Investment Policy

PaineWebber

Converging Technologies

Investing in the Information Age for the new millennium

Highlights

■ "Moore's Law" rolls on: Current technologies' limits, laws of physics do not prevent creation of even more astoundingly powerful chips for many years to come. The relentless advance of semiconductor technology converging with emergence of installed PC base in office and home, shift to inter-networking have laid groundwork for Information Age in which creation, distribution and manipulation of information is central wealth-creating activity.

■ Convergence of computer, communications, consumer applications, content means that leading growth companies will not be defined simply as "software" or "hardware" or "content" companies, but as information companies.

- PC is central, multipurpose consumer device of Information Age. PC to be as ubiquitous as phone is today, enabling global access to personal log-in environment. PC and TV converge but don't merge. PC used *primarily* for work—to actively *get* information. TV used *primarily* for entertainment—to passively *receive* information. But PC *will* receive information (e-mail); TV *will* get information (via Web browser).
- Internet is a key medium. Net is home to three business models chasing three revenue sources: entertainment (advertising/subscription revenues); information (subscription revenues); commerce (sales revenues). Most valuable Web sites owned by companies with strong brands. Net also offers huge cost saving opportunities.
- With information the basic economic resource, data management and data warehousing are critical for organizing and exploiting data.
- Bandwidth to the home will always be in short supply as it lags advances in chip technology, content.
- Huge demand for vast amounts of data storage. Primary storage method still likely to be magnetic.

■ *Winners*: Content companies (entertainment, newspaper companies with valuable brands), data companies (management, warehouse, storage), Moore's Law beneficiaries (chipmakers, semiconductor capital equipment companies), Networking companies (Internet, Intranet, servers, bandwidth), PC-related.

■ *Losers*: Small Internet companies lacking a franchise, "commodity" information companies (e.g., directory publishers, some financial data companies).

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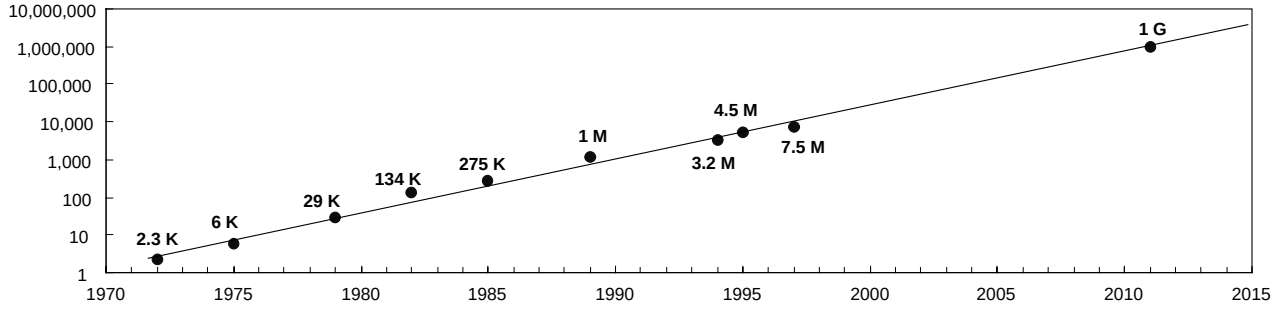
Chart 1

Moore's Law

Number of transistors per chip (in thousands)



Peering into the future

Six years ago, the Strategy group wrote a report entitled *New Frontiers–Industrial innovation and technological trends in the late 1990s* (November 15, 1991). One of the main conclusions of that report was:

> "the personal computer is evolving from a mere stand-alone tool for number crunching and word processing into a . . . window through which users can receive all forms of information (numeric, text, video or sound) not just from a PC's own hard disk, but also from remote computers attached to a high speed network."

In 1991 it was not very obvious that PCs around the world would soon be networked together. Remember, six years ago the Internet was comprised almost exclusively of educational, government and research sites, and the interface was text driven. Many of the companies that have been a key part of the Internet phenomenon were not even in existence at the start of the decade: Cisco (the 24th largest company in the S&P 500 today) went public in 1990, America Online went public in 1992 and Netscape only went public in 1995.

Following up in *The Information Highway—Speeding Along* (September 5, 1993), we observed that

> "For investors it's not over yet. The potential of the information highway is just beginning to be recognized. As these concepts now become reality, the information highway is likely to be one of the great growth industries of the late 1990s."

Given how the scenarios outlined in those earlier reports have played out, we thought it worthwhile to attempt once again to peer into the not too distant future. Accordingly, we asked each of the PaineWebber analysts covering the technology, communications, media and entertainment industries "What will your industry look like in ten years? How will it differ from the conventional view? Who are the winners and losers?"

Why you ask ten years from now? Ten years is far enough to define a secular trend that today is not fully recognized—but not so far off that we are dealing with futuristic speculations that are irrelevant to today's portfolios. In other words, the focus is on trends that, in most cases, are already visible to those who are thinking systematically about the future, but where the near-term impact of these trends is still limited.

The Information Age

So where are we going? We would argue that we are at the dawn of a new era. The relentless advance of semiconductor technology (as graphically illustrated by Moore's Law in Chart 1), the emergence of an installed PC base in the office and the home (Chart 2), and the shift to inter-networking (Chart 3) have laid the groundwork for the move to an information age in which it is *the creation, distribution and manipulation of information that is the central wealth-creating activity.* In other words, the basic economic resource is information rather than land, labor or capital.

The significance of this shift to an information age can not be understated. A recent article (by Peter Leyden, Managing Editor of *Wired)* puts it like this: "we are living through an extraordinary moment in human history. Historians will look back on our times, the 40-year span between 1980 and 2020, and classify it among the handful of historical moments when humans re-organized their civilization around a new tool, a new idea. . . the mid-1990s, perhaps even 1995, may be come to be viewed as the defining moment when society recognized the enormity of the changes taking place and began to re-orientate itself."

Figure 1
Converging Technologies in The Information Age

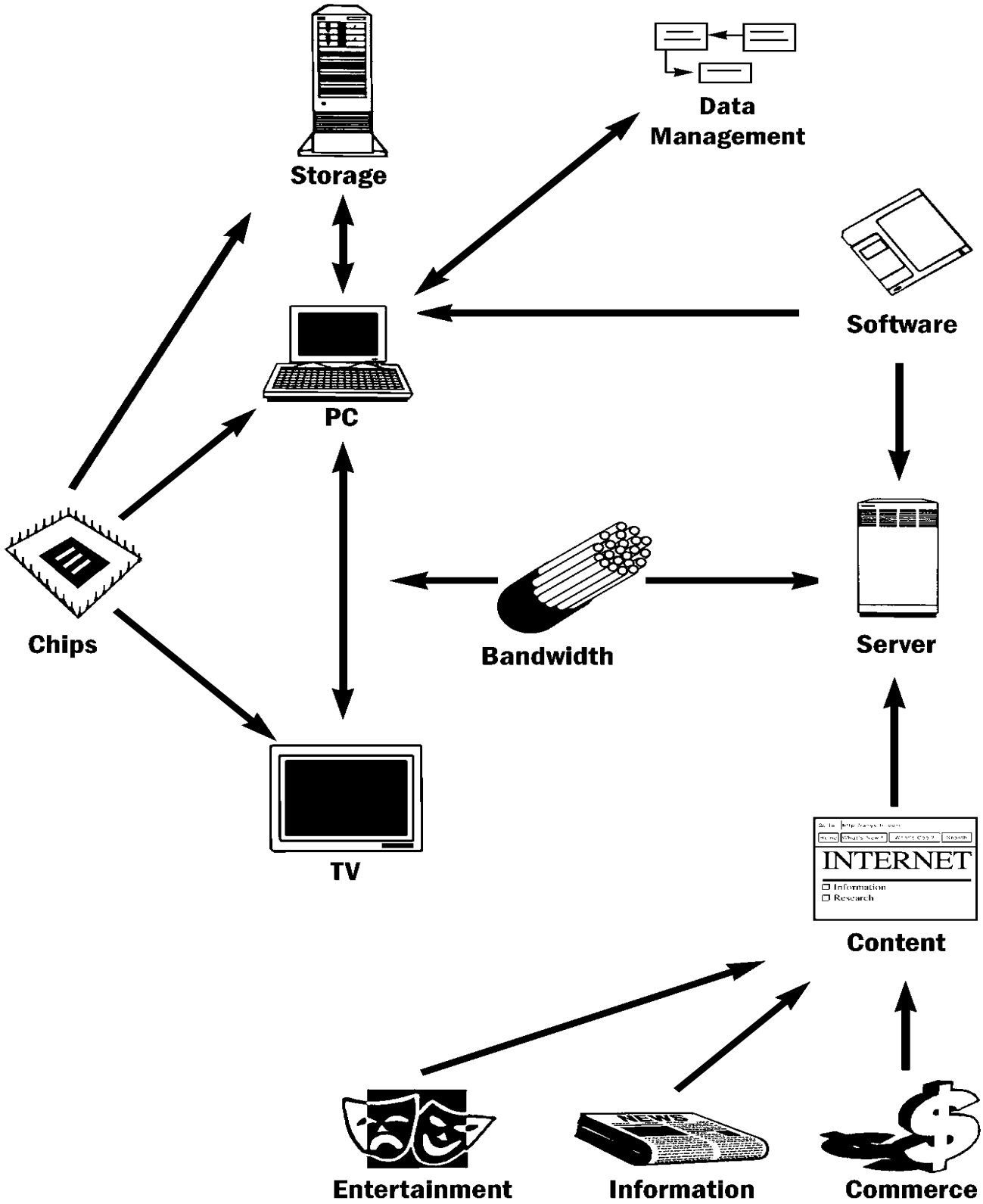


Chart 2

U.S. installed PC base

(*in millions)*

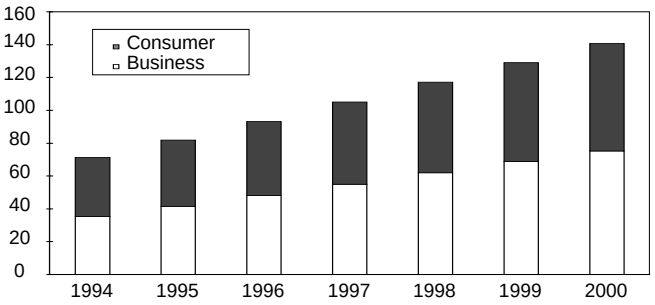
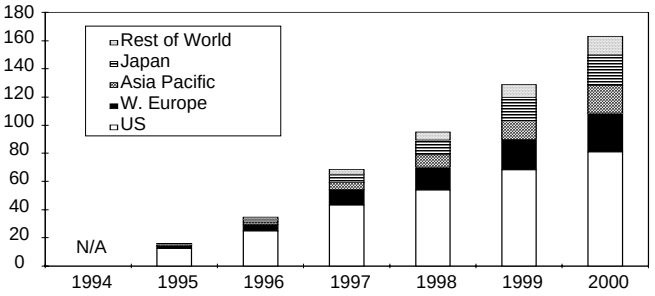


Chart 3

Number of individuals using the Web

(*in millions)*



To put this shift into perspective, some of the previous evolutionary "tools" around which people have re-organized their society include:

- The factory—the most advanced societies (initially England) moved from an agrarian, village economy where the family was the central unit of production to an industrial economy centered around factories.
- The steam engine—allowed factories to be located away from water, the previous major source of power.
- Electricity—permitted the development of mass manufacturing and also caused massive changes in transportation and home life.
- The telephone—brought instant communication into the office and home. In effect, this was the first tool that enabled widespread and immediate dissemination of information.

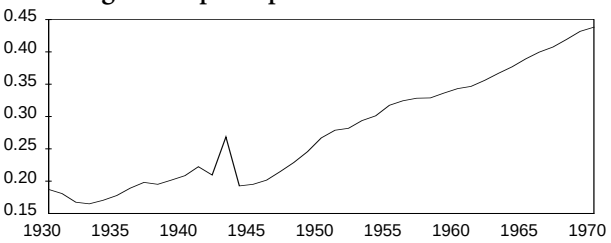
Perhaps the most appropriate historical analogy to what is occurring today is, however, the automobile. Although autos entered mass production in the second decade of the 20th century, they became much more ubiquitous after World War II. Autos registered per capita rose from 0.19 in 1930 and 0.18 in 1945 to 0.34 in 1960 (Chart 4). The key reason for this was that it was not until after World War II *that a fully integrated "auto infrastructure"—consisting of interstate highways, shopping malls, and greatly expanded suburbs—was built.*

Consider just how numerous and important to investors were the ramifications of this phenomenon:

- The rise of the trucking industry and relative decline of railroads.
- Rapid growth of roadside enterprises such as hotels and restaurants.
- Strong demand for road building equipment and materials.
- Strong demand for gasoline, tires, motor, oil, etc. as many more Americans commuted by car.

Chart 4

Autos registered per capita

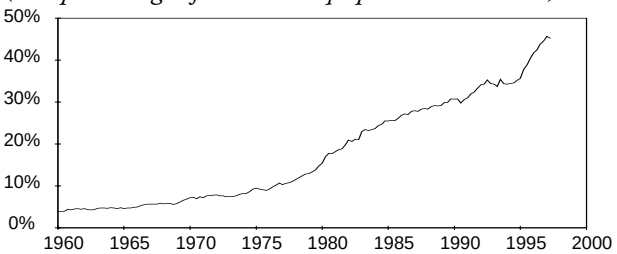


Similarly, although the personal computer has been around since the 1970s, *today there is finally a widespread installed base in the office and the home.* And it is just recently that the "information age infrastructure"—consisting of networks, Internet Service Providers and Web sites—has begun to be built. In the last few years, U.S. firms have poured money into the Information Age infrastructure at an astonishing pace—information processing now accounts for about 45% of total equipment investment, up from 15% in the early 1980s (Chart 5). So, with the shift to the Information Age just getting underway, it is the investment implications of this shift that are the focus of this report.

Chart 5

Information processing

(*as a percentage of total real equipment investment)*



The "five Cs"

The next major Information Age development can be summarized by "five Cs," or the Convergence of the Computer, Communications, Consumer applications and Content. The key factor that is enabling this convergence is the shift to digital. Digital technology makes it possible to convert text, sound, graphics and moving images into coded digital messages which can be combined, stored, manipulated and transmitted quickly, efficiently and in large volumes over wired and wireless networks without loss of quality. As a result, the computer, broadcast, cable, telephone, satellite and media entertainment industries are gradually becoming part of one single market-place. This convergence will accelerate in coming years, so that the leading growth companies of the future will not be defined as "software" or "hardware" or "content" or "communications" companies but rather as information companies.

The smart companies today realize this. That is why:

- **Disney** acquired ABC and established Internet sites for many of its branded products.
- **Hewlett-Packard** bought Verifone, the dominant supplier of hardware point-of-sale credit card swipe terminals and one of the leading players in integrating credit card payments with Internet commerce.
- **Microsoft** bought WebTV (which makes devices that enable Internet access over a TV) and acquired a stake in cable TV company Comcast.
- **Oracle** bought Navio, which develops technologies to link consumer appliances, such as televisions and telephones, to the Internet.
- **Time Warner** bought Turner Broadcasting and established Internet sites for many of its branded products.
- **WorldCom** bought MFS Communications which owns UUNet (the largest Internet service provider).

To access information, some analysts have predicted that there will be a single "information appliance" which will be the primary device for computing, communicating, entertaining, etc. We disagree. Rather, there will be many smart devices *most of which will be linked together and many of which will perform several functions.*

So, for example, PCs will also be wireless telephones. Wireless handheld personal digital assistants will handle text, graphics, audio messages and video. PCs will be TVs, high definition TVs will be Web browsers, and both PCs and TVs will have video cameras attached.

But while there will not be one single "information appliance" *the PC will be the single most important tool.* It will be the central, multipurpose consumer device and will be as ubiquitous in the home as the telephone is today—poor families will have one; rich families will have several.

The two key factors that are making the PC the critical tool of the Information Age are (i) its versatility and (ii) its relatively low cost (which is falling all the time). It has been the versatility of the PC that has been the key in its adapting to the mainstream needs of users. From its earliest roots as a hobbyist toy in the late 1970s, the PC has evolved to:

- A business productivity device. With the aid of major business applications (such as spreadsheets, word processors, graphics, etc.) the PC has become a fixture on almost every office desktop.
- A communications device. Beginning with the advent of local area networks and electronic mail in the late 1980s/early 1990s, the PC took on the added role as an important communication device. Given the explosive growth of the Internet and the rapid installation of Intranets, this role expanded from an internal communications device to a tool to connect to the outside world as well.
- A visual entertainment device. Advances in multimedia have been significantly enhanced with such technologies as **Intel's** MMX chip, digital video disk (DVD) storage devices and improved 3D graphics capabilities. These video/graphics advances have enhanced the utility of the PC in the home as a visual entertainment device.

As noted above, while there will be many smart devices in the Information Age, most of which will perform several functions (compute, communicate, entertain, etc.), *the PC will be the only device which performs all of these functions easily and efficiently.* For example, it will be possible, but somewhat taxing on the eye, to shop over the Internet using a handheld device. It will also be possible, but not very cost effective, to search and manipulate a large database using a TV as the interface to a network computer. And it will be possible, but cumbersome, to edit digital photos on a TV. The PC will be the device of choice for performing these and many other functions.

Even faster, even cheaper

If the PC is to become the central, multipurpose device of the Information Age, it must offer even greater power at even lower cost than is the case today—in other

words, Moore's Law must hold true for many years to come.

In 1965, **Intel** co-founder Gordon Moore predicted that transistor density on integrated circuits would double every two years. This prediction, so far, has proven amazingly accurate. If it continues, microprocessors should contain between 50 million to 100 million transistors early in the next century and execute 2 billion instructions per second. These are truly amazing numbers, leading some observers to question the ability of companies, such as Intel, to develop new techniques to fabricate such complex processors.

Current technologies' limits and the laws of physics will not prevent the creation of more astounding chips for many years to come. To appreciate why, consider some of the basic steps involved in chip production.

- Chip manufacturers begin the process by purchasing silicon wafers. The bigger the wafer, the better for two reasons. First, the more chips that can be made per wafer the less expensive they are. Second, more complex chips are faster than smaller ones because they can hold more transistors. (The Intel P6, for example, contains 5.5 million transistors and is much larger than the Intel 4004 which had a mere 2,300 transistors.) Today, the biggest silicon wafers come in sizes of 200 millimeters, but 300mm wafers are expected to be in production by the turn of the century, and development of even larger wafers is under way. That chips are likely to be silicon-based forever is because of the massive installed base of equipment and expertise, and because of the ability to grow large silicon crystals—such big crystals cannot be grown in other materials.
- Next comes lithography, which is the imaging technique that precisely patterns each circuit element. Precision optics are used to focus a light wavelength onto the wafer which is coated with light-sensitive photoresist chemicals. While the light wavelength is currently 350 nanometers (one-two-hundredth the width of a human hair), experts believe that getting to a much shorter wavelength of 193 nanometers is eventually possible. Then a physical limit is likely reached, but before that point it should be possible to put several hundred million or a billion transistors on a chip.
- The wafer is then "developed" (the exposed photoresist is removed) and baked to harden the remaining photoresist pattern.
- Etching comes next in the production process. The wafer is exposed to a chemical solution (or gas plasma) so that areas not covered by the hardened photoresist are etched away.
- Atoms with one less electron than silicon (such as boron), or one more electron than silicon (such as phosphorous), are then introduced into the area exposed by the etch process to alter the electrical character of the silicon.
- The above steps are repeated several times until the individual active devices of the circuit have been formed. Then these devices are interconnected using a series of metal depositions and patterning steps of insulators ("dielectric films"). Current semiconductor fabrication includes as many as three metal layers separated by dielectric layers.
- Finally, individual chips are separated from the wafer, packaged and tested to ensure that they function properly.

So, by various technical advances, such as improving the optical lenses, shortening the wavelengths of light and improving the photoresist materials, smaller lines can be etched on the silicon which means more transistors can be squeezed onto a chip and more chips made on a wafer. If the engineers keep Moore's Law going for another 50 years, then by 2047—exactly one century after the invention of the transistor—computer chips will be 10 billion times more powerful than they are today.

The PC: The central, multipurpose consumer device

While the Information Age PC will offer much more power and functionality (e.g., speech and handwriting recognition), its physical shape and size will likely not change much from that of today's laptop.

The *shape* of the PC is unlikely to change because there will continue to be a need for:

- A screen (although screens will become much thinner thanks to LCD—Liquid Crystal Display—technology).
- A keyboard and mouse (voice and handwriting recognition *will supplement but not replace* the mouse and keyboard, as we discuss below).
- A central processing and storage unit (which, thanks to wireless technology, will not be physically attached to the screen or keyboard. Further, as discussed below, while network-centric computing will be commonplace, *it will not be predominant*, so there will be huge demand for local storage and local processing capabilities).

As for the *size* of the PC in the Information Age, it will be lighter and slimmer *but no smaller* than today's stan-

dard laptop, because there are limits as to how small a keyboard and a screen can be made before they become too challenging for the hand and the eye.

In terms of how we *interact* with the PC, while many things have changed since IBM's first model in 1981, the one notable exception is that the majority of our computer interaction still takes place through the keyboard. The idea of "an alternate user interface" holds tremendous appeal, and two technologies will make the keyboard at least optional within a few years: voice recognition and handwriting recognition. Given the enormous computing power that is required, both of these technologies only exist in a restricted format today. For example, "continuous speech" in which you talk at normal speed requires much more computing power than is found in today's typical desktop PC but that power will exist in abundance in the very near future.

Voice and handwriting recognition will supplement *but not replace* the mouse and keyboard for several reasons:

- Apart from the most basic commands ("File—Open—C:\Work\Report.doc") it is hard to imagine a situation where, for example, it will be more efficient to dictate a report to your PC, rather than typing it in and editing and revising as you go.
- A society where many people are "talking" to electronic devices would not only be noisy but also confusing. (Imagine shouting to your spouse that you are "ON the phone" and simultaneously turning ON the PC, the TV and the burglar alarm).
- As for handwriting recognition, most people still type faster (and, obviously, more legibly) than they write.

That is not to say that voice and handwriting recognition will not have important functions in the Information Age, but their importance should not be overstated. Some likely applications for voice and handwriting recognition include:

- When on a business trip, an executive dictates a letter onto a digital dictation recorder. Back at the office, she downloads the digitized voice data into a PC and puts some finishing touches on the letter before printing it out.
- During an examination of a patient, a doctor (or a dentist) updates the patients record by dictation. Such a report is more accurate than a report written later from memory.
- An American journalist reporting on an event in Paris, dictates a report in English and has a French language document produced instantaneously.

Another key feature of the PC in the Information Age is that it will be *ubiquitous*. In much the same way as it is taken for granted that you can find a telephone in any home, office, hotel or airport, so too will the PC be omnipresent. (And remember, just because phones are ubiquitous does not stop people carrying one with them at all times and having several more at home.) This will enable you to log-in anywhere to your personal computing environment. Microsoft's Bill Gates describes this environment as follows: ". . . anywhere you go, if you find a screen you can just log-in and your personal environment will be there. You won't necessarily always have to take hardware with you because the network will retain the things that you care about. Computing will be ubiquitous." (And note that if you do decide to take hardware with you, vastly improved battery technology plus low-power displays, CPUs and other components will mean that most PCs will be without an AC cord tether.)

Just like Mr. Gates, however, we do not subscribe to the idea of the NC—or network computer—which would allow users to get on the Internet and download "applets" of information on an as needed basis from a central server and not require the resources of a full configured PC. Supporters of the NC, notably Oracle Systems and Sun Microsystems, claim that for a relatively low price, a stripped-down NC could be built because: 1) They would not need local disks as they could access data and programs stored on a network; and 2) They would use less powerful processors and less memory than stand-alone computers, as compute intensive code portions would execute in powerful network servers. Given that the evolution of PCs to date has consistently been in the direction of *more* powerful devices with *more* memory and *increased* local storage, a move toward widespread adoption of network appliances would represent a sharp change in direction.

Skeptics also point out that IBM has, in the past, attempted a move to a NC, first by trying to extend the life of "dumb terminals" and then suggesting diskless PCs as the best device to attach to networks. *Both efforts failed.* And history shows that both business and consumers have consistently voted with their pocketbooks for products that offer more functionality—that's why the PC and Mac displaced cheaper Tandy, Commodore, and Apple II machines.

Other obvious deficiencies of a NC include:

- No storage means complete dependency on connection to a network—if the server goes down, the entire network goes dark.

- Lack of a monitor means having to use a large screen TV to display text, do spreadsheets, etc.
- There are costs involved in connecting to and accessing programs and data on networks: telephone connection charges, monthly Internet provider fees, and transaction or access fees for using software, processing and storing data on Internet servers.
- Network appliances on a corporate network will cause increased network traffic and server workload. To overcome this, substantial costs will have to be incurred expanding bandwidth and adding additional or faster servers (which is, of course, what Oracle and Sun want).
- The power of these devices is deliberately limited in order to force a return to "time sharing" of expensive mainframes.

Notwithstanding these issues, NCs will gain some acceptance in the business market, as they appeal to elements of the business community on the basis of a lower total cost of ownership proposition relative to PCs (e.g., to replace the dumb terminals used by airline staff for inputting reservations data). Thus, the "Wintel" community, which initially dismissed these devices fairly quickly, is now talking of introducing lower-cost computing devices and has begun to focus in on this cost of ownership problem. But while network-centric computing will be commonplace, *it will not be predominant.*

So what will the powerful and ubiquitous PCs of the Information Age be used for? The PC will be used *primarily but not exclusively* for "work," i.e., to *actively* get information (get a video clip about a vacation destination, work on the plans for your home renovation with your architect) rather than to *passively* receive information (watch a movie, gossip with your mother in Toledo). But one important area where the PC will continue to passively receive information is e-mail—the low cost and efficiency of e-mail (no lost letters or incorrect addresses, given that users addresses follow them wherever they go) will lead to an explosion in its use.

The TV and the PC: Converge but not merge

While the PC will be used primarily for "work," the TV will be used *primarily but not exclusively* for entertainment. Importantly, although they will move closer together, the PC and TV will not merge for two key reasons.

First, in the minds of consumers, the PC will remain the primary device for "work" while the TV will remain the primary device for randomly receiving entertainment and information. *The key difference between the PC and TV is that that the PC is truly interactive with users in control, calling up only the information they want.* After a hard day's work, consumers in search of entertainment will not flop in front of the PC in the home office, nor will they sit in front of the TV in the family room to review their finances.

Second, the small screen of a PC is not conducive to watching a movie, while the large screen of a TV is not conducive to running a spreadsheet. However, the TV and the PC will move much closer together in several ways. First, every TV will come equipped with a built-in Web browser. Accessing the Net via a TV is already feasible thanks to WebTV (the company acquired by **Microsoft**) and its proprietary technology that enables users to access the Internet through their living room TV sets. WebTV "set-top box" adapters sell for about $350, and users can send and receive e-mail and surf the World Wide Web.

Second, many Web sites will transmit television over the Internet, as presently evidenced by both MSNBC and CNNfn, which are using both real audio and video streamers to provide a television like experience over the Internet today. As increased computing capacity materializes, it will only be a matter of time until the current jerky images look like full motion video.

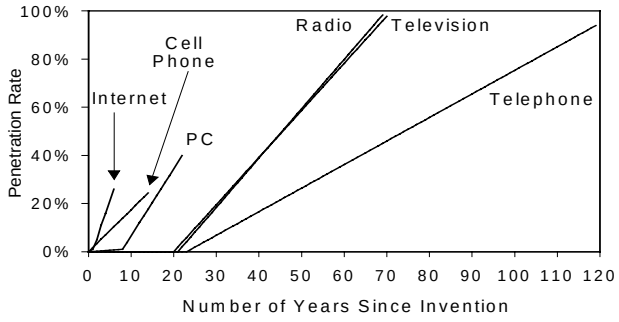
But just as is the case that most Americans receive 30+ TV channels but often cannot find anything worthwhile to watch, when it comes to television over the Internet, *content will be critical* in ensuring success. This further reinforces the notion, discussed below, that the most valuable Web sites will be owned by companies that already have valuable real world franchises.

The Internet: A key medium

As any Web surfer is very well aware, much of the stuff out there today is mindless or useless. But how could anything more be expected from a medium still in its infancy? After all it was many years before television produced anything worth watching. (Many readers are probably too young to remember the TV game shows and wrestling matches of the 1950s.) But while TV took 35 years to reach 30% of households, the Web, by most estimates, will hit that critical mark by the year 2002, only eight years after its popular debut (Chart 6).

Chart 6

Years to reach various household penetration rates
of key new technologies



In the case of radio and TV, 30% of households appeared to be the magic number for justifying big spending by advertisers. As ad revenue surged, producers could pay for the best creative talent which in turn attracted larger audiences which led to higher ad rates. Today's new medium should be no different.

When the Internet does evolve into a truly viable medium, it will be home to three distinct business models chasing three distinct revenue sources:

—Information (subscription revenues).

—Entertainment (advertising and subscription revenues).

—Commerce (sales revenues).

But while for many companies revenue gains from the Internet have been slow to materialize, *the most immediate benefit of the Net to corporate America is the significant cost savings it offers.*

The most valuable Web sites will be owned by the companies that already have strong brands, e.g., entertainment companies with large film and music libraries, newspaper companies with respected publications and retailers with a reputation for quality merchandise. One exception to this is "portal sites," the best example of which is **America Online** (discussed below), which has a valuable franchise because it is the port by which many users enter the Web.

Portal sites aside, the risks are very high for many of today's so-called "Internet plays." Although the Internet is growing phenomenally right now, not all companies touted as "Internet plays" are good investments. This is because the first firms into a market are not necessarily best positioned; they may represent "interim" technology, committed to an approach that turns out to be a dead end. This often happens in infant industries. After all, one could have correctly concluded in 1903 that the automobile was "the next big thing" and still lost a bundle by backing companies that made steam-powered or electric-powered vehicles.

Further, with technology changing rapidly and big companies muscling into the Internet market, many small specialized companies will see their markets disappear or will be undercut on price by bigger competitors—Netscape's main competitor, **Microsoft**, is distributing both its Web browser and Web server for free.

Unquestionably, some young Internet companies will turn out to be terrific investments, but we would prefer to focus on those companies that already have a valuable franchise, and which can use the Internet to further leverage this franchise. As noted above, the three areas that will offer the best Internet opportunities are information, entertainment and commerce.

Internet Information

The Web is a wonderful way to distribute information. It is cheaper to distribute bits than paper, the data can be constantly updated, and well-designed hypertexts are easier to navigate than big, bulky books. Bits are already replacing books in the realm of business to business communications such as technical manuals and extensive price lists/catalogues for such product lines as specialty chemicals and auto parts. Farmers are using the Internet to get the latest commodity prices, to check on how much of a grain contract has been filled, etc. A farmer who tracks the prices of the grains he feeds his cows says, "To get this information before, we had to make telephone calls—lots of them. On the Net, it's easy to find, and we can check it whenever we want." The key beneficiaries of this trend are, obviously, the companies that can charge for the information (e.g., via subscriptions), *as well as the companies that build the infrastructure that transmits the information.*

Table 1

Key beneficiaries of converging technologies in the Information Age

America Online

The company has the premier brand name in interactive online services. It is effectively leveraging this position to develop the high margin, high growth areas of the Internet, i.e., advertising and electronic commerce.

Applied Materials

A leading "Moore's Law" beneficiary. It is the principal independent supplier of wafer fabrication systems to the worldwide semiconductor industry.

Cisco Systems

A leading supplier of networking equipment to the three key networking markets: the service providers (who are constructing the backbone of the Internet), corporations (Intranets, Extranets), the home/consumer.

Cognos

A developer of retrieval and analysis tools that make it easy for businesses to access and analyze data. As the amount of raw data increases, businesses will be challenged to understand and use information constructively.

Compaq

A leading PC maker which is a key beneficiary of the emergence of the PC as the central, multipurpose consumer device. Heavy corporate spending on the Internet and Intranets is very positive for its server business.

CUC International

The nearly 68 million member shopping club claims over 500,000 online members for its Net Market Internet site. Its merger with HFS means that CUC now has well-known brand names to offer on Net Market.

Disney

One of the smart companies at the forefront of the convergence of the computer, communications, consumer applications and content. Smart moves: acquiring ABC; establishing Web sites for many of its branded products.

EMC Corp.

It benefits from strong demand for disk storage because it buys disk drives and packages them with specialized software to create a storage subsystem for managing data in large corporations.

Fore Systems

Its products, ATM switches, are well suited for carrying voice, video and data and are popular devices among companies constructing the backbone of the Internet.

Gannett

The company controls a vast array of news and information content both in text and visual form from its newspapers and local television stations. It is already leveraging the *USA Today* brand successfully on the Web.

Hewlett-Packard

Its dominance of the printer market gives the company an important franchise. And its acquisition of Verifone bolsters H-Ps efforts to gain market share in the fast growing Internet commerce and smart-card markets.

Intel

The supplier of one of the principal engines of the Information Age—the X86 microprocessor architecture. It is a key player in the convergence of the PC and the TV—its video/graphics advances are enhancing the utility of the PC as a visual entertainment device. INTC is also closely involved in efforts to increase bandwidth to the home.

KLA-Tencor

The company has a dominant position in an essential corner of the semiconductor chip-making industry: chip measurement and inspection systems that enable semiconductor manufacturers to improve yields.

Microsoft

Given its dominant position across the entire Information Age spectrum, it is perhaps the leading beneficiary of the convergence of the computer, communications, consumer applications and content.

New York Times

Owner of two of the major brand names in the newspaper business: *The New York Times* and *Boston Globe*. It has already had success in creating dynamic Web sites for these and several other of its newspaper properties.

Northern Telecom

The only large company with broad exposure to data networking, telecommunications and wireless.

Open Market

A software company whose products facilitate commerce on the Internet.

Oracle

A key beneficiary of strong demand for data management products. The amount of data that major corporations store doubles about every 3-4 years, and this will only accelerate as businesses capture more customer data.

Quantum

As one of the largest providers of disk drives to PC related companies, it will continue to be a leading beneficiary of strong demand for huge desktop storage capacity.

Seagate Technology

It has the largest market share in the high end (servers, workstations) of the storage market. Given the growth in Web based activities, server growth is likely to continue to exceed PC growth.

Staples

As the Information Age advances, many more people will be teleworking and working out of the home, which will spur even greater demand for home office products ranging from paper clips to filing cabinets.

Sun Microsystems

Arguably one of the top suppliers of servers within the Internet and Intranet markets. Server growth is likely to continue to exceed PC growth given rapid expansion of the Internet and Intranets.

Teradyne

A leading supplier of automatic test equipment to the electronics industry. As device speeds increase, even faster test equipment is required.

Time Warner

One of the smart companies at the forefront of the convergence of the computer, communications, consumer applications and content. Smart moves: acquiring TBS; establishing Web sites for many of its branded products.

3COM Corp

A leading global data networking company. Following its merger with US Robotics—a leading modem and remote access vendor—the company also has the dominant position at the "edge" of the network.

Western Digital

As one of the largest providers of disk drives to PC related companies, it is highly focused on supplying low-cost, high quality disk drives to the top PC vendors.

WorldCom

Through its UUNet subsidiary, the company is the largest Internet access provider. It is a key beneficiary of the emergence of the Internet as a new medium and the associated demand for high-bandwidth data transfers.

There continues to be explosive growth in spending on Internet, Intranet and Extranet hardware, software and devices. (Intranets are internal corporate networks that use Web-related technologies and formats. Extranets are customers/suppliers linked to corporations.) At the very least, Intranets can be used to distribute internal information such as phone numbers, manuals, etc. Extranets are being used to distribute information to large groups of people that are widely dispersed: Federal Express' system lets customers track their own packages, and most financial firms—from banks to brokerages—will soon permit their customers to view their accounts on Extranets.

Heavy spending on the Internet and on Intranets and Extranets is bullish for selected companies that supply three different types of networking equipment.

First is the equipment used in the construction of the backbone of the Internet. This construction is being carried out by local and long distance carriers, international telephone companies, various Internet Service Providers (ISPs) and several specialized telecom carriers. Collectively, this group is referred to as "service providers." Second is the equipment used in the corporate world to build Local Area Network (LAN) and Wide Area Network (WAN) infrastructures which form the basis of Intranets and Extranets. Third is equipment that is used to access the Internet, Intranets and Extranets, and that is purchased by corporations or the home/consumer. This equipment is generally routers or modems.

Beneficiaries of this equipment spending include:

- **Cisco**: dominates the market for enterprise inter networking software. This software links together LANs to create WANs.
- **Compaq**: the company has built a commanding market position within the server sector of the PC market.
- **Fore Systems**: its products—ATM (asynchronous transfer mode) switches—are well suited for carrying voice, video and data and are popular devices among companies constructing the backbone of the Internet.
- **Microsoft**: in a relatively short period of time, the company has completely re-engineered its entire operation around the Internet and turned a major competitive threat into a substantial growth catalyst.
- **Sun Microsystems**: arguably one of the top suppliers of servers within the Internet and Intranet markets
- **3Com Corp**: has gradually become a supplier of complete networking systems.

Turning to the companies which should be able to charge for Internet information, one well-positioned group is the newspapers. Traditionally, savvy investors have liked newspapers because they are local monopolies. Importantly, bear in mind that the "monopoly" status of many newspapers extends beyond coverage of the latest city hall scandal or recent crime wave. For example:

- *The Wall Street Journal's* "local monopoly" is Wall Street and the financial markets.
- *The Washington Post's* "local monopoly" is the affairs of the nation's capitol.
- *The New York Times'* "local monopoly" is world affairs, given its unparalleled coverage of events outside the U.S.

Theoretically, the World Wide Web threatens these monopolies, because a Web page can inexpensively provide an abundance of information, updated daily. But there is no reason to believe that newspapers will, in fact, lose market share for these reasons:

- Newspapers are aggressively developing on-line offerings; there are already 1,218 on-line newspapers on the World Wide Web. And while subscriber-based sites are still in their infancy, several on-line newspapers already have paying subscribers—*The Wall Street Journal* has over 100,000 paying subscribers; the *San Jose Mercury News* has over 15,000 subscribers; and ***The New York Times*** has a large number of paying international subscribers.
- People buy or subscribe to local newspapers to get the local news, and for that you need local reporters. You cannot create a news product for Des Moines from corporate headquarters in Silicon Valley or Seattle.
- Many people read newspapers on their way to work, and it is hard to imagine a train-full of commuters scanning the sports page on a laptop.

But not only should newspapers, in general, not lose market share to Internet rivals, well-positioned newspapers should actually *gain new readers* (who prefer an electronic newspaper to a paper version) and *increase revenues from existing customers* (as some readers subscribe to both the text and electronic version). For example, a money manager in London is highly likely to subscribe to the online version of *The Wall Street Journal* so that he can peruse *Heard on the Street* before his colleagues in New York wake up. Similarly, a resident Manhattanite who is frequently out of town is likely, in

the near future, to subscribe to both the text and online edition of ***The New York Times*** so that, when he is on the road, he can browse the newspaper on the Web and check just how poorly The New York Mets are doing.

Selected newspapers will be key beneficiaries of the Information Age because they can charge for proprietary information that is in popular demand. By contrast, companies that sell information that is rapidly being commoditized will be losers in the Information Age.

One big casualty here will be companies that publish phone books, both white and yellow pages. In addition to being expensive to print and deliver, phone books are partly out of date in a couple of months. But their biggest flaw is that they are regionally restricted—of no value if you are making a long distance call or, in the case of the yellow pages, purchasing a specialized item and, therefore, want to canvass a larger area than is served by one book. For example, if I live in Atlanta and want to buy scuba diving gear, I would want to see the listings for southern Florida.

Another casualty of the Information Age will be some providers of financial data, particularly suppliers of data that becomes commoditized. To appreciate why, consider the following:

- Primark's Disclosure unit, a major financial document and database business, has been adversely affected by tough competition from Edgar, the SEC's free Web-based Electronic Data Gathering, Analysis, and Retrieval system. In other words, faced with the choice of paying for a paper document to be sent to them or retrieving that same document immediately over the Web for free, individuals have, not surprisingly, chosen the latter option.
- When a leading financial information vendor bid for a contract to provide market data to a major Wall Street firm, it found itself facing unfamiliar competition: a pitch from NYQuotes, a company which started up less than a year ago and has only 11 people on staff. The NYQuotes proposal significantly undercut that of the larger company.

Companies such as NYQuotes can offer such low prices because, instead of delivering financial information via dedicated cabling and terminals, they use the Internet, to which the employees of most international investment firms are now connected. *The Internet has tremendously reduced the cost of entry for potential rivals to existing financial data companies.* And not only has the cost of entrance been reduced, but the proprietary systems that many financial information vendors have developed at vast expense are rapidly becoming redundant as their clients shift to "open systems" which collect data from several providers.

Internet Entertainment

Three companies discussed below are good plays on the rapid growth in Internet entertainment.

America Online is the number one on-line service with about 8.5m subscribers. Its users spend an average of 80% of their time in AOL's proprietary areas, and 20% of the time out on the Web. Within AOL's proprietary areas, the bulk of user time is spent with e-mail, chat and other communication services; about 35% of time is devoted to AOL's information and entertainment offerings.

AOL's goal is to become the "mega-leader" of interactive services. The company already has the strongest brand name of any online service, as well as the largest marketshare. (AOL is such a major player for home Internet access that 38% of all household Web traffic passes through it.) Ultimately, it plans to become as integral a piece of everyday life as cable television. Indeed, AOL households already watch 15% less television than non-AOL households, or about 7 less hours of TV per week. AOL's prime usage hours are approximately 8 PM to midnight, directly competing with prime TV hours.

AOL derives its revenues from three sources:

- Subscriptions. The number of AOL subscribers is growing at a 25% annual rate. In excess of 80% of subscribers use the flat $19.95 monthly pricing plan.
- Advertising. Being #1 in market share, AOL is also a leader for advertiser's media buys in interactive services—AOL has attracted 352 total advertisers in 1997 to date. With its broad subscriber base, it can offer advertisers flexible programming packages to target broad, as well as narrow, user audiences. And given its large content base, including email as well as chat rooms, AOL effectively has unlimited advertising space in which it can place visible ads. In other words, unlike television, which has a fixed amount of inventory, AOL can add additional shelf space. This allows the company tremendous pricing flexibility with which to offer advertisers.
- Electronic commerce. Increasingly, the lines between advertising and electronic commerce are converging and blurring. (If you see it and want it, click and buy it). Because of its high volume of traffic, AOL owns the "Park Avenue" real estate of

the interactive services world which it can use to leverage its opportunities for advertising and commerce. AOL's large user base, reliability, security and brand name are all key pieces that allow it to exploit this opportunity as a distribution channel. The company's strategy is to derive transactional fees as a partner in distribution—some recent key, visible partners include CUC and Barnes & Noble.

Another company at the forefront of Internet Entertainment is **Disney.** The company has recognized that its core audience of 6-10 year olds today will be the main users of the Internet in 2015, and so is developing a variety of beachheads to ride the curve as those techno-savants grow up. Disney has five major Internet sites—brand extensions for everything from Walt Disney World to ESPN—the majority of which are currently free to users.

- ***Disney's Daily Blast***, the company's fledgling Internet service for children 12 and under, is a collection of interactive games, comics, news and sports that offers kids a fresh dose of entertainment every day. New services to be unveiled later this year include "D-Mail," which allows users to send electronic mail that has dynamic visual and audio components incorporating Disney characters. Another feature called "collaborative theater" allows kids in different locations to meet in a 3-D environment in role-playing games, taking on the personae of such Disney characters as Aladdin. Disney, of course, is the only company with access to its ever-growing roster of animated characters, from Mickey Mouse to Hercules.

  Access to the site costs $4.95 per month. Disney is banking on a combination of on-line innovation and a powerful brand to extract this price. The developing scenario is in many ways similar to Disney's experience in cable television during the early 1980s, when the company launched the Disney Channel as a premium service that charged beyond the cost of basic cable.

- ***Disney.com*** is the company's free corporate Web site. The site attracts more than 300,000 visitors a day. Its entertainment features are part of a much bigger package that includes sales of theme-park tickets, movie ads and Disney Securities and Exchange Commission documents.

- ***Family.com*** which is part of Disney.com, offers a barrage of parenting information, with tips on everything from "the right way to give time outs" to "cultivating ambition in your child." Much of Family.com is free, but some elements require a subscription that includes Daily Blast. Using search functions, for example, a parent can find advice on sleep disorders for eight-year-olds; generate a list of arts-and-crafts activities in the community this weekend; or find chicken dishes that can be prepared in 15 minutes or less.

- The ***ESPN Sports Zone*** site, based on Disney's ESPN cable network, has for some time been one of the most successful outposts in cyberspace.

- ***ABCNEWS.com*** is based on Disney's ABC News division.

Time Warner's Pathfinder Web site is consistently near the top of all Web sites with regard to the large audience it attracts. Pathfinder offers all of TimeWarner's intellectual properties, such as *Fortune*, *Time*, *People* and *Sports Illustrated*, for a total of over 90 different offerings all available on the Web.

Pathfinder has taken Time Warner's content and layered on top some level of interactivity. For example, *Money* magazine's annual feature on the best places to live, rather than being a static list, has been personalized to allow users to specify what characteristics are most important to them. A personalized best places to live list is then compiled and delivered to users based upon the criteria that is relevant to them.

Pathfinder generates the bulk of its revenues from advertising, although it recently added a subscription mode to its revenue repertoire. The subscription model, dubbed Personal Edition, generates user-specific content and allows customized news service delivery.

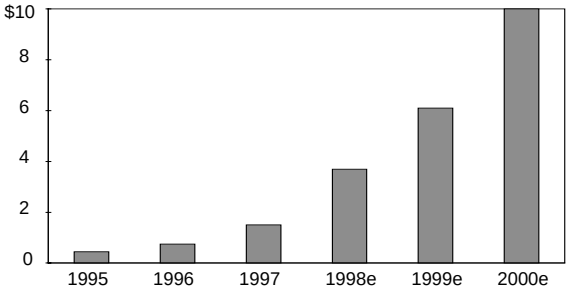
Internet Commerce

Current electronic retailing implementations are a desolate and static environment, devoid of the interactivity between merchants and consumer required to attract and retain a mass consumer audience and fully differentiate it from other static media such as paper catalogs. This interactivity is required to facilitate the shopping experience, maintain customer interest and create greater customer personalization, adding value beyond that of the physical shopping environment. Additionally, convenience, as well as an easy to use shopping interface, are also required to continually attract the mass consumer base.

It is estimated that eventually the Web will take a 10-15% share of traditional, store-based retailing plus most of the catalog market (Chart 7). And while consumer online revenues will grow rapidly, *the big money in Internet commerce will come from business-to-business sales over the Net.* This mirrors the physical world where business transactions are worth ten times as much as consumer sales.

Chart 7

Revenues from consumer commerce on the Internet
(*in billions)*

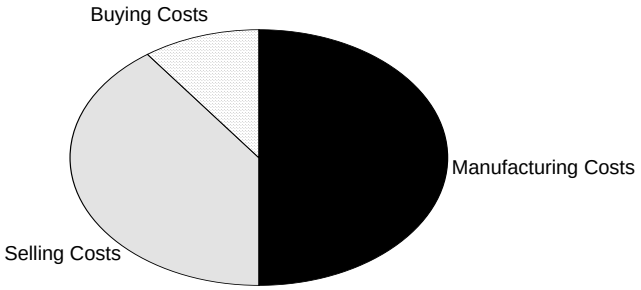


What the Web brings to retailing is speed, convenience and, significantly, *low cost*: no brick, mortar and real estate taxes; no bored salesmen leaning on counters; no "shrinkage" through shoplifting; and fewer glossy catalogues that go straight from the mail box to the trash can. And because customers are inputting orders into the retailer's computer system, they can be processed very efficiently.

So, *the most immediate benefit of Internet commerce is significant cost savings*. It is estimated that U.S. corporations currently spend approximately $250 billion, or close to 5% of total GDP, simply on the overhead associated with the processing of paper documents related to commerce such as purchase orders, invoices and statements. A large percentage of total product costs is related simply to the associated buying (searching for and selecting raw materials) and selling (marketing) costs, rather than the manufacture itself (Chart 8). In some cases these costs can account for nearly half the products' total cost. And it is estimated that physical money transfers in the U.S. cost nearly $60 billion per year, an expense that could be significantly reduced in an electronic environment.

Chart 8

Breakdown of a typical product's total cost
(*for buying raw materials, manufacturing, marketing)*



As for *revenues*, the largest near-term opportunities for electronic commerce implementations will come from several key areas:

- The first major area concerns the *management of data* (such as customer records and accounting information) as electronic commerce will serve to drive the expansion of digital information. Here the major players will be the traditional relational database vendors such as **Oracle** and **Microsoft**.
- Electronic commerce will also serve to drive the *data warehousing* market by targeting consumers with a tighter focus through harnessing the accumulated wealth of customer data. Data warehousing companies include not only the aforementioned relational database vendors, but also new entrants that focus on this specialty such as **Cognos**.
- *Merchant Servers* are required to manage the volume transactions generate by electronic commerce. The merchant server market, in the near term, could potentially become one of the more profitable Internet software market segments. The merchant server market consists of larger vendors such as **Oracle** and **Microsoft,** as well as smaller companies, such as **Open Market**, that are focused on this piece of electronic commerce.
- *Security* will be required to protect sensitive information and transactions.
- Online *payment systems* will be required to complete and settle transactions with both credit cards as well as emerging technologies such as digital cash. **Hewlett-Packard's** Verifone unit is a leading player in this market.

As noted, database companies will be key beneficiaries from rapid growth in electronic commerce, and they should also benefit from two other Information Age trends:

- Corporations not engaged in electronic commerce will still gather vast amounts of data about their customers which will only be useful if it can be organized and exploited. ("Mass customization" refers to the process of mining data in data warehouses and transaction databases so as to provide large numbers of potential customers with targeted marketing and sales information.)
- Companies will share vast amounts of data between themselves about inventories, pricing, etc. Some aspects of industry are already becoming data integrated, e.g., Wal-Mart does not manage its own supply chain but relies on real time cash registers connected to its suppliers.

Three companies that already derive significant revenues from Internet commerce are Cisco (which generates about $2 billion annually from the Web) and Dell Computer and Gateway 2000 (both of which get about $2 million a day in Net revenues). Table 2 lists five retailers which currently derive a significant portion of revenues from catalog sales and which, therefore, are prime candidates to benefit from an expansion in Net commerce.

Table 2
Five leading catalog retailers

Retailer	Main Product	1996 Catalog Revs
J.C. Penney	Clothes & housewares	$3.77bn.
Spiegel	Clothes & housewares	1.78
Fingerhut	Gifts	1.64
Lands' End	Clothes	1.12
L.L. Bean	Clothes	0.91

Another key Internet commerce beneficiary is **CUC International**. The nearly 68 million member shopping club that sells by catalog and telephone claims over 500,000 online members for its Net Market Internet site, the company's central on-line market place at which one can buy everything from a book to a Buick. CUC estimates that its online customers are more than twice as profitable as its other memberships, due to the lower member acquisition costs, operating costs and better renewal rates associated with them.

The company's merger with HFS Inc. means that CUC will now have well-known brand names (Avis, Days Inn, Ramada, Century 21, Coldwell Banker) to offer on Net Market. And it recently announced the acquisition of Hebdo-Mag International, an international publisher of classified advertising periodicals.

CUC believes that that classifieds are a critical ingredient for building high frequency utilization of Net Market, because print classifieds are inferior to the interactive version in almost every way. Internet classifieds are real time (no ads for cars that were already sold), they are searchable, they can include far more data including pictures or even video, they can provide a direct immediate link between the seller and prospective buyer, and each ad costs next to nothing to produce. The seller inputs the data and there are no printing costs. These can all be huge positives for Hebdo's business as it migrates to the Net.

With the Internet the next book retail battleground, **Barnes & Noble** is well positioned for the fight. While Amazon.com established an early lead in the online book business, Barnesandnoble.com should quickly rival Amazon for the leadership role, given:

- ***Brand power***. Amazon may have a first user advantage with existing Web surfers, but that isn't true of the million new users signing on to the Web each month. BKS is by far the brand leader of book retailing for consumers both on and off line.
- ***Price***. By buying billions of dollars of books directly from publishers, BKS has a sizable cost advantage, as Amazon buys only millions of dollars of books mainly from wholesalers.
- ***Marketing clout***. BKS can, at little incremental cost, promote its site in its 1,013 stores, on millions of shopping bags, and as part of the $20 million it already spends on advertising.
- ***Access to capital***. BKS views the online book battle as a 'must win' situation. The company can devote enormous resources to win if necessary.
- ***Upstream leverage***. With an approximate 15% share of the book industry, BKS can leverage its clout with publishers to get more frequent and greater access to authors for online promotions.

But while it will face increased competition, Amazon will not disappear. The company has strong focused management, a popular site, a first entrant advantage and online customer knowledge.

Access bandwidth: Information Age bottleneck

One key issue slowing the advance of the Information Age has been the fact that bandwidth to the home (also known as access bandwidth) has not been developing as quickly as PC chip technology. While large institutions and government agencies maintain their own networks, consumers at home access the Internet by dialing into a local or long-distance telephone company, or to a company such as America Online. But compared with the power of most PCs, today's typical modem access is frustratingly slow. Indeed, for remote connectivity, most people at home still dial up using the same old modem technology over telephone network equipment that has been around for decades.

Today, the most widespread and affordable connection to the Web is a 33.6kbps modem. At this connection rate, however, downloading content rich, multimedia Web pages can prove tedious at best. While each successive improvement in modem speed feels fast enough for a while, it is not long before the content being viewed and downloaded becomes larger and more complex, making the "fast" modems feel slow again.

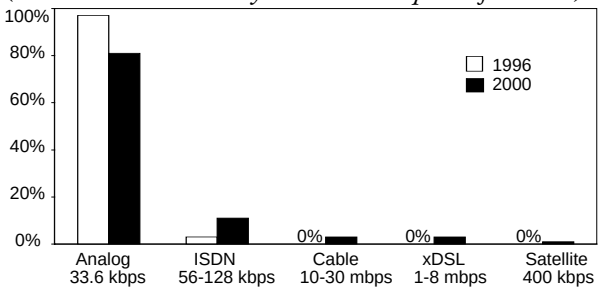
In order to truly move to an Information Age, consumers at home must have significantly higher connection speeds made available to them. New technologies

promise to make drastic increases in bandwidth capacity in the next few years, but it is likely to be a slow and frustrating process, especially since just when bandwidth catches up with content the content invariably becomes more complex (Chart 9).

Chart 9

Access technology

(*home Internet access by method and speed of method)*



Who will provide homes with high-speed access to the Internet? Will it be the phone company, the cable company, the satellite or wireless service provider or some dark-horse company such as the electric company? In the near future, the RBOCs will likely increase the bandwidth of their copper wire into the home. And ultimately, many companies will offer Internet access. But the access bandwidth issue will likely remain the major Information Age bottleneck.

Rather than speculating about the companies that will eventually provide high-speed Internet access to the home, investors will do better to focus on the companies that are supplying the bricks and mortar for the construction of the information highway. These companies include several previously mentioned (**Cisco, Compaq, Fore Systems, Microsoft, Sun Microsystems, 3Com**) as well as Lucent Technologies (the leading supplier of network infrastructure in North America) and **Northern Telecom** (the second largest supplier).

Focusing on the builders of the infrastructure rather than the eventual suppliers of the service makes sense given the myriad of issues hanging over some of the likely Internet access providers.

RBOCs

The value of the copper wire into the home can not be overlooked. But the problem for the RBOCs is that they have a narrow bandwidth "twisted pair" copper wire as well as network architecture designed for voice not video.

However, the RBOCs may be lethargic but they do have very solid franchises, plenty of capital, good technology and a strong desire to develop—rather than lose—their core franchise. So, ways will be found to make the copper into the home more useful. For example, by putting chipsets (costing no more than $300-500 to deploy) at each end of the copper wire, the current bandwidth capacity of the twisted pair can be increased by about 60 times. But there is a physical limitation as to how much bandwidth can ultimately be squeezed out of a twisted pair copper wire.

Long distance companies

The long distance companies are currently engaged in an intense battle for market share and are not particularly focused on the issue of increasing bandwidth to the home.

Cable companies

The cable TV industry has broadband wires into 60% of homes, which enables it to offer Internet access via cable modems. Cable modems operate over the same cable TV infrastructure, and as such, are already wired to 65 million households. These modems, unlike telco-based systems, do not need to be dialed for a connection—like television, the service is always "on" and available at all times. And cable modems can deliver 10 megabits of data per second, several orders of magnitude above that of a standard modem, while also allowing standard cable TV to simultaneously be delivered across the same line.

But for the cable companies, there are three particular problems associated with cable modems. First, the cable network needs to be upgraded in order to be able to offer Internet access. This will be an expensive undertaking. (One short-term solution, however, is to use the existing cable infrastructure to download data and use telephone lines to upload signals to the network.) Second, as more cable modem users are added to the neighborhood line, all these users will share the same bandwidth. In other words, the online habits of your neighbors will determine your actual throughput. Third, there have been concerns that the supply of modems will not be sufficient to meet demand, given reluctance by several hardware manufacturers to commit production lines to a singular design. Mitigating much of this concern, however, was the agreement reached by the Cable Television Laboratories, Inc. (an industry research consortium comprised of cable operators) on a set of design standards.

Satellites

Unlike cable modems, satellite modems do not require a physical connection to be wired to the point of access, providing availability to remote users (assuming a clear line of sight to the satellite). Satellite modems are currently being delivered by Hughes (the provider of the DirecTV satellite system) under the name DirecPC.

But DirecPC only delivers 400 kbps of bandwidth (significantly less than cable modems), uses a different satellite dish than DirecTV and costs approximately $1,000 to set up. (A new product, DirecDuo, allows customers to use the same dish for both services, i.e., television and modem.) In addition, DirecPC has additional monthly service charges as well as per megabyte data delivery charges. And another drawback of satellite is that you also need a modem and a phone line for outbound data, since satellites are broadcast-only.

Wireless

In the long run, wireless connectivity will be the norm, but right now there are still a lot of problems with wireless, particularly the cost of building a nationwide service. Fixed wireless providers and cellular companies both plan on attacking this market, but the broad market will not likely be tapped for several years.

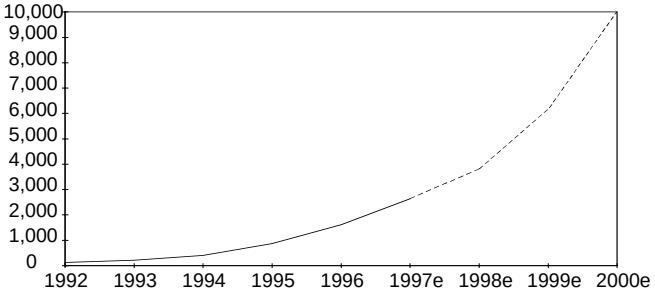
Storage

While there are many issues that are unclear about the future of bandwidth, when it comes to the area of storage two things are very clear. First, there will be huge demand for vast amounts of data storage. Second, the primary storage method will, in all likelihood, still be magnetic.

Since the first computers appeared, the story of storage has been one of steady growth in capacity with shrinking sizes and prices. As recently as the early 1980s, the 10MB hard disk on the IBM XT seemed to be enough for any user. Today, the typical desktop capacity is closer to 200 times that: 2GB. (Chart 10).

Chart 10

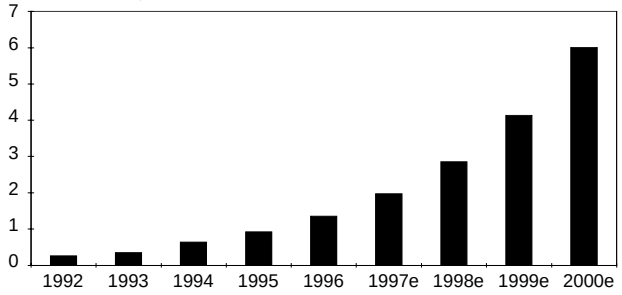
Storage capacity of typical desktop PC
(*in megabytes)*



The trend to greater capacity has been built on the ability to squeeze more and more bits (which are magnetized areas on the disk) into any given area, a measure known as areal density (Chart 11).

Chart 11

Areal density of disk drives
(*gigabits per square inch)*



That the primary storage method will, in all likelihood, continue to be magnetic for the next 10+ years is:

(i) Because the widespread use of network storage will dampen demand for vast desktop storage capacity (although desktop systems will still have huge storage capacity—given the current rate of growth, a typical desktop system in a dozen years will offer 200GB of storage), and

(ii) Because magnetic storage is the most cost effective technology, i.e., rust (magnetic oxide) will remain much cheaper than glass (optical) or other exotic systems.

The primary route to improving density during the next five years is to improve the sensitivity of the read head. (A simple analogy: you can squeeze more words into a book by reducing the font size, but the key is to keep the words legible.) Much of the recent improvement in areal density has come from better read heads, and from the migration to magnetoresistive (MR) heads (which are more sensitive than the older thin-film inductive heads) which has just begun to get under way. MR heads are still new enough to have plenty of room for straightforward, evolutionary improvement so that drive capacity should grow as much as ten-fold by the turn of the century.

As for the companies that will benefit from these trends, whereas in the 1980s disk storage was largely a commodity item with lots of sources of supply, today disk drives are the second most expensive component of a PC. In addition, the suppliers of drives have shrunk to a handful—only three domestic suppliers have survived the industry consolidation intact: **Quantum, Seagate Technology** and **Western Digital.** And **EMC Corp,** although it is not a manufacturer, benefits from strong demand for disk storage because it buys disk drives and packages them with specialized software to create a storage subsystem for managing data in large corporate environments.

Additional information is available upon request.

Prices of companies mentioned as of 8/26/97:

Amazon.com[4] AMZN $28 1/8
America Online AOL $66
Apple Computer[1] AAPL $22 1/4
Applied Materials[1] AMAT $98 3/8
Barnes & Noble[2] BKS $47 1/2
Cisco Systems[1] CSCO $77 9/16
Cognos[1] COGNF $31 1/2
Commodore Applied Tech CXI $4 3/16
Compaq Computer[3] CPQ $65 1/2
CUC Int'l[3] CU $24 3/4
Dell Comp[1] DELL $82 13/16
Disney (Walt)[3] DIS $77 1/2
EMC Corp[3] EMC $52 3/16
Federal Express FDX $67 1/4
Fingerhut Cos FHT $20 1/2
Fore Systems[1] FORE $20 1/16
Gannett[3] GCI $98
Gateway 2000[2] GTW $40 3/16
General Motors Cl 'H GMH $63 7/8
Hewlett-Packard[3] HWP $62 7/16
Int'l Bus Mach IBM $103 5/16
Intel[1] INTC $92 11/16
KLA-Tencor[1,2] KLAC $71 1/8
Lands' End LE $26 1/2
Lucent Tech[2] LU $82 1/4
Microsoft[1] MSFT $135
New York Times NYT.A $47 13/16
Northern Telecom NT $101 7/16
Open Market[1] OMKT $10 1/2
Oracle[1] ORCL $38 5/8
Penney, (J.C.)[3] JCP $59
Primark Corp[2] PMK $26
Quantum[1] QNTM $36 3/4
Seagate Technology[3] SEG $40 13/16
Spiegel SPGLA $6 3/8
Staples[1] SPLS $24 3/16
Sun Microsystems[1] SUNW $50 15/16
Tandy[3] TAN $66 5/8
Teradyne TER $53 7/8
Time Warner[3] TWX $51 3/4
3COM Corp[1] COMS $49 7/16
Wal-Mart[3] WMT $36 1/16
Western Digital[3] WDC $51 3/8
WorldCom[1] WCOM $31 3/4

[1]PaineWebber Incorporated makes a market in this security.

[2]PaineWebber Incorporated has acted in an investment banking capacity for this company.

[3]A subsidiary of PaineWebber Incorporated acts as a specialist that makes a market in this security. At any given time the specialist may have a position, either long or short, in the security, and as a result of the associated specialist's function as a market maker, such a specialist may be on the opposite side of orders executed on the floor of a national securities exchange.

[4]These securities can only be offered in such states as may be legally permissible.

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