in the previous 5-year span, so the only cost will be the ongoing one of service expansion, service upgrading, and product distribution. Distribution should cost almost nothing since subscribers pay phone connect cost. Billing can be automatic just as electricity, phone, gas, cable, newspaper, and magazine subscriptions are now.

6.3 Competition

No one will copy and try to sell a product if anyone anywhere can instantly get the same service plus continuous updates for 33 cents a day. When any one copy of a book has a marginal price of $1, pirates are irrelevant and publishers will not need to copy protect their books. There are only so many books a human being can read in a lifetime, so there is no need to worry that every subscriber will demand many titles; once the initial flurry of excitement dies down, demand should average less than ten titles per subscriber per month. There will be far greater demand for ferreting, mapmaking, and filtering.

Later on publishers should tailor their books to specific groups of subscribers, based on information supplied by subscribers about their tastes and interests. Even later, publishers should tailor down to individual subscribers. Such publishers will then be immune from pirates producing uniform copies of one version of each book. Few would buy off the shelf clothes if tailor-made clothes were as cheap and as available.

Further, the new publishers should not sell their subscription list; their greatest danger will come from electronic publishers with competing titles. Selling them the subscription list is begging for them to compete; they should be made to pay to develop their list in the same way that the first of the new publishers did. Since they come in later they are already at a disadvantage and it should be straightforward for the early publishers to keep their edge.

On the other hand, this goes against the desirability of letting subscribers know who other subscribers are; which in turn curtails interaction among subgroups interested in particular topics. Publishers may not see this as a business advantage, but one of the biggest sellers of books is word of mouth. The benefits of identifying special interest groups and fostering a community may outweigh the liabilities of letting other publishers get their subscription list. These are some of the questions that the subdivision has to answer in the first or second phase of the venture.

The subscription scheme works especially well for two diametrically opposite types of publishers: publishers of static information (out of print or public domain books, annals, histories, and so on) and publishers of volatile information (magazines, journals, encyclopedias, fact books, almanacs, and so on). It will work particularly well for publishers like Dover who already have an effectively infinite list, since all of their books are in the public domain. But it may work as well for all other publishers—including newspaper publishers.

6.4 Entrepreneurs

The subscription scheme will also work for entrepreneurial publishers. Anyone can be one of the new publishers; all you need is an audience. A startup with as few as 20 productive authors and 10,000 captive readers, charging each reader only \$10 a month, will gross \$1.2 million.

After display technology becomes cheap enough there will be a (perhaps) 5 year window of opportunity for capital-light startups. Initially the market should be similar in growth potential to the software market of 1977–1984.

After that period of explosive growth (and huge profit) the market should stabilize to a few large companies and many niche companies. Then the largest companies will compete for market share and the thousands of niche companies would become the self-replenishing part of the market. Given an audience, 5 years from now anyone could become a publisher without getting a mortgage.

For example, a race car enthusiast might acquire titles on formula racing, racing news, racing in history, car maintenance, car technology, biographies of racers, short stories, and adventure novels. Further, there may be discussion groups handled by the publisher's machine on aspects of racing or on that month's novel or story. And the same would be true for a lover of 19th century novels, or science fiction, or any other niche. Each title may be almost useless to its author, but being selected as part of a well-chosen group gives value (social and economic) to the author, publisher, and readers. Few authors have the capital or the will to develop, promote, and distribute their product.

Besides salaries, advertising, and phone bills, such a startup today only needs an initial capital outlay of about $20,000 to buy (or even lease at 1/10th the cost) the machines answering the phone, and a continuing cost of perhaps $10,000 a year for maintenance. And these costs will halve every 2 to 3 years as equipment prices continue to plummet.

Expansion of the number of distribution sites is even more non-linear than increasing print run size today; a few thousand dollars of equipment translates to support for millions of dollars of subscriptions. Rents can be low too since distribution sites need not be in New York. No humans are necessary, so Alaska will do just as well.

Not even the phone bills would be that high. A subscription service can first send each of its users a fixed program to uncompress its books, and send books on demand in compressed form, taking only a few milliseconds to complete each call. Such a startup could attract $1 million in venture capital with a short payback period, unlike startup paper publishers today. With venture capital and a ready market, it could become a billion dollar publisher in 10 years. The fortunes of 7 of the 10 richest U.S. billionaires are based on media, communications, or computers; publishing is right in the middle of this triumvirate.

Established publishers should brace themselves for increased competition.

7 Technological Hammers

It has become obvious that the machine is here to stay.... The sensible thing to do is not to revolt against the inevitable, but to use and modify it, to make it serve your purposes. Machines exist; let us then exploit them to create beauty—a modern beauty, while we are about it. For we live in the twentieth century; let us frankly admit it and not pretend that we live in the fifteenth.
Aldous Huxley, "Printing of To-Day," in [34]

Armed only with a hammer, everything looks like a nail. To technologists, every problem has a technological solution, particularly since technolust can blind them to potential problems. But industry has to look at more issues. Just because a new technology is technically superior to an older technology does not mean that it will win; it can lose for social reasons that have nothing to do with technology [9].

For example, digital audio tape has not yet replaced analog tape in the U.S. thanks to strenuous obstruction from the Recording Industry Association of America. Although automated teller machines were a success for Citibank, Chemical Bank lost tens of millions on their experimental home banking system [21]. Videocassette recorders succeeded over analog videodisc players because videocassettes were rewriteable and the videodisc industry paid no attention to the renting market. Fax machines are more prevalent than electronic mail in the business community because they require no special protocols and business people are more familiar with paper. And most telling of all for this report, after 15 years most videotext systems have yet to take off [41].

On the other hand, matches replaced flint, cars replaced horses, telegraphs replaced the pony express, transistors replaced vacuum tubes, digital optical discs replaced analog phonograph discs, fiberoptic cable is replacing copper cable, and cable television is replacing airwave television. Such examples can be multiplied indefinitely, for they are the records of our civilization.

Superior technology beats inferior technology if it can be adopted without too much initial social change. And even that inertial barrier can be overcome if the technology is so important that it must be adopted or the society dies—as happened with radar and all other warfare-originated technologies, or is so superior that it must be adopted or the industry dies—as happened with steamships.

For the technologist, a world of 5.5 billion that is growing by 96 million people a year—32 Chicagos, 8 Cairos, or 4 Canadas—needs all the technological help it can get. Particularly in the richest and most powerful nation in the world; a nation that ranks 23rd in infant mortality, a nation where 1 in 4 children are below the poverty line, a nation where 1 in 8 college students cannot place it on a map, a nation whose schoolchildren rank behind those of most developed nations in general knowledge, math, and science, and a nation where, as of November 1st, 8.6 million people are unemployed. The technologist's job is to tell the rest of society about possibilities they may be unaware of. The technologist's problem is to estimate the rest of society's reaction to a new product.

An examination of why some technologies languish while others explode and an exploration of potential relations between each such reason and the publishing industry's mission would turn this report into a book. For example, businesses saw fax machines as superior to electronic terminals. Initially they cost the same, but training time was shorter since they used a phone with no special protocols and faxes could carry arbitrary images, including pictures and handwriting.

However, once received a fax must be processed in the old way, but electronic documents can be stored, searched, cross-referenced, indexed, linked, and retrieved by machines. Further, it is more convenient to send long documents electronically, electronic documents can contain working programs and animated illustrations, and electronic documents do not bounce if the target phone is busy. Electronic documents can also be reformatted for a new display. And of course they can always be printed. It is to the discredit of the computer industry that the opportunity and need for paper fax machines even existed. Paper fax machines would not have been necessary were it not for endless squabbling over interface standards and an unthinking allegiance to arcane interfaces and protocols.

Instead of exploring the social issues further, this report has presented, in decreasing order of confidence: the technology likely to affect publishing over the next decade; reasons why that technology will become widely used; a way for publishers to exploit the technology (albeit, a way that is biased toward the interests of educators, scientists, and technologists); and a case that if some publisher adopts that strategy then other publishers will lose revenue. Publishers must determine how much faith they should place in each step of the extrapolation. Their decisions may determine who will be succeeding and who will be succumbing 10 years hence.

8 Thanks

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: "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, 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.

In this report I have tried 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 what I believe to be avoidable near-future confusion, disruption, and conflict during its implementation.

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A Appendix: 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 in [28]

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, fiberoptic 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 [36]; in that time computers have gone from the lab to the lap. In terms of size alone, in 40 years computers shrank from large rooms, to cars, to refrigerators, to ovens, to microwave ovens, to record players, to large books, to magazines. They have stopped at magazine 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 even 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 2 or 3 years. The present pace is expected to continue for at least 2 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 10 years from now can be used to keep the self-improvement ball rolling. The industry's watchwords are: smaller, lighter, faster, denser, stronger, cheaper.

A.1 Computer Memory

A bit (binary digit) is a one or zero (off or on), and 8 bits is a byte. The number of bytes a device can store is its memory, or storage. Five years ago memory used to be measured only in the thousands or tens of thousands (1 kilobyte is roughly 1,000 bytes). Nowadays memory is measured in the millions (1 megabyte is roughly 1 million bytes), or billions (1 gigabyte is roughly 1 billion bytes). In 5 years 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 21,000 words and is about 132 kilobytes.

Memory cost is dropping fast. Seven years ago 1 megabyte was a large amount of memory; few people could afford that much memory, and they all worked at large institutions. Today, hundreds of thousands of personal computer users have over 8 megabytes of computer memory and 1 or 2 gigabytes of tape or disc memory.

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.

Last year IBM succeeded in storing 1/8 gigabyte on a 1 inch square magnetic disc. Just 6 years separate the first IBM 1/8-megabyte chip from the first Hitachi 8-megabyte chip; a 64-fold increase. Some expect terabyte memories within 10 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 (1 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 4 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.

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 eyeblink 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 7 years. At present they are expensive, but the price is expected to drop rapidly as technology improves and demand drives their development [17]. Fujitsu, the second largest computer company in the world, and Intel are presently working on a 64-megabyte memory card.

A.2 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.

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 [6].

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 the U.S. Federal Communications Commission (FCC) approved 3 experimental pocket phone systems in Atlanta, Boston, and Long Island by 3 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 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 [30].

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, 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 90 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 Fiberoptic Cable

Fiberoptic cables use lasers to send information down glass fibers. Fiberoptic 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 fiberoptic cable has increased 100 times while the cost of fiber fell from $3 a meter to 15 cents a meter [51]. Currently every developed nation is laying millions of kilometers of fiberoptic 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 fiberoptic local-area networks (LANs) have bandwidths of 6.25 to 18.75 megabytes per second [19], 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 [3]. In 1989, LAN sales (hardware, software, and cabling) exceeded $5.68 billion in the U.S. alone [43].

In September the U.S. Senate approved a $1 billion expenditure over the next 5 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 10 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 [14]. These bandwidths let us send a 500-page book in under 4 milliseconds.

A.3 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 [47]. 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 [1]. 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 [11]. Worldwide annual sales of flat screens now exceed $2 billion [18].

A.4 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 [20].

Portables are divided by size into palmtops, handhelds, notebooks, and laptops, and they are further divided by whether they have a keyboard. Notebooks are 3-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 [4].

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 this, the second year of pen-based computers, there are already 33 companies producing pen-based computers.

Notebooks were introduced 2 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. In 3 years notebooks may weigh under 1 kilogram and cost \$2,000. In 5 years 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 2 to 3 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, the Zenith MastersPort 386SL, priced at \$5,000, improved enough to extend battery life to 8 hours. The U.S. Army immediately placed a \$50 million order. The MicroSlate Datellite 300S is touch-sensitive and keyboardless and runs for 8 hours, but it needs 2 12-volt batteries to do so. It costs \$6,000. The Dataworld NB320SX has a smaller screen and only 2 hours of battery life. It costs \$2,300.

A.5 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 7-fold increase in only 5 years [26]. 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 the first week of October IBM cut prices on the PS/2, its personal computer, by 20 percent; last year Apple halved the prices of all its computers—a common occurrence in the computer industry over the last 10 years.

Introduced 3 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 occurrences of that pattern anywhere in Shakespeare's works.

After only 3 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 3-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; today it costs $5,000 to the general public and $3,000 to students and academics. In 5 years it may cost as little as $1,500. In 7 years equivalent power will be available for $500.

B Appendix: 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 Bookmen

The Sony Data Discman, called the Bookman here, is a modification of the Sony Discman, their portable disc player. The Bookman 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 [29]. It also plays music compact discs.

Sony initially offered 17 titles, and by April offered over 30. They sold 200,000 titles in 5 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 Bookmen in Japan at a list price of $450. Sony is making 20,000 Bookmen a month, and introduced them in the U.S. on November 1st. For its U.S. debut, Sony changed its name to the Electronic Book Player, upgraded its screen from 2 inches to 3 inches, 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 Bookmen 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 Bookman-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 2 years.

B.2 Problems with the Bookman

Bookman 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 very 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 [44].)

But making the Bookman'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) [46].

In September, Philips introduced the Magnavox 461; a computer that plays music discs and comes packaged with *WordPerfect* and *Grolier's Electronic Encyclopedia.* In October, 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 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 [58], for an overview see [23]).

By Christmas 1993, Bookmen or Bookmen-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 7 years ago.

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 Bookman-equivalent companies solved the problem by buying the chicken. They started 3 years ago.

Sony lined up 63 Japanese publishers and other companies to produce the books that will be read on the Bookman. 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 Bookman-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 6 of the world's largest music companies are now owned by international corporations; the only remaining independent music company is the 7th largest, Virgin Records—and it is British. Bertelsmann Group, A.G. already owns similar properties in 20 countries [49]. Of the major U.S. entertainment companies all but one, Warner Brothers, are now foreign-owned. And in October Toshiba and C. Itoh paid $1 billion to own 12.5 percent of Time Warner.

B.3 Dynabooks

Bookmen are only the near-future electronic threat; turning paper books into aluminum-coated polycarbonate discs will not remove all of 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 [28]. 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 2 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.4 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 [24, 25]. Since April 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 of the above dynabook functions.

But both obstacles will be overcome in 5 years. Computer power will not be a problem, but high resolution could remain an issue for several years, perhaps as many as 5. 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 5 years.

B.5 Grave New World

Cheap computing power, cheap memory, high-resolution flat screens, cellular radio, radio frequency modems, satellites, fiberoptics, 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 4 milliseconds instead of 4 days and many postal workers are jobless. Imagine a world where the proportion of the work force in manufacturing, presently 25 percent, drops to 16 percent—only 8 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 presently 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, 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 50 years from now may be as different from us as we are from preindustrial societies.

References

[1] John A. Adam; "Industries transcend national boundaries," *IEEE Spectrum,* 26–31, September 1990.

[2] W. Brian Arthur; "Positive Feedbacks in the Economy," *Scientific American,* 92–99, February 1990.

[3] Trudy E. Bell; "Telecommunications," *IEEE Spectrum,* 44–47, January 1991.

[4] Trudy E. Bell; "Incredible Shrinking Computers: Redesign of systems and components let engineers create desktop-power notebook computers weighing under 8 pounds," *IEEE Spectrum,* 37–41, May 1991.

[5] David Bjerklie; "The Electronic Transformation of Maps," *Technology Review,* 54–63, April 1989.

[6] Uyless Black; *Data Networks: Concepts, Theory, and Practice,* 128–132, Prentice-Hall, 1989.

[7] Stewart Brand; *The Media Lab: Inventing the Future at M.I.T.,* 201–206, Penguin Books, 1987.

[8] Anne W. Branscomb; "Common Law for the Electronic Frontier: Networked computing challenges the laws that govern information and ownership," *Scientific American,* 154–158, September 1991.

[9] Herb Brody; "Great Expectations: Why Technology Predictions Go Awry," *Technology Review,* 38–44, July 1991.

[10] Mark Chrysler; "Canon: more than just cameras," *IEEE Spectrum,* 113–116, November 1990.

[11] Elizabeth Corcoran; "Flat Horizons: U.S. pursues research but little development of advanced screens," in the Science and Business section of *Scientific American,* 112–114, June 1991.

[12] Richard Curtis; "Here Come the Cyberbooks," in the Agent's Corner section of *Locus: The Newspaper of the Science Fiction Field,* February, March, and April 1991.

[13] Ellen Dempsey; "Impact II, a teacher's network is striving for both short- and long-term changes," *Omni,* 8, April 1990.

[14] Peter J. Denning; "The Arpanet after Twenty Years," in *Computers Under Attack: Intruders, Worms, and Viruses,* Peter J. Denning (editor), 11–19, Addison-Wesley, 1990.

[15] John Diebold; *The Innovators: The Discoveries, Inventions, and Breakthroughs of Our Time,* 177–202, Plume, 1990.

[16] K. Eric Drexler, Chris Peterson, and Gayle Pergamit; *Unbounding the Future: The Nanotechnology Revolution,* page 148, Morrow, 1991.

[17] Deborah Erickson; "Lighten Up: Memory cards are key to the truly portable computer," in the Science and Business section of *Scientific American,* 116–117, June 1991.

[18] Richard Florida and David Browdy; "The Invention That Got Away," *Technology Review,* 42–54, August/September 1991.

[19] Mario Gerla and Joseph A. Bannister; "High-speed local-area networks," *IEEE Spectrum,* 26–31, August 1991.

[20] Michael Goldstein; "Toshiba: An Interview with Tom Martin," *PC Lap-Top,* 68–73, September 1991.

[21] R. Guenther; "Chemical Banking: AT&T to scrap home banking service," *The Wall Street Journal,* 21, December 5, 1988.

[22] Robert Haavind; "Hypertext: The Smart Tool for Information Overload," *Technology Review,* 42–50, November/December 1990.

[23] Nancy K. Herther; "Interactive Multimedia at Philips: CP Interviews Philips' Bert Gall About CD-ROM, XA, CD-I and Their Future," *CD-ROM Professional,* 34–37, September 1991.

[24] John Ioannidis and Gerald Q. Maguire, Jr.; "PIP-1: A Personal Information Portal with wireless access to an information infrastructure," Technical Report CUCS-055-90, Columbia University, 1990.

[25] John Ioannidis, Dan Duchamp, and Gerald Q. Maguire, Jr.; "IP-based Protocols for Mobile Internetworking," *SIGCOMM'91 Conference: Communications Architectures and Protocols,* 235–245, ACM Press, September 1991.

[26] Gadi Kaplan; "Revolution in the Workplace," *IEEE Spectrum,* 32–34, April 1991.

[27] Pam Kassner; "Competitive Intelligence: Executives stalk info with new data tool," *Online Access,* 18–21, Fall 1991.

[28] Alan C. Kay; "Microelectronics and the Personal Computer," *Scientific American,* September 1977.

[29] Tom Koppel; "Reading Books Byte by Byte," in the Science and Business section of *Scientific American,* 116, June 1991.

[30] Erika Kotite; "Upwardly Mobile: Offices That Really Go Places," *Entrepreneur,* 73–77, May 1991.

[31] Nathaniel Lande; "Toward the Electronic Book: A Proposal for a system that would introduce readers electronically to mountains of material is currently making the rounds," *Publishers Weekly,* 28–30, September 20, 1991.

[32] Daniel Loeb; "An Electronic Journal of Mathematics: Feasibility Report 5," electronic manuscript, loeb@geocub.greco-prog.fr, Département des Mathématiques et de l'Informatique, Université Bordeaux I, 1991.

[33] Stan Luxenberg; *Books in Chains: Chain Bookstores and Marketplace Censorship,* National Writers Union, 1991.

[34] Douglas C. McMurtrie; *The Book: The Story of Printing and Bookmaking,* page 594, Dorset Press, 1943.

[35] Joshua Meyrowitz; *No Sense of Place: The Impact of Electronic Media on Social Behavior,* page 85, Oxford University Press, 1985.

[36] Hans Moravec; *Mind Children: The Future of Robot and Human Intelligence,* 62–65, Harvard University Press, 1988.

[37] Nicholas P. Negroponte; "Products and Services for Computer Networks," *Scientific American,* 106–113, September 1991.

[38] Pauline Ores; "The CD-ROM Universe," *Desktop Communications,* 53–55, September-October 1991.

[39] Adam Osborne and John Dvorak; *Hypergrowth: The Rise and Fall of Osborne Computer Corporation,* 166–169, Avon, 1984.

[40] Richard L. Phillips; "MediaView: A General Multimedia Digital Publication," *Communications of the ACM,* 74–83, July 1991.

[41] Darrell R. Raymond; "Why videotext is (still) a failure," *The Canadian Journal of Information Science,* 14, 27–38, March 1989.

[42] Sharon J. Rogers. and C. S. Hurt; "How Scholarly Communication Should Work in the 21st Century," *The Chronicle of Higher Education,* A56, October 1989.

[43] Alfred Rosenblatt; "Data Communications," *IEEE Spectrum,* 48–51, January 1991.

[44] Pamela Samuelson; "Digital Media and the Law," *Communications of the ACM,* 23–28, October 1991.

[45] Terrence J. Sejnowski and Charles R. Rosenberg; "Parallel networks that learn to pronounce English text," *Complex Systems,* 1, 145–168, 1987.

[46] Elliot Soloway; "How the Nintendo Generation Learns," in the Log on Education section of *Communications of the ACM,* 23–26, September 1991.

[47] Lawrence E. Tannas, Jr.; "Flat-panel displays displace large, heavy, power-hungry, CRTs," *IEEE Spectrum,* 34–35, September 1989.

[48] Alvin Toffler; *Future Shock,* Bantam, 1970.

[49] Alvin Toffler; *Powershift: Knowledge, Wealth, and Violence at the Edge of the 21st Century,* 341–343, Bantam, 1990.

[50] M. Turoff and S. Hiltz; "The Electronic Journal: A Progress Report," *Journal of the American Society for Information Science,* 33, 195–202, 1982.

[51] Karen Wright; "The Road to the Global Village," *Scientific American,* 83–95, March 1990.

[52] Richard Saul Wurman; *Information Anxiety,* 302–303, Doubleday, 1989.

[53] G. Pascal Zachary; "Grokking Nintendo," *Upside,* 26–34, October 1991.

[54] Barry Zuber; "Hub of Activity: Departmental printers share computer connectivity and boost office productivity," *Publish,* 56–62, September 1991.

[55] *Intellectual Property Rights in an Age of Electronics and Information.* U.S. Office of Technology Assessment, 1986.

[56] "The American Association for the Advancement of Science (AAAS) Electronic Journal is Unveiled," The Association of Electronic Scholarly Journals, aesj-l@albnyvm1.bitnet, electronic notice, 24th September 1991.

[57] "Display Net: An electronic catalog gives new meaning to impulse buying," *NewMedia,* 25, September/October 1991.

[58] "CD-I: A Designer's Overview," Philips International, Inc., McGraw-Hill, 1988.

[59] User Manual for the Xerox/Kurzweil Personal Reader Model 7315, Kurzweil Computer Products, July 1988.