# THE INFORMATION AGE AND THE PRINTING PRESS: LOOKING BACKWARD TO SEE AHEAD[1]

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## INTRODUCTION

We are in the midst of the “Information Age.” Pundits have proclaimed it for years; articles in the popular press have plumbed its implications for every imaginable enterprise;[2] businesses are enamored with it; on-line and print magazines are devoted to it; government is wrestling with it, movies have been made about it; people are talking about it--can there be any doubt?

So, where will it all lead and why should we care? And what exactly *is* the Information Age anyway?

It is my intent in this paper to describe a way to think about what the Information Age is and where it will lead. And, put succinctly, we should *all* care because that way of thinking suggests the Information Age is likely to have profound effects throughout society--even if the specific effects are hard to see at this point.

But I'm getting ahead of myself. At this point I want to suggest that it is both important and difficult to see where the information age might lead. Important, not least, because gargantuan fortunes are there to be made for those who see the future clearly. Important also, because information is affecting a wide variety of human enterprises in significant ways (businesses are "flattening" and globalizing; people are buying faxes, cell phones and computers; schools are wiring themselves in anticipation; governments are scrambling to handle information age problems, etc.).

It is difficult to see where the information age is leading primarily because the technologies fueling it are still being developed and at a furious rate. It is difficult also *because* of the breadth of the impact of information technologies to date. With so many areas of society being affected, many effects are transitory, many are insignificant, some are contradictory and some are even undesirable.

Because or perhaps in spite of both the importance and difficulty of addressing the future of the information age, there has been no shortage of attempts to do so. These attempts break down roughly into three categories. The first contains those who would project from the capabilities generated by information technology where

[1]This paper was funded by a RAND President’s Award. The award funded four weeks of effort dedicated to a topic of my choosing. This is a piece of speculation, with as much flesh and bones on it as four weeks of research, thought, RAND’s usual superb library assistance, and conversation with colleagues can provide. While retaining blame for its contents, the author has appreciated comments on earlier drafts from Tony Hearn, Willis Ware, Bob Anderson, and Carl Builder.

[2]As one measure, the February 1995 *Scientific American* (p. 30) has a graph showing that articles on the “information superhighway” in newspapers, magazines and broadcasts peaked at over 2800 in the Jan.-Feb. 1994 period.

the information age might go. Let's call these people *technologists*. Prominent in this category would be Microsoft's Bill Gates. His best-selling book--*The Road Ahead*[3]--is a good example of suggesting how technological advances might affect our lives in the years ahead. Other examples in this genre include Nicholas Negroponte's *Being Digital* and Michael Dertouzos' new book, *What Will Be: How the New World of Information Will Change Our Lives*.[4]

The second category of people addressing the future of the information age contains those who would "invent" rather than try to predict the future. These are the *inventors*. These include people who are looking for "killer app[lication]s" or hardware breakthroughs that will yank the future of information onto a whole new trajectory. I would include here people like the Steves--Jobs and Wozniak--who are credited with developing the first personal computer; Alan Kay who invented (among other things) "windows" and Marc Andressen who developed the first "killer" web browser. More generally, many businesses are in this second category as they try to create new markets.

In the third category are those who try to divine the future by drawing on parallels with the past. These are the *historians*. Chief among these in the popular literature would have to be the Tofflers who argue[5] the information revolution is following the agricultural and industrial revolutions as important "waves" in human history. Also included here are the works of colleagues Carl Builder--who argues information technologies could bring down the power of the nation-state in the same way the printing press helped bring down the power of the Catholic Church in the Middle Ages,[6] and David Ronfeldt--who argues that the network is next in the progression of societal forms from tribes through hierarchies and markets.[7]

I put myself squarely in the historian camp and want to use this paper as a forum for arguing it is the historical era of the printing press that contains the "best" parallels to today's situation. Specifically, I want to argue that **the parallels between the printing press era and today are sufficiently compelling to suggest**:

- **Changes in the information age will be as dramatic as those in the Middle Ages in Europe.** The printing press has been implicated in the Reformation, the Renaissance and the Scientific Revolution, all of which had profound effects on their eras; similarly profound changes may already be underway in the information age.

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[3]Bill Gates, et.al., *The Road Ahead*, Penguin, 1996. For reviews of several other recent books on the subject, see the Review of Books and Multimedia, *The Economist*, September 6-12, 1997, p. 7.

[4]Nicholas Negroponte, *Being Digital*, Knopf, 1995, and Michael L. Dertouzos, *What Will Be: How the New World of Information Will Change Our Lives,* Harper San Francisco, 1997.

[5]See Alvin Toffler, *The Third Wave*, Bantam Books, 1991, and Alvin and Heidi Toffler, *War and Anti-War*, Little, Brown and Company, 1993.

[6]Carl Builder, "Is it a Transition or a Revolution?," *Futures*, March 1993, pp. 155-168.

[7]See, for example, David Ronfeldt, "Tribes, Institutions, Markets, Networks: A Framework About Societal Evolution," RAND, P-7967 (1996).

- **The future of the information age will be dominated by unintended consequences.** The Protestant Reformation and the shift from an earth-centered to a sun-centered universe were unintended consequences in the printing press era. We are already seeing unintended consequences in the information age that are dominating intended ones and there are good reasons to expect more in the future. Thus, the *technologists* are unlikely to be accurate and the *inventors* may neither have their intended effects nor be the most important determinants of information age progress.
- I**t will be decades before we see the full effects of the information age.** The important effects of the printing press era were not seen clearly for more than 100 years. While things happen more quickly these days, it could be decades before the winners and losers of the information age are apparent. Even today, significant (and permanent) cultural change does not happen quickly.
- **The above factors combine to argue for: a) keeping the Internet unregulated, and b) taking a much more experimental approach to information policy.** Societies who regulated the printing press suffered and continue to suffer today in comparison with those who didn't. With the future to be dominated by unintended consequences and a long time in emerging, a more experimental approach to policy change (with special attention to unintended consequences) is soundest.

This is speculation of the highest order. I am essentially saying the Internet era is very similar in important areas to the printing press era, and, because the printing press had broad and profound effects on its age we should expect similarly broad and profound effects from the information age. My primary focus in the remainder of this paper, then, will be to make those parallels so compelling that the analogy can stand on its own. I'll finish with some afterthoughts and more complete arguments for the implications sketched above.

The parallels will be broken into three sections. The first concentrates on the nature of the communications breakthrough that fueled the printing press era and is fueling the information age. The breakthrough technologies enabled important changes in several of the ways that people dealt or deal with knowledge. The second section will draw out the similarities in those changes. The third section will explore the dominance of the printing press era by unintended consequences and a similar dominance of unintended consequences already visible in the information age.

## PARALLEL #1: TECHNOLOGICAL BREAKTHROUGHS IN COMMUNICATIONS

It is here I want to return to the question of what the information age really *is*, for that is at the heart of my thinking. In fact, my basic argument can be stated as follows:

- As the first true many-to-many communications medium,[8] the networking of computers is the defining characteristic of the information age,
- There has been only one comparable event in the recorded history of communications--the printing press. It was the first true one-to-many communications medium, and no change since has been as dramatic as networked computers,[9]
- The impact of the printing press on its era was profound in breadth and depth, and was directly related to its one-to-many communications capability,
- It is thus that I argue the many-to-many capability enabled by networked computers will play a role in similarly broad and deep changes in the information age.

For me, then, it is networked computers that define the information age. Other definitions of the information age are much broader, encompassing other information technologies such as faxes, cellular phones, non-networked computer applications, few-to-few intranets, and so forth. While there are clearly other aspects of the information age, networked computers will be the focus of this paper.

I am not the first to make use of this parallel. It was several years ago that colleague Norm Shapiro first suggested the qualitative difference in communications represented by networked computers.[10] This difference is now a widely-shared talking point in discussions of networked computers. Several authors have also made reference to the printing press as a watershed in history similar to that of the information age. At least one author,[11] moreover, has done a considerable comparison between the printing press and networks.

What will distinguish this paper is its aggressive search for parallels between the one-to-many effects of the printing press and potential many-to-many effects of networked computers. The more such parallels, the more likely the implication that the similarities with the printing press impact will carry over into broad causative impacts from networked computers.

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[8]Colleague Bob Anderson pointed out (by e-mail communication) that anyone could buy a radio transmitter in the mid-1920s, but that radio spectrum limitations and government regulation of the airwaves kept it from reaching critical mass. Colleague Bill Lisowski added (by e-mail communication) that Citizen's Band radios could be classified as another "attempt" in the 1970s, but with the same problems as the radio transmitter. Networked computers are not spectrum-limited in this way.

[9]I will concede that either public speaking or the advent of written language is arguably the first one-to-many communications medium, but will hide behind the words "recorded" and "true" in defending this statement. If more were known about the impact of public speaking or the earliest writings, I might be forced to reconsider. Also, it is the combination of the immediacy of the communication and the sheer numbers of the "many" in "one-to-many" that are of interest to me. The printing press was the first medium in a string followed by film, radio, TV, etc. (maybe even the bull horn) that allowed a small group of people to reach a very large group of people fairly quickly.

[10]Private communication.

[11]"Net surfing" led me to a paper by Michael Hauben, a senior at Columbia University, *The Expanding Commonwealth of Learning: Printing and the Net,*

At this stage I want to buttress the first three bulleted points above. We are still at a very early stage in the introduction of networked computers and the technology is changing very rapidly. Arguments need to be made that networked computers will persist (not be a fad) and that their ultimate capabilities will be sufficient to have a significant impact on society.

The claim that the printing press had a major impact on its era is not without some controversy and I need to be clear on the source for it.

**The Future of Networked Computers**

While profound cultural changes are generally slow in developing, the same cannot often be said of technological changes that propel them. The printing press spread quickly (for its time) from Gutenberg's first press in Mainz in 1450 throughout Europe by 1500. In that time, as many book copies were printed as had been produced in the previous millennium by scribes.[12] The technology, though it continued to evolve, was largely in place after 50 years. The impact of the change was not clearly seen for another century or so, but the capabilities of the technology were seen reasonably clearly early on.

We are not yet to the point we can see the capabilities of networked computers. Their growth has been no less dramatic in our time, but we are still on the "steep part of the curve" from the technology standpoint. Since ARPANET first went on line in 1969, the growth in networked computers has been exponential. The growth rate has slowed recently, but is still doubling every 12-15 months.[13] We are also still on the steep part of the curve for the capabilities of the computers themselves. If the parallels between the print and network eras are to be useful, some measure of the "eventual" characteristics and capabilities of networked computers as a communications medium must be known.

The enthusiastic projections that accompany any new technology usually overestimate actual progress, but can vary wildly in their prescience on either side of the eventuality. Projections of electronic computer usage were laughably understated, while those of dirigibles were just as laughable in the opposite direction. Since we are still at the growth and hype stage of networked computers, where can we turn for prescience?

The eventual impact of a technology is at least weakly dependent on its ubiquity; the more widely spread the greater the likelihood and magnitude of impact. The typical new technology is very expensive or esoteric and, thus, is initially restricted to a small segment of the population. Some technologies, such as space travel, languish there indefinitely. Others, such as books, stay in the province of the elite for some time, and eventually make their way throughout the populace. Still others, such as calculators and televisions, start out expensive and enjoy a steady drop in price and a concomitant rise in circulation. Where exactly are we with networked computers and where might we wind up?

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[12]This should be taken as a rough order of magnitude. Quotes of this exact nature can be found, but hard statistics are difficult to come by. Typical early printing editions ran in the 200-1000 copies range and took much less time to produce than a single hand-written manuscript.

[13]See, for example, The General Magic statistics at their web site: http://www.genmagic.com/Internet/Trends/index.html.

***Access to Networked Computers.*** Reaching pervasiveness depends primarily on access to networked computers being affordable and on people's interest in having that access. Affordability, in this case, depends on the affordability of both the networking and the connections to the network. Due to its peculiar history, networking itself has been relatively inexpensive since its inception. A crucial element of the Internet dates back to 1962 at RAND when Paul Baran developed the concept of packet switching as a means to maintain connectivity of the military command and control network in case of nuclear attack.[14] In 1969 the Advanced Research Projects Agency funded the first large-scale test of this concept. In the fall of that year the first node was installed at UCLA (RAND was the seventh node). Because of the decentralized structure of the ARPANET and a telephone network in place to support it, expansion was easy and the net grew rapidly. In 1983 ARPANET broke off the military part (which became MILNET) and the non-military part grew into what is known today as the Internet (with ARPANET officially closing down in 1989).

If one has a computer, connecting to the Internet costs little or nothing, since each node is independent, and has to handle its own financing and its own technical requirements. While the price of connecting to the Internet has been historically low, it still requires a computer. Though computers continue to drop in price, they still cost several hundred to several thousand dollars new. On the other hand, computers have enjoyed the longest stretch of uninterrupted exponential growth of any technology known to man. A plethora of available projections show continued uninterrupted exponential growth in performance and exponential decreases in cost, size and power requirements for several more generations. But decreases in cost are usually figured on a performance-per-dollar basis. The price of a new generation of computers is about the same as that of the previous generation. However, there are other options for connecting to the Internet. If one were not afraid of swap meets and minor begging, one could start from scratch and connect (with generations-old equipment) to the Internet today for under $200 initial outlay and $10 a month.[15] Another option is the "set-top" box. This is a computer designed specifically to hook up to the web using an ordinary TV set as the monitor.[16] Today it can cost as little as $100 and $15 a month, and there is growing competition in this market.

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[14]This history derives mainly from Bruce Sterling, "Short History of the Internet," *The Magazine of Fantasy and Science Fiction*, Feb. 1993. As with many successful developments, the many-to-many communications revolution appears to have more than one father. J.C.R. Lickliter and Leonard Kleinrock of MIT are also credited with the earliest origins of the Internet (around 1962). See, for example, "A Brief History of the Internet" at http://www.isoc.org/internet-history/.

[15]Michael Specter, in "Russians' Newest Space Adventure: Cyberspace" (New York Times, March 8, 1994), describes the explosion of e-mail traffic in Russia. It is much faster than most other means of communication despite the fact that the typical machine is a "first-generation IBM-PC clone of the type that most Americans long ago consigned to yard sales or donated to charity, and most modems work like molasses at speeds of 2,400 bauds[sic] or less."

[16]This is a particularly interesting development because televisions have become more common worldwide than the telephone. In the United States, an amazing 66% of households have more than one.

As far as the interest in networks today, Joel Birnbaum would say we are in the third of four stages for a pervasive technology--where it has become well known and commonplace, but is used directly by only a rather small portion of the population.[17] The fourth stage is where the technology becomes integral to daily life.

Best estimates today say there are at least 19.5 million computers connected to the Internet in 241 countries.[18] One respected estimate says in the United States 40.6 million people over 18 have used the Internet in the last year.[19] At these rates, worldwide saturation would be achieved before 2010. We know not to trust the timelines of such simple projections, but is there evidence we are headed for saturation? Anecdotal evidence provides some provocative snippets at this point. Win Treese, for example, writes that 25% of all Australian households have a personal computer, 16% of Estonian elementary and secondary schools are connected to the Internet, and two daily newspapers in Iran have websites.[20]

***Computer technology.*** What will be the situation when the exponential growth of both networking and computers has finally tailed off? It is the many-to-many nature of networked computers rather than the specific technology that is the heart of this paper. For that reason, but realizing that the ubiquity/availability question is an important one, I will use very conservative estimates of the capabilities of networks and computers when they “stop growing exponentially.”

Colleague Bruno Augenstein has suggested the following conservative benchmarks for technology growth in computers and networks at least out to 2010:[21]

<u>(General Purpose) Computer</u>

| | |
|---|---|
| 1995-2000 | $10^{11}$ FLOPS (Floating Point Operations/Second)<br>factor of ~ 250 in volume reduction |
| 2000-2010 | $10^{12}$ - $10^{15}$ FLOPS<br>appropriate volume reduction |

[17] Joel Birnbaum, “Toward the Domestication of Microelectronics,” *Communications of the ACM*, Vol. 28, No. 11, Nov. 1985, pp. 1225-1235.

[18] Accurate statistics are difficult to obtain, but many observers rely on the Network Wizards counts shown here and available at: http://www.nw.com/zone/WWW/report.html. These should be considered conservative estimates because an increasing number of users are “hiding” behind “firewalls” that make accurate counts even more difficult.

[19] Though only 31.3 million describe themselves as current users. From “The 1997 American Internet User Survey” which is accessible at: http://etrg.findsvp.com/internet/overview.html.

[20] Win Treese, “The Internet Index #5” and “The Internet Index #6”, and “The Internet Index #11.” These and others are available on the Internet at: http://www.openmarket.com/intindex/. The sources for the statistics are also reported.

[21] These figures come from an unpublished paper. FLOPS may not be the best measure of speed in networked computers, but at worst they underestimate better measures.

Communications

| | | |
|---|---|---|
| Available backbone: | 1992 - ~ $4 \times 10^3$ | Megabits/second |
| | 2010 - ~ $2 \times 10^6$ | " |
| Local area network: | 1992 - ~ $4 \times 10^2$ | " |
| | 2010 - ~ $10^4$ | " |
| Wide area network: | 1992 - $10^2$ | " |
| | 2010 - ~ $4 \times 10^4$ | " |

These computer projections are based on currently-used lithography technologies (primarily the 150 nanometer electron-beam lithography in development at IBM). Lithography can arguably be pushed down to the 5 nanometer range, and more exotic methods based on different phenomenology (Scanning-Tunneling Microscopy, molecular machines and self-assembling systems) hold promise for making even more remarkable advances. To put these numbers in more graphic terms, a computer of 2010, in a size no bigger than portable computers today, would have the computational power of today's supercomputers, and it would cost about the same as today's portables. Lesser capabilities would be available at lower costs in much the same way they are today.

The network capacities of 2010 are less than an order of magnitude away from NREN, the National Research and Education Network, which was approved by the US Congress in the Fall of 1991, as a five-year, $2 billion project to upgrade the Internet "backbone." NREN will allow the electronic transfer of the entire Encyclopedia Britannica in one second. Projections are for networks worldwide to feature 3-D animated graphics, radio and cellular phone-links to portable computers, as well as fax, voice, and high-definition television. The NII (National Information Infrastructure) or "Information Superhighway" is intended to be even more capable, but I digress. The more conservative projections above will be sufficient to make the case.

***Uses of networked computers.*** What about the uses of the Internet? Again, I will depend on today's uses. To review, the current primary functions supported by Internet are four:[22] e-mail, discussion groups, long-distance computing and file transfers. E-mail is electronic mail that is similar to FAXs. It is global in scope with more than 240 countries accessible today (up from 137 in 1993).[23]

The discussion groups, or "newsgroups," are a world of news, debate and argument generally known as "USENET." Sterling describes USENET as "rather like an enormous billowing crowd of gossipy, news-hungry people, wandering in and through the Internet on their way to various private backyard barbecues."[24] There are some 2800 separate newsgroups on USENET,[25] and their discussions

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[22] These descriptions borrow heavily from Sterling, *Op.Cit.*

[23] See, Network Wizards at: http://www.nw.com/zone/WWW/top.html.

[24] *Ibid.*

[25] Rough count from "USENET Newsgroups by Hierarchy" at: http://alvarez.physics.csbsju.edu/News-groups/news_overview.html.

generate 400,000 articles and 800 megabytes of data traffic a day.[26] The variety of subjects discussed is enormous, and growing.

Both USENET and e-mail are widely available, even outside the high-speed core of the Internet itself. News and e-mail are easily available over common phone-lines from Internet fringe-realms like BITnet, UUCP and Fidonet. The other two Internet services, long-distance computing and file transfer, require what is known as "direct Internet access"--using TCP/IP (Transmission Control Protocol and Internet Protocol).

As above, long-distance computing was an original inspiration for ARPANET and is still a very useful service for some. Programmers can maintain accounts on distant, powerful computers, run programs there or write their own. Scientists can make use of powerful supercomputers a continent away.

File transfers allow Internet users to access remote machines and retrieve programs or text. Many Internet computers allow anyone to access them anonymously, and to simply copy their public files, free of charge. Internet file-transfers are becoming a new form of publishing, in which the reader simply electronically copies the work on demand, for free. One aspect of file transfers is the latest rage on the Internet, and embodies an important computer software technology that will figure in the speculations below. That aspect is the World Wide Web (WWW, or "Web").

As with packet switching, the WWW was developed (by physicists at the European Particle Physics Laboratory) for a narrow, specific problem (creating a unified hypertext markup language (HTML)[27] network for high-energy physicists working in a variety of locations internationally). It is leading to is a "point-and-click" way of browsing through the entire Internet. With browsers such as Netscape Communicator or Microsoft Explorer, the user can "surf" the Internet in a more user-friendly way. Further, making current Internet documents compatible is easy: "Using a relatively simple set of commands, World Wide Web users can turn their documents into hypertext: nsert the proper bit of code, and a word becomes a link; ...nearly any [Inter]Net document--text, picture, sound, or video--can be retrieved and viewed on the World Wide Web."[28] WWW services are currently growing by 60% per *month*.[29]

At this point let me draw a very conservative picture of a networked computer system in the year 2010. The network will have a wide variety of computers connected to it, including personal computers with the memory and processing capabilities of today's supercomputers. About 50% of the households

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[26] Extensive statistics are kept on USENET traffic. See, for example, http://www.nntp.primenet.com/feedinfo/lastday.html#BYWDAY.

[27] HTML is an important software technology that will figure in the speculations. It allows documents to be "linked" together in a way that makes what can be thought of as a "three-dimensional" book. Text on one page can be linked to text anywhere else on the Internet; to a traditional footnote, to a dictionary, to a further description of that text, to actual secondary references, to pictures, sounds or videos, etc. Clicking on that text then transfers the user to that link. HTML keeps track of your wandering so that backtracking is easy.

[28] Gary Wolf, "The (Second Phase of the) Revolution Has Begun," *Wired*, October, 1994, p. 117.

[29] See, for example, http://tig.com/IBC/stats/html/index.html.

in the U.S. will have computers (up from 28% today) and 30% of households will be connected to the network (up from 11% today). A disproportionate percentage of computer ownership and network usage will be in White and Asian households, in the upper quartile of income and belonging to college graduates.[30] The network will be based on something like hypertext with browsers bringing "point-and-click" friendliness to WWW interactions containing text, pictures and videos. At least three of today's network functions will still be popular: discussion groups, e-mail, and file transfers. Most major domestic and many foreign libraries, universities and governments will be accessible through the network with direct access to millions of individual documents. As to where we are on the "curve," I am suggesting that we will get "that far" before the curve starts to tail off. More importantly, I am suggesting that "that far" is critical mass in terms of making the system permanent. It may not yet be pervasive in the sense the Birnbaum uses it, but it will be at least as pervasive and permanent as books were in their early history.

I want to conclude this section by trying to put the projected network in perspective. While the projections were deliberately conservative the projected system is not conservative when compared with the telephone system. It took 75 years for phones to reach 50% of U.S. households (now at 93% after 100 years). On the other hand, the projected system is quite conservative with respect to more modern technologies such as televisions (now in 95% of U.S. households), VCRs (85%), and cable TV (64%). Video cameras are currently in 28% of U.S. households (same as computers) and are projected to take over for photographic cameras.

The networked computer system I have posited for 2010 will, thus, achieve "ubiquity" (in a way that radio transmitters and CBs did not), at least in the United States and potentially worldwide. This positions it to have a significant impact on society and culture.

Next, I want to argue that the impact of networked computers could lead to changes as profound as those that took place in Europe in the "Renaissance" period 1450-1650 AD. To do that, I will rely on arguments that the impact of the printing press was importantly responsible for the changes that took place during that period.

## The Impact of the Printing Press

While the history of the printing press has been studied voluminously, its effects on society have received little attention. Elizabeth Eisenstein's book, *The Printing Press as an Agent of Change*,[31] was the first and is still the only comprehensive attempt to study the impact of the printing press. Before the publication of her book in 1979, historians generally conceded the role of the

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[30]Ownership in these groups is not only greater today, but growing faster than in other groups and points to a situation much like that in the early print era, when books were primarily the province of the elite. There are movements underway, however, to provide at least universal e-mail access in the U.S. (see, Robert Anderson, et. al., *The Feasibility and Societal Implications of Universal Email Access in the U.S.*, MR-650-MF, RAND, 1995).

[31]Elizabeth L. Eisenstein, *The Printing Press as an Agent of Change*, Cambridge University Press, New York, (1979).

printing press in weakening the power of the medieval church, but gave it little credit beyond its assist to Luther and his Protestant Reformation. Eisenstein persuasively implicated the printing press in the Renaissance and the Scientific Revolution as well, magnifying both the breadth and depth of its impact. Her latter views are more controversial. Since I will rely heavily on those views, I want to describe briefly both what those views are and how they have been received by the community of historians in general.

Eisenstein's work was provoked by Marshall McLuhan's similar (less carefully researched) notion that the printing press was an important watershed[32] and her book created a stir among her fellow historians.[33] While several reviewers found parts of Eisenstein's work problematic, D.W. Krummel echoed the sentiments of many in writing:

> "...just as Western civilization was never again the same thanks to the invention of printing, so our understanding of the invention of printing will never again be the same thanks to Eisenstein's scholarship."[34]

Historians before Eisenstein generally studied the invention of printing, but not its long-run impact. She took seriously Bacon's aphorism,

> "We should note the force, effect, and consequences of inventions which are nowhere more conspicuous than in those three which were unknown to the ancients, namely, printing, gunpowder, and the compass. For these three have changed the appearance and state of the world."[35]

but found little written about the impact printing. As she says,

> "What were some of the most important consequences of the shift from script to print? Anticipating a strenuous effort to master a large literature, I began to investigate what had been written on this obviously important subject. To my surprise, I did not find even a small literature available for consultation. No one had yet attempted to survey the consequences of the fifteenth-century communications shift."[36]

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[32]Marshall McLuhan, *The Gutenberg Galaxy: The Making of Typographical Man*, Toronto (1962).

[33]In fact it led to a book in response, Peter F. McNally, ed., *The Advent of Printing: Historians of Science Respond to Elizabeth Eisenstein's "The Printing Press as an Agent of Change,"* Montreal: McGill University Graduate School of Library and Information Studies, (1987), with a bibliography of 52 reviews of her book.

[34]D. W. Krummel, *The Printing Press as an Agent of Change, A Review Essay*, Journal of Library History, Vol. 15, No. 2, Spring, 1980, p. 205.

[35]Francis Bacon, *Novum Organum*, Aphorism 129, quoted in Eisenstein, *Op. Cit.*, p.43.

[36]*Op. Cit.*, p. xi.

Eisenstein argues that the printing press changed the conditions under which information was collected, stored, retrieved, criticized, discovered, and promoted. She recognizes explicitly that change is multi-causal, but argues that--as *an* agent--printing had important causative effects on the Reformation, the Renaissance and the Scientific Revolution. I will leave significant details to the section on the changes enabled by the technologies, but before then, a general discussion of the causative effects of printing is in order.

Eisenstein, better than anyone, recognized the difficulty in trying to establish the impact of the printing press. As she points out, "the first century of printing produced a bookish culture that was not very different from that produced by scribes,"[37] and "one must wait until a full century after Gutenberg before the outlines of new world pictures begin to emerge into view."[38] As Rosaldo said in a way that might echo more strongly today:

> "...roughly during the first century after Gutenberg's invention, print did as much to perpetuate blatant errors as it did to spread enlightened truth. Putting scribal products into print resulted in a cultural explosion. Never had scholars found so many words, images, and diagrams at their fingertips. And never before had things been so confusing with, for instance, Dante's world view achieving prominent visibility at the same time that Copernican views were making their way into print. Nonsense and truth seemed to move hand in hand with neither made uncomfortable by the presence of the other. Though many have discussed Renaissance culture's playful spirit, love of many-sided accomplishment, or lighthearted indifference to historical fact, Eisenstein more prosaically says that things simply had not yet been sorted out."[39]

This long delay between cause and "sorted out" effect is not surprising when the effects are cultural and profound. It does, however, complicate establishment of the cause-and-effect relationship. Given the difficulties, the strength of Eisenstein's work is her careful argumentation about the connection between a given cultural change--seen clearly only many decades after the invention of the printing press--and the more tangible changes brought about by printing. The following summaries of her arguments for the impact of printing on each of the Reformation, the Renaissance, and the Scientific Revolution, draw heavily on summaries made in the several reviews of her book.

Eisenstein's arguments about the impact of the printing press on the Reformation are aptly summarized by Kingdon:

> "Scholars have long recognized the essential role of the press in spreading Protestant doctrine. Luther himself, in fact, claimed that the invention of printing was a gift from God to reform His church.

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[37] *Ibid.* p. 26.

[38] *Ibid.* p. 33.

[39] Renato Rosaldo, *The Cultural Impact of the Printed Word, A Review Article*, Comparative Studies in Society and History, 1981, Vol. 23, No. 3. p. 508.

> But Eisenstein argues that print did more than spread the Protestant Reformation: in an important sense, print caused the Reformation. Without access to the printed editions of biblical texts and church fathers, and the worrisome variants on crucial dogmatic issues they contain, Luther might never have been stimulated to develop his revolutionary new theology. And without accessibility to print, Luther might never have spread his ideas not only in the Latin of the scholarly community but also in the vernacular German of the lay community."[40]

Eisenstein argues that, while the medieval Catholic church was a prolific user of printing, the changes it wrought were outside the control of the church. The proliferation of different biblical texts eventually cast into doubt the existence of a single infallible text. This led to alternative interpretations such as Luther's, but the ability to publicize those interpretations by the same means of printing kept them from being crushed as were earlier heresies.

As for the Renaissance, it began well before the invention of the printing press. Historians credit Petrarch with its origins in the mid-fourteenth century in Northern Italy. The "renaissance," or "rebirth," refers to a return to the humanism of the classical Greeks. To argue the causative effects of printing, Eisenstein divides the Renaissance into pre- and post-printing phases. "Rebirths" of humanism were not uncommon in the medieval period. Two of the largest were the Carolingian in the 9th century and one in the 12th century. As Marvin points out,

> "throughout the Middle Ages periodic revivals of classical interests at different cultural centers were normally ended by war, famine, and other adversities that drew energy and attention back to more pressing problems of survival."[41]

Eisenstein points out that the Italian renaissance differed little from earlier ones until the printing press "fixed" it and helped spread it north of the Alps. "Typographical fixity" refers to the preservative power of print. Ideas recorded in only a few manuscripts were always in danger of being forgotten or lost by the intellectual community. Put those same ideas in hundreds of identical printed copies, and they were much more likely to spread and endure. Eisenstein suggests that before the printing press, the fall of Constantinople (and its extensive collection of classical texts), in 1453, would have been disastrous for humanism.

Another argument applies to all three of the major events of the printing press era, but perhaps best to the Scientific Revolution. This is the idea that the printing press changed attitudes towards the past. As Mander puts it,

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[40]Robert Kingdon, "Review of *The Printing Press as an Agent of Change,*" Library Quarterly (1980), Vol. 50, no. 1, p. 140.

[41]Carolyn Marvin, Book Review, *Technology and Culture*, (1979), Vol. 20, No. 4, p. 794.

> "Scribal culture revered the ancients because they were closer to uncorrupted knowledge--that is, knowledge not yet corrupted through the process of scribal transmission... Print culture, because it allows for cumulative advance of knowledge, views the past from a fixed distance."

Eisenstein argues that this change in attitude led to a willingness to question the ancients and to consider new ideas; fueling both the rise of humanism and Protestantism. In science, the notion of cumulative and progressive knowledge was absolutely revolutionary. "Scientific data collection was born with printing" and new contributions became part of a "permanent accumulation no longer subject to the cycle of rapid decay and loss."[42] Copernicus compared the ideas and data of Ptolemy, Aristotle and others; noted their errors and inconsistencies; and published "De Revolutionibus Orbium Coelestium" in 1543--starting the Scientific Revolution. This change in culture is captured neatly in:

> "the reversal of meaning undergone by the term "original." In its old meaning it meant closest to the origin of things, to the initial creation of the cosmos. In the first truly typographical culture it increasingly meant "novel," a break with precedent."[43]

These summaries do little justice to the case Eisenstein builds for the impact of the printing press. While not all historians share her enthusiasm, there is a general concession that the impact of print has been under-researched and, thereby, underestimated. The printing press was not the only change taking place in the period from 1450 to 1650, (just as networked computers are not the only change taking place today). Nonetheless, Eisenstein's research is clear evidence that the printing press had a profound effect on society during the time Europe was making the transition from a medieval to a modern world.

The stage is set, then, to draw parallels between the change-producing capabilities enabled by the printing press and those enabled by networked computers.

## PARALLEL #2: ENABLING CHANGES IN HOW WE MANIPULATE KNOWLEDGE

At this point, I am supposing that: networked computers are here to stay; they represent a change in communications (many-to-many) unlike any we have seen since the printing press (one-to-many); the printing press had profound implications for society; and parallels between the changes brought about by these two advances in communications media will help us better appreciate the potential for societal change from networked computers.

The one-to-many nature of the printing press had important effects on several fronts relating to the manipulation of knowledge. These effects are seen

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[42] *Ibid.*, p. 797.

[43] Eric J. Leed, "Review Essay: Elizabeth Eisenstein's *The Printing Press as an Agent of Change* and the Structure of Communications Revolutions", *American Journal of Sociology*, (1982) Vol. 88, No. 2, p. 420.

in retrospect. I would like to draw parallels between those changes enabled in the printing press era with similar changes in the networked computer era, but we can't see the latter in retrospect, yet. So I need to be careful in what I mean by a parallel between a change in the manipulation of knowledge enabled by the printing press and one enabled by networked computers. Here, then, are the ground rules for each of the parallels in this section:

- In order to make the case that the chosen aspect from the print culture is related to significant societal change, it must a) represent a change from the scribal culture related to the one-to-many character of the printing press, and b) be relatable to a some change in society.
- The parallel from the network culture must represent a change from the print culture *that is enabled by* the many-to-many character of networked computers. This will *not* be a prediction of what is to come, nor will I speculate at length on the potential effects of the enabled capability. It will be sufficient to draw the parallel in *enabled* capabilities.
- Contradictions between separate parallels are allowed. There were definitely contradictions in the era of the printing press. For example,

> "...we still seem to be experiencing the contradictory effects of a process which fanned the flames of religious zeal and bigotry while fostering a new concern for ecumenical concord and toleration; which fixed linguistic and national divisions more permanently while creating a cosmopolitan Commonwealth of Learning and extending communications networks which encompassed the entire world."[44]

A word about the format of the titles of the parallels: The second part of the title attempts to capture the essence of the capabilities in each of the scribal, print and networked computers eras. The printing press will be "responsible" for the change from the capability in the scribal era to that in the print era and networked computers will be responsible for the change from the capability in the print era to that of networked computers. (To separate the change brought about by the printing press from that brought about by networked computers, I'll insert a line of asterisks in the text for clarity.) Finally, I consider these five examples to be in increasing order of speculative content. The early ones seem quite defensible, while the later ones are both more tentative and potentially contrary to our current culture.

**Preserving, Updating and Disseminating Knowledge: From Manuscripts to Books to Internet books**

The printing press didn't create the book, it changed or redefined it. In the scribal culture, books or manuscripts were produced laboriously by scribes, each

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[44] Eisenstein, *Op. Cit.,* p. 705.

slightly different from other copies of the book. Errors in one manuscript were propagated to the next copy of that manuscript, and new errors were typically added. The knowledge or thought that resided in a manuscript was available to very few to read or to own. "Wandering scholars" were a primary source of feedback and dissemination. As they read a given manuscript, their marginal notes added any corrective or additive thoughts they may have. As scholars wandered, they carried the knowledge from the manuscript with them and could offer it to others. The paucity of manuscripts and wandering scholars made the preservation of knowledge precarious at best.

The effects of the printing press on this situation were enormous. One cannot doubt its impact on the preservation and dissemination of knowledge. Thousands of copies of a single manuscript virtually assured both its survival and spread. Even if restricted primarily to the wealthy, the sheer numbers of available books made them much more available to the general public.

Updating the knowledge in books had a more subtle and interesting history. In the early stages, printed books still contained and propagated errors, but their wider availability slowly had a dramatic effect.

> "A printed book, unlike a handwritten manuscript, was a standardized product, the same in its thousands of copies. It was possible for publishers to solicit corrections and contributions from readers who, from their own experience, would send back a report--and this was common practice."[45]

Eisenstein (and others) argues that this feedback reversed the slow degradation of recorded thought and ushered in the era of accumulation of thought upon which the Scientific Revolution was built:

> "The advantages of issuing identical images bearing identical labels to scattered observers who could feed back information to publishers enabled astronomers, geographers, botanists and zoologists to expand data pools far beyond all previous limits...The same cumulative cognitive advance which excited cosmological speculation also led to new concepts of knowledge. The closed sphere or single corpus passed down from generation to generation, was replaced by an open-ended investigatory process pressing against ever advancing frontiers."[46]

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The many-to-many communications medium of networked computers enables the process of preserving, updating and disseminating knowledge to be carried one or two steps further to the immediately available, instant feedback, constantly-updated, "3-dimensional" (non-fiction) book. There are two important aspects to this. The first relates specifically to the updating of knowledge. A well-documented book can do a creditable job of addressing all the knowledge and thought up to the time of

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[45]Eric J. Leed, *Op. Cit.*, p. 421.
[46]Eisenstein, *Op. Cit.*, p. 687.

its publication, but can't address even the reaction to itself, let alone the thoughts it provokes. Subsequent editions are used to correct this "problem," but are rarely published less than a year (more commonly 3-12 years for reference works) after the original. At that point, parts of the first edition are obsolete, but there is no good way to so indicate on a first edition copy.

A good example of the changes enabled by networking is the FAQ (Frequently Asked Questions) found in the discussion groups of USENET. After a group (such as sci.math) has been in existence for a while, users new to the group will begin asking questions that have been discussed at length earlier. At some point, a regular user will offer to generate a FAQ--a list of frequently asked questions and answers that represent the author's concept of the group consensus. The FAQ will then be posted to the group and recommended changes can be discussed and incorporated (the many-to-many part in action). The resulting FAQ is then archived (and posted periodically in some groups), to be referred to when one of the questions is brought up again and to be updated as necessary (again taking advantage of the potentially wide readership and discussion capabilities). The sci.math FAQ, for example, was a useful place to look recently to keep track of the status of Andrew Wiles's proof of Fermat's Last Theorem.

More generally, any "official" site can be the location to check for the latest on an unfolding situation. A recent example is the NASA site and the Mars explorer. Literally millions[47] of enthusiasts could stay as current as they wished in a way previously available only through 24-hour coverage by traditional broadcast media.

Another activity that takes advantage of many-to-many feedback capability is on-line journals. The Association of Research Libraries (ARL) counted 74 peer-reviewed electronic journals at the beginning of 1994, and 142 a year later.[48] As of July 1996 there were 1688 electronic journals, newsletters, and newsletter-digests accessible through the Internet.[49] These generally publish articles that have been refereed in the usual way, but make available to a wide readership the potential for *ad hoc* discussions of articles that appear. For example, Paul Ginsparg, in remarks about the "E-print" journal "High Energy Physics - Theory" said:

> "The communication of research results occurs on a dramatically accelerated timescale... In addition, researchers who might not ordinarily communicate with one another can quickly set up a virtual meeting ground, and ultimately disband if things do not pan out, all with infinitely greater ease and flexibility than is provided by current publication media."[50]

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[47]One recent show claimed there were over 500 million(!) hits on the NASA site dedicated to the mission.

[48]From Andrew Odlyzko, "On the road to electronic publishing," at: http://www.research.att.com/~amo/doc/tragic.loss.update.

[49]According to the Association of Research Libraries. Other statistics available at: http://arl.cni.org/scomm/edir/dej96pr.html.

[50]From http://xxx.lanl.gov:80/blurb/pg14Oct94.html. The journal URL is http://xxx.lanl.gov/archive/hep-th.

The second aspect of change with networked computers is that of hypertext linking and relates more to how knowledge is disseminated. From the printing press era, encyclopedias do a good job of providing pointers to other reference material on a given subject. With hypertext linking, this referencing becomes immediate. If the reader has an interest in further information, a click on the hypertext link will take the reader to that information. This capability opens the book into a new dimension with immediate accessibility to definitions of words, alternative means (say, more visually-oriented) of understanding a concept, active discussions of a given topic, further research on the subject, alternative interpretations, etc. The dissemination of knowledge is importantly changed by the immediacy of this new referencing capability. It takes important advantage of the many-to-many capabilities of the Internet both in the sense of the interconnectivity with data from all over the network, but also in the sense that building the individual pieces of an "Internet book" can--and from an efficiency standpoint, must--be done by a large group of people.

Ironically, both the FAQ and hypertext capabilities work best with a *single* copy of a work that is accessible by anyone on the network.[51] Further, there is nothing particularly new in the capabilities enabled by the network: books are widely available; feedback (e.g., reviews) on books and incorporating feedback into subsequent work/editions are both common; references can be discovered and obtained from any library. The same was true of manuscripts in the scribal culture. What makes the two communications breakthroughs important are the quantum increases in the ease and speed with which knowledge could be promulgated; feedback could be received and incorporated; one could find up-to-date knowledge and one could be put in touch with a wide range of materials on the topic. I'm uncomfortable suggesting just what the social impact will be of the Internet book. On the other hand, anyone who would argue there will be little impact must argue that the same kind of jump increase in speed and ease of updating and disseminating knowledge that led to dramatic changes in the printing press era will not have much of an effect in the networked computers era.

**Retrieving Knowledge: From Mnemonics to Indexes to Full-text Search**

In the scribal era, the ability to retrieve information was largely dependent on an individual's recall capabilities. There were numerous mnemonic devices to aid the individual memory. There were authorities available for consultation, but for instant recall, the individual had to rely primarily on his/her own memory. The ability to retrieve information took a significant jump in moving to the print culture. Indexes to books existed in the scribal culture, but were not systematically enforced.

> "Before printing...the task of indexing a book was up to each manuscript's owner. Manuscripts with a detailed index bravely begun for A and B but faltering later in the alphabet are familiar to medievalists...'La naissance des index'...elegantly surveys the contrivances that medieval readers used to find their way around

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[51]There are various methods for safeguarding such a "single" copy from being lost. On the other hand, without such a "single" copy, questions can arise as to which copy is the genuine or official mark-up copy.

> manuscripts:  ingenious bookmarks, lists of chapter headings, concordances, marginal glosses, arcane symbols, numbered lines and columns, alphabetically arranged epitomes."[52]

With the generation of hundreds of identical copies of a book, 'more complete and better arranged' indexes became a selling point for printers in the late fifteenth century.  But indexes were just the iceberg tip.  The printed book brought a variety of changes that led to a more orderly, systematic approach to the printed word: title pages, regularly numbered pages, punctuation marks, section breaks, running heads, tables of contents, etc.  All of these had their obvious and subtle effects.  Of an introductory 'Tabula' that John Rastel provided to his 'Great Boke of Statues 1530-1533', Eisenstein says, "He was not merely providing a table of contents:  he was also offering a systematic review of parliamentary history--the first many readers had ever seen."[53]

Eisenstein says of title pages:

> "Most studies of printing have, quite rightly, singled out the regular provision of title pages as the most significant new feature associated with the printed book format.  How the title page contributed to the cataloguing of books and the bibliographer's craft scarcely needs to be spelled out.  How it contributed to new habits of placing and dating, in general, does, I think, call for further thought."[54]

Bibliographies, book catalogues and encyclopedias flourished thanks to these systematic changes brought about by the printing press.  These, in turn, contributed to the retrieval of and critical reflection on published works and the accumulation of knowledge that characterized particularly the Scientific Revolution.  In fact, cataloguing of all kinds became popular.  "Medieval botanists knew some 600 varieties of plant, essentially not many more than in the ancient world.  By 1623 some 6,000 varieties had been catalogued."[55]

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The ability to retrieve information has taken another significant jump in the age of computers.  Eisenstein says of the printing press, "Until the recent advent of computers, has there been any other invention which saved so many man-hours for learned men?"[56]

Typical word processing programs have the ability to search through entire documents at high speed for phrases, words, or partial words.  Ordinary algorithms can search hundreds of pages in seconds.  Oft-searched documents--such as dictionaries or encyclopedias--can be formatted so that similar searches take

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[52] Karen Reeds, "Recent Books on the History of the Book," *Scholarly Publishing*, July, 1984, Vol. 15, No. 4, p. 331.

[53] Eisenstein, *Op. Cit.*, p. 105.

[54] *Ibid.*, p. 106.

[55] Joachim Whaley, "Gutenberg Revisited," *New Society*, Vol. 48, No. 869, p. 530.

[56] Eisenstein, *Op. Cit.,* p. 521.

fractions of a second. Specialized routines can search for word patterns (such as all five-letter words that start with “b”, followed by two consecutive vowels). This is a powerful “indexing” capability that doesn’t rely particularly on the many-to-many nature of networked computers. Encyclopedias on CD-ROMs permit quick retrieval of widely disparate entries that contain specific words or phrases. Few users of a CD-ROM encyclopedia will go back to a multiple-volume book version.

On the other hand, for several years, libraries have had the capability to electronically search for words or word combinations in the titles or keywords of documents in a wide variety of remote databases. Further details on the “hits” could be accessed as well.

What networked computers enable is the combination of these two capabilities. Anyone connected with the network can become a “super librarian,” searching remote databases via full-text search for any combination of words imaginable. Colleague Jim Gillogly tells of writing a document recently and wanting to include a half-remembered quote from “Little Women.” He accessed a distant electronic library, downloaded “Little Women,” used full-text search to find the quote, and copied it into his document; all in a matter of minutes, without leaving his chair.[57]

In the same way that indexes were only a part of the retrieval revolution in the printing press era, full-text search is part of a wider computerized search that is changing the way people access knowledge. A good example here is the variety of “search engines” for the Internet itself.[58] Developers of these engines are busily trying to outdo each other in the ability to find information on the Internet. A recent personal communication about a young woman who found her estranged father through the Internet suggests the breadth of information retrieval capabilities that such search engine developers could hope to provide. Such “data-mining” tools are still in their infancy in the network culture, but are sure to be as significant as their counterparts in the printing press culture. Libraries will undergo tremendous change in the network culture, as librarians are well aware.[59]

**Owning Knowledge: From Attribution to Copyrights to ???**

Before printing there was little “ownership” of intellectual property. The Bible is a classical example. Who wrote the Bible? Many parts that are attributed to specific authors are various rememberings of what the author actually wrote or said. The same is true with other ancient manuscripts attributed to single authors--including those of Socrates, Plato, and Aristotle. It wasn’t until the printed book that the notion of literary property rights developed. In fact, the first rights were “privileges” and were granted, not to authors, but to printers.

> “A landmark in the history of literary property rights...came in 1469 when a Venetian printer obtained a privilege to print and sell a given book for a given interval of time....”[60]

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[57]Gillogly also tells of feeling “mentally diminished” when on vacation and disconnected from the Internet for several days.

[58]Several of these are collected at the Starting Point website: http://www.stpt.com/.

[59]See, for example, the Association of Research Libraries website at: http://arl.cni.org/.

[60]*Ibid.*, p. 120 (footnote 239). It wasn’t until the Statute of Anne in 1710 that the actual copyright law was set down (in Britain).

> "By 1500, legal fictions were already being devised to accommodate the patenting of inventions and the assignment of literary properties. Upon these foundations a burgeoning bureaucracy would build a vast and complex legal structure."[61]

Eisenstein suggests that printing had a dramatic effect on personal celebrity:

> "The 'drive for fame' itself may have been affected by print-made immortality.... The wish to see one's work in print (fixed forever with one's name in card files and anthologies) is different from the desire to pen lines that could never be fixed in permanent form, might be lost forever, altered by copying, or--if truly memorable--be carried by oral transmission and assigned ultimately to 'anon'."[62]

Preserving intellectual property rights--through both 'privileges' and patents--was a notion that grew out of the one-to-many power of the printing press. Eisenstein argues that this pride of authorship helped fuel the individualism that characterized the Renaissance. She also argues that the title page came to have promotional value for both author and printer, and that control of and the requirement for the publicity apparatus gave printers an important role in the rise of capitalism.

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In recent years, copyright protection has been extended to computer software programs, highlighting the problems of copyrights and computers in general. As John Perry Barlow says in a seminal work on intellectual property and networked computers:

> "Software piracy laws are so practically unenforceable and breaking them has become so socially acceptable that only a thin minority appears compelled...to obey them.... Whenever there is such profound divergence between the law and social practice, it is not society that adapts."[63]

The pirating of software was a problem before widespread networking of computers, but, again, the many-to-many aspect of networks dramatically exacerbates the situation. It enables (some would say it encourages) the unlimited reproduction and instantaneous distribution of digitized intellectual property of any kind worldwide virtually without cost. A good joke travels even faster on the Internet than it does on the street.

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[61] *Ibid.*, p. 120.

[62] *Ibid.*, p. 121.

[63] John Perry Barlow, "Everything You Know About Intellectual Property is Wrong," *Wired*, Issue 2.03, March, 1994. Can be found as "Selling Wine Without Bottles: The Economy of Mind on the Global Net," at http://www.eff.org/pub/Intellectual_property/idea_economy.article.

> "The source of this conundrum is as simple as its solution is complex. Digital technology is detaching information from the physical plane, where property law of all sorts has always found definition. ...Throughout the history of copyrights and patents, the proprietary assertions of thinkers have been focused not on their ideas but on the expression of those ideas...Copyright worked well because, Gutenberg notwithstanding, it was hard to make a book. Furthermore, books froze their contents into a condition which was as challenging to alter as it was to reproduce. Counterfeiting or distributing counterfeit volumes were obvious and visible activities, easy enough to catch somebody in the act of doing."[64]

Copyrighting will not work on networked computers. Barlow likens copyrighting on networks to a leaking boat and suggests, colorfully, that legal efforts to adjust current canon to apply to the Internet "are taking three forms: a frenzy of deck chair rearrangement, stern warnings to the passengers that if she goes down, they will face harsh criminal penalties, and serene, glassy-eyed denial."[65] He explores several models for thinking about protection of intellectual property in the network culture. He then ends with three maxims that he believes will hold true for whatever replaces copyrights on networks:

> "- In the absence of the old containers [books], almost everything we think we know about intellectual property is wrong. We are going to have to unlearn it. We are going to have to look at information as though we'd never seen the stuff before.
> - The protections which we will develop will rely far more on ethics and technology than on law.
> - Encryption will be the technical basis for most intellectual property protection."[66]

Copyrights and patents evolved slowly in response to perceived problems of intellectual ownership emanating from the unique properties of printing. The problems introduced by networks would appear to be no less confounding. If Barlow is right, networked computers have *enabled* another period of evolution in intellectual property rights with the outcome very uncertain at this point.

**Acquiring Knowledge: From Listeners to Readers to Users**

One of the immediate and recognizable impacts of the printing press was on how one learned. In educating the elite in the scribal culture, manuscripts were scarce, learning primarily involved listening (to someone read a manuscript or give a lecture), and--as above--memorization was paramount. Apprenticeship training and memorization were the primary means of educating the underclasses.

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[64] *Ibid.*
[65] *Ibid.*
[66] *Ibid.*

That the printing press wrought significant changes in this system of learning cannot be doubted. As Eisenstein says,

> "Possibly no social revolution in European history is as fundamental as that which saw book learning (previously assigned to old men and monks) gradually become the focus of daily life during childhood, adolescence and early manhood.... As a consumer of printed materials geared to a sequence of learning stages, the growing child was subjected to a different developmental process than was the medieval apprentice, ploughboy, novice or page."[67]

The structural changes are clear. People shifted from being listeners to being readers. Learning no longer required the presence of a mentor; it could be done privately. People talk of celebrated auto-didacts such as Tycho Brahe and Isaac Newton who learned primarily by reading. Such dramatic structural changes should lead to significant societal and cultural changes, but pinning those secondary changes down is very difficult.

> "Print is credited with altering personal consciousness either by shifting communicative formats from image to word or by transferring perceptual emphasis from ear to eye. The ways in which restructured consciousnesses rearranged particular societies in particular circumstances are left maddeningly fuzzy in such theories, although this is just what we want to know in order to take printing seriously as a historical agent."[68]

Eisenstein emphasizes the difficulties by finding, for example, that despite the supposed shift from image to word, there was a reinforcement of the use of images in both printed works and art books. Similarly, while a reading public was more dispersed (and communal solidarity thereby diminished), vicarious participation in more distant events was enhanced. When subjected to careful historical scrutiny, "grand" theories about the implications of a culture of readers have been difficult to defend. More restrictive theories fare better. For example, "printed books in an educational setting signaled the abandonment of the principle that the material of knowledge and texts are dead things if they are not imprinted on the memory, or to use the biblical phrase, 'bound to the heart'."[69]

The transformation of learners from listeners to readers, then, was a complex social and cultural phenomenon. It was also incomplete. Not until the industrial era did the concept of universal literacy take root. Nonetheless, it is generally conceded that, despite the ambiguity of its effects and its incompleteness, this transformation to learning by reading was a fundamental change in a world that was going from medieval to modern. Despite the invention and widespread utilization of other

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[67]Eisenstein, *Op. Cit.*, p. 432.

[68]Carolyn Marvin, *Op. Cit.*, pp. 793-794.

[69]Birger Gerhardsson, "Memory and Manuscript: Oral Tradition and Written Transmission in Rabbinic Judaism and Early Christianity," E. Munksgaard, Copenhagen (1961), referenced in Attwood, "Book Review," *Media, Culture and Society*,(1980), Vol. 2, No. 2, p. 191.

potential education-affecting technologies such as film, radio, and television, formal learning is still largely reading based today.

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Computers, too, have the potential to affect how people interact with knowledge. In the western world, computers have inched their way into the curricula from kindergarten to graduate school. Their successes have been modest and their failures have been legion. Yet, even though we have not seen the full promise of networked computers, there are indications that they will enable a fundamentally different kind of interaction with knowledge.

The first people to deal with computers were “programmers.” As libraries of programs became available and computers became more powerful, cheaper, and friendlier, the people who interacted with them came to be called “users.” It is this notion of users that I want to develop.

Early educational computer programs had users doing “drill and practice” exercises. These were interactive, but crude and repetitive. More recent efforts have young users interacting with the computer to develop correspondence (via e-mail), keyboarding, writing, editing, and publishing skills. Current encyclopedias on CD-ROMs represent a further step in this evolution of computer interactions. Full-text search capabilities allow instantaneous access to any word in the encyclopedia. The words are hyper-linked, which gives the user easy access to greater details on a given topic, and there are thousands of pictures, and hours of multimedia maps, movies, sounds, and narrated animations available for perusal (all for under $100).

In combination, full-text search, hypertext, multimedia and similar technologies provide a capability to interact with knowledge in a way that was unattainable before computers. They provide a user access to knowledge that is multimedia oriented and less sequential than the printed book. Again, these are available on standalone computers and not dependent on networks, but a CD-ROM in this context is just a “superbook”--frozen at production. Connecting with the network adds three capabilities: access to a much wider array of knowledge, the potential for access to constantly-updated knowledge, and on-line help (today in the form of news groups and individuals that are available to answer questions). Serious questions asked in today’s newsgroups rarely go unanswered.

Consider the auto-didact in the world of networked computers. These capabilities open up the possibility of just-in-time learning--having the ability to access information on a topic of immediate concern (the best time for learning) in ways that are self-paced and matched to a variety of learning styles. It is not too far fetched to talk about the shift from a ‘reader’ of printed knowledge to a much more interactively involved ‘user’ of knowledge and of other users (many-to-many).

Whether these capabilities will be available on the “ultimate” network of computers or will be widely utilized are separate questions. It is clear from today’s technology and industry focus, however, that networked computers *enable* a much more interactive user of knowledge. Further, that ability to interact is unique to the many-to-many communications era.

**PARALLEL #3: THE DOMINANCE OF UNINTENDED CONSEQUENCES**

Every successful technology has unintended consequences. Sometimes the consequences are an inconvenience--cellular phones have created a tremendous burden on Forest Rangers because of the number of hikers who call asking for directions or assistance. Sometimes the unintended consequences are more serious--microwave ovens can be fatal for people with heart pacemakers. And sometimes the unintended consequences come to dominate the intended ones--Edward Tenner, for example, writes of methods for preventing forest fires that have been so effective in preserving dry underbrush that wildfires are now enormous conflagrations, destroying forests that survived lesser fires for centuries.[70] I'll argue here that the printing press belongs in that latter class. We are also seeing some provocative unintended consequences surrounding networking technologies.

In the printing press era, there were efforts in both religion and science to "clean up the manuscripts"; to take the now-available copies of a variety of manuscripts and to edit and correct them into a clean copy. Briefly, the effort in religion was a failure; that in science, a success. But the more significant outcome was that, in each case, the effort to clean up the manuscript helped send its respective discipline on an importantly new trajectory.

> "Copernicus...was cast in much the same role as was Erasmus who had set out to re-do the work of Saint Jerome. Both men set out to fulfill traditional programs: to emend the Bible and reform the Church; to emend the *Almagest* and help with calendar reform; but both used means that were untraditional and this propelled their work in an unconventional direction, so that they broke new paths in the very act of seeking to achieve old goals."[71]

The work of Erasmus paved the way for the Protestant Reformation and the work of Copernicus upset the entirety of Medieval cosmology. One can argue a variety of other major and minor unintended consequences, but these two absolutely dominated their respective intended consequences and arguably helped bring the European nation-states to world power.

Has anything similar happened in the network age? Chris Kedzie argues there are causative links between democracy and interconnectivity.[72] He suggests that governments who try to squelch the new information technologies to protect their monopoly on power do so at the peril of economic growth. He cites the Soviet Union having introduced or allowed new information technologies for economic reasons and found they played a role in supporting the emergence of democracy.

Less arguable are some dominating unintended consequences associated with the networking technology itself. Two have already been alluded to. The

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[70] Edward Tenner, *Technology and the Revenge of Unintended Consequences*, Knopf, New York, 1996.

[71] *Ibid*., p. 693.

[72] Christopher R. Kedzie, *Communication and Democracy: Coincident Revolutions and the Emergent Dictator's Dilemma*, RGSD-127, RAND Graduate School, 1997.

original intent of ARPANET was to share computational resources at a distance. By its second year of operation, users had “warped the computer-sharing network into a dedicated, high-speed, federally subsidized electronic post-office.”[73] The physicists at CERN who developed HTML were not trying to develop a WorldWide Web. Even Paul Baran, although he recognized early on that packet switching could lead to a large domestic communications net, was originally intent on developing a network that could withstand a nuclear attack. A fourth dominating unintended consequence may be in the making. The Java language, that some suggest will dominate applications on the WorldWide Web and could bring the downfall of Microsoft,[74] was originally developed for programming consumer electronic gadgets.

In the information age, then, we are already seeing some examples of the dominance of unintended consequences over intended ones. Particularly in light of similarities with the printing press era, it would be surprising indeed if there weren't more dominating unintended consequences to come. This is not to suggest that we shouldn't take action for fear of unintended consequences. Far from it. It is to suggest that we are beyond our cause-and-effect reasoning abilities when it comes to networked computers and that we should be prepared for--and actively seeking--unintended consequences of actions we do take.

**AFTERTHOUGHTS**

So far I’ve concentrated on what networked computers enable on the “bright” side of the parallels with the printing press era. It is worth digressing briefly to mention two other aspects: 1) what networks enable on the “dark” side, and 2) what they might enable that have no good printing press parallels.

There was a dark side to the printing press. Eisenstein mentions it only briefly (and then fences it off from further discussion), but there were propaganda wars, secret societies, and other abuses that were created or enhanced by the capabilities of the printing press.

Without trying to draw specific parallels in this area, we are already seeing some of the dark side of networked computers. Colleague Jim Gillogly has catalogued some of the more egregious:

- new and interesting ways of breaking into computer systems are being circulated both openly and covertly,
- chain letters (that are both illegal and bandwidth intensive) are multiplying on the net at an alarming rate,
- “roboposters”--one of whom automatically responds to any message that contains the words Turkey or Armenia with messages about the Armenian genocide of Turks (yes, it was the other way around)--are a growing aggravation,

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[73]Sterling, *Op. Cit.*

[74]"Rival's Wave of Hot Java has Microsoft Steaming," *Los Angeles Times*, October 1, 1997, p. A1.

- posters are starting to “spam” (sending messages to ALL newsgroups) with irrelevant advertisements, interest group messages, etc.,
- posters are locating addresses of people (and those of their neighbors) who have aggrieved them in some way, and asking others on the Internet to harass them (and to tell their neighbors what terrible people they are),
- “trollers” are posting to newsgroups for the purpose of starting “flame” (angry message exchange) wars,
- there is a thriving pornography traffic (with celebrated--and much discussed--prosecutions under federal statutes),
- posters continue to send increasingly clever viruses (with the worst of them intended to damage the contents of other computers),
- people are developing ways to intercept messages that have been sent and prevent them from reaching their destination.

This small sampling is included here to point out: 1) the obvious--that not all uses of networks are high-minded, and 2) that it might be worth trying to sort out those abuses that are common to other new communications media (such as telephones, CB radios, video cameras, etc.)--and for which there are “solutions” that would transfer to networks--from those that appear to be unique to networks.

The more entertaining digression deals with those things networks enable that have no apparent parallel in the printing press. An example from Gillogly will suffice:

> “Fifteen years ago at Carnegie-Mellon University we snickered at our sophistication when we put our Coke machine on the ARPANET -- you could finger it to find out what drinks were out, and how recently it had been loaded so we could estimate how cold the last ones were. Since then many appliances have showed up on the net, including the Prancing Pony food dispenser at Stanford and more sophisticated drink machines that monitor the actual rather than estimated temperature of the Cokes.”[75]

While these connections have the flavor of clever tricks, interfacing with machines other than computers (or the computers of other machines) opens up a potentially interesting complication in divining the impact of networks.[76] It also opens the door for similar speculations about things networks might enable that have no precedent.

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[75] Jim Gillogly, e-mail communication. For a collection of devices attached to the web, see http://www.yahoo.com/Computers_and_Internet/Internet/Entertainment/Interesting_Devices_Connected_to_the_Net/. Devices include pagers, robots, soda machines, spy cameras (over 300), clocks, coffee machines, and a wine cellar.

[76] See also, Birnbaum, *Op. Cit.*

## SUMMARY

There are some provocative parallels between the communications changes enabled by networked computers and those enabled by the printing press in its early days. Each defining technology represents an important breakthrough in the ability of humans to communicate with each other; each enables important changes in how we preserve, update and disseminate knowledge; how we retrieve knowledge; the ownership of knowledge; and how we acquire knowledge. The printing press era was dominated by unintended consequences of applications of the technology and we are already seeing the dominance of unintended consequences in some areas of networked computers. Despite the strength of the parallels between the two eras, it would be unwarranted to conclude that the network era will progress as did the printing press era. However, the strength of the parallels does suggest that: 1) networked computers could produce profound cultural changes in our time, 2) unintended consequences are not only possible but likely to upset conventional extrapolations of current trends (or even historical parallels), and 3) the changes could take decades to see clearly. Further, the strength of the parallels suggests some "lessons learned" from the printing press era would make for prudent policy today.

## GENERAL IMPLICATIONS FOR MAKING POLICY

The parallels discussed here between the printing press era and the networked computer era suggest at least two important implications for policy making.

The first has to do with regulation of networked computers or the Internet. For this it is particularly instructive to look at the printing press and its effect (or lack thereof) outside Europe. After all, the first movable type (of baked clay) was made in China in 1045 AD; the first practical wooden movable type was also developed in China around 1300 AD; and the first *metal* movable type preceded that (in Korea in the thirteenth century).[77] If the printing press is such a causative agent, why didn't it transform other cultures as it did those in Europe? Eisenstein largely ignores this aspect of the problem, but more recent work has addressed it. Some examples will provide a flavor of their findings.

Several authors point out the obvious difficulty in China--the thousands of ideograms required by written Chinese made printing on a large scale impractical. Macioti adds[78] that Chinese inks were watery and not well suited to metal type. Korea is even more interesting. At the prodding of King Sejong in 1446, an alphabet of twenty-five letters was developed. Korean printers and scholars, however, stubbornly hung on to traditional Chinese characters, perhaps depriving themselves of a Renaissance and Scientific Revolution. In the Islamic community--seat of scientific progress from 750 to 1100 AD--great Islamic empires arose about the time of the printing press and effectively suppressed that technology until the nineteenth century, when it did transform the culture. Robinson speculates that printing

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[77] Manfredo Macioti, "Innovation and Diffusion of Technology: an Example of the Printing Press", *Impact of Science on Society* (1989), no. 154, p. 144.

[78] *Ibid.*

threatened the fundamental oral transmission of the Quran, delaying introduction of the printing press into Islamic culture for four centuries.[79]

Even in Europe, the role of Protestantism in the Scientific Revolution is instructive. In centralized Roman Catholic countries, censorship of Copernicus and others seriously affected printers; but in Protestant countries with weaker central governments, there were no risks involved in printing science. It was primarily Protestant Dutch printers that kept the Scientific Revolution alive in the early 17th century.

Countries that failed to take advantage of the printing press fell behind Europe. Those that strictly suppressed the printing press fell were eclipsed on the world stage. Even in Europe, countries that tried to suppress "dangerous" aspects of the printing press suffered. This strongly suggests that the advantages of the printing press outweighed the disadvantages. Further, it suggests that, in retrospect, it was more important to explore the upside of the technology than to protect against the downside. In the information age this suggests to me that **the Internet should remain unregulated**. The printing press was and is regulated to some extent, but those countries that regulated the printing press least gained the most. This should be a powerful argument in favor of regulating the Internet as little as possible. We should work through the problems of pornography, copyright protection and other such problems, rather than risk throwing the baby out with the bath water.

The second general implication is more diffuse. To suggest adopting a **policy of experimentation, paying particular attention to unintended consequences,** seems weak gruel indeed from such supposedly powerful parallels. This isn't just a call for more R&D or more pilot projects, however (though both could result). Rather, this recommendation comes from an explicit recognition of the possibility that unintended consequences are likely to dominate in the information age and from a sense that--as with the printing press--this is a long term enterprise with success most likely going to those who have explored the possibilities most thoroughly.

If the future is to be dominated by unintended consequences, it would be a good idea to get to those consequences as quickly as possible and to work to recognize them when they appear. In some cases this won't be a problem. It certainly wasn't with email--people quickly took advantage of it; similarly with HTML and the possibilities of the WorldWide Web. Where working to spot and take advantage of unintended consequences becomes a more telling implication is with regard to institutions--such as the educational system or the government--that move slowly and risk being overrun by those unintended consequences as was the Catholic Church in the printing press era.

How then, can a policy of experimentation help? An interesting example comes from the way the Internet adopts new technical standards.[80] Most standards groups work top-down, toward *de jure* standards, and strive to solve problems with the greatest possible generality and for the longest term possible. As an accident of history Internet standards have been largely bottom-up, *de facto*, narrowly focused

[79]Francis Robinson, “Technology and Religious Change: Islam and the Impact of Print,” *Modern Asian Studies* (1993), Vol. 27, No. 1, pp. 229-251.

[80]The following is taken largely from D. Crocker, "Making Standards the IETF Way," *StandardView*, Association for Computing Machinery, Vol. 1. No. 1, 1993, pp. 48-56.

and near-term. This should make its specifications rigid and short-lived, but the experience has been different and the reasons for that are instructive.

The general problem of Internet standards is handled by the Internet Engineering Task Force (IETF). Its general mode of operation is to convene working groups to solve near-term technical difficulties. The process takes advantage of the many-to-many capabilities of the Internet in at least three important ways: First, the working groups largely do their work (open to anyone) on the Internet which enormously increases the number and diversity of people who can contribute. Second, proposed solutions are made available to anyone with Internet access. This is in marked contrast with other standards organizations and permits better analysis and broader use. Third, "The Internet, itself, provides a very large scale live test environment and as is often true with software, once it passes the test it is instantly used in production. If a working group's efforts are not useful, this is quickly evident before the work is made into a standard."[81]

It remains to be seen whether this approach to standards will be short-lived (though the approach is still largely used even as the Internet has grown to mammoth proportions), whether it is an artifact of the Internet technologies, or whether the many-to-many capabilities are that crucial to its success. Nonetheless, it stands as a provocative example of how small-scale experimentation coupled with the many-to-many capabilities of the Internet have produced important results in a manner that confounds traditional thinking. It is this kind of small, open experimentation that takes advantage of the Internet that is, for me, an important implication of the parallels between the era of networked computers and that of the printing press.

The final implication is more personal. A more thoroughgoing exploration of the parallels between the printing press era and the information age may reveal further insights into policy making. This is particularly true in the area least explored by Eisenstein--the negative consequences of the printing press, including the spread of pornography, secret societies and the like. How they were handled in that day may yield suggestions for how to deal with similar problems today.

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[81] *Ibid.*