ABSTRACT
         This publication contains six essays responding to
the following themes: information as a resource to be shared; whether
and how new technologies are causing change in the nature and
definition of information; and how changes are affecting the fields
of education, economics, sociology, technology, business, and world
affairs. Following the foreword (Paul J. Myer), examples of the range
of information available to everyone are reviewed in an introduction
to the essays (Nicholas Johnson). The value of information is
discussed in "The Role of Technology in an Information Age" (Stephen
H. Haeckel and Richard L. Nolan). "The Economics of Information"
(Roger G. Noll) provides a readable introduction to the subject for
noneconomists. "Competing with Information" (Blake Ives and Sirkka L.
Jarvenpaa) provides a theoretical base and a case study for
conclusions about the nature of information for business, predicting
information and expertise will supplant physical goods as the basis
of developed nations' economies. "The Promise of a New World
Information Order" (Peter F. Cowhey and M. Margaret McKeown)
addresses issues such as the utility of the content of global
communications. "Technology, Information, and Social Behavior" (Sara
B. Kiesler and Pamela Hinds) suggests that it may be as important to
study people as information technology itself. "Network Literacy in
an Electronic Society" (Charles R. McClure) describes the educational
implications of the changing nature of information. (KRN)

Institute for
Information
Studies

THE
KNOWLEDGE
ECONOMY

The Nature of Information
in the 21st Century

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Annual Review of the
Institute for Information Studies

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The Institute for Information Studies was established in 1987 by Northern Telecom in association with The Aspen Institute, a prestigious international center for the study of the humanities and public policy alternatives. IIS programs recognize the increasingly significant role and responsibility of senior executives in leveraging the information assets, as well as formulating the strategic direction of the enterprise. Through discussions and workshops on vision and change within an organization, the program focuses on the importance of information communication in business, and addresses the impact of business principles on the individual, community, and society.

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FOREWORD

O chestnut tree, great rooted blossomer,
Are you the leaf, the blossom or the bole?
O body swayed to music, O brightening glance,
How can we know the dancer from the dance?
"Among School Children"
William Butler Yeats

As Yeats's famous poem shows that the tree's leaf, trunk, and blossom are actually manifestations of a single organism, so the borders between information, knowledge, and wisdom are not clearly delineated. And as a choreographer's marks in a notebook are meaningless without the disciplined human body to give them life, information is meaningless without human intelligence to give it form and coherence.

Certainly one of the most significant challenges confronting us today is that of transforming information into knowledge. There is a hierarchical progress in this transformation, beginning with technology that enables us to to collect, store, and manipulate data. From data, we assimilate information. With information we must progress to knowledge or understanding. Ultimately, we hope to gain wisdom, here defined as the capacity for informed, sound, effective judgment.

A visitor to the Ford Motor Company factory happened to meet Henry Ford himself. The visitor admired a finished automobile. Ford proudly declared, "There are exactly four thousand, seven hundred and nineteen parts in that model." Impressed with the top man's degree of involvement and grasp of detail, the visitor later asked a Ford engineer if the figure was accurate. The engineer shrugged and said, "I don't know. I can't imagine a more useless piece of information." Ford had information. The engineer had knowledge.

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As technology builds on earlier technological breakthroughs, the changes it effects in peoples' lives diminish from the the climactic to the incremental. Whereas a new invention may revolutionize a procedure, even open an entirely new realm of activity, the impact of subsequent developments in the same arena shrinks, simply yielding gains in speed, volume, and scale.

This rule holds whether we are contemplating the evolution of the horseless carriage, the computer, or the airplane, from its invention and subsequent development toward faster, more commercially available air transportation. Becoming airborne was a stunning achievement. Less so is crossing the Atlantic in 24 hours versus three weeks on a ship, or eight hours by commercial jet today, or even three on the Concorde.

Moreover, as Taichi Sakaiya demonstrates in *The Knowledge-Value Revolution, or A History of the Future*, as changes and improvements in a technology become less dramatic, the next phase of development yields diversification, conservation of resources, and the diffusion of intelligence or function. We are at this juncture with information technology; will we be able to bridge the gap to knowledge and ultimately to wisdom?

Information is the new enabler, beyond matter and energy. But it brings a cauldron of conflict and confusion. In *The Executive's Compass: Business and the Good Society*, James O'Toole identifies "an implosion of the speed of global communication, and a simultaneous centrifugal explosion of information." Hence, despite the fact that they are becoming more interdependent, managers and individuals have access to information that will enable them to make more independent decisions. Can they learn to collaborate rather than compete? Can we evolve the wisdom that will afford us distance on today's conundrums?

Very soon the commodity that will exist in abundance, and be most valued and sought after, is information. Much work is no longer physical, no longer consisting of manipulating matter, of matter being transformed into other matter, matter into energy, or energy into matter. Yet we are trying to deal with problems generated in our age with tools, techniques, and philopsophies generated by an older one, the aftermath of the Industrial Revolution, with its drive toward mass production, consumption of resources, and accumulation of wealth.

Must we not expect a discontinuity? In order for us to deal with information's massive quantity and speed of delivery, we must seek and create organizing principles.

As Russell Ackoff points out in "The Second Industrial Revolution," the invention of the telegraph, the telephone, and the computer set us on a different path. These instruments perform no physical labor: they manipulate and/or transmit symbols—language, numbers—which communicate or represent information, giving us the components for mental work, or thought. Though 93 watts of power are required to operate a personal computer, and only four watts are consumed when the human brain is engaged in deep thought, there still remain some higher modes of information assimilation which can be performed only by humans. Only humans can furnish organizing principles.

Parallel developments include the wireless, the radio, and the television, as well as the gramophone and moving pictures. These technologies, as Taichi Sakaiya points out, like all technologies at their inception, were employed only to improve upon the limited purposes previously conceived: documenting serious information needed by government or business. It was only later that the potential of these technologies in the entertainment field was grasped. They have undeniably transformed our popular culture in the 20th century.

We have the ability through technology to store, process, and disseminate information on an incomparably vaster scale. And information has several unique qualities: It can be used by a number of individuals or groups at one time; it is not dissipated by use; and it can be given and retained simultaneously.

As we move into the 21st century, sorting out the role of information in our collective future, we note that raw materials and the processing of them into other articles will continue to decrease in value, but that knowledge value—that *particular element added by humans employing information and judgment*—will increase. It is areas such as design, new technology, and image making—areas that require human creativity—that will rise in value.

The Institute for Information Studies provides a forum for business and government leaders, scholars, and thinkers to explore, elucidate, and discover the organizing principles we must have to manage through the labyrinth. One of the foremost tools the Institute provides for this mental journey into the future is the *Annual Review*, a collection of

sponsored research from leading scholars addressing issues on infor-
mation and its use and impact from various perspectives. It is our in-
tent that this edition provide a window into the thought of tomorrow
on "The Knowledge Economy: The Nature of Information in the
21st Century."

Paul J. Myer
Vice President
Integrated Marketing
Communications
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INTRODUCTION

THE NATURE OF INFORMATION

I

This is the fifth *Annual Review of the Institute for Information Studies*. Previous *Reviews* in this series have dealt with such topics as universal service and the national telecommunications infrastructure. They have been useful and well received. But "information is our middle name," and in all those years the Institute has never before actually dealt with "the nature of information." Can it be done? As 1992 presidential candidate Ross Perot might have put it: "We can do it, but it won't be pretty."

The authors of this year's *Annual Review*—and the participants at The Aspen Institute River House conference held to discuss early drafts—have made a first effort to get their arms around this marshmallow of a topic. (The names of participants are listed elsewhere in this volume.) Authors and participants have chosen to leave to the reader any aesthetic judgments as to how "pretty" the results may be.

But we would also be the first to hope, and believe, that the reader will find between these covers ideas and insights (and "information") of profound practical application in business, government, military, academic, and other institutions—and in daily life.

The challenging theme of this year's *Review* was put to the authors and conference participants in this way:

The theme . . . is the nature of information. Within it we hope to examine information as a commons, a resource to be shared, not owned; to consider whether and how the availability of and

access to new technologies are causing or influencing change
in the nature and definition of information; to demonstrate how
these changes are affecting the fields of education, economics,
sociology, technology, business, and world affairs.

The reader should know, as do the authors, that these essays repre-
sent no more than a first attempt to deal with such a theme. So, to those
who ask why we have "just scratched the surface," we respond with the
insight of anyone who has ever been bitten by a mosquito—whether of
the Maryland Eastern Shore variety or not—"What is there to scratch
but the surface?" The authors and conference participants believe this
task, which they have begun, needs to be, and should be, continued. The
implications for our international competitiveness and domestic well-
being are obvious.

This volume contains six informative and provocative essays that
do, in fact, go well beyond the surface. They represent the insights of
individuals who combine both intellectual rigor and the practical
realities of life in the information age. They also represent whatever
revisions the authors thought necessary as a result of the participants'
critiques at the River House sessions June 24 and 25, 1993.

II

Radio personality Michael Feldman of Madison, Wisconsin, in-
cludes in his program of humor, commentary, and quiz questions a
category he calls "things you would have learned in school if you had
been paying attention." This volume, like Feldman's program, is de-
signed for readers who, while curious and informed—and educated—
may not always have been paying attention.

Stephen H. Haeckel of IBM's Advanced Business Institute, and
Professor Richard L. Nolan of Harvard's Graduate School of Business
Administration, open this volume with an exploration of what they call
"transforming symbols into action." In doing so they address, among
many other things, the *value* of information, note the distinction
between the "potential value" of information and what they call its
"value in use." The latter, they note, is a function of its "applicability,
accuracy, timeliness, completeness, ease of use and access, and 'inte-
grate-ability' by a user."

They use the analogy of the OODA loop (observation, orientation, decision, and action) of the fighter pilot "flying by wire." In today's fighter planes, events (that is, information about those events) come faster than a human's sensory capacity can comprehend. Thus, information technology is used to make it possible for a human to participate in "flying" such a plane. It is accomplished because, as the authors note, "The pilot is not flying the plane, but an informational representation of it." This is called "flying by wire," something the authors suggest is a useful way of thinking about the demands on (and opportunities for) today's institutional "managers."

In the spirit of Michael Feldman, Professor Roger G. Noll, a Stanford economist, provides an intriguing and very readable introduction to the economics of information designed for those of us who are not economists, forgot what we once knew, or weren't paying attention in the first place. Besides, even if we were paying attention, it's unlikely our professor was talking about the economics of *information* when we were in school, let alone in the way that Professor Noll does.

A couple of Texans next take on the implications of the nature of information for business. Blake Ives is at the Cox School of Business at SMU; Sirkka L. Jarvenpaa is at the University of Texas Graduate School of Business in Austin. What does it mean to be in business when "information" becomes not only the product but the organization (or lack thereof)? In commendable business school fashion, they provide both the theoretical bases for their conclusions and a case study: the case of the hypothetical Global Petroleum Services. As Ives and Jarvenpaa put it, "The buying and selling of expertise and information will, over time, supplant physical goods as the basis of developed nations' economies."

UCSD Professor Peter F. Cowhey and M. Margaret McKeown, a partner in the Seattle firm of Perkins Coie, have authored the next paper, "The Promise of a New World Information Order." Their paper is a response to the "world affairs" element in the charge to the group.

Upon hearing of the plan to build a telegraph line between Maine and Texas, Henry David Thoreau wrote in the first chapter of *Walden*, "We are in great haste to construct a magnetic telegraph from Maine to Texas; but Maine and Texas, it may be, have nothing important to communicate."

That is among the questions Cowhey and McKeown attempt to address. As we approach the time when every global citizen can communicate

with (provide information content to) every other resident of the planet, how can we maximize the utility of that content? Have we been focusing more on the wonders of the electronic toys and tracks than their cargo? Is "the market" an adequate mechanism for equitable distribution to the "information rich" and "information poor" alike? If not, is there a role for governments in effecting fundamental fairness in the information age?

The "sociology" component falls to Professor Sara Kiesler and doctoral candidate Pamela Hinds, both of Carnegie-Mellon University. In their essay, "Technology, Information, and Social Behavior," they explore a variety of contexts in which the members of the human species who are, after all, using this technology, have as much impact as the technology itself. "Information technology" is not just about "lights and wires in a box," as Edward R. Murrow once noted of television. The examples will likely lead the reader to their conclusion that "it may be as important to study people as the technology itself."

In the final essay, "Network Literacy in an Electronic Society: An Educational Disconnect?" Syracuse Professor Charles R. McClure deals with educational implications of the changing nature of information. He uses the information resources available through the network of computer networks called the "Internet" to make the important point that there is considerably more than one kind of "literacy" in the information age. "Reading Is Fundamental," to borrow from the name of a program designed to increase Americans' literacy, but it is apparently not enough for the overeducated owners of VCRs who have access to printed operation manuals, and can read, but can't figure out how to program the devices to stop flashing "12:00."

To make use of what the Internet offers, not only must one know how to read (including computer manuals), but one must know about computer communications (and modems) in particular, something of the UNIX operating system, the general structure of the Internet, how to get access to it, how to navigate the Internet with commands (like "Archie" and "WAIS" and "anonymous ftp")—and perhaps most difficult, how to make sense out of what has been retrieved (say, data from the spacecraft Voyager) once in one's mainframe account or personal computer. Obviously, in a global sense, there are then the added hurdles associated with multiple "foreign" languages and alphabets.

By now it should be obvious that these essays really do considerably more than scratch the surface, and that no summaries can do them justice.

Read them. Scan if you must. It is sometimes said that one must bring to good poetry 90 percent of what one will carry away. But oh, that 10 percent! None of the authors believes this is a volume of good poetry. But they have provided a marvelous catalyst for the curious and thoughtful reader's creativity. The more the reader brings to this volume, the more time and thought he or she is willing to give to it, the more will be taken away.

<p style="text-align:center">**III**</p>

As we struggle with the nature of information we are somewhat like the six blind persons describing an elephant—while each feels a different part of it. In our case, those are the parts of information characterized in the theme of the *Review* as "education, economics, sociology, technology, business, and world affairs."

In the spirit of feeling this elephant called information, this opening essay will consume a few more pages with observations from yet a seventh point of view. Hopefully, it may be a useful overview of sorts of the elephant these essays attempt to describe.

The Nature of Information

To discuss the nature of information is a task not unlike that posed in the classic undergraduate essay question: "Describe the nature of the universe and give two examples." After all, the gathering and processing of sensory input, and the creation and manipulation of symbols about that input, is what it is we humans do, as a species, that distinguishes us from other plant and animal life on earth. And all five to six billion of us do it constantly, many thousands of times a day each, from birth to death, in virtually every situation in which we find ourselves.

So before attempting to formulate anything as exalted as a "general theory of information," perhaps the subject should be set up by reviewing a random sampling of some very common examples of the range of information familiar to all. Like the man who was so thrilled to find out he had been speaking prose all his life, we may be surprised when first considering the routine of our daily lives as rising to the level of information. And yet, surely those experiences should be included. Here are some examples, selected in the most random way imaginable from thousands of possibilities.

<p style="text-align:center">*1* 4</p>

Sensing without symbols. We step outside and sense, from temperature, humidity, and sky, that we'd better take an umbrella. We first feel, rather than see, that mosquito on our forearm and swat at it. We smell a container of leftovers from the refrigerator and decide, whatever it may once have been, it is now spoiled and should be thrown out. No words are spoken, no symbols created, but information is clearly involved.

Being able to "read" nature, whether animal tracks, weather, or landmarks, is a kind of information-gathering we associate with Native Americans, farmers, or those who enjoy fishing. Being able to "read" a green, or fairway, is another kind of outdoor literacy.

Simple technological aids to sensing. We get information from our equipment: the thermometer in the Thanksgiving turkey, our car's gasoline gauge, the timer on the clothes dryer. We glance, take in the information, and alter our behavior accordingly without giving a lot of thought to the "information processing" that is going on.

The signs of our species. Humans' signs are everywhere. Sale. Scenic Overlook Next Right. $29.95. Hours 9 to 9. Now showing. Exit. Some, like a stop light, are symbolic systems without words.

Whatever they are, when we are seeking the information they provide they can be valuable help indeed. When we are not, however, they become "ugly billboards" or a contribution to our "information overload."

Conversation. Much of the information we seek we get from conversation with each other. It's practical, serves an immediate purpose, and is often of only short-lived value. "Where's a good place to eat around here?" And, once there, "Where are the restrooms?" "Is it supposed to rain today?" "How'd the game come out?" "Do we have class tomorrow?"

Other, relatively informal, conversations—whether with acquaintances or strangers—may provide information of more long-lasting value. Then again, they may not.

A seat mate's life story may provide insights into the human condition, and fascinating entertainment, during a long trip by plane or car. Or it may just be a boring, self-indulgent monologue. A chance exchange between customers at a lunch counter may lead to a

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salesperson's newest lead, or an otherwise unknown opportunity for employment. Chatting with a neighbor may lead to the discovery of a shared interest, and practical solutions to frustrations with a computer program or leaky basement. Morning coffee may produce insights into a marital problem, based on a coworker's sharing of personal experience and insights.

Manuals. Manuals accompanying equipment—sometimes only a few pages or less—scarcely rise to the level of "education" or even "training." But they provide information when we need it (though not necessarily in the form we would prefer) to resolve a particular problem: assembling a wheelbarrow, installing new word processing software— or figuring out how to make a VCR stop flashing "12:00."

Transactional information. What I will call "transactional information" makes up a great proportion of what employees and customers exchange.

The elements are present when someone strolling along a busy city sidewalk asks a street vendor, "How much for that ring?" Or a customer in a small-town hardware store asks the clerk, "Do you have any RG-58 coax cable?" and is either told where it is or that the store is out of stock—and, if so, very likely where else in town it may be available ("Have you tried Radio Shack?"). The clerk (who may, in that instance, be the owner), either knows the answer from recent examination, or physically makes a trip to the stock room to find out.

Today much of that information involves the use of global networks of 800 numbers, credit card verification systems, computer terminals, and very large real-time electronic data bases. Increasingly, it may involve direct connection between the customer and the firm's information system—as when a subscriber dials a long-distance phone number or gets cash from an automatic teller machine (tasks formerly requiring employees).

But the most common transaction involves a company employee, whose work involves continuous matching of somewhat similar information from, on the one hand, customers, and, on the other, company data bases. The nature of this information can be perceived from the vantage point of the customer, the employee, or perhaps the data bases used by one or both of them.

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The transaction may even begin by the customer calling 800-555-1212—the 800-number that provides a human to "look up" other 800 numbers (actually, to access and then switch the inquirer to a computer-generated voice). Once the customer is connected to the company supplying the goods, services, or information desired, she or he may first deal with routing information—what office location, department, or individual is most appropriate to their request. This may be handled by a human receptionist or operator. As likely, today, it will be a computer-generated and controlled series of questions requiring touch-tone responses from the customer's computer terminal—the keypad we today still call a "telephone." (Although relatively uncommon for individual consumers, it is also possible the entire transaction involves computer-to-computer communication from the customer's computer we *do* call a computer directly into the firm's computer. Indeed, large firms' dealers and suppliers are increasingly finding that the only way to order, or bill.)

Once the connection is made between the human customer and the most appropriate human employee the information necessary to the transaction is exchanged. The answer to "Your name?" may result in the employee calling up on a computer screen, and repeating to the customer for verification, the customer's billing and shipping addresses. The customer may refer to catalog item numbers that correspond with those in the employee's computer, and then provide a Visa or other credit card number—which the employee, in turn, may quickly run through the Visa electronic network for credit verification.

Something similar occurs when a customer makes theater, airline, rental car, or hotel reservations, or calls a local merchant and asks if a particular item is in stock and how much it is.

Transaction-related information might also be thought to include the items we may exchange when meeting someone we will want to contact again: "What's your phone number?" or "Do you have a card?" It may involve future luncheon plans: "What day next week would be good for you?"

The reader can undoubtedly think of hundreds of more, and very likely better, examples of the range of situations and types of information that make up the day-to-day life of a member of our symbol-creating species.

Imagine if you will the task of describing the nature of the internal combustion engine, and the range of its uses. It would require a description of everything from diesel locomotives to small portable electric generators, from 18-wheelers to power lawn mowers or leaf blowers. The nature of information is no less daunting.

So as a concession to the shortness of life, and the virtually limitless list of potential examples, we now pause in the middle of that task and take the leap of extrapolation and imagination that may permit the identification of some general categories and principles.

Categories

We have already identified a number of categories of information: raw sensory input, data from low-tech sensors, signs, conversation, and institutional transactions. What might be some others?

Consumer information. Consumers may seek *pretransaction* product or service information from advertising, catalogs, *Consumer Reports,* the public library—or conversation with others.

Institutional operations. Any institution—corporate, government, academic—is, as Ives and Jarvenpaa illustrate, a network of rapidly moving information of all kinds. For purposes of this category we exclude the information used in transactions with customers (which we have already identified) and the "management information" used in administration. Institutional operations information would include personnel records and manuals, training programs and texts, employee newsletters and notices on bulletin boards, and e-mail systems for internal communication.

Management information. So much has been written about the information needs of management, and "management information systems" and "command and control," that little need be added here to what the business literature would often leave one believing is the only form of information. Whether one is "managing by wire," as Haeckel and Nolan would have it, or in the old-fashioned way, management information is that which an administrator needs to track and direct a collection of individuals toward group goals. It may involve information about costs and sales, projects on and off schedule, as well as general information about the state of the economy and the political environment.

Applied research. Research and development (usually called simply "R&D") is yet another corporate information gathering and processing activity. Most broadly defined it could involve the test marketing of a new corporate logo or product packaging. It might involve the search for a new gasoline additive—or petroleum reserve. Someone may be trying to improve a strain of corn—or a stain in paint. Such activities involve yet another type of, and use for, information—one that bears a great resemblance to formal education.

Education. Formal education—K–12, community colleges, private small colleges and major research universities—is big business in its own right involving millions of citizens and billions of dollars. Some of the participants are motivated by a genuine intellectual curiosity and joy of learning. Others are simply interested in getting jobs that pay more than those in which the most common question asked of customers is, "Would you like fries with that?" Since we have not yet made the "data, information, knowledge, wisdom" distinctions we can treat the commodity of this industry as another category of information.

Training. Distinctions between *education* and *training* are a little silly perhaps; how should one most properly categorize barber school—or law and medical school for that matter? In any event, the category is being used here to describe the acquisition of function- or product-specific information to be used for an immediate and specific purpose, most often on-the job and after one's formal education is over. (*Training* would therefore include the relatively formal "continuing professional education" requirements imposed on a number of professions.) It might involve an informal bit of instruction, perhaps by a secretary for the "boss," on how to operate the new, computerized copy machine. It might involve months of quite rigorous and formal instruction, complete with simulators, on how to "fly by wire" one of the fighter planes of which Haeckel and Nolan have written. A sales force has to learn enough about the new product line to sell it. The assembly-line worker has to know how to operate (and perhaps repair) the new robots.

Hobbies and recreation. What is most often the self-study involved in recreational activities is, in some ways, the closest many of us get to

genuine intellectual curiosity. Formal education may not fully engage the student. On-the-job training mandates minimal attentiveness and mastery, but isn't exactly fun. But those who are learning to sail, or fly a plane, or improve their photographic technique or golf swing, or upgrade an amateur radio license, approach learning and information in a different way. It *is* fun; and when the fun stops they may stop doing it, because it is otherwise an almost totally useless undertaking. It not only doesn't pay money, it costs money. It doesn't save time, it takes time.

Entertainment. For this purpose, *entertainment* is distinguished from hobbies. Entertainment involves the relatively passive activity of watching and listening to audiovisual media: television, radio, movie theaters, videotapes, and the various media used for music reproduction. Video and computer games involve considerably more interaction and skill development but are still classed as relatively passive entertainment for this purpose. When virtual reality offerings become more readily and commercially available they would be included here. The information represented by such entertainment is, of course, an enormous, multibillion-dollar global industry. It is for our purposes, however, just one more category of information.

Qualities

Although far from exhaustive, the above examples give a sense of the concept and breadth of range of categories of information we might identify. But such information, regardless of category, can be thought of in a second dimension as well: qualities of information.

Accuracy. There is a distinction between information and accurate information, between precision and truth. A malfunctioning digital thermometer or bathroom scale may continue to be quite precise—it just happens to be precisely wrong. A juicy newspaper story, replete with details, may turn out to be sufficiently erroneous to support a defamation action. There are still debates about the accuracy and adequacy of the "management information" provided President Johnson about the Vietnam War. Lab results, whether for "pure" or "applied" research, may turn out to have been deliberately falsified. "Intelligence" agencies, in this and other countries, may engage in deliberate efforts at what is called "disinformation."

Timeliness. Movement in a stock's price between 10:30 and 11:00 a.m. may be of little interest if the information involves a stock trading day 10 years ago. On the other hand, it may be quite useful to some people, under some circumstances, if it's now 11:05 of the day in question. Those suffering the slings and arrows of the print media are sometimes consoled by friends, "Yesterday's newspapers are used to wrap fish." One of the qualities of information, one that distinguishes some types of information from others, is timeliness. The table of elements changes over time, but much more slowly than the stock ticker. The information in an encyclopedia, or world almanac, changes more rapidly but may still be useful for months, or even years, after publication. When evaluating timeliness the questions are, Is this the kind of information (and use) for which timeliness is even relevant? And, if so, how timely is it?

Relevance. Information may be accurate and appropriately timely, but of little relevance. Like the man looking under a streetlight for a coin lost elsewhere "because the light is better," an up-to-date, accurate map won't help you find your way if you happen to be elsewhere. "Information overload" is sometimes simply another name for information we do not find relevant at the moment: advertising for products we neither need nor want, news stories about events that don't affect us, or TV programs we find boring or offensive.

Efficiency. There are costs associated with information: the newsstand price of a magazine, tuition for a course, the notebook computer to access Internet data bases. There are also costs associated with its distribution: the phone bill for online computer time, postal or delivery charges on a book, the transportation charges for equipment sold in stores. Storage may require another file cabinet or bookshelf. If the user needs to move the information other efficiencies become relevant: A paperback book is often a very efficient package, but a large library may be more easily transported as microfilm or CD-ROM disks than as shelves of hardback books. And there are the costs associated with accessibility that go beyond out-of-pocket payments: the time and hassle involved in getting the information. Interlibrary loan arrangements make books much more accessible than requiring patrons to travel to distant libraries. Indexes and tables of contents

save time. If you want to find a particular phrase in, say, *The Federalist Papers*, the cost of reading through the book looking for it is much greater than the cost of downloading it from the Gutenberg Project (an Internet-accessible collection of electronic texts) and using a computer's "search" command to find every use of the phrase. But accessibility requires not only some money and ease of access, but the capacity to comprehend, to make sense out of, what is retrieved. Satellite data, chemical formulas, legal regulations, the contract specifications in a request for proposals—all may be quickly obtained, at little or no incremental cost, and yet be virtually incomprehensible to the reader.

Form. In a multimedia age, the form in which information is presented is another important quality. Print, numbers, graphs and charts, still or moving pictures, color, sound tracks, and exhibits sometimes help enormously in acquiring information. On other occasions they can vary between kind of silly and a real impediment.

Levels of abstraction. One of the essays refers to the distinctions between (a) data, (b) information, (c) knowledge, and (d) wisdom. A general semanticist would express this as differences in levels of abstraction. Whatever we call it, useful distinctions can be drawn for our purposes between factual, verifiable, reports of events in space and time, and the generalizations, or conclusions, drawn from those facts.

We all recognize a statement that "Senator Jones was elected in a three-way race with 42 percent of the vote" is somehow different from "Senator Jones sure isn't very popular" or "Senator Jones doesn't stand a prayer of getting reelect↑ l" or "Senator Jones is the worst senator in Washington."

A statement that "I saw someone who looked like that Jones boy running from the drug store about 11:30 last night" is different from "Tommy Jones robbed the drug store last night" or "None of them Joneses is any damn good anyhow."

This is not the time or place to launch into a paperback-length discussion of the principles of general semantics, but they are clearly relevant to any discussion of the nature of information.

IV

Our charge, quoted in full at the beginning of this chapter, primarily deals with the nature of information. But it also asks that we consider "whether and how the availability of and access to new technologies are causing or influencing change in the nature and definition of information."

For these purposes, let us define information most broadly to include all the examples, categories, and qualities discussed in Part III, above—and more. So defined, new technologies clearly have an enormous impact on many aspects of our information—indeed, so great is the impact that we can do little more here than provide a superficial sampling.

- Item: Surveillance satellites are capable of "seeing" movements of fish—and hurricanes, and the location of mineral deposits—and missile silos.

- Item: With such satellite technology, plus thousands of observation devices on earth, electronic communication, and the so-called supercomputers capable of rapid evaluation of all this data, the human species now benefits from five-day weather forecasts.

- Item: The law (court opinions, statutes, and regulations) has for decades been one of the most thoroughly indexed and cross-referenced of any academic body of literature; however, today's electronic searches of services such as Lexis and Westlaw not only enable radically faster retrieval of items, but uncover material formerly unavailable (as well as overlooking material older search methods would have located).

- Item: Computerized library "card catalogs" (not to mention their accessibility on the Internet to anyone with a computer and modem), coupled with interlibrary loan procedures, provide not only more rapid access to library information previously available but the capacity to uncover information formerly unknowable.

- Item: Online information services often offer clients the ability to fashion standing requests for particular categories of information as it becomes available, such as the stock prices, or news, about a particular company, or the latest cases involving some narrow point of law—letting the computer, rather than a research assistant, do the "scanning" through dozens of magazines or other sources.

- Item: So-called artificial intelligence, or expert systems, computer software can manipulate geological data to find mineral resources geologists might have overlooked, can suggest possible medical diagnoses formerly perceived only by a handful of the very best doctors, and can suggest translations of foreign language texts, or editorial changes in our writing.

- Item: Portable satellite dishes now make it possible for, among other things, journalists to provide voice (and video) transmissions from places on earth formerly inaccessible.

- Item: Currently available "notebook computers," linked to cellular telephones, already provide mobile, wireless access to electronic sources of information; the coming "personal communicators," with more widespread (and cheaper) communications services, will only increase this ability.

As we think about these examples, and the dozens of others that will spring to the reader's mind, what generalizations can we draw? How are these "new technologies . . . causing or influencing change in the nature and definition of information"?

Some uncover or produce information formerly unavailable (the surveillance satellites and weather forecasts). Some give us access to information formerly available, but in quantities and with speeds previously unimaginable (legal research, library card catalogs). Others give us techniques and tools for searching, processing, and evaluating that information and improving its utility (standing requests of online services, artificial intelligence). Such techniques and tools can often fairly be credited with improving the quality of that information. Finally, they may give us a portability and mobility—indeed, an almost

ubiquitous access to that information (mobile satellite dishes, cellular/computer wireless networks).

In short, information technology has become more than an engineer's intellectual challenge, a consumer's status symbol, or a hobbyist's latest toy. It is becoming, finding, and shaping the very nature of the information we seek and it provides.

V

Those of us who are working in, studying, or simply fascinated by "the information age" have tended to focus our attention almost exclusively on the technology of equipment: the computer networks, cable television, exotic computer software—the smallest, the fastest, the highest level of artificial intelligence, the most convincing virtual reality.

This year we pause briefly to look at what it is we are using this technology for, the information we are moving about planet earth in ever greater quantities and at ever faster speeds, and the impact of the technology on that information.

This essay has been an opening effort to aid that process by beginning the task of evolving a multidimensional matrix that can help us sort out the various elements that make up the nature of information. Hopefully, as it is further developed and refined by others, it can help us see a little more clearly the impact of our new technological toys upon what it was they were supposed to be about in the first place: aiding us in the information gathering, processing, distribution, and storage that makes our species unique.

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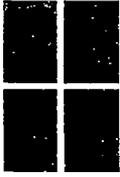
THE ROLE OF TECHNOLOGY IN AN INFORMATION AGE: TRANSFORMING SYMBOLS INTO ACTION

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This is a discussion of how technology can and may alter the nature of information. Our assumption is that the changes of most interest are those that have the greatest impact on the economic value of information. Since this is usually operationalized by "value-in-use," our focus will be on applying technology to create wealth with information.

After a brief description of the unique economic characteristics of information and information technology, we draw implications from these attributes in terms of four fundamental parameters that determine a technological infrastructure's potential to enhance the value of an organization's information resource. Our thesis is that a technology infrastructure that incorporates these parameters appropriately can transform the nature of information from a passive to an active agent of wealth creation. We will elaborate this idea with a description of a particular application of technology: codifying and creating an *institutional* capacity to learn.

1

Information's primary function is changing from recording what happens to making things happen. Sometimes it *replaces* physical things, as in the case of electronic mail and electronic money. Sometimes it *represents* them with sufficient completeness and rigor io become a reliable surrogate—for example. the way "fly by wire" systems represent an airplane to its pilot. In these and other ways, information is living up to the billing given it by Daniel Bell: codified information and knowledge are replacing capital and energy as the primary wealth-creating assets, just as capital and energy replaced land and labor 200 years ago.[1]

This historical transformation is dramatically displayed in Figure 1, which is based on research by Bruce Merrifield, formerly undersecretary of commerce and now at the Wharton School. Merrifield reports that fully 90 percent of the codified information that has been created since the end of the last ice age was created in the last 30 years, and projects that this will double in the next 15 years. Printing-press technology triggered this explosion. Computer technology made it a chain reaction. The result is a change in scale that brings about a change in state.

Nowhere is this change more important than in its effect on the nature of human work. Figure 2 illustrates the extent to which the trans-

Figure 1   The Information Explosion

Codified Information and Knowledge

%

> Codified information
> and knowledge are
> replacing capital and
> energy as the primary
> transforming economic
> resources.
>
> *Daniel Bell*

8000 BC   2000 AD
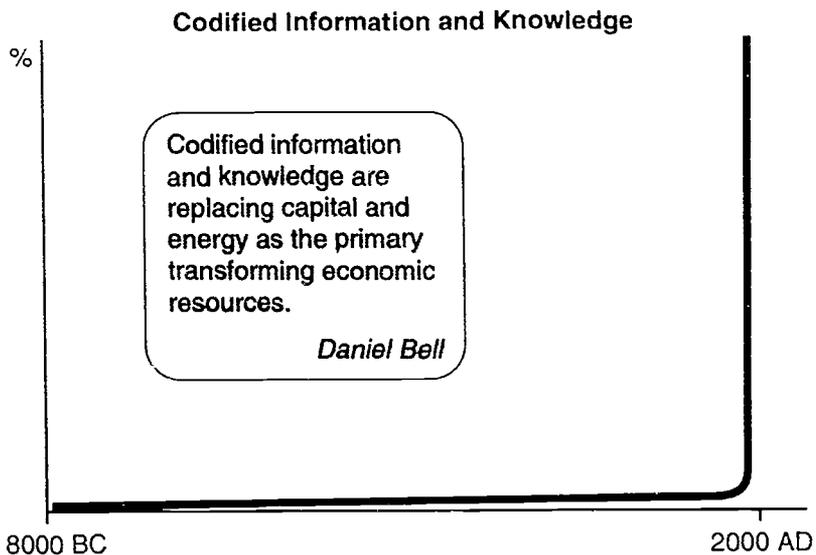
Figure 2   The Changing Nature of Work

The Nature of Work

Supervisory Work

Physical Work

Knowledge Work

8000 BC   2000 AD
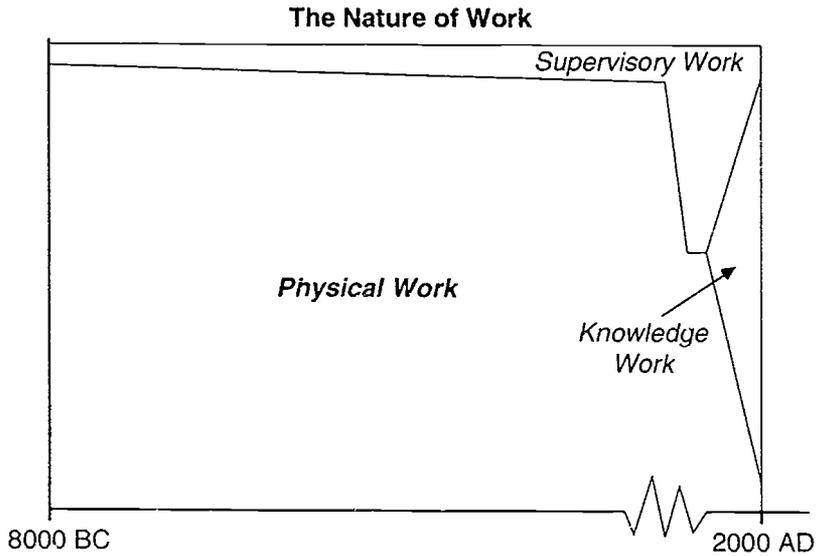
formers of physical resources (laborers) are being replaced by knowledge workers—people skilled in transforming abstractions.

Extracting value primarily from information resources is a very recent development in the history of work, and constitutes a major management challenge. For the past century, the theory and practice of management have been focused on the supervision and allocation of tangible assets. Now we must learn how to manage the intellectual assets of an information economy, which makes management itself more knowledge-work intensive. Today's manager uses technology to formulate and implement abstractions called strategies and plans.

In 1985, Peter Drucker pointed out that the commodity economy had become uncoupled from the industrial economy. Further, a symbol, or information, economy had arisen that was two orders of magnitude greater than the goods economy, growing two-and-a-half times as fast.² This shift had occurred abruptly, and largely in the decade of the '70s, making a shambles of the Club of Rome's scenario that mankind would run out of food and many natural resources by 1980. In fact, with the exception of oil, there was a resource glut by 1980. Raw materials and labor fell to less than 25 percent of the cost of goods sold in many

industries, while the cost contribution of knowledge and information-based services soared—to more than 50 percent of the cost of goods sold for *manufacturing* companies in the United States by 1990.

How and why this happened is explained by the degree to which the world economy has become information intensive, and by the unique economic attributes of information, and of information technology.

THE ECONOMICS OF INFORMATION AND TECHNOLOGY

Information is a strange economic resource. In 1949 Claude Shannon defined it as anything that reduces uncertainty. Therefore, its value-in-use has a subjective component. Unlike tangible assets, information's value tends to increase with (selective) sharing. Furthermore, it doesn't depreciate or obsolesce with use, though it may with time; and it is nonappropriable—that is, you can give it away without giving it up. Because of these traits, an economic value theory of information has not been developed,[3] which means that there is no theory that can be used to determine the incremental value of output due to an incremental unit of information input.

This explains the lack of measurements for information value. Because a basic tenet of American management practice is, "If you can't measure it, you can't manage it," information is rarely managed as the wealth-creating resource it can be—another instance, in the words of Aldous Huxley, of "elevating methodological ineptitude to a criterion for truth."

The ridiculous-looking curve in Figure 1 gets its shape from the advent of first, mechanical, and later, electronic information technology. The latter, like information itself, is an unusual economic resource: it is capital-conserving—as opposed to, for example, energy technologies, which are capital-consuming.[4]

Using Shannon's definition, enhancing the value of information means enhancing its capacity to reduce uncertainty. Technology does this by virtue of its speed, which continues to increase and become less expensive per unit of increase. This productivity engine has been getting more efficient at an aggregate rate of about 25 percent per year for the past forty years, and will continue at the same rate, or better, for at least the next 10 years. That's why we can do things with computers that made

29

no economic sense five years ago, and why we will be doing things with them five years from now that make no sense today.

Relating Information and Technology to Economic Value

Information must be digitized before digital computers can work on it. In this process, some information is lost, as many music afficiandos claim to sense when they listen to compact disks. Analog signals of sound, image, pressure, spectral analyses, and legions of other "real world" information sources have been converted to digital form for processing. In some applications they are "enhanced," which is to say that the technology *creates* information to exaggerate or complement the "real" information in such a way as to give it more meaning to human beings. The computer-enhanced pictures of Neptune and its moons that we all saw in 1989 are pictures no camera ever took of scenes no human space traveller will ever see. The computer processed signals from outside the visual spectrum, and from multiple instruments, to present a visual pattern in terms much more meaningful to humans than reams of telemetry printouts could ever be.

Some of the digitized information can be codified—rendered as symbols with a standard meaning—as in the case of letters and numbers. This allows the technology to behave as an extension of human memory—just as books do—and an extension of human inferencing capability, which books cannot do. This augmentation of intelligence makes information technology even more significant than the telescope, microscope, radar, and sonar technologies that extended our senses of sight and hearing.

Technology can be used to capture, digitize, codify, store, process, deliver, and present information. These are fundamental functions that enhance the *potential value* of information. Its *value-in-use* is a function of the information's applicability, accuracy, timeliness, completeness, ease of use and access, and "integrateability" by a user—attributes that can also be influenced by technology.

Value-in-use is to a great extent determined by the relevance information has to a problem at hand. "Relevant" information has context that conforms to the context of the problem. Context and meaning, in turn, derive from structure, i.e., information about information. Familiar examples of structure include indices, tables of content, "see also" references, and the panoply of filters humans use to screen out

of our consciousness all out an estimated one one-trillionth of the information signals bombarding our senses. (Our names for the higher layers of such filters include "mental models," "constructs," "para-digms," "gestalts," and "worldviews.")

Figure 3 depicts a generic hierarchy of information structure in which value and subjectivity increase, while volume and completeness decrease, as more structure is applied.[5]

While not rigorous, there is a meaningful parallel between the "Facts to Wisdom Hierarchy" and certain information systems termi-nology—at least up to the level of "Knowledge." For example, data can be equated with FACTS; data bases and data models with INFOR-MATION; and expert systems or algorithmic procedures with IN-TELLIGENCE. Because certitude often has a considerable subjective component, it is debatable whether or not it is meaningful to say that information technology can "know" anything. Nevertheless, we shall make a case later on for using technology to design what we have called a learning "corporate mind" that "knows a lot" about how an organization should behave in a wide variety of both foreseen and unprecedented situations.

Figure 3 Information Hierarchy

From Facts to Wisdom

Volume
Completeness
Objectivity

WISDOM

KNOWLEDGE

INTELLIGENCE

INFORMATION

FACTS

Value
Structure
Subjectivity
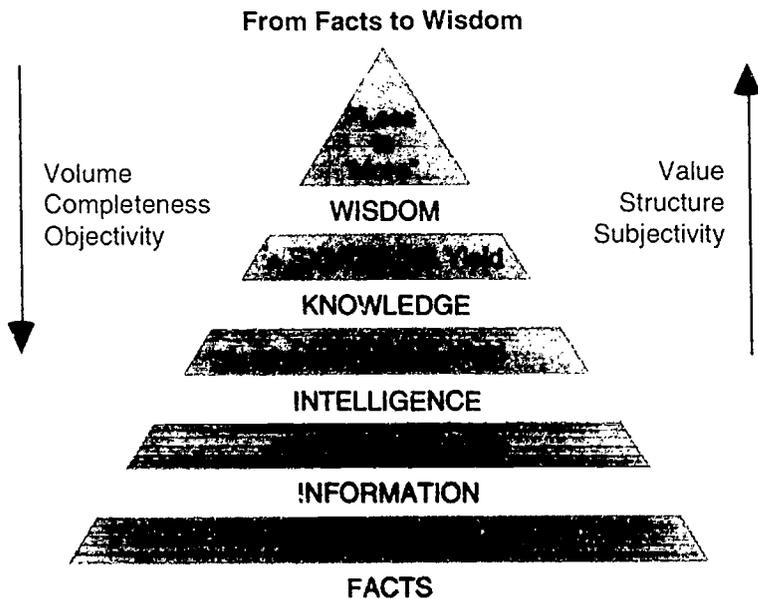
Key to Figure 3

FACTS: Observations with an assumed truth value of 1 (e.g., "Sales are down in Pittsburgh and Indianapolis").

Context: (facts about facts)

INFORMATION: FACTS in context (e.g., "Sales fell off only in the two cities where these four things happened in the same period: we raised prices; a competitor entered with an introductory special offer; the weather was unseasonably cold; and sales of new houses fell off sharply").

Inference: (reasoning)

INTELLIGENCE: Inference applied to INFORMATION (e.g., "Multiple linear regression analysis shows that sales volumes are highly correlated with the price differential between us and our nearest competitor").

Certitude: (conviction—both objectively and subjectively based)

KNOWLEDGE: Certitude about INTELLIGENCE (e.g., "Sales fell off in Pittsburgh and Indianapolis because we raised our prices at the same time a competitor entered with an introductory low price. The same thing happened three times in the last four years in other cities").

Synthesis: (integration of multiple types of knowledge)

WISDOM: Synthesized KNOWLEDGE (e.g., "Insist on forecasts of competitive price and promotional actions as a formal part of our pricing process").

In a discussion of an early draft of this paper, Eric Vogt, president of Micro Mentor, Inc., pointed out a relationship between the information hierarchy and learning: namely, that as one progresses higher in the triangle, one can be said to have "learned more." We will later discuss organizational "learning loops": cycles of sense-interpret-decide-act. A rough mapping of these two constructs can be readily made: facts can be sensed; information and intelligence are essential in interpreting the context/meaning of facts; the certitude that begets knowledge enhances the quality of any decision-making process; and action guided by wisdom is certainly superior—especially if there is wisdom enough to link the elements of a learning loop into a self-reinforcing cycle (Figure 4).

Figure 4   Generic Learning Loop

Learning Organisms
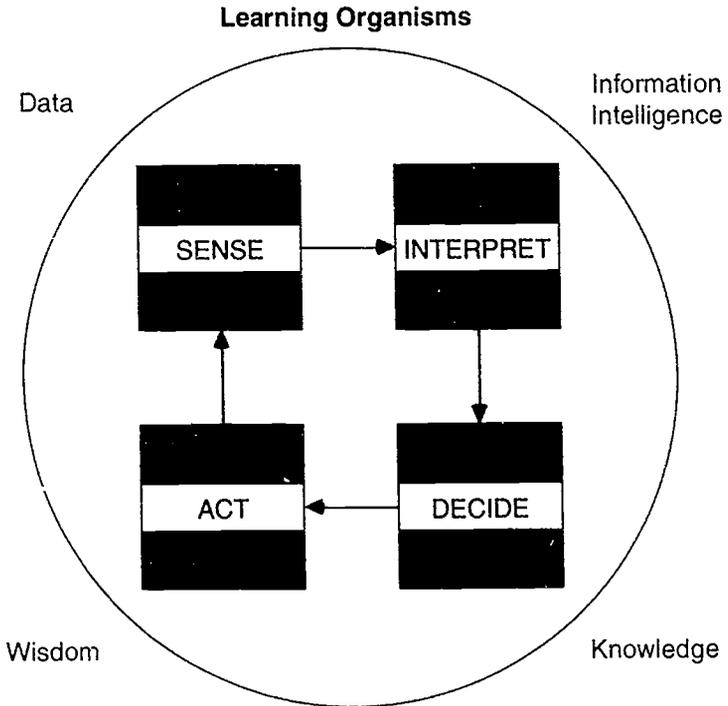
HOW TECHNOLOGY OPERATES ON INFORMATION
TO ENHANCE VALUE: PROCESSING, CONNECTING,
SHARING, AND STRUCTURING

Information technology (IT) can change the value of information simply by *processing* it faster. Greater *speed* means that more decision options can be explored in more depth in a given amount of time, increasing management's confidence in the choice made. Or a given option can be explored more quickly, allowing managers to make more timely decisions because they know sooner what they need to know. Using speed to do more in the same amount of time, or do the same amount in less time, has been the primary basis for justifying investments in information technology since the days of mechanical calculators, sorters, and tabulators. But this is now changing: The primary

value enhancement provided by IT is increasingly a function of the degree to which it is used to organize, manage, and link information sources and users.

Technology can be used to *connect* more sources and users of information, thereby *making the information more comprehensive.* More detail about more events, sampled more frequently, can be the basis of important and sustainable competitive advantage. Bear Stearns, Gallo Wine, McKesson, American Airlines, Progressive Insurance, Allstate, American Hospital Supply, and many others have invested in capturing information close to the customer that is ordinarily unavailable to firms in their part of the distribution chain. USAA, a leading insurance industry exemplar in exploiting information technology, has made a corporate policy out of capturing customer input, which goes by the acronym ECHO: "Every (customer) Contact Has Opportunity."

The result of sensing more of "what's going on out there" has been an enhanced ability to skim the high-margin customers in market segments that appear monolithic to their competition. In some cases, this strategy has altered the balance of power in an industry. When McKesson and American Hospital Supply (now a part of Baxter) first initiated their ECONOMOST and ASAP systems, only 47 percent of pharmaceuticals were distributed through wholesalers. It is now over 80 percent and still climbing.[6] In various industries retailers (e.g., Wal-Mart), wholesalers (e.g., McKesson), producers (e.g., Progressive, Bear Stearns), or third parties (e.g., ADP) have gained leverage and power by taking initiatives to capture information at the customer level.

Connecting users also facilitates knowledge exchange, and the rise of IT-enabled network organizational forms are testimony to the powerful potential advantages inherent in being "connected" to people in the know, and to current information.

An important extension of information exchange is information *sharing,* which *facilitates coordinated activity* among multiple players. Technology can be used to organize and integrate information in such a way that users and applications have a common view of data, and therefore a shared mental model of "what's going on out there." Similarly, software logic can be organized and integrated for sharing by people and applications to enable common understandings of "how we do things around here."

Examples of the payoff from using technology to share information and logic include USAA and Brooklyn Union Gas. USAA's telephone representatives are able to display a comprehensive, current and integrated knowledge of their clients, no matter who happens to answer the phone. Brooklyn Union Gas has implemented their Customer Related Information System with 650 reusable modules of software, using a technology called Object Oriented Programming Systems (OOPS). In permissible combinations ("permissible" defined by their information systems professionals on the basis of logic and legal and business policy constraints), these software modules represent 10,000 distinct organizational behaviors appropriate in 850 different business situations.

Information about information can be managed in a way that provides context and meaning. *Structuring* information to capture the important attributes and relationships between elements of data *turns the data into information by providing context*. Diagrams of these relationships and attributes, in the form of data models, codify the way an organization interprets information. That is, these models *filter information through* the *patterns* of relationships and attributes defined in the model. Modelling methodologies are among the technological tools that can be used to tame the data glut and make it possible to glean meaning out of massive amounts of raw data.

Wal-Mart sends 5,000,000 characters of information every night to Wranglers—a supplier of bluejeans. Not only do the retailer and supplier share the data, they have agreed to use a common data model for interpreting the meaning of the data, and common application software that acts on that meaning. The result of this shared learning loop is a win-win situation that results in lower inventory costs, fewer out-of-stock situations, and lower logistics costs. These mutual benefits stem directly from one of the unique economic properties of information—that value is enhanced by sharing.

When technology uses its *speed* to enhance the *connecting, sharing, and structuring* of information, the results can be expressed in terms of improved comprehensiveness, integration, and meaning, which are words normally used to describe "understanding" or "intelligence." The use of these words is not another case of anthropomorphic exaggeration. They are parameters that reflect the way technology can act on information to change its nature—from passive to active; from descriptive to transforming.

The specific transformation we are interested in is that of investing an organization with intelligence—and of making it a "learning" organization in the true sense of the word.

INFORMATION, TECHNOLOGY,
AND THE LEARNING ORGANIZATION

Peter Senge. in his book *The Fifth Discipline*, describes a learning organization as one in which

> people continually expand their capacity to create . . . results . . . where new and expansive patterns of thinking are nurtured . . . and where people are continually learning how to learn together.

He cites Arie de Geus. former coordinator of group planning for Royal Dutch Shell:

> . . . institutional learning . . . is the process whereby management teams change their shared mental models of the company, their markets, and their competitors.

John Seely Brown, vice president of technology for Xerox and director of its Palo Alto Research Center, provided some provocative insights in a recent presentation to the Marketing Science Institute describing the results of research by anthropologists on how learning occurs in Xerox. Based on their work. Brown's conclusion is that organizational learning occurs on the institution's periphery—where intellectual outlyers, renegades, closet philosophers, and others who think "outside the dots" experiment and speculate. He is convinced that learning is a social. rather than a private process. and that the primary mechanism by which it occurs is storytelling. It is the swapping of stories that causes mental models to change and learning to take place. A primary function of technology should therefore be to facilitate storytelling among people with common interests throughout the organization. Accordingly. Xerox will deploy networks and mobil technology to enable continuous networking among individuals grouped into "communities of interest."

But what about *institutional* learning? How much does the organization know when the people go home? Most organizations would still know how to process payrolls. Some would know how to dispense cash and others how to replenish stocks. These firms can be said to have "learned" certain things through automating them, but it would be a stretch to describe them as learn*ing*. That suggests a dynamic process, and the capacity to adapt.

We will operationalize a definition of *institutional learning as the systemic capacity to change the codified models an organization uses to interpret and act upon information,* (Codified models include data models, mathematical models, and procedural models.) Such a capacity can be provided by technology to create an institutional intelligence.

OODA Loops and Adaptive Organisms

The United States Air Force uses the acronym "OODA loop" to describe the iterative mental process of a pilot. "OODA" stands for: Observation (sensing environmental signals), Orientation (interpreting the meaning of the signals captured), Decision (selecting from a repertoire of available responses), and Action (executing the response selected).[7] Fighter pilots with faster OODA loops tend to win dogfights, and those with slower OODA loops get more parachute practice.

The advent of the jet engine in the 1950s was a technological discontinuity. It increased the speed of fighter planes to a level that made it impossible for pilots to keep up with events. The response to this technologically induced phenomenon was itself technology based: Use technology to help humans assimilate information and react in time.

"Heads-up displays"—computer-generated pictures projected onto the pilot's helmet visor—are selected abstractions of a few vital environmental factors captured and presented by the technology to assist a pilot in apprehending "what's going on."

Instrumentation and communication technologies aid in evaluating alternative responses. And when the decision is made—say, to take evasive action by banking sharply to the left—it is technology that intercepts the pilot's action and translates it through software into the myriad of detailed, nuanced orders that orchestrate the plane's behavior in real time.

The pilot is not flying the plane, but an informational representation of it. In the aviation business, this is called "flying by wire."

It is important to distinguish "fly-by-wire," which *augments* a pilot's function, from "autopilot," which *automates* it. Auto-pilot systems are much more limited in the number of situations that can be dealt with, and are only used in stable environments. Fly-by-wire systems, on the other hand, integrate the pilot into the command and control structure of the plane, and incorporate many degrees of freedom for pilot initiative.

Flying a modern jet airplane is a complex, sophisticated operation. More than 20 million lines of computer software are required for the current generation of commercial aircraft fly-by-wire systems. The fact that it is possible to deal successfully with this level of complexity raises the question: How close are we to "manage-by-wire" systems that can augment the management of complex, rapidly changing businesses? We will return to this question later.

Any adaptive system, be it an airplane, flatworm, computer virus, human being, or business has the four essential functions of the OODA loop: sensing, interpreting, deciding, and acting (Figure 4).

Sensing. Every organism has a specific and selective process for capturing signals from the environment. Because it is selective, it is also incomplete. There are sounds we cannot hear, sights we cannot see, pressures we cannot feel, odors we cannot smell, and flavors we cannot taste.

Similarly, there are buyers, sellers, customers, competitors, transactions, and many other environmental elements that a business is unaware of. If it does not sense enough of the critical components of "what's going on out there," it will perish from sensory deprivation.

Interpreting. Interpretation is the process of assigning meaning to what has been sensed. It involves filters, prioritization schemes, and mental models that structure raw data into recognizable patterns. Concepts, paradigms, and world-views are good or bad depending upon their relevance, their scope, and the degree to which they are integrated with response mechanisms. In every case, however, meaning is acquired at the cost of completeness. This tradeoff is perhaps most obvious in the case of specialists: They see the world in terms of their specific paradigms, and miss the meaning that other models might provide. That is why John Seely Brown hired anthropologists to help Xerox "see" itself better.

Note that Senge and Brown's notion of learning as a changing of mental models positions it in the domain of interpretation.[8] Sensing and interpretation together establish the capacity for a change in knowledge, and an improved understanding of "what's going on out there."

Deciding. If learning is a change in knowledge, *adapting* is a change in behavior. An adaptive organism necessarily has a capacity for predicting outcomes, so that it can select an option that improves things. Selecting from an available repertoire of responses on the basis of an interpretation of the signals sensed is our operational definition of "deciding." The repertoire may include unilateral, collaborative, or delegation options. Responses may be involuntary and reflexive, or conscious and reflective. In either case, to be effective they must exhibit coherency and coordination. Otherwise they appear as spasms and twitches.

Analogously, effective organizational responses must integrate the behavior of all of the units and processes required to produce them. A coordinating mechanism must operate during both the decision and action phases. One such mechanism is a codified design, or model, of procedures and human accountabilities for producing a desired outcome.

An interesting aspect of organizations is the possibility of adapting by acquiring the response repertoire of other organizations or people. Individuals, of course, do not have this option, but teams of individuals do. The team or organization *learns* to the extent their acquisition changes their collective mental model.

Acting. Executing a selected response completes the cycle. Since the action changes the real world, there is the potential for sensing that change and factoring it into a modified interpretation of the environment.

Deciding and acting comprise the response mechanism of an adaptive system. The mechanism for coordinating decisions with actions determines "how we do things around here." If the results of the action are monitored and interpreted to modify action in the future, a learning loop is established. The closed feedback loops of control theory are obvious examples. Our interest, however, lies in creating learning loops for "open" and ill-structured business environments in order to establish the self-reinforcing cycles that scientists have noted can bring order out of chaos. Business writers have appropriated scientific termi-

nology such as "chaos," "turbulence," and "discontinuity" to describe the environmental dynamism of the new economy. Why not appropriate some of the theory behind these concepts as well?

TECHNOLOGY-ASSISTED INSTITUTIONAL LEARNING

As mentioned above, current discussions about organizational learning include ways of using technology to foster the creation and evolution of shared mental models among *people* in the organization. In terms of establishing institutional learning, technology is engaged—but usually in isolated, unintegrated ways (Figure 5).

Technology can and does help augment both human and institutional sensing. Telephones, microscopes, telescopes, magnetic reso-

Figure 5   Technology-Assisted Institutional Learning Functions

The Technology-Asisted Firm

Electronic Probes   Data Models

SENSE   INTERPRET

ACT   DECIDE

Ad Hoc Activities   Decision Support

Application SW   Process Models
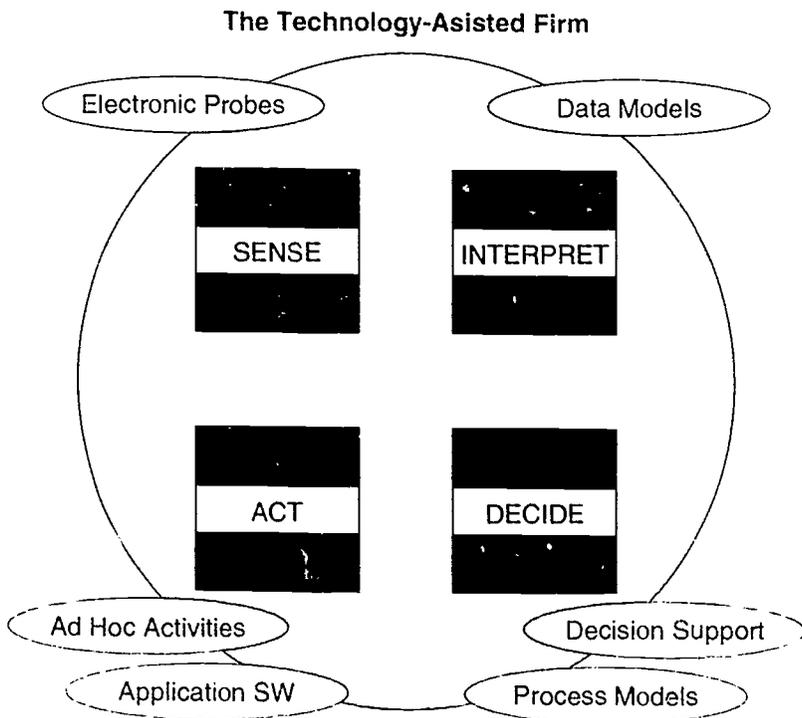
nance imaging, sonar, and mass spectrometers are but a few of the devices that extend our sensory reach from the quark to the quasar. ATMs, scanners, portable computers, ticketing machines, automated taco-making kiosks, intelligent shopping carts, carburetors, vending machines—and a raft of other devices with imbedded digital circuitry— are all potential electronic probes in the environment.

And even as we write, the long-awaited (and last) human interfaces to technology—speech and handwriting—are being introduced as serious commercial products. This will effectively remove computer literacy as a barrier to capturing human expressions.

Data Models, Mental Models and Neural Networks

Data models are explicit renderings of the way an application program—or a collection of them—views the world. These are constructed to identify relevant patterns, in terms of the *entities* of interest, their important *attributes*, and the key *relationships* between them. When these models are used to create data bases and data warehouses, they institutionalize specific ways of interpreting raw data. Information systems specialists call these "data views." These can have "meaning" to a computer program, in the sense that it knows what processes to apply to transform the data. On the other hand, the views may represent patterns whose significance is only established when people see them.

The analog of data models to mental models is irresistible. It leads to the notion that *an ability to systematically change data models based on experience is an indispensable function for institutional learning* in the literal sense (data models persist when all the people go home). Elaborate data models are worth fortunes to banks, airlines, food manufacturers and others who use them as the basis for creating shared mental models among the people in the organization. More than one executive has asserted that the coordinating potential of shared data views is the most valuable aspect of their data asset.

Neural networks, creatures of computer science labs for more than 35 years, are beginning to solve real-world data interpretation problems. Their application falls into three broad areas:

- Function approximation: This involves training a neural net to find the best mathematical model for expressing the relationships in a large amount of data. Neural nets appear to be superior

to statistical methods when the model is not well known and the relationships are nonlinear.

- Cluster analysis: Neural nets are trained to isolate similar categories of data, and to arrange the categories so that the ones with greatest similarity are closest together.

- Adaptive control: Typical applications in this area include robotics and process control systems.

The implications for systematic institutional learning are provocative. Pattern recognition/discrimination is the essence of interpretation, and neural nets are building a track record of successful applications. For the last four years they have been used by IBM's East Fishkill plant to help analyze production data. The categories created by the neural net revealed patterns leading to process changes that increased chip yield by 50 percent. Some retail and package goods companies are investigating the utility of training neural nets on scanner and point-of-service data.

Because they can be trained on each week's data, neural nets can create new models on a regular basis, capturing the dynamics of many product categories, such as fashion goods. *To institutionalize the systematic updating of codified models that interpret the environment and modify business processes accordingly is to institutionalize learning.*

Decision support systems and expert systems are familiar examples of technology-assisted decision making. Process control systems, robots, and payroll applications are equally well-known uses of technology that transforms information to change reality.

Information Business Models: The Missing Link

In spite of all that has been done over the past 40 years to apply technology, we doubt that any organization would claim to have leveraged their technology investment to create institutional learning in the sense we have defined it. But we do know of some companies that are in the process of doing so.[9]

These firms are using a tool called enterprise modeling to link and integrate their previously fragmented "sense, interpret, decide, and act" functions. They have identified a level at which coordinated activities among units would provide value above the sum of the values

created by the individual units. At this level—typically a line of
business or division for large companies—they have begun to identify
and codify their critical processes and data flows to describe "how we
interpret what's going on out there," and "how we do things around
here" (Figure 6).

The companies we have studied are not creating a giant flow chart
to automate the business. They are designing degrees of freedom into a
business model that specifies, as a matter of policy, who is responsible
for *all* the key process of a business—both well-defined procedures and
ill-structured, ad hoc processes. They are attempting to be rigorous
enough in their design so that its implementation can be faithful to
managerial intent.

They are also having a lot of trouble. The problems stem from three
sources. First, it is incredibly difficult to identify, specify, and codify the

**Figure 6   Use of Enterprise Model to Integrate and Link
Learning Functions into Learning Loops**

The Corporate Mind
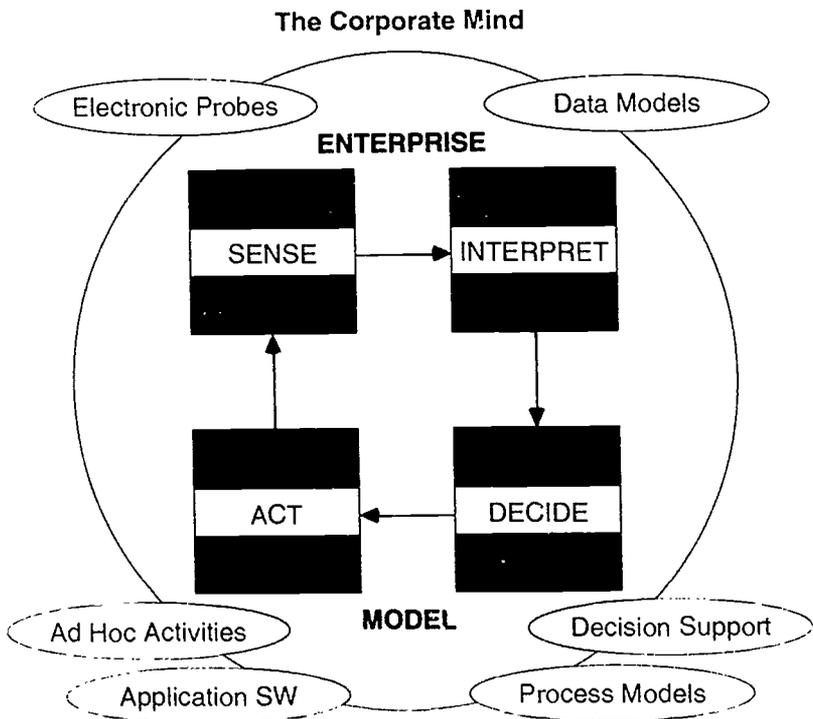
essential processes of a business with any confidence that these are the right designs for the right processes. This is an information age skill with which no managers have experience. Second, with existing enterprise modeling tools (which have been used by information systems professionals for 20 years), they are forced by the limitations of their tools to design bureaucracies, that is, organizations which are all process and no accountability—like most mailrooms.

Finally, they are using information systems professionals, the people who know how to use the enterprise modeling tool, as intermediaries to interpret management's policies and specifications in order to translate it into the language of the particular tool—and typically there are many such languages used by different functions in a given company. This intermediation of management intent leads to further distortion between reality and the model that is supposed to represent it.

But help is on the way. A new generation of business design tools is emerging which promise to turn enterprise modeling into a management, rather than an IS exercise. These tools use business terminology; have sufficient rigor to identify *at the design phase* the systems requirements for implementation; have "run-time" capability for monitoring the operations of the business to ensure consistency with the design—and to change (learn!) data and process models and business policies as experience accumulates. Most importantly, they explicitly incorporate human accountability for every key procedure.[10] Elsewhere, we have proposed the use of these new enterprise design tools to create "manage-by-wire" capabilities for business managers.[11] Analogously to fly-by-wire, manage-by-wire is defined as the ability to manage an organization by managing a robust informational representation of it (Figure 7).

We are on threshold of seeing sizeable domains of business activity managed by wire in a sense comparable to the fly-by-wire systems described at the outset of this article. But the image is not one of a few executives in the corporate cockpit controlling the behavior of a large, people-free corporation. Complicated as it is, the operation of a modern jet airplane is automatable to a degree that companies cannot be. The picture is rather one of multiple pilots running linked and modularized parts of the business by wire. People with higher levels of responsibility manage-by-wire larger and larger integrated clusters of business modules.

Figure 7 Managing By Wire
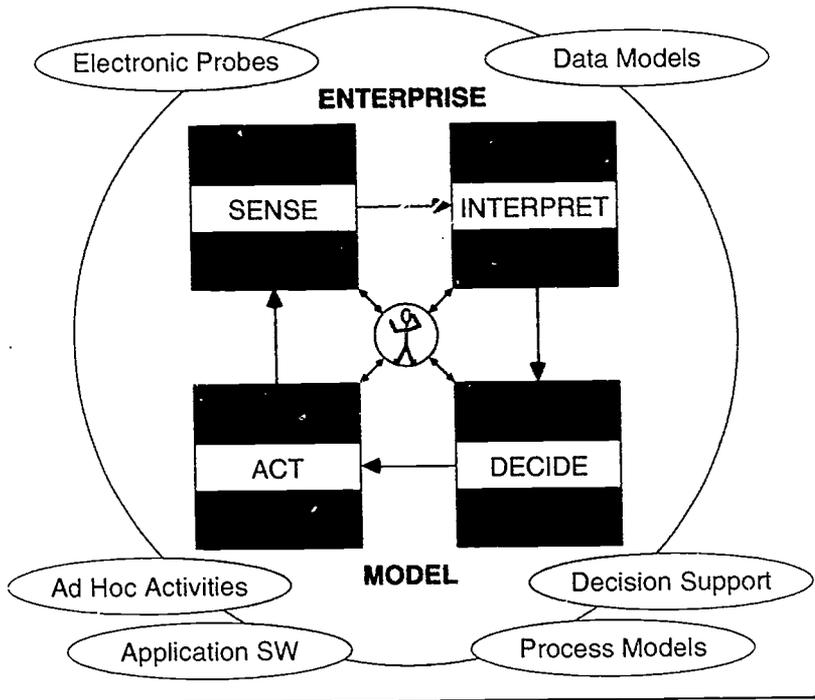
A POSSIBLE FUTURE: REAL VIRTUAL REALITIES[12]

When an informational representation of a real system produces
outputs that are indistinguishable by humans from the "real thing," we
have perhaps the ultimate change in the nature of information that
technology can induce: virtual realities. These are much further off than
the popular press would have us believe. Current examples, largely in
the entertainment field, are spectacular, and do significantly lower our
threshold of credibility. But given the elaborate and intrusive apparatus
they require, and the fact that their sensory outputs are very limited, few
people are ever likely to confuse them with reality.

Nevertheless, that is clearly the direction technology is headed. In
his 1984 novel *Neuromancer*, William Gibson coined the term "cyber-
space" to describe a world created by computers and inhabited by
symbolic abstractions of people, places, and things . . . all accessible by

technology. One of the main characters is a symbolic representation of a dead friend of the (real) protagonist. The only way he knows that it is not his friend reincarnated is a certain "hollowness" in its laughter. This is fiction, but fiction with the insight of a Jules Verne.

From flow charts to enterprise models to virtual reality, the incremental progress toward abstracting more and more of the world into information models continues. As more of the relationship between humans and their experiences is intermediated by symbols, information becomes the agent, rather than recorder, of change (Figure 8).

Toward a New Set of Management Principles

One consequence of this trend is a substantial change in the role of management. In the "make and sell" industrial age, managers added value by finding better ways to organize and allocate tangible assets. In a "sense and respond" information and services economy, the premium

Figure 8   Intermediating Human Experience with Symbols
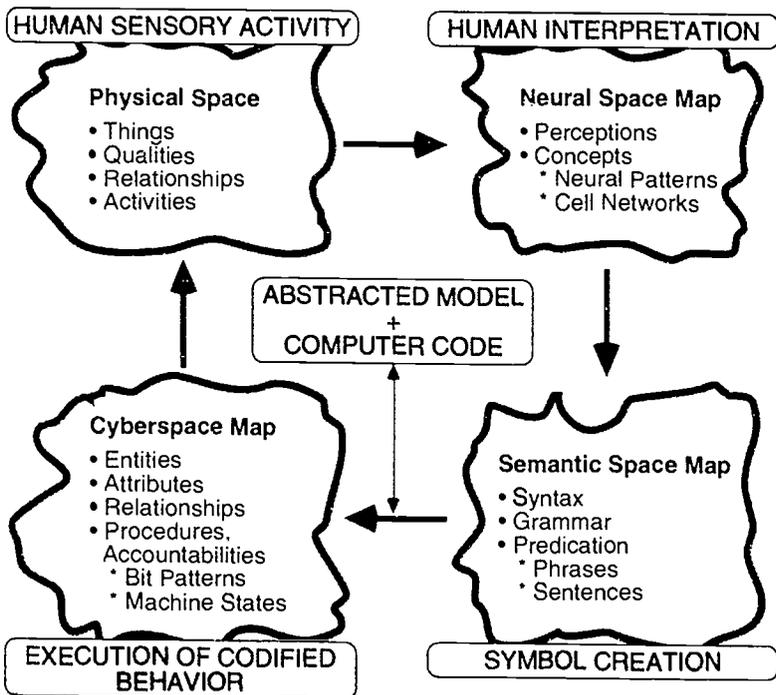
will be on management skill in organizing and deploying intangible assets—including, but not limited to, information and knowledge.[13]

This transition will require a change in long-held management principles and attitudes. Industrial age managers, when they think at all about their information resource, tend to do so in terms of the cost of managing it, limiting access to "need-to-know," avoiding "data glut," or preserving proprietary know-how. Managers attuned to the wealth-creating potential of their information asset think more in terms of maximizing access to it, sharing common interpretations of its meaning, structuring it in ways to create more meaning, and reducing the time required to translate that meaning into appropriate action.

THE OTHER SIDE OF THE COIN:
DOWNSIDES AND CAVEATS

Assume for the moment that sense-and-respond and manage-by-wire become strategic imperatives. What are the major risks associated with adopting them as organizational design points?

First there is the technological risk to consider. Some of the IT prerequisites (object-oriented programming, information ware-houses, "run-time" process execution managers, etc.) are proven in labs, but have limited track records in production environments. Not many companies have the in-house skills to implement and maintain them.

Of far greater concern is management's ability to create a robust design for the business. There is not a body of experience or examples to serve as reliable guidelines for how to map a business into an information business model. The present generation of managers will lay the foundations and establish the disciplines of this new skill. The model may not accurately reflect management intent, or incorporate systematic learning, or operate on the basis of a sufficiently complete and accurate view of what is happening in the marketplace—in which case using it to manage the organization would be disastrous.

Even if the technology is successfully implemented, and the model robust, there is the huge risk associated with having created a world-class instrument for implementing bad decisions efficiently and effec-tively. As pioneers begin to climb the learning curve in designing

adaptive organizations, it will be important to differentiate between decisions, design, and strategy as the cause of success or failure.

One more time. It is difficult to talk about technology and information assuming the roles we have ascribed to them without evoking a reaction that we have correspondingly reduced the role of human beings. That is precisely why we like the fly-by-wire analogy. Even though it theoretically could, no one is about to let a plane take off without a pilot at the controls. Too much of what happens—even when flying a commercial jet—is ad hoc.

The major implication for humans is the need for more "pilot skills." Leadership, judgment, know-how, and accountability will command premiums in a manage-by-wire business. We are, to repeat, talking about the use of information and technology to significantly *augment*, rather than automate, human abilities.

When augmented people can run enterprises by manipulating informational representations of the "real thing," technology will have transformed the nature of information in that company—from passive certainty-reducer to active value-producer.

ENDNOTES

1. Bell, Daniel. *The Coming of Post Industrial Society*. New York: Basic Books, 1973.
2. Drucker, Peter. "The Changed World Economy." *Foreign Affairs*, Spring 1986.
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4. Bell, Daniel. "The Frameworks of The Future." *Proceedings of the Marketing Science Institute 20th Anniversary Conference*. Cambridge, MA: Marketing Science Institute, 1981.
5. See Barabba, V.P., and G. Zaltman. *Hearing The Voice of The Market*, Chapter 2. Boston: Harvard Business School Press, 1991, for a discussion of what the authors call "Haeckel's Hierarchy" and its application to managerial decision support systems.
6. Quinn, James Bryan. *Intelligent Enterprise*. New York: The Free Press, 1992.
7. Hout, T.M. and M.F. Blaxill. "Make Decisions Like A Fighter Pilot." *New York Times*, November 15, 1987. The antecedents of the OODA loop can be traced back to John Dewey and his definition of the "Scientific Method."
8. "Institutional adaptation" can occur with each cycle of the learning loop, as long as the data sensed are adequately explained (interpreted) by the existing model. When this is no longer the case, institutional learning is required, i.e., a change in the model itself.

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9.   See Haeckel. S.H., and R.L. Nolan. "Managing By Wire." *Harvard Business Review*. Vol. 71, No. 4, September–October 1993.

10. Scherr, Allan. "A New Approach To Business Processes." *IBM Systems Journal*. Vol. 32, No. 1, February 1993.

11. Haeckel and Nolan, *op. cit.*

12. "Real Virtual Companies" is a term R. Glazer, of U.C. Berkeley, and S.H. Haeckel use for work in progress on abstract economic enterprises that produce real wealth.

13. Customer perceptions, preferences, and dispositions (or "good will," to use an industrial age balance sheet term), are intangible assets of major importance to service firms. Systematically sensing signals about these, interpreting them accurately, and designing service "clues" that enhance the quality of service encounters will inevitably be the focus of a new generation of management principles—as opposed to the art form it is today. Lewis P. Carbone has, in fact, developed a service practice around a method he calls "Experience Engineering" (SM) to systematically sense, interpret, design, and implement important service clues that materially effect a customer's perception of a service encounter, and therefore establish a differentiated preference.

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THE ECONOMICS OF INFORMATION: A USER'S GUIDE

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The ec.)nomics of information is a relatively new, rapidly expanding, and extremely important area of research. Characterizing its scope and subject matter with a few generalizations is impossible, for the economics of information is not a coherent subdiscipline. Instead, it is a collection of research methods and topics dealing with how individuals produce, transmit, and use knowledge and ideas. It includes:

- highly abstract theories about how new facts affect human decisions:

- broad empirical studies of the nature and consequences of the flow of information in the economy:

- narrow empirical studies of the market for a product in the loosely defined "information sector" of the economy:

- even narrower studies of how the creation and flow of information in an organization affects its performance: and

- evaluative studies of the economic consequences of a variety of information policies, ranging from economic regulation of telephones to the application of the First Amendment to the media.

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The key practical lessons from so broad an area of inquiry cannot be summarized comprehensively in the few pages that are appropriate for an essay in this compendium. This essay will focus on two major themes: the interesting, somewhat unusual, but not unique fundamentals of the economics of the production and distribution of information; and the basic concepts of learning in the rational-actor theory of behavior, which is sometimes called statistical decision theory. Although the essay will not deal at length with studies of the information sector or information flows in the economy, these topics and their associated policy issues will be used to illustrate the core ideas in the two major themes.

Despite the focus on general conceptual issues, the topics examined here are of substantial practical importance for public policy. The two major themes define the real-world constraints facing policymakers who seek either to improve the performance of the information sector, or to increase national welfare. In either case, policies based on incorrect implicit theories of how information is produced and distributed, and how individuals make use of it, are unlikely to be effective.

DEFINITIONS

The concept of information is broad and elusive, so I will make explicit my use of the term. I will use a relatively broad definition that incorporates three general concepts.

First, information can be facts about reality. One example is a data base (e.g., the closing price of IBM stock on each day for a specified period of time). Another example is a completely understood cause-effect relationship (e.g., the chemical formula for determining the quantitative relationship between an initial amount of hydrogen and oxygen and the amount of water produced when they interact). Unfortunately, a great deal of human knowledge is not accurately characterized as a fact or natural law like these examples.

The second meaning of information is some objective fact or conceptual model that reduces uncertainty about how the world works, perhaps thereby improving human decisions. For example, a weather forecast is not a revelation of a fact about the future, but an informed guess that reduces uncertainty. Likewise, a computerized weather forecasting model is not an aggregation of deterministic cause-effect

relationships, but a compendium of empirical regularities that were derived from partial, inexact theoretical insights and imperfect measurements of past events. The computer model is informative about the causes of weather, and the forecast is informative about whether tomorrow will be sunny and warm, in that both are, on average and over the long run, better than no knowledge at all. An important part of the economics of information is how inexact knowledge of this form can be used to improve decisions, and whether it is worth acquiring.

The third meaning of information is simply communication that is valued by the sender or receiver, perhaps exclusively as an end in itself. The economics of information deals with the production and consumption of novels, rhetorical essays, art, music, television series, and other forms of communication that either the producer or the receiver regards as an end in itself—a form of consumption rather than a means for making better decisions.

These distinctions among types of information are of no importance in the first of our two general themes: the economics of information production. The basic conceptual model of how new information is produced and transmitted is applicable to new scientific laws, imperfect insights about an uncertain world, and informational consumer goods. These distinctions are potentially more important in considering the second issue: how rational humans decide, first, how much information to acquire, and second, how to make use of new information to improve decisions. Here the distinction between a novel and a computer model is uncomfortably problematic. Most novels presumably are not generally used to inform decisions; however, historians have concluded that the publication of *Uncle Tom's Cabin* galvanized Northern opposition to slavery and, hence, hastened the onset of the Civil War. This example demonstrates that a great work of art can, somewhat mystically, give its audience a deeper insight about human affairs, and so have greater claim to being information than a computer program containing a virus that destroys, rather than analyzes, the data that is fed to it. The general point from this example is that if a communication causes individuals to change their evaluation of alternative courses of action, the communication is information and can be analyzed, at least in principal, by applying the methods of statistical decision theory.

The final definitional issue that requires elaboration is the meaning of the economic language and analysis that is applied to information

production and use. The economics of information, like all of economics, is built upon the premise that individuals respond to economic incentives. This assumption does not imply, as many incorrectly believe, that all decisions are motivated solely by the desire to maximize monetary income or wealth. In studying information production and use, economic analysis takes into account the plausible claim that for both producers and users a new information product can be an end in itself. That is, some producers of information products are themselves consumers—perhaps the most important consumers for the purpose of understanding why the product takes the form that it does. Recognizing this motive, however, does not vitiate the importance of market incentives, for the main focus of analysis in information economics is on decisions that are marginal, i.e., a decision to produce an additional information product that, in the view of the producer, is just barely worth the effort. If information producers place high personal consumption values on their products, they still can be expected to produce still more new information if the amount others will pay them for it increases. Moreover, they can be expected to bend the content of the information just a bit—not to produce the product that would give them the greatest personal satisfaction—if sufficiently well rewarded for it. Even the most iconoclastic, self-absorbed artists probably will accept a commission to paint a portrait if the pay is sufficiently high.

A related definitional issue is the economist's concept of cost, which also does not necessarily refer to monetary payments. In economics, a cost is a foregone opportunity. The cost of telephone service is not the monthly payment to the telephone company, but the allocation of scarce resources, embodied in lines, switches, terminal equipment, and the effort of telephone company employees, to provide telephone service instead of something else. For the artist, the cost of the commissioned painting is, in part, the paint and canvas that could have been used to produce an entirely different work of art, and in part the time the artist devotes to painting the portrait, rather than producing another painting, or doing something else.

In the case of information products, an important part of the cost of information usage is the time of the user. A "user friendly" computer program is usually more complex, and therefore consumes more programmer time to write and requires a better computer to operate, both of which are costs in the sense of foregone opportunities. To all but the

most inveterate computer hacker, who derives personal pleasure from dealing with complexity, the greater cost of producing a user-friendly program (which is reflected in a higher price to consumers) is more than offset by the reduced time that the user must devote to operating it. Taking into account a user's implicit value of the time and effort that are required to learn a complex program, the more expensive (i.e., pricey) option actually has a lower cost.

This somewhat arcane distinction between monetary expenditure and true social cost is especially important in understanding the economics of information. One important characteristic of information is that it necessarily requires time and effort to internalize, whether the purpose of using it is pure consumption, an increase in production efficiency, or improved decision making. A second important characteristic of information is that it can be used to make better use of other valuable resources. Information that saves time or leads to better decisions increases the opportunities available to a user, thereby reducing costs in the sense the term is used in economics. Thus, a more expensive computer or a telephone network that can transmit more information per unit of time may reduce costs. But in a large organization, an office head contemplating the purchase of a new computer or telephone system may see only a budget constraint, and not the implicit value of the increased productivity of office employees that these technologies allow. And, a state public utilities commissioner may be held accountable for only the price increase that must accompany an enhancement to the network if the telephone company is to remain solvent, not the reduction in total costs that the enhancement can bring forth. This core problem of a difference between financial accounting and true social cost is difficult to comprehend without the economist's distinction between monetary expenditures and opportunities foregone, yet it is extremely important in understanding the economics of information.

THE ECONOMICS OF INFORMATION PRODUCTION

In the jargon of economic theory, information, in all senses defined above, is a "public good": the cost of producing a given piece of information does not depend on how many people will use it, and its use

by one person does not prevent or diminish its use by others. Consider the following examples:

- The effort required by Newton to invent classical mechanics did not depend on how many physicists and engineers would ultimately make use of these ideas.

- If James Michener spends more time writing a novel, he may improve its quality and so sell more copies; however, if we could inform Michener in advance whether his next novel would sell one million or 10 million copies, he would find the information interesting, but not useful in deciding how much effort to devote to writing it.

- The cost of a state-of-the-art computerized weather forecasting model does not depend on the number of people who will receive the forecast, and if one person receives the forecast, another person experiences no reduced ability or increased cost to receive it as well.

- If one person decides to view a television program, the other viewers of the program experience neither an additional cost nor diminished access to the program.

In the publishing business, the cost associated with the creation of information, which is the aspect of information production that is a public good, is called the "first copy cost." That is, to produce a new information product requires some work that is independent of how extensively the product is used. In the newspaper business, the first-copy cost includes the work of reporters, writers, editors, and print shop personnel that takes place before actual printing. Then additional costs, called the dissemination costs, are associated with actually printing and distributing the newspaper. These costs depend on how many copies are actually sold. For newspaper publishing, examples of dissemination costs are the machinery used in printing, the time press-room employees spend running these machines, the amount of ink and newsprint used in printing, and the trucks and personnel involved in circulation. The amount of resources that are devoted to printing and

distributing a newspaper is essentially proportional to the number of copies produced, so that the opportunity cost of increased production runs for one publication is an essentially equal reduction in the production of another.

To illustrate the importance of the cost structure of information products, consider the local newspaper business. The cost of having five newspapers with 100,000 circulation rather than one newspaper with 500,000 circulation is almost exclusively the fact that five newspapers require five first-copy costs, whereas one newspaper requires only one. If the five newspapers are sufficiently different, catering to different consumers and advertisers, incurring five first-copy costs may produce higher net social benefits than incurring only one. Nevertheless, the important truth imbedded in this example is that first-copy costs create a form of economies of scale or natural monopoly.

The importance of scale economies in information production depends on the relative importance of first-copy cost compared to dissemination costs, the number of users over whom the first-copy cost is spread, and the degree to which consumers differ in their tastes for publications. If the first-copy cost per user is small compared to dissemination costs, because either a large number of users receives the product or the dissemination costs per copy are very high, consumers will experience only a small price reduction if the number of producers is reduced. In this circumstance less intensely felt demands for variety are more likely to be served because they require only a small cost penalty per customer.

The nature of technological progress in information production can have an important effect on the amount of variety and diversity in information products. Suppose that dissemination technology is advancing much more rapidly than the technology of producing the first copy. One effect will be to lower the cost and therefore the price of usage in general, which will expand use and lead to still further price reductions as first-copy costs are spread over more users. This effect can then make a wider variety of publications economically viable. The other effect is that the relative importance of first-copy costs, holding circulation constant, will increase, thereby increasing the percentage price difference that is necessary to sustain the same extent of product diversity. This effect leads to consolidation: fewer distinct products, with a lower total expenditure on first-copy costs, a lower price per copy,

and a larger circulation per product. Which effect predominates, of course, depends on the facts: the magnitude of the changes in cost structure compared to the intensity of demand for diversity.

In the case of newspapers, technological change has reduced dissemination costs more dramatically than first-copy cost. As a result, the number of papers has fallen, while their average circulation has increased. In the case of magazines, distribution costs have increased because their primary method of distribution, the U.S. mail, has over the years substantially reduced the fourth-class postal subsidy. The effect has been to reorient the circulation strategies of the vast majority of publications. Typically, magazines seek narrow, homogeneous audiences, leading to lower circulation but a readership that is highly prized by advertisers that seek to reach the same narrow readership.

The distinction between first-copy and production costs in the publishing business is completely general with respect to all forms of information products. The creative part of information production is always a public good in that its cost does not depend on eventual use. The dissemination and use of information inevitably involve some costs that are associated with each individual who receives it, and so depend on the number and extent of usage. Returning to the four examples listed above:

- If one more student learns classical mechanics, the ability of other students to learn it is not diminished; however, the student must study a book that was printed rather than some other medium, must devote valuable time to the enterprise, and probably will use pencils and paper to take notes and solve problems.

- If, after studying physics, the student relaxes reading Michener, the student's copy of the novel can not simultaneously be read by others, and is diminished in that, eventually, usage will make it unreadable, or at least unpleasant to hold.

- If the best place to read Michener is in the park on a sunny day, the student may want to know whether rain is likely, and so will turn on the television to watch The Weather Channel, which is itself a public good, but watching it nevertheless requires using

(and depreciating) a television set, consuming electricity, and spending some valuable time listening to the forecast instead of reading in the park.

Thus, using information always requires the time of the user, which is valuable in that it could be devoted to other activities. It may involve effort, which the user would rather not put forth, such as the effort required to study physics. And, it almost always will require the use of some other valuable economic resources that are consumed in the act of acquiring and using the information, or that cannot simultaneously be used by others while one person is consuming information. All of these constitute the private-goods (as opposed to public-goods) aspect of information production.

For all information industries, changes in production costs can have a dramatic effect on the number and diversity of products, as was illustrated by the publishing examples. Broadcasting, for instance, has very low dissemination costs relative to first-copy costs in comparison with newspapers, magazines, and books; hence, assuming that the taste for diversity among consumers is roughly the same in all media, product diversity is expected to be lower in broadcasting than in publishing. In telecommunications, massive reductions in the cost of information transmission have increased the attraction of data-base sharing. For example, if records must be kept on hard copy and accessed physically by clerks, each office is more likely to maintain its own records. Cost reductions in telecommunications transmission and scale economies in computerized records have led to greater centralization of record keeping, and also to greater standardization of record-keeping practices among offices, which is a kind of loss of diversity.

A great deal of the policy debate about information products derives from the simple economic facts about their production. At the heart of the problem is the harsh fact that, as a practical matter, completely efficient production and distribution of information is impossible. If an information product must recover all of its costs in a market, the price of accessing it (a book, a diskette, a connection to a data base) must include both the private costs associated with an individual use and some portion of the first-copy costs associated with producing it. But as the price of access increases, usage will decline, so that a markup over the private distribution costs will exclude some users who would value

use at more than the private cost of access. Because these excluded users impose no costs beyond the private distribution costs if they are given access, to exclude them is economically inefficient. Hence, recovering first-copy costs through the price system always produces less extensive use of information, and less total production of information, than is economically optimal.

A related problem arises from the attempt to charge more for an information product than the private costs of distribution. If the product can be copied, a user can avoid contributing to the first-copy cost by duplicating an "authorized" or "authentic" copy. Not only is copying perfectly rational, it can also contribute to efficiency if the copier is a user who would be excluded from use at the full price. But, of course, if enough users avoid the full price, the first-copy cost cannot be recovered, and, again, society ends up with too little information production, although that which is produced is distributed more efficiently.

The private market is not necessarily helpless in these circumstances. In some cases, information producers can make information products in a manner that makes them relatively invulnerable to copying. One avenue is to change the product, such as by writing a "copy protected" computer program or using a printing process that can not be completely or perfectly photocopied. The other avenue is public policies that grant and enforce intellectual property rights. In general, these strategies require additional costs, and so at best ameliorate, but do not solve, the efficiency problem. A protected product is still priced above the minimum cost of delivering it, and even above the minimum cost including a proportion of the first-copy costs.

The television industry provides an especially good example of the emergence of a different strategy regarding protection against unauthorized use. Television programs can be protected by encryption of the signal. This process is very expensive compared to the cost of delivering free TV to users, with signal scrambling and descrambling systems in some cases costing hundreds of dollars per television set. Initially, television did not seek to use this technology, instead relying on free distribution to maximize audience size and the sale of audience access to advertisers. But cable television and satellite distribution, combined with rising consumer income, have gradually transformed the profit-maximizing strategy of broadcasters, so that limiting access and charging consumers for use has become increasingly common. In essence, the

costs to broadcasters of the scrambling technology plus loss in advertising revenues from loss of viewers is increasingly being offset by the increased revenues from charging the audience for access.

Even if property rights can be protected, information producers still face the problem that a single price that exceeds the costs of distribution causes the producer to lose profitable opportunities to make sales to users who would be willing to pay more than distribution costs but less than the universal price. To deal with this problem, information suppliers may be able to use price discrimination so that users who cannot or will not pay their proportionate share of the first-copy cost can be given access at a lower price.

Price discrimination is widely practiced in the market for scholarly journals. Organizations typically pay a much higher price for subscriptions to academic periodicals than do individual scholars. This price discrimination is possible only if users who face a low price either will not or can not resell to users who face a high price. As a practical matter, the ability to prevent resale is conceptually similar to the ability to thwart extensive copying in that both deal with preventing one user from reselling the information product to another. In addition, in order to practice effective price discrimination, the producer must be able to identify which users are willing to pay more, and how much customers in each category will pay without significantly reducing their purchases. For example, because there are relatively few universities, the publisher of a scholarly journal can relatively easily determine whether a university library is acquiring its periodical through an individual subscription by comparing a university's catalog with the subscription list. A publisher can also experiment with different pricing strategies for broadly similar periodicals to determine the price level at which institutional subscriptions begin to fall off.

By contrast, enforcing price discrimination against institutions would be very difficult for a newspaper or other popular publication that is usually not saved and catalogued, and which would face considerable difficulties in categorizing subscribers according to how much they are willing to pay. In fact, with respect to computer programs, producers are frequently forced to use lower prices for institutions— site licenses—because enforcement of a policy to make all users in the same organization buy their own copy of the program, rather than duplicate the copy of their office mate, is impractical. The result is a

form of reverse price discrimination in which user categories that might have a higher willingness to pay if property rights were fully enforceable actually end up paying less than individuals with a lower maximum willingness to pay.

An important insight about information products is that price discrimination, which in most contexts is regarded as a socially undesirable mechanism by which firms with market power enrich themselves, has an important efficiency advantage in information industries, or in any industry with scale economies. Charging higher prices to users with more intense demands, and lower prices to users who might otherwise be excluded, maximizes the diffusion of the information product. Moreover, the inability to practice price discrimination can lead to excessive diversity among information products. Suppose an information product is ideal for one set of users, but less than ideal for others. If both pay the same price, a new information product may successfully enter, winning the second group of consumers (for whom it is ideal), but forcing a higher price for the old product to recover its first-copy costs. By using price discrimination, however, the supplier of the first product might retain the second group by lowering their price enough to keep them (they would rather pay a lower price for a slightly inferior product), and recapture the lost revenue by increasing the price to its most satisfied customers (but not to the level that would need to be charged if the second group defected to the new product). In this case, price discrimination would prevent the entry of the second product, yet benefit all users.

An important special category of information products is information for which it is close to impossible to prevent copying or reuse, and so to enforce any price based on usage. Such information is likely to be vastly undersupplied by the private sector. A good joke is surely in this category, for its creator has no way to prevent another user (e.g., Milton Berle) from retelling it, thereby deriving nearly all of the benefits from its creation. (The economics of information explains why there is simply too little humor in this world!) Beyond levity, the best examples of almost completely unprotectable information are found among the products of fundamental research. One cannot imagine Newton coming close to extracting royalties for every use of classical mechanics, or Einstein collecting a fee every time someone used $E = mc^2$. In most cases, the very act of using a fundamental new insight about how the

world works provides a sufficiently skilled observer with considerable information about the nature of the new knowledge. Consequently, even if the fundamental knowledge is a secret initially, it will be far less costly for the second person to discover it than it was for the first. "Reverse engineering," a common practice in microelectronics, is one example of a much more general phenomenon, whereby one person can infer a great deal about what another knows simply by observing the behavior and products of the informed person.

The issues surrounding the privacy of information provide another illustration of the same principles regarding the appropriability of knowledge. Privacy refers to preventing others from having access to information without the approval of the person who asserts a property right over it. For business information—whether a customer list or the secret formula for Coca-Cola—the economic character of privacy is apparent: Privacy is necessary to retain the private value of the information in the context of a market, and presumably the business holding such private information would sell it or license its use if the price were right. Likewise, although its economics are more subtle, personal privacy issues have the same basic structure. Individuals assert the right of privacy about their personal lives because they value freedom from harassment, public embarrassment, or other unpleasant consequences when personal information is disseminated to others. But, in a sense the issue is again appropriability. When the price is right, intimate details are revealed, whether through spicy confessional biographies or interviews on *Inside Edition*, or to professionals, such as doctors and lawyers, who can use the information to improve service to its owner.

Policy regarding privacy faces the classic trade-off in values that is common to all forms of information. A right to privacy enhances the value of personal information to individuals, but dissemination of the information without compensation provides value to others. And the latter need not be only the taste for the scandalous. The information may pertain to a person holding a public trust, such as president or Supreme Court justice, and citizens may rightfully believe that these personal details are useful indicators of how such an official will carry out the duties of office. The policy dilemma, then, is a fundamental conflict over which values count the most, those of the person who is the subject of the untoward information or those of others who might be both titillated and informed by its revelation.

In research, the analog to the issue of unauthorized copying is the concept of appropriability, which refers to the ability of the inventor or discoverer to capture the economic value of new technical knowledge. The patent system is the primary weapon for increasing the appropriability of new knowledge, but its applicability is severely restricted. Patents afford no protection to processes or novel combinations of existing products, and do not protect concepts or abstractions, such as a new scientific law. Patents protect only specific inventions that are commercially valuable and that are not "simple" or "obvious" extensions of products in common use or previously patented, meaning that an innovator cannot protect a large number of incremental improvements to a product that add up to something that is not a simple or an obvious extension of existing knowledge if each incremental change is not patentable. And, the practicality requirement for patents means that a technically brilliant new invention, which has no immediate use but which, with the invention of another item, suddenly becomes so, cannot be prote   d, even if the first invention was less obvious and more costly th..n the second. Finally, because patents cover specific solutions to a problem, not the basic idea behind the solution, they do not prevent another invention which uses that idea in a different way.

The inability to protect fully new scientific knowledge is not an unambiguous problem for society. If the value of all new knowledge were fully appropriated by its inventors, most of the growth in per capita income since the Stone Age would be in their hands. The phenomenon of economic development as we know it, with generally rising incomes, enables individuals to share in economic growth by learning. By acquiring skills at approximately the private cost of learning them, workers improve their productivity and hence the earnings they command in the labor market. Nevertheless, the incomplete protection given to advances in useful knowledge by the system of intellectual property rights raises the identical problem discussed in the context of the production of other forms of information: incomplete appropriability causes too little research to be undertaken, too many resources to be devoted to copying and applying old methods rather than inventing new ones, and too few resources to be devoted to finding new ways to improve the quality of the work force (i.e., to innovations in education).

The problem of innovation in education is especially acute. To improve educational productivity—the depth of knowledge acquired by students for a given allocation of time and resources to educating them—requires exposing the students to the new method. Unless the new method is embodied in a device with patent protection, the student, once taught, knows how to reverse roles and become the teacher, applying the same technique. Hence, educational innovations are especially likely not to be appropriable, and so to suffer from underinvestment in the private sector.

In the domain of research and education, a policy response other than intellectual property rights is readily apparent: partial or complete public financing of information production. The government provides a great deal of the support for basic research in all rich countries, and quite a bit of support for even clearly commercial developmental research. The logic of these programs applies equally to all areas of information production: If government pays the first-copy cost of any new information, whether in particle physics, fiction, or advanced mousetrap design, users need only pay the costs of distributing and using this information, so that information usage becomes more efficient.

The difficulty with public provision of information is that whereas it can solve the second stage of the efficiency problem—efficiently using what we know—it will not clearly solve the first-stage problem, which is producing the right amount and types of new information. In the field of R&D, two issues that are persistently raised in the policy debate illustrate the nature of the first-stage problem.

One issue in R&D policy is whether basic researchers pursue new knowledge that has the greatest value to society, rather than simply study topics that they find most enjoyable. The argument for public support for research is not that it increases the wealth and happiness of researchers, but that it improves the lot of others. Is the Superconducting Supercollider the key to a wave of technical wonders for the next generation of Americans, or an expensive toy for a few thousand physicists? The essence of the policy problem is that we cannot answer this question definitively unless we build it, for the results of fundamental research are inherently unpredictable. How society assures that projects are picked in a socially responsible way, but without destroying creativity and the productivity of researchers, is a serious policy question that probably will never be answered in a completely satisfactory way.

The other persistent issue in R&D policy is the propriety of "picking winners." This issue refers to the problem of assuring that the commercial research projects that the government undertakes really are the ones that society will value highly but the private sector will not support because the costs of discovering the new knowledge cannot be recovered in the market. The problem is a real one because government officials cannot hope to be well informed about which proposed projects are most likely to advance commercial technology. Moreover, because of the necessity for politicians to face reelection, elected leaders cannot reasonably be expected to resist the temptation to support the projects that benefit their friends, and not to support projects that threaten the investments and livelihood of their friends.

The two core R&D issues generalize to all forms of new information production. Consider, at the other extreme, the fundamental problems associated with public agencies that support cultural products, such as the National Endowment for the Arts or the Corporation for Public Broadcasting. The premise behind the case for public support is not just that the arts, like all information products, are underproduced. A second, equally important premise is that the government can fix the problem without either catering to the private tastes of artists (letting them earn a living by egotistically suiting their own tastes rather than creating a public good) or allowing the identities of supporters and opponents in the political process, rather than the merits of the product, drive the allocation of support. As with R&D, the core problems are the difficulty of knowing before the fact which information is worth producing, and the distorting influences when choices are made in a narrowly political context rather than in response to a more universal and encompassing system of evaluating products.

INFORMATION AND DECISIONS

Much of information policy is motivated by the special problems associated with the use of information to improve decisions, although this fact is not always readily apparent. Consider the especially controversial issue of discrimination. One motive that can explain why a business might discriminate is pure prejudice, whereby the decision maker is willing to suffer an economic loss in order to serve a personal

taste not to associate with a particular group. Another possible motive is statistical generalization: Members of a particular group, perhaps due to prejud::ial discrimination by others, may have lower average productivity on the job or cause the business to have higher average costs of service.

For example, residents of Keokuk, for some inobvious reason that is unrelated to simple observables like income and education, might have a default rate on installment loans of five percent, while residents of Dubuque might have a default rate of three percent. The installment loan officer of the Illinois-Iowa National Bank, with branches in both towns, is likely to base installment loan interest rates on the expected cost of a loan (including the default risk), and so is likely to charge Keokukians two percent more than Dubuquers are charged. Nevertheless, 95 percent of Keokukians actually present no risk of default, and quite justifiably are likely to feel abused. In this case, discrimination is motivated by the fact that it pays: the business that practices it will be more profitable. The identity of a person, because it is correlated with a useful attribute, even if the correlation is extremely weak, is nonetheless a valuable signal to the decision maker. To ignore the signal (and not to discriminate) is then costly, inducing decision makers to discriminate while honestly proclaiming themselves not to be prejudiced.

Whereas the ethical distinction between these cases may be nonexistent, the economic distinction is very important. Eliminating the first form of discrimination will be productivity enhancing, will impose damage only on the prejudiced, and will on balance redistribute income from the less productive to the more productive. Eliminating the second will reduce economic measures of national output and redistribute income from the more productive to the less.

In the installment loan example, regulators might respond to the cries of outrage from Keokukians by forcing the bank to charge the same interest rate in both cities, based on the combined average default rate of four percent. If effective, this regulation will tax Dubuquers beyond the cost of serving them in order to cover the higher default rate in Keokuk, thereby reducing the standard of living in Dubuque, raising it in Keokuk, and, in the end, subsidizing the five percent of Keokuk residents who are bad risks. But the regulation is quite likely to be ineffective. Dubuque Savings, which does not operate in Keokuk, can

continue to charge the old interest rate, taking away the customers from Illinois-Iowa National and forcing it to close its Dubuque office—and raise its interest rates in Keokuk to their old level. Or, in expectation of this outcome, Illinois-Iowa National may simply stop making install-ment loans in Keokuk, thereby harming all Keokukians, who would prefer loans at the old rate to no loans at all and who, quite accurately, will claim that they are being victimized by a "red line" policy.

If the politics of the two forms of discrimination are quite different, so, too, are the most effective policy actions to overcome them. In the first case, simply enforcing nondiscrimination requirements is reason-ably likely to succeed and to be politically acceptable as long as most citizens are not highly prejudiced. In the second case, the optimal policy is almost never to enforce a nondiscrimination requirement because of economic consequences on noncompliance. Instead, the best policy response may be to provide decision makers with a more reliable means for assessing productivity and costs than the observed group identity of a prospective employee or customer. In the install-ment loan example, the Federal Reserve could undertake a research project to identify more precisely the personal characteristics of loan applicants that affect default risk, and provide the results to banks. If the research produces a method that more accurately predicts default than simply observing in which town the applicant resides, bankers will abandon this attribute as a factor in setting interest rates because the new method is superior—and more profitable. Or, if the true cause of default risk can not be uncovered, the government's most effective option is somehow to reduce the costs of doing business in Keokuk, such as by lowering taxes on Keokuk operations or selling subsidized default insurance for loans made to Keokukians. Again, these policy conclusions are not driven by any ethical distinction between the two cases, but purely by the likelihood that a policy intervention will actually deal with the problem effectively.

The fundamental point that is illustrated by the discrimination example is that the amount and quality of information available to decision makers affects their decisions in a systematic and predictable way. How information affects decisions can be explained through a simple example. Suppose that two people are flipping coins. One person flips, the other calls either heads or tails while the coin is in the air, and, depending on whether the call of the coin is correct, one player pays the

other a dollar. The game is fair, in that the chance that the coin will be heads is exactly .5 and is known by both players. For both players, the objective economic value of this game is zero, because they are equally likely to win or lose and the amount they can win is exactly equal to the amount they can lose. They play the game only because they enjoy it, not because either can reasonably expect to profit from it.

Now suppose that a psychic wanders by, and whispers to one player that the result of the next coin flip is perfectly predictable. The psychic offers to inform this player of the outcome of the next flip, but only for a price. Assuming that the psychic is telling the truth, what price should the player be willing to pay? If the player knows for sure how to call the coin, the flip no longer has a value of zero, for the player will always make the correct call and so earn $1.00. Hence, the act of being informed increases the wealth of the player by the difference in the average outcome of the flip—from zero to $1.00. At any price less than one dollar, becoming informed is profitable.

Of course, the player might not pay a price close to a dollar, because once the player becomes informed, the coin flip is no longer a game, and the player no longer derives value just from engaging in it. The act of buying the information transforms the coin flip from a recreation in which the value derives from the process to an occupation in which the value derives from the outcome. But this is a detail. If the enjoyment value of an uncertain fair game is 50¢, the value of the information is the net gain from perfect knowledge, which in this case is 50¢ ($1.00 in payoff minus 50¢ in lost enjoyment). Henceforth, the discussion will focus solely on the outcome value of improved decisions. It will also ignore any perverse pleasure a player might receive from fleecing an unsuspecting opponent who thought the game was for fun.

Embedded in the coin-flip example are several general principles about the role of information in decision making. A decision maker can benefit from information only if initially the decision maker's knowledge about cause-effect relations is imperfect and if new knowledge can reduce uncertainty about these relations. But whether the uncertainty is fundamentally irreducible or can be reduced by learning more about how the world works may be unclear to the decision maker. If so, the discoverer of new knowledge faces an additional problem: How can a user be convinced that the new knowledge is valuable and so be induced to use it (and even pay for it)?

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To return to the coin flip example, if the coin flip really is fundamentally uncertain, as is almost certainly the case, information cannot improve decisions. Knowing this, the player who is approached by the psychic is likely to be highly skeptical that the outcome of the flip can be predicted. In response, the psychic expresses sympathy for the player's doubts, and in the spirit of consumer protection, guarantees the product, offering to collect 10¢ for the forecast only if it proves to be accurate. (This example is actually derived from a criminal fraud case brought against a racetrack tout in the 1930s.) Superficially, the guarantee seems valuable: The player will pay 10¢ only if the forecast is true, leaving a net gain of 90¢ (the dollar payoff minus the 10¢ fee). In fact, the guarantee provides absolutely no protection to the player. If the psychic is a fraud, on half the flips the psychic will collect 10¢, and on half nothing, for an average gain of 5¢ per flip for a worthless forecast. The player will lose a dollar half the time (when the psychic is wrong), but will gain only 90¢ when the psychic is correct, for an average net loss of 5¢ per flip.

The "satisfaction guaranteed" example reveals another major principle of information economics: information is valuable only if the user has independent reason to believe that it is accurate—or at least more accurate than the other information that is available. Moreover, the decision maker must be able to infer not only the value of better information, but also whether the terms of the transaction themselves confer any additional insight about the true value of the information. In the preceding example, the psychic presumably knows whether the forecast is accurate or simply a guess. The performance guarantee was valueless; however, a psychic that is accurate can make a much better guarantee by agreeing to cover all losses incurred by the player. By making this guarantee, the psychic effectively communicates the fact that the forecast is certain to be accurate. Otherwise, the psychic would never sell information for 10¢ that had a 50-50 chance of causing the loss of a dollar. The player, knowing that the psychic would not make this guarantee unless the forecast was accurate, is therefore secure in the value of the acquired information.

Still another feature of information and decisions is illustrated if the example is altered again. Instead of a psychic, the third party is nature, and one of the players is Newton, who is considering studying the mechanics of coin flips in order to predict how a coin will land. Here the

counterpart to the payment to the psychic is the research necessary to understand the mechanics of coin flipping. The primary difference between nature and psychics is that nature always tells the truth, but speaks in a language that is costly and difficult to translate. Newton presumably will undertake research if he believes that he can success-fully communicate with nature—that is, that he is reasonably likely to produce a good model for predicting the outcome of coin flips. More-over, he must also believe that the effort required to discover this model will be more than recovered from increased profits from coin flips.

As an expert in mechanics, Newton may be certain that an accurate model of coin flips can be discovered, in which case the problem is simply comparing the net gain from the flip ($1.00) with the effort necessary to produce the model. In this case, the basic calculation is identical to the one concerning the psychic. But Newton may believe that he is not certain to find a solution to the coin-flip problem, in which case the comparison is more complicated but broadly similar. If Newton thinks that after spending 20¢ in effort he will stand an even chance of discovering the law of coin flips, he will undertake the research after making the following calculations: Half the time he will have a net gain of $1.00 per flip, and half the time he will gain nothing, so that the average gain from the two possible outcomes is 50¢ per flip. This expected gain exceeds the 20¢ cost of the research. Thus, exposure to a new source of uncertainty (whether a law can be discov-ered) is valuable because it has a more than compensating net effect on the other source of uncertainty. Nevertheless, half the time the research project will fail, not because the decision to undertake it was incorrect, but because Newton simply had bad luck.

The last insight from the coin-flip research problem contains one of the most important lessons from the economics of information: Good decisions can lead to bad outcomes, and vice versa. The test of a good decision is not whether it turned out to produce a good outcome, but whether the decision-making process made the best use of the informa-tion that was available at the time the decision was made. The shibboleth that one should learn from one's mistakes is highly misleading—one can learn from one's mistakes only if the mistake produces valuable new information that, had it been known in the past, would have altered the original decision. And, if the old decision did produce valuable new information, it was not a mistake!

Still another important insight about the relationship between information and decisions can be derived from the observation that few coin flippers are Newtons! Because good decisions require knowledge about the nature and cost of information that might be used to make better decisions, decision makers are advantaged if they possess more information and knowledge about how to use it than others possess. As knowledge becomes more precise, including knowledge about how best to use new knowledge, those who possess information are increasingly advantaged in comparison to those who do not.

In the coin-flipping example, the existence of either a true psychic or Newton's Law of Coin Flips redistributes income from one player to the other and, in the first case, to the psychic, but creates , · new wealth. Indeed, in the second case, Newton's research into coin-flip mechanics is a complete social waste of resources, serving only to enrich Newton at the expense of the other player. Moreover, if Newton publishes his new law in the next edition of *Principia Mathematica*, society will experience a net loss of welfare as all coin flippers learn how to predict coin flips and so permanently lose the enjoyment value of flipping coins with their friends.

This example is far from frivolous: The much-touted foolproof system for winning at blackjack, discovered in the 1950s, was knowledge of precisely this form. It initially transferred wealth from casinos to informed players, but then led casinos to change the rules and to enforce a ban on gamblers who played the system, thereby reducing the net losses of the casinos but imposing costs on players who did not use the system.

The preceding example illustrates still another principle about information. Better knowledge is *always* valuable to a single decision maker, although it may not be worth the cost; however, it also can have a net negative value to all decision makers even if its net value to some people is positive. Whether the social value of information is positive depends on whether income redistribution weighs heavily in the payoff from acquiring it. The closer the decision-making problem is to a pure game of chance that is played primarily for enjoyment, the more likely it is that the social value of new information is negative. Thus, if Bobby Fisher discovers the perfect, unbeatable strategy for players using the white pieces, his discovery will have no effect other than to destroy the value of the game of chess. But if the primary effect of the information

is to improve productivity—to make products better or cheaper—the net economic benefits will be positive, although they may also significantly redistribute income. An important example of the latter type of information is a technological innovation that reduces the unit cost of production, but requires a different set of labor skills than the technology it replaces. Such a change *always* has net positive benefits because it increases the opportunities available to the entire society. But, if laborers cannot easily switch their type, it will bid up wages for one type of worker and depress them for another, and perhaps also impose transition costs in the form of unemployment on the latter.

As a practical example of how the process of developing superior information can be socially wasteful, consider the case of computerized trading systems for securities markets. The basic idea of these models is that computers are programmed to issue buy and sell orders, based on events in the market. Of course, these programs require resources to create, and then still more resources to operate, since they must continually update their market assessments on the basis of the most recent trades. Access to a computerized trading program is valuable to an individual trader because it reduces the uncertainty of investments. Because investors typically are risk-averse, a reduction in the uncertainty associated with a portfolio of securities provides economic value to the holder, which is why portfolio holders will invest resources in these programs.

The problems with computerized trading arise because it has a broader effect in the market than simply reducing the risk of a single trader. One issue that has received considerable coverage in the press, but which actually may not be true, is the claim that computerized trading programs, when extensively used, actually increase market risk because the programs can interact with each other to produce a "feeding frenzy" of buys or sells. As many programs take the same actions, collectively they change the market price in precisely the same direction that the programs were trying to avoid, thereby creating a self-fulfilling prophecy and triggering still more computerized trades in the same direction. Whether computerized trading actually has this effect is highly controversial, but if it does, the use of these programs produces a result that corresponds to the theory of an arms race: Each individual trader faces an incentive to buy into computerized trading, because to do so reduces an individual trader's risks, but the cumulative effect of all these decisions is to make the market more risky and hence to harm all traders.

Regardless of the truth of this claim, another effect is not contro-versial. Computerized trading derives its value in part from the ad-vantage it gives computerized traders in comparison with standard traders. Stop-loss or trigger-buy orders require more time to execute if they are not computerized, so the gains from these actions to traders without the program are smaller than the gains to those who use them. As a result, part of the incentive to buy such a program is redistribu-tional. Hence, even if the advocates of computerized trading are cor-rect—that the programs, on balance, reduce market volatility and risk—there still will be overinvestment in these programs because part of the motivation for using them is purely redistributive, as was the case with the coin-flip example.

The last problematic aspect of the value of new information in-volves its strategic use. The idea here is that parties with a great deal of information will reveal only part of it for the purpose of taking advantage of the basic decision calculus described in the coin-flip example. To illustrate strategic use of information requires a more complicated example. Suppose that three events, X, Y, and Z, are collectively inclusive and mutually inclusive (one and only one must occur), and are all equally likely. Suppose that nature may reveal clues before one of these events transpires. The two possible clues are C_1 and C_2. If C_1 is observed, Z cannot happen, and if C_2 is observed, X cannot occur. When both clues are observed, then Y must happen. When one clue is observed, the two nonexcluded events are still equally likely. Now suppose that consumers want to buy protection from some of these events. For example, X might be pleasant weather, Y might be a big thunderstorm, and Z might be a tornado, which produce losses of zero, $2.25, and $6.50, respectively, to an unprotected consumer. Suppose also that a consumer can protect against the damage from Y for $1.00, and for $3.00 can protect against both Y and Z. Finally, suppose that the company selling the protective devices can observe the clues, but consumers cannot.

With this information, the behavior of consumers under a variety of conditions can be predicted. Without a clue, consumers do nothing. The chances are only one-third that the $1.00 device will save $2.25, and an expected saving of $2.25/3 is not worth $1.00. Likewise, the expected saving from the $3.00 device is $8.75/3, which also is not worth it. If the company observes both clues (unknown to the con-

sumer). it knows that Y will happen. If it announces that it observes both, all consumers will buy the $1.00 device and save $2.25. But if the company announces only C_2, the consumer will infer that Y and Z are equally likely (each with probability of .5). The consumer's best choice is to buy the more expensive device, with a net profit of $8.75/ 2 – $3.00, rather than the cheaper device with a net profit of $2.25/2 – $1.00. Thus, strategic revelation of partial information, as long as it is undetected, causes the company to sell more protection than it knows the consumers really need.

The preceding example constitutes an interesting argument for public subsidies of information production and dissemination (such as weather forecasts or the risks associated with consumer products). The crucial assumption in the example is that consumers cannot or will not obtain the clues about the future that lead to better decisions. Of course, this assumption is not always true. for another company—maybe the Consumer Federation of America (CFA)—can undertake the effort to detect the clues and then sell the information to consumers. The argument for giving standing and even subsidies to consumer advocates in regulatory agencies is based on these same arguments: Without doing so, regulated firms will use information strategically, and will not be subject to refutation as often as they should be. But this alternative brings us back to the problems in the previous section: Because of the nature of the market for information, there is likely to be too little such information supplied, and in any case all parties who possess relevant information have the same incentive to reveal only the part of the information that serves their interest. For example, when the CFA studies the performance of a product, it produces a public good, and so the act of publicizing that information benefits all consumers, not just those who belong to CFA by subscribing to *Consumer Reports*. Consequently, CFA's budget for informing consumers and government regulators is likely to be too small in comparison to the consumer benefits that arise from this information. Of course, CFA also may not represent attitudes about product quality and risk that reflect the values of many consumers, leading it to underinvest in some kinds of information, and not bother to reveal other information that it discovers in the course of its studies. If so, fully informed decisions by both consumers and regulators may call for subsidies for several sources of information, not just CFA.

CONCLUSIONS

The decision-theory side of the economics of information has many important implications for information policy. This conclusion summarizes a few of these implications for some policy issues that government officials are facing in the 1990s.

One important insight pertains to policies regarding the proper disposition of information that is generated and supplied by the government itself. The act of engaging in the public's business causes the government to collect vast amounts of information, and puts the government in a unique position about informing citizens about core facts about the society, and about how government programs actually work. In recent years, public policy about government-provided information has not reflected an informed consideration of the economics of information.

First, consider the decisions in the 1980s that effectively privatized much of the information collected by the government. As a concrete example, the only source of comprehensive data about the new federal program to encourage cooperative research between federal laboratories and private industry is a private company that charges $300 for that information. By adopting policies that lead to a price for this information that substantially exceeds its dissemination costs, the federal government actually undermines the effectiveness of its own program by creating an unnecessary communications barrier between itself and its potential research partners. In so doing, the government is ignoring a principal lesson of information economics: The necessity of the private sector to recover first-copy cost through prices that exceed dissemination costs is a disadvantage, not an advantage, of private information production. Because the government already pays the first-copy cost in collecting the information in order to carry out its own functions, the clearly optimal policy is to provide the information at the cost of dissemination, which in this case is a tiny fraction of the price charged by private providers.

Second, the federal government has adopted a very peculiar policy regarding information about tax liability that is provided by employees of the Internal Revenue Service. A consumer who follows the incorrect advice of the IRS is subject to the same fines and penalties as a consumer who makes the same mistake without consulting the agency. This system is very much like the fraudulent warranty in the example of the

psychic who predicted coin flips. An IRS agent has absolutely no incentive, other than altruism, to devote the slightest effort to answer inquiries accurately, and a rational consumer has absolutely no reason to give any credence to the advice that is given. The program is, in short, a waste, and will continue to be as long as IRS agents bear no responsibility for the advice that they give.

A third important insight pertains to the desirability of public investments to speed the enhancement of information technology, whether in the telecommunications backbone network or in R&D subsidies for computers and microelectronics. One of the important consequences of rapid advance in information technologies is that it will improve decisions because the lower cost of information will cause more of it to be used to reduce uncertainties about future actions. For the most part, improved decision making is socially beneficial, but there are aspects of these policies to worry about.

A troublesome feature of these technologies is that they can offer opportunities to redistribute wealth to the informed from the unin-formed. In part, this redistribution is from consumers (who as yet possess insufficient information to know exactly how much enhance-ment to the telecommunications system they really want) to providers of information technology (who most definitely know that they want to sell as much of it to consumers as they can). In addition, this redistribu-tion is from the less educated to the more educated, from people in the role of consumers to people in their role as income earners, and from income earners in occupations where the future is relatively unaffected by uncertainty to income earners where future technology and con-sumer demands are highly uncertain.

These points do not necessarily argue against policies to encourage information technology, for a lesson of the previous section is that the private sector will underinvest in new information technologies, all else equal. But other conclusions are also warranted.

First, some of the expressions of enthusiasm for these programs is motivated by the prospect of wealth redistribution, rather th .n social efficiency, so government would be well advised to give the advocates less than they want. In particular, proposals for enhancements that are motivated primarily on the basis of the fact that they are technically possible, rather than on the basis of specific applications that justify their cost, should be viewed with suspicion.

Second, experience with the new technologies will produce more information about its potential and its cost, and so make future decisions about support for more investment in these technologies more informed. This possibility for learning suggests a policy of maintaining flexibility and, in the short run, committing to no more than is necessary. In a sense this consideration works in the opposite direction of the first, for one value of experimenting with a new technology—beyond the uses to which it is put—is that it generates information that will lead to better decisions about the development of the next technology.

Third, a balance should be struck between education, public provision of information, and public subsidies of information technologies. An educational system that produces a declining fraction of people who think reasonably clearly about decisions under uncertainty and about making inferences from information is fundamentally inconsistent with an information technology sector that offers increasing rewards that are available only to the educated. Of course, federal policies are always in some loose sense competitive substitutes, but in this case the complementarities are especially strong. A public policy that emphasizes enhancing the network and high-end terminal equipment largely for business purposes, but that is not accompanied by a program to enhance public education, and in particular to get computers into the schools and to create data bases and software for use by ordinary citizens, is unbalanced at best. The social value of new information technology is maximized if the maximal number of people can use it, and the act of maximizing the number of informed users also serves to minimize the extent to which redistribution of wealth will motivate the adoption of the technology. Thus, better education in how to use information is an essential component of rational public policy toward the information sector.

COMPETING WITH INFORMATION: EMPOWERING KNOWLEDGE NETWORKS WITH INFORMATION TECHNOLOGY

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INTRODUCTION

> In an economy where the only certainty is uncertainty, the one
> sure source of lasting competitive advantage is knowledge.
> *Nonaka, 1991, p. 96*

Management gurus predict the winners of the global business wars
to be organizations designed as virtual knowledge networks (e.g.,
Peters, 1992; Davidow and Malone, 1992; Quinn, 1992). Organizations
will no longer be distinguished by how they manage physical material
or product flows. Instead, successful differentiators will harness the
expertise of knowledge workers to the problems and opportunities
presented by customers, suppliers, and business partners. Success will
be determined by how rapid and effective a firm can be in responding

to unique customer requests, changes in government policy, opportunities for strategic alliances, breakthroughs in materials technology, and competitive challenges. Battles will be waged in unfamiliar settings, where existing business processes will not apply or may prove disastrous for the campaign. The old hierarchical organizations were usually driven from the top. A strategic alliance between two firms might have been identified over a game of golf or at a board meeting. Today's new business opportunity is more likely to emanate from a customer and his or her customer representative, two former college friends communicating via electronic mail, or a customer repositioning competing proposals into a cooperative venture.

This changing environment will necessitate major changes in the way organizations collect, store, process, and distribute information. In the past information processing technology was an enabler of management control. In the future it will become central to the knowledge-creation and -dissemination process of an organization. An organization's key distinctive competency will be its ability to integrate new information with existing expertise. Modern information and communication technology, in turn, will define the battlefield on which organizations, armed with their knowledge-based competencies, will compete. These battles will be far flung. Knowledge-based competition will take place in an "anyplace, anytime, with anyone" environment.

By harnessing advances in information technology to the requirements of an increasingly volatile world, organizations will add further volatility to the environments of their competitors, suppliers, and even customers. They will do this by using information technology to personalize service, by encouraging knowledge work to flow to the least expensive human resources, and by empowering organizations to harvest worldwide economies of scale and scope in knowledge work. In such a world, responsiveness, adaptability, and flexibility become far more central to organization success than they have been in the past.

The organizational designs that are emerging to provide the necessary new flexibility resemble networks rather than hierarchies. In a networked world everyone is interconnected to everyone else and to powerful data bases that span department, division, and even organizational boundaries. Supervisory and midmanagement positions give way to empowered knowledge workers and cross-functional work teams. Information technology lets such teams span international boundaries

to benefit from a 24-hour-a-day, seven-days-a-week work window. Information and communication technology is hence both an enabler of and driver for knowledge-based economies and organizations.

In this paper, we look at competition in this new knowledge era. In the next section, we explore the network organization form, a form that can harness complex knowledge flows while taking advantage of the communications bandwidth and memories of modern information technology. Transformation to a network organization will be a long and perilous journey for those firms that have operated as a hierarchy in the past. We describe a fictitious example of such a firm which realizes that it must learn to compete with information and construct a global corporate nervous system. We then discuss the reengineering journey that many companies such as this one are undertaking to take them into the age of the networked organization. We conclude by discussing the roadblocks that we believe will prove to be insurmountable for many firms that prospered in the age of the hierarchy.

COMPETING WITH INFORMATION:
THE ORGANIZATIONAL DESIGN REQUIREMENTS

If your business has anything to do with information, you're in deep trouble.

> *Bill Gates, Cofounder and CEO of Microsoft*
> Fortune, *June 14, 1993, p. 56*

The computer industry is in the midst of a not-so-quiet revolution. The industry that created information technology is undergoing major shakedowns as yesterday's winners seek to transform themselves from highly vertically integrated companies to much more modularized core companies. In the volatile electronics industry, firms that have practiced outsourcing (i.e., buying their products ready-made or purchasing large part of their parts from suppliers) are proving to be considerably more profitable than those firms that are vertically integrated (*Fortune*, February 8, 1993). In the process of modularizing, some well-known electronics giants are facing massive layoffs, restructuring, loss of market share, deposed chief executives, and even bankruptcy. The way this industry is reshaping is a forerunner of how other industries will be

transformed (*Fortune*, June 14, 1993). These transformations will be driven by the ever-increasing turbulence in our environments.

Environmental Turbulence

There are numerous forces fueling environmental turbulence. Among these are more open capital markets, new markets in Eastern Europe, rising subnational movements, free trade zones, and regional market communities. But advances in information technology and the resulting availability of a global work force are two major storms that will wreak havoc with business environments.

Mobility of information and human expertise fuel both environmental turbulence and the rise of knowledge-based economies. The more transportable and affordable information and communication technology becomes, the more shareable and transformable information will be. Easy and inexpensive cross-border flow of information increases interdependencies of markets. Information technology also allows firms to disperse their value added processes around the globe, again increasing the reciprocity of markets. Firms extract the information components of their operations and relocate them to somewhere else in the world with a more favorable cost structure. For example, semiconductor manufacturers typically locate design facilities in high-tech corridors of the United States, Europe, or Japan, and then inexpensively transport work-in-progress to fabrication and assembly plants located in countries with more advantageous cost structures. The customized chips, often designed with considerable customer input, are later delivered to locations throughout the world based on last-minute direction from the customer. Information technology also reduces, and sometimes totally eliminates, time delays and the transportation, reproduction, and inventory costs associated with information-based products and services (e.g., software). These have dramatic effects on development, production, and marketing cycles. The shorter the cycles the more volatile the marketplace.

The global work force is also becoming more mobile, thereby increasing the volatility in labor markets. This mobility is facilitated by "electronic migration" of skills and expertise, adding to an already large international electronic trade consisting of movements of knowledge and services. Increasingly, the tools of production, such as software systems, are themselves instantly transported to anywhere in the world. For

example, consulting firms are turning to offshore software developers in countries such as Ireland and India to improve their cost structures. Consequently, the key resources of the knowledge era—information and expertise—can flow nearly instantaneously to a new business opportunity with little regard to borders, time zones, or outdated trade laws.
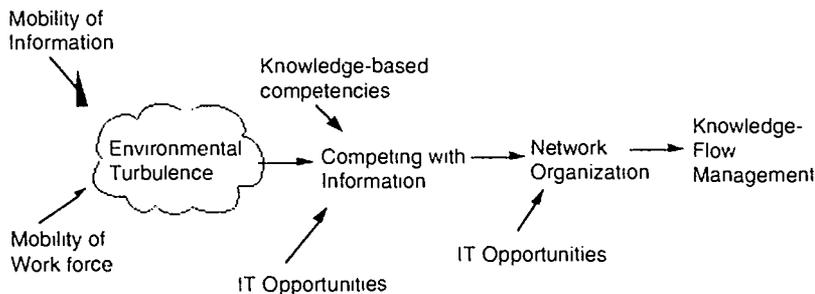
Competitive Strategies

The greater the environmental turbulence, the greater the need to compete with information and knowledge.[1] In uncertain markets, winners will be those that can quickly move resources—information and expertise—in response to unpredictable opportunities (Miller, 1992). But in doing so, they further increase the volatility of the marketplace for others. Moreover, any advantage is short-lived as competitors improve upon the innovations of others. The only sustainable advantage will be in the process of innovation—combining market and technology know-how with the creative juices of knowledge workers. Environmental volatility will also result in products and services becoming more information intensive (just keeping a customer abreast of changes involves information). Mass production, on the other hand, assumed, and contributed to, environmental stability. Volatility will increase as customers demand personalized but more integrated worldwide services. Personalization often involves providing customers with a role in product specification and even design. Personalization, global account management, and greater customer communication all increase information requirements. In fact, it will be the information-rich components of customer service that will increasingly become the key strategic differentiators.

As environmental turbulence increases the need to compete with information becomes greater. But so too do opportunities to take advantage of advances in information and communication technology. Information technology allows organizations to combine one expert's knowledge with that of another located a half a world away without either leaving their office. Information technology also allows creative packaging and dissemination of that expertise. Broad-bandwidth[2] global networks at Texas Instruments and Ford let process engineers in the United States access and monitor, in real time, quality data for plants in countries where a relatively less-educated work force is employed. At Motorola, engineers in Austin and Phoenix participate in teleconfer-

ences with customers in Japan. A portable video camera shows them problems occurring at an internal customer's wafer fabrication plant half a world away. In a few hours, the problem is diagnosed, a repair is initiated, and the customer is delighted. At Air Products and Chemicals, a videoconference network is used to convince a customer in a remote corner of the world that they will have the firm's worldwide expertise to draw upon. At Korn/Ferry International, videoconferencing lets executive recruiters meet face to face with executive talent located throughout the world. Information technology is hence used to facilitate knowledge flow—know-how about products, services, key resources, and processes—from one corner of the organization to another.

In the knowledge era, a company's success will depend on its ability to derive value from information. The greater the environmental turbulence, the greater the need as well as opportunity to compete with information. Information requirements must be met by stitching together human skills and expertise with the threads of information and communications technology. As information flows change from control and transaction flows to knowledge flows so too must the organizations designed to process them (see Figure 1).

Figure 1 Competing in the Knowledge Era

Mobility of
Information

Knowledge-based
competencies

Environmental
Turbulence

Competing with
Information

Network
Organization

Knowledge-
Flow
Management

Mobility of
Work force

IT Opportunities

IT Opportunities

Past Organizational Forms—Functional Hierarchy and Divisional Organization

Competing with information requires us to change the paradigms we use to think about the relationship between information and organizational design. The traditional organizational forms—functional hierarchy and divisional organization—assumed that: (1) information is a source and means of control and (2) the amount and complexity of

information that the organization processes is to be minimized. Exceptions to standard operating procedure, of which there were few in the relatively stable environment of mass production, tended to slowly make their way up and down the organizational hierarchy. The matrix organization was later developed to provide the additional information processing required by increasing environmental turbulence, but even here information flows were still controlled in a hierarchical manner. The organization's information processing capability was used primarily to coordinate and control resources.

By using a limited number of product lines, infrequent model changes, arms-length relationships with customers and suppliers, and stable channels of distribution, firms were designed to reduce the complexity and amount of information their organization faced and shared with others. If significant differences existed across market segments, as in international subsidiaries or customer segments, divisional organizations were established that could operate largely autonomously. Autonomous structures in turn minimized the effects of one division on another and reduced information processing for cross-divisional coordination.

In addition to being poorly prepared to cope with environmental turbulence, functional and divisional organizations are incapable of taking advantage of the high information bandwidth available from modern information and communication technologies. Sadly, in many firms business processes are today often only recoated with the shiny veneer of advanced information technology, thus overinflating management's expectations for the organization's information processing capabilities. Although the computers may be powerful and the workstations easy to use, they only further cement the functional specialization embedded in current business processes. Worse, though these processes often cross organizational boundaries, associated information systems and data do not. Because of the common practice of aligning information systems investments to the boundaries of functional and divisional structures, information is usually inconsistent, incompatible, or nonexistent at the process level. Improvements within one functional area's processes and information systems often lead to new bottlenecks elsewhere with little overall improvement. Despite frequent reorganizations, organizations find their current information systems have locked them into an inflexible hierarchy. Recent trends

toward client server technology and the decentralization of information system responsibility may even be exacerbating the problem of parochial systems' solutions.

In an era in which we will compete with information, we require an organization structure based on very different assumptions about information: first, information is to be shared, not hoarded and, second, information is a source of knowledge as well as control. Knowledge generation requires "free access to company information" (Nonaka, 1991, p. 102). Information can not be hoarded nor restricted functionally, divisionally, or hierarchically. According to Nonaka, "When information differentials exist, members of an organization can no longer interact on equal terms, which hinders the search for different interpretations of new knowledge" (p. 102). The network organization is the one organization form that assumes information is a shared resource (Miles and Snow, 1986; *Business Week*, February 8, 1993; Reich, 1991).

Dynamic Network Organization

> Information will be the core of the virtual organization.
> *Davidow and Malone, 1992, p.72.*

In the dynamic network organization, often called the virtual organization, knowledge workers work in self-directed teams, information is shared freely, and suppliers and customers are coproducers of products (*Business Week*, February 8, 1993). The key organizational resources of the network organization are human expertise and information that can be focused on problems wherever in the organization they occur (Reich, 1991).

Information processing skills will be of paramount importance in the network organizations, but many organizations have yet to learn to manage more than the most elementary form of information. The network organization must excel in processing four types of information (Davidow and Malone, 1992): content, form, behavior, and action. Organizations are already proficient in the most basic form, content information. Content information provides historical status information (e.g., quantity, location, and type of resource). Form information helps to describe the shape and composition of a product or service (e.g.,

architectural blueprints). Behavior information helps to simulate a service or product (e.g., crash testing cars on desktop computers). Action information is dynamically converted into actions (e.g., lights-out factories, orbiting satellites, or computer highway systems). The success of the virtual corporation will be determined by how well it masters the four information processing types, particularly for knowl-edge- and service-based products (Davidow and Malone, 1992).

Table 1 lists, and below we discuss, a generic description of the network organization. The particular network configuration will depend on a specific situation (Davidow and Malone, 1992). Customers who are themselves moving to a network structure will lobby enthusiastically for these capabilities in their suppliers and business partners.

Table 1 Characteristics of the Network Organization

- Network of knowledge nodes

- Knowledge nodes made up of knowledge workers

- Commodity type functions outsourced

- Home base is a network of "homes"

- Less emphasis on organizational titles, hierarchy, and organiza-tional charts

- Internal and external asset transfer via market mechanisms

- Shared vision

- Common culture

- Common measurement system

- Shared information and communication systems

The network organization is an assembly of knowledge nodes. A knowledge node can be an individual knowledge worker or a team of knowledge workers. Each node has its own distinctive competency that it brings to a particular problem. Once the problem is solved, a network is disassembled with its components becoming available for new problems and opportunities. In these "intelligent organizations," the

processes that add most value are knowledge-based service activities (Quinn, 1992). Consequently, the more permanent nodes of a network will increasingly focus on knowledge and service activities rather than manufacturing or production. These latter functions are often obtained as easily substituted commodities.

For a true network organization, particularly one operating globally, the concepts of headquarters and subsidiary or domestic versus foreign begin to lose their meaning. There will be a home office somewhere (primarily for legal and financial reporting reasons) and perhaps a central computer system, but the problem-solving web has no permanent home base. For instance, Asea Brown Boveri emerged in 1989 from the merger of Asea, a Swedish producer of electrical power equipment, and Brown Boveri, a Swiss firm producing similar products. After numerous acquisitions the firm now employs more than 200,000 people in sales and manufacturing facilities throughout the world. Headquartered in Zurich, with a CEO from Sweden, communicating in English, and reporting in U.S. dollars, ABB might be seen by some as a company without a country. But, according to Percy Barnevik, its CEO, "We are not homeless. We are a company with many homes" (Taylor, 1991, p. 92).

Even the definition of the corporation becomes tenuous for a network organization. "There is," according to Robert Reich (1991), "no 'inside' or 'outside' the corporation, but only different distances from its strategic center" (p. 96). That strategic center is a network (not a place), and consists of brokers who put dynamic networks together (Reich, 1991; Miles and Snow, 1986).

For the network organization, the traditional symbols and signals of control—organization titles, hierarchy, and organization charts—become less salient. The symbols and signs of "open" and "dynamic" are celebrated instead. Teams crossing legal corporate boundaries are the order of the day. For instance, engineers from Apple, IBM, and Motorola have recently been assembled to build a chip that will compete with Intel. Recognizing that openness was going to be a key to success among these sometime competitors, the usually security-minded IBM provided participants from Motorola and Apple with access to IBM mainframes. Apple, in turn, provided an IBM representative with one of their computers complete with a link into the Apple corporate electronic mail system (Lohr, 1993).

Managing across Knowledge Nodes. The glue that temporarily binds the knowledge nodes of the network organization are market mechanisms, trust, vision, and information technology. Bureaucratic controls give way to market mechanisms such as transfer pricing and electronic markets. But market mechanisms will be no more important than the reputations of, relationships among, and social contracts formed between the people participating in the nodes (Johanson and Mattson, 1987). Prior exchanges will build the trust and knowledge that will facilitate or impede future interaction among nodes (Jarillo and Ricart, 1987). For instance, Kingston Tech is a fast growing $500-million international company that upgrades personal computer systems. Doing business in 30 countries, it ships thousands of products a day, across the globe, on little more than a telephone call. Formal contracts are rare and the firm employs no lawyers. At Kingston Tech, "trust" and "family" replace contracts, lawyers, and hierarchy (Meyer, 1993).

A traditional hierarchy needs no overarching objective that must be shared with most employees. Rather, as objectives change, functional areas are tweaked by middle managers in the form of subtle changes in tools, plans, training programs, or business processes. Specialists proceed largely as before, focused not on the big picture but the small piece they are assigned. In the network organization, new stimuli and ideas usually come from lower levels within the firm. Knowledge generation is everyone's responsibility (Nonaka, 1991). Hence, a shared vision in the form of shared understanding of what kind of world the firm or business unit stands for or wants to create is critical for directing and leveraging synergy in the knowledge-generation activities.

To function as a network organization, the nodes must have a common measurement system (Handy, 1992). At Asea Brown Boveri, a worldwide financial system captures consistent data from 4,500 profit centers making up 1,200 corporate entities. The average size of these profit centers is 50 employees. Such a small group can clearly focus on such shared objectives as its own survival, while being compared to a similar unit a half a continent away. ABB also keeps staff units small, thus ensuring considerable local business unit autonomy. But a matrix management structure, made possible by the information system, lets the firm simultaneously manage around local markets and global products (Simons and Bartlett, 1992a; 1992b). ABB has the luxury of

comparable business units and results that can be expressed in U.S. dollars. In some instances, the outputs of networks and, more commonly, knowledge nodes, will be neither repeatable nor easily converted to a common currency. More subjective measurement systems, often based on peer or customer evaluations, will become common.

To survive in a dynamic environment, each node in the network organization must be continuously nourished from a wellspring of shared information. At Kingston Tech the "company's books are open to everyone" (Meyer, 1993). Similarly, at Kao, "All company information (with the exception of personnel data) is stored in a single integrated data base, open to any employee regardless of position" (Nonaka, 1991, p. 102). Business units at Asea Brown Boveri must quickly transmit monthly results to headquarters (Simons and Bartlett, 1992a, 1992b). These results are massaged and fed back into the organization, thus permitting business units to see how they compare with sister businesses elsewhere in the world. Best in company operations can be quickly identified and their business processes studied and copied. Such openness means that nodes participating in a common network must provide other nodes with broad access to their information resource. But broad information sharing will require a new set of values about information and strong social or legal contracts to formalize the interactions among nodes. "No technology has yet been invented that can convince unwilling managers to share information or even to use it." (Davenport et al., 1992, p. 56). At Asea Brown Boveri reporting requirements guarantee that certain information will be required on a timely basis. A sophisticated information system provides the reporting mechanism. A management culture of "no excuses" ensures that participants focus on problem identification and solution rather than finger pointing and justification: blame the process not the person.

Information Management Challenges of the Network Organization. Although the network organization is a child of the information technology revolution, its adherents still wrestle with information management challenges. The network organization requires anytime, anyplace, multimedia interconnectivity across a constantly evolving network as well as a unified corporate memory fashioned from the multitude of data bases that exist in all organizations. Even though information will be shared, it will not be free. It is, after all, the most

valuable resource in the knowledge-based economy. Hence, there are concerns related to the pricing of information in the corporate memory and for providing incentives for people inside and outside the organization to contribute to it. Voluntary sharing will not go far enough although the deep interdependencies among knowledge nodes will promote cooperative behaviors (Miles and Snow, 1992). Policies must be established, also, for linking and sharing that memory across organizational boundaries. There will be problems navigating and filtering through the massive and somewhat unstructured data that constitute such a memory. And, in a global world where business is always being conducted somewhere, accessibility and personal freedom issues must be confronted. Providing mechanisms for quickly coupling and decoupling with value-adding partners will also be required. Present implementations of just-in-time production typically reduce drastically the number of potential business partners, thus decreasing complexity. But in the network organization we will have to manage the cycle time required to establish productive partnerships as well as the cycle time we currently strive for in key operating business processes such as order fulfillment and new product development.

To compete with information requires a dynamic network structure. Only a dynamic network can adequately facilitate the integration of human expertise from anywhere and at any time with information from anywhere and at any time to respond to a one-of-a-kind customer problem. Although the literature provides examples of firms moving to a network structure such as Kingston Tech (Meyer, 1993), Unilever (Maljers, 1992), Asea Brown Boveri (Taylor, 1991), and Baker and McKenzie (*The New York Times*, March 14, 1993), the new organization form is more vision than reality in today's business environment.

BACK TO REALITY: GLOBAL PETROLEUM SERVICES

Before we examine the challenges of the network organization it will be helpful to understand the situation facing many firms as they start the long road of organizational transformation. To provide that perspective, we next eavesdrop on a teleconference of some of the senior executives of Global Petroleum Services (GPS). GPS is an oil field services provider that makes drill bits, lubricants, and various other

products used for the exploration and production of oil. GPS, like many of its large customers, operates in many countries around the world. Although fictitious, we believe that GPS is typical of many multinational firms today. It realizes that the rules have changed, but it has trouble pointing at how its core competencies must be altered. The changes in its business environment have led management to reexamine its information systems. Management believes that as long as the systems are restructured and redesigned, the firm can compete in the new world. They seem less sensitive, however, to GPS's historical roots, the similarities and differences in key business processes, and the decentralized business strategy that has, up to now, been a key to the firm's success.

William Adams, CEO: Thank you all for joining our teleconference today. I know I am taking you away from your families and have turned others out of warm beds, so I will turn quickly to our agenda. GPS's record five-year growth in international sales has been accompanied by an ever-accelerating drain of resources spent on information systems. For our money we are getting uncontrolled growth of disjointed, often contradictory, financial and operations data that never seems to be available when, and in the form, we require. I fear that these incompatible and inflexible systems will prevent us from adapting to our customers' demands and pursuing new global opportunities.

Our business has thrived by a simple formula. We acquire manufacturing firms from around the world that are in the oil field servicing industry. We provide their founders with the capital and autonomy necessary to fuel rapid growth. We leave those founders with nearly full control. We have benefited from these entrepreneurs' understanding of the local markets and from their initiative and creativity. I am not prepared to abandon that legacy, but I have asked Tom Andrews to help us think about how to navigate around the information iceberg that is fast approaching. Tom, please summarize your proposal on information strategy.

Tom Andrews, Corporate Controller: Several months ago Bill asked me to look at our information systems resources on a worldwide basis. The results were about what we anticipated. If there is a hardware or software vendor who hasn't sold us some equipment somewhere in the world, they are truly inept. There is a wide variation in the

applications as well as in the tools, standards, methodologies, and human resources we are using to develop systems.

I propose we move quickly to a worldwide set of systems solutions which, in the long run, would lower our costs while giving us a more consistent set of numbers at headquarters. We would look first at our financial reporting systems and then bring on the logistics and manufacturing modules. These systems would be identical except for those modifications required for the local environment. Except for the financial summaries we would continue to maintain separate data bases for each country. In other words, the systems would be identical but would operate on local data files. This lets country management retain control over their own data. We are already doing considerable business with the software supplier here in the United States, which means we are already moving up the experience curve.

Colin Palmer, President of UK Subsidiary: Tom, this is Colin in London. I must jump in before your systems shock troops hit the North Sea beaches. Your scheme assumes that our business processes are essentially identical or at least that they can be forced to look the same. We have had some positive experiences moving product and process innovations from one side of the ocean to the other, but the successes have been offset by some spectacular failures. And who do you intend to pay for this? Bill, unless you give me the axe, I have no intention of paying double duty. Our businesses are different and many if not most of our requirements are unique. Also, finding software suppliers who can support us on a worldwide basis will be a real challenge.

Henk Vanderdam, Director of Strategic Planning: Gentlemen, this is Henk. Let me give you some examples that might help make a business case for Tom's proposal. Colin you know that you, Norway, and our Mideastern units are relying on many of the same suppliers. But our collective volume with those suppliers have never translated into the kinds of corporate discounts or support we could be getting if we managed our influence with them on a worldwide basis. Similarly, most of the country units have established some sort of research and development operations but few can afford the kind of staff that is increasingly required for the sophisticated product innovations our customers are looking for. And then there are the missed opportunities to share

manufacturing capacity or to effectively meet unanticipated demand by drawing down on excess inventory or underutilized engineering expertise elsewhere in the organization. We have been very successful in the past by optimizing at the country level. But increasingly we are going to have to find ways to use information so that the whole can be greater than the sum of the parts. It seems to me that our information systems should be providing an integrated global nervous system to make such coordination a reality.

Mary, you are looking after our worldwide customers. Aren't you getting pressure for worldwide coordination?

Mary Shepherd, Director of Worldwide Markets: Yes, our leading-edge customers are beginning to demand to be treated as a worldwide entity. The big engineering firms, for instance, are moving toward worldwide engineering systems and global suppliers as their customers seek worldwide consistency. Last week one of our big customers demanded a single contact point for processing their orders on a worldwide basis, and an integrated invoice. Others want the kind of worldwide discount structures that Henk says we should be getting from our own suppliers. Colin, you know that you have recently had problems with customers that are price shopping among our divisions, thus benefiting from inequalities in our own pricing structure. We lose money, get mad at each other, and look like vulnerable bumblers to the customers.

For the most part we are handling those administrative problems today, but we are doing so with long-distance phone calls, courier services, airplane tickets, long hours, and overworked expediters like me. Our big customers fortunately still see us as relatively seamless most of the time, but the forward-thinking customers who are pushing the leading edge of global business often watch the seams unravel.

Despite those demands I am wary of a big-systems solution such as Tom proposes. Personal contact is what makes the marketing side work—even for our worldwide customers. I need better tools to facilitate and follow up on those contacts. We need a worldwide mail and communications system and ready access to video conferencing on an as-needed basis. I need to know which of our companies is offering what products and at what prices and who has expertise in particular applications areas or who knows which customers. These need not be grand, all-encompassing, real time data bases. I could have data that is 10 times

better than what is available today with a very modest investment in some simple tools. I would also propose that we focus on the communications channels rather than on trying to formalize the messages and transactions that get sent across those channels.

Carlos Riaz, President of Argentinean Subsidiary: Senorita Shepherd and gentlemen, permit me to provide the perspective of Argentina, one of our smaller units. Unlike Colin, we have very limited information systems resources. Applications long available in the United Kingdom and the United States are still things for which we dream. My primary concern, however, is time. We needed these systems five years ago and I can wait no longer. Tom, I invite you to begin your implementation in Buenos Aires.

Many of the requirements for integration discussed by Henk and Mary would infrequently apply in Argentina. Our operations remain relatively autonomous, though with our relatively low labor cost we sometimes can steal an order from elsewhere in the world—sometimes even from my good friend Colin. Our primary concern, however, is being responsive to the needs of our local marketplace. On the other hand, we have in Jose Mueller one of the finest fluid measurement engineers in the entire industry. Somehow, engineers from other subsidiaries have found out about Jose's gift and he now is in great demand from an informal team of troubleshooters that includes some of our customers. We are very proud of Jose and welcome a more formalized mechanism for making his expertise available to the rest of the world—perhaps for a modest transfer payment.

William Adams, CEO: Well, Tom, your proposal may not have captured everyone's imagination but it has captured our undivided attention. It has also helped to highlight the opportunities, risks, and some potential alternatives. But, I do want to ensure that our future investments in information systems move us toward the kind of integrated global corporate nervous system that I believe the future will demand.

Global Petroleum Services faces the challenge of competing with information on a global scale. Like many organizations, domestic and international, GPS serves a growing group of customers who have

growing aspirations for integrated and personalized customer service and global pricing structures. Pressures from such customers can provide the necessary organizational impetus for change. Unfortunately, the focus leans too much toward restructuring information systems rather than challenging the constraints of legacy, culture, and the organizing logic of the firm. The migration from GFS's current divisional structure to a dynamic network structure promises to be a long journey.

How are other organizations responding to the customer challenges beginning to be faced by GPS? Yesterday's best practice was to develop integrated information systems without changing the underlying functional business processes. Today, best practice demands that we redesign the business processes so as to harness technological opportunities to best serve customer needs. Much of the focus on reengineering is on seeking systemic solutions across divisional and functional boundaries. In the case of GPS, the focus should be on worldwide business processes that add value to global customers.

Next we review how firms are attempting to reinvent themselves via reengineering. As we will discuss later, we fear that for many industries the transformation required from current business processes will be so great as to favor new entrants over established players.

TRANSFORMING KNOWLEDGE WORK

Reengineering business processes is high fashion in nearly all private and public industries. Consultants and in-house reengineering task forces search for radical improvements in such business processes as order fulfillment, production, new product design, and new business development. Although benefits are being achieved, these activities cannot, by themselves, produce the information infrastructure required to wire the network organization. Although reengineering implies parallel changes not only in information systems, but in other organizational pillars—business processes, organizational structures, rewards, culture, measurement systems—more often than not only one or two of the pillars are changed. Below we discuss reengineering activities and then speculate on information processing solutions that transcend the current scope of most reengineering activities.

Reengineering Business Processes

At the core of business process reengineering is the process. Definitions for a process include: (1) "A specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs" (Davenport, 1993, p. 5); (2) "The structure by which an organization does what is necessary to produce value for its customers" (Davenport, 1993, p. 7); and (3) "A set of activities that, taken together, produce a result of value to a customer" (Hammer and Champy, 1993). Whether clearly stated in the definition or not, process reengineering assumes that processes are repeatable and have enough elements of consistency (e.g., "clearly identified inputs and outputs") to justify developing a standard process. Customers, either within the firm or outside, are also usually central to any reengineering activities. Processes present difficult redesign challenges because they cross functional boundaries, span the white spaces on organization charts, and are often deeply rooted in culture and power structures. Moreover, the midlevel managers whose participation is critical to reengineering success often find that behaviors and skills that were previously valued now become dysfunctional. In fact, reengineering lives in a world of such paradoxes, as illustrated in Table 2.

Such paradoxes make reengineering projects inherently high-risk undertakings. They also guarantee that reengineering, though a popular vehicle for selling consulting services, is neither a miracle drug nor a silver bullet.

Reengineering projects must have high payoff to justify their high risk. To deliver the payoff, reengineers reexamine the assumptions that lie at the foundation of existing business processes. They must have license to hunt in the pasture of sacred cows and those previously tolerated, but impotent, white elephants that voraciously gobble resources in every organization. "Out of box" discontinuous thinking is the reengineers' stock-in-trade. A reengineer sitting in a classroom might ask, why do the students sit in rows while the teacher in the front? Why is the teacher in the same room as the students? Why are classes 50 minutes long, three days a week? Why do the students sit quietly while the teacher prattles on? Why does the teacher act as expert rather than facilitator or fellow student? Why don't the students assign homework to the professor? Why do the students call the teacher "professor" while the teacher calls them by their first names? Why, on

Table 2 Reengineering Paradoxes (Deloitte, Touche, Tohmatsu, 1992; Stoddard and Jarvenpaa, 1993)

- The biggest potential for reengineering is in large organizations, but the environment of large firms is usually the least conducive to innovations.

- The biggest payoff of reengineering comes with cross-functional scope, but an effort that crosses functional boundaries is most likely to be stymied by functional managers defending parochial interests.

- Reengineering attempts to change many things at one time—work processes, skills, roles, organizational structures, corporate values, and management systems—but simultaneous change leads to organizational confusion and identity crises.

- Employee participation is intended to increase their commitment, but may instead produce alienation as employees begin to understand the impact of change.

- The owners of business processes are asked to lead the "downsizing" efforts, but the prevailing compensation schemes based on head count and the size of their total budget demotivates their participation.

- Reengineering tends to encourage projects with large scope, but large projects are most likely to be left undone because of U S. firms' common drive for short-term results.

- Reengineering assumes breaking the rules, but in bureaucratic settings rules need to be applied to the exercise of breaking the rules.

- Automation is viewed as the catalyst for a new order, but usually serves to cement the old process instead.

the first day, does the teacher tell them what and how they will learn rather than asking them?

Understanding the existing process as well as customers' unmet needs requires analytical skills. The actual redesign process, however, usually involves considerable creativity. Rules of thumb serve as creative lenses to help in "seeing" these new opportunities. Among those previously proposed are (Hammer, 1990):

1. Organize around outcomes rather than tasks: Capital Hold-
    ing Company assigned a particular set of customers to a cus-
    tomer service team empowered to meet most of their needs
    (Stoddard, 1992).

2. Have the user perform the process: Federal Express installed
    Powership workstations at more than 25,000 customer sites to
    print labels and track packages. FedEx Online, a network of
    electronic drop boxes, or kiosks, in office buildings and shop-
    ping malls, further decrease the need to take telephone calls and
    dispatch couriers to collect packages. The system also stan-
    dardizes package labels so that the bar-code scanners at hubs
    can sort them more quickly and correctly (*The New York Times*,
    March 31, 1993).

3. Treat geographically dispersed resources as if they were cen-
    tralized; Otis elevator replaced its local answering services with
    one centralized dispatch service equipped with a sophisticated
    data base (Stoddard and Linder, 1986).

4. Perform activities in parallel rather than sequentially; engineers
    at Air Products and Chemicals U.S and European headquarters
    work concurrently on the same designs using common CAD/
    CAM tools and shared data bases (Ives and Jarvenpaa, 1992).

5. Eliminate such nonvalue-adding activities as editing, walking,
    inspecting, and warehousing; Ford Motor Company reengi-
    neered a parts distribution warehouse so that parts came to
    workers rather than workers walking to parts. Operators sit
    between three carousels that, under software control, are ro-
    tated in turn so that the worker can pull the appropriate parts as
    identified on a screen above the carousel (*Insights*, Fall 1989).

As the above examples imply, information technology provides
powerful mechanisms to fuel reengineering opportunities. Among these
exploitable opportunities are instantaneous worldwide reach, shared data
base access, ability to capture and repeat the decision processing of
experts, a prodigious memory, and the ability to personalize almost any

transaction based on the needs of the user, organization, or customer. Customer interactions can provide particularly lucrative opportunities to use information technology to add value throughout a product's acquisition, use, and retirement life cycle (Ives and Mason, 1990).

Usually reengineers seek to harness the capabilities of information technology to business processes, but in many instances the real benefits do not become apparent until the organization scales the learning curve of the new technology. For instance, Wingtip Courier is a Dallas courier service that, despite the threat of increased competition from fax technology, made a "bet the company size" investment in cellular communications and portable computers for its fleet of delivery vehicles (Ives, 1989). Although fax continued to make significant inroads on Wingtip's paper-based delivery business, there was an unexpected benefit. Service organizations, seeking to reduce mean-time-to-repair cycle time while reducing costs have outsourced their parts delivery logistics operations to courier services. The in-vehicle computer system gave Wingtip an advantage over less reliable competitors in attracting this high-margin business. The second-order impact of the technology, though difficult or impossible to predict, proved far more beneficial to the firm than the readily predicted first-order impact (fax driving out paper-based courier service). Many of the classic illustrations of strategic uses of information technology such as the American Airlines SABRE airline reservation system (Copeland and McKenney, September 1988) or Baxter American's ASAP system (Konsynski and Vitale, 1991) illustrate this same learning curve phenomena.

Global Petroleum Services must redirect its focus from building integrated information systems toward redesigning business processes. The processes apparently in need of redesign are those that interface with large engineering customers. These firms are themselves increasingly being forced by competitive pressure to provide integrated customer service to their own customers. Currently, GPS manages the new requirements of the engineering firms as unwelcome exceptions. But, over time, more and more customers will demand similar services, further taxing the information capabilities of GPS and the patience of those customers. Interestingly, meeting the needs of leading-edge customers, or lead users, as they are referred to by Von Hippel (July 1986), can often ensure that a firm's products remain innovative and

leading edge. Hence. GPS must begin to simplify its administrative functions such as order entry, billing, and the like. But in addition to administrative functions, the organization must restructure its interactions with customers and optimize the internal business operations that affect cycle time, cost, and product and service quality.

For example, customers might value having GPS's electronic catalog linked to their computer-aided design systems or being able to query the finished goods inventory for availability information. These customers may also wish to know which GPS product manufactured and sold in one country is functionally equivalent to another product intended for another market. Such knowledge, of course, will simplify customer price shopping across divisions, thus intensifying the need for a centrally managed pricing policy. In fact, one of the biggest challenges in carrying out reengineering is the creeping scope of projects. Rarely does a reengineering project start at a high enough level and involve all the divisions and functions that are impacted by the process.

Post-Reengineering

Business process reengineering is appropriate where important repeatable processes can be identified. Processes currently subject to reengineering tend to be limited to such operational aspects of the business as customer service, logistics, finance, and production. But networked organizations must function in an environment where unique solutions are frequently required. When diverse teams are pulled together on a one-time basis to deal with a major new business opportunity, standardized processes must be supplemented with ad hoc business solutions. Networked organizations will require tools to link a cadre of knowledge workers with each other and with a dispersed organizational memory.

How will reengineering operational processes differ from reengineering knowledge processes? Will knowledge processes have repeatable cycles with definable outputs and inputs? What might be some of the knowledge processes? Robert Reich's (1991) description of the nature of knowledge work in a network organization inspires us to draw the following set of knowledge processes:

Problem and opportunity identification: Creating opportunities and identifying needs for existing, new, and potential customers.

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Brokering: Knowledge workers, both inside and outside the organization, must be identified and their expertise brought to bear on problems. Negotiating, rewarding, and evaluating will all fall within the scope of this process.

Problem solving: Teams must be quickly focused to design, engineer, produce, deliver, and service products produced to customer requirements.

Team development: This process provides the infrastructure and human resource development required to continually reduce the cycle time and cost of the other three processes while continuously improving quality.

GPS has only begun to see a rudimentary requirement to reengineer organizationwide business processes to meet the needs of its global customers. It is therefore unlikely to soon be concerned with the four knowledge processes described above. One can imagine, however, that groups such as the fluid measurement engineers Jose Mueller belongs to could eventually emerge as value-adding business entities within GPS. Opportunities would need to be identified, from around the world, in which some subset of these unique skills could provide competitive advantage. A team consisting of GPS's fluid measurement engineers and customer representatives could meet, perhaps by videoconference, and then, using computer-supported cooperative working systems, focus its combined energies on the customer's problem.

BARRIERS TO COMPETING WITH INFORMATION

As discussed above and elsewhere (e.g., Davidow and Malone, 1992; Peters, 1992), advances in information technology have fueled dramatic changes in prevailing management paradigms. They have shifted attention from:

- mass production to mass customization

- national and multinational to regional and transnational

- managing money to managing time and information

- autonomy to integration

- hierarchies to networks and markets

- reorganizing to reengineering

For organizations such as GPS these paradigm shifts will present difficult if not impossible challenges. GPS will increasingly find itself squaring off against competitors, often newcomers, who bind together corporatewide operations and strategies, yet are able to tailor their products and services as customers and markets require. How does an established firm transform itself for the battles that lie ahead?

Above we have described one piece of the transformation challenge: redesigning business and knowledge processes. In this section we look at four challenges that, for many organizations, will become insurmountable barriers to transformation. These are areas that are usually ignored or superficially dealt with in today's reengineering projects. The first deals with organizational legacy. In many cases the legacy is so powerful that only a "greenfield" approach provides an alternative for creating the new organization. The second deals with information technology. Throughout the paper we have focused on how information technology is both a critical driver and an enabler of information-based competition and new business process designs. Here we will discuss information technology as an undisciplined child that no one seems able to civilize. The third challenge deals with ensuring free—that is, accessible but competitively priced—flow of information. The fourth challenge deals with the fundamental impacts of the new technology on the sociology of work and home life.

Organizational Legacy

Paradigm shifts in science are notorious for the tenacity with which the proponents of the old order hold on to their outdated notions. This is not surprising given that acceptance of the new paradigm usually invalidates much of the work that has gone before, thereby discounting or bankrupting the value of previous contributions as well as hard-won skills. In such situations, change may well be driven from outside the existing establishment. Moreover, network organizations rely far less on economies of scale than they do on flexibility. This, coupled with heavy use of external providers for non-core competency functions, suggests that tomorrow's organizations will be far smaller than today's. Or, as with Asea Brown Boveri, that they will be run as a series of small,

often competing but cooperating, business units. Neither model reflects the management mind sets that most executive-level managers have grown up with.

Further, U.S. managers have been brought up in a heritage in which international operations were relatively independent and essentially by-products of domestic operations. Few really understand the implications and opportunities of managing business processes on a global level. Moreover, they have little understanding how to transform dispersed organizations that are only partially within their reign. We see these deficiencies in the GPS management. No clear business vision is provided from the top. In a firm like GPS, although strategy implementation must be voluntary and bottom-up, the overall vision must come from the top and be wrapped in a compelling message that no responsible country manager can ignore. The bottom-up implementation is necessary to maintain future flexibility. The organization must stand prepared to respond to the needs of both global and local customers. Moreover, it is reasonable that country units will continue to focus on some businesses of only local interest and will, to some extent, compete using different sometimes incompatible strategies.

Another legacy that will doom many organizations is the executive mind set about information technology. In an era where distinctive competencies are information-based, organizations run by senior executives who wear as a badge of honor their ignorance about information technology are an endangered species. These executives are likely to view information technology as an operational rather than strategic asset, and will not likely nurture the firm's competency in technology skills. In fact, many executives are, through outsourcing agreements, attempting to wash their hands of the entire business. It remains to be seen whether they are mortgaging their companies' future in exchange for short-term savings.

In the computer industry, one of the most dynamic in our economy today, we have seen example after example where established firms clung too tightly to past paradigms (mainframes, minicomputers, high profit margins, proprietary architectures), while newcomers, playing by a different set of rules, prospered. We predict that this phenomenon will be widespread as information technology and knowledge-based competition become pervasive in industry after industry. For example at GPS, the decentralized culture, the entrepreneurial style of local managers, and

the country-based P&Ls are likely to be show stoppers. The ability to forget past rules of success, forego skills that took years to develop, and to adopt new heroes develops with considerable alacrity only when an organization finds itself staring death in the face. By then it may be too late.

Limits of Information Technology

Throughout this paper we have assumed that many organizations are not yet harnessing existing information technology to the effective management of knowledge resources. This might suggest that we view the problem as primarily a management problem rather than a technical problem. But, despite the remarkable advances in the computer and communications industry, many technical problems remain. Perhaps the most significant, and one that we will return to later, is that the information technologies are still focused on processing objective, historical information. Technologies have made little progress in capturing and efficiently processing feelings or subjective information such as intuitions, beliefs, insights, and hunches. Additionally, we still suffer from "islands of technology" (Cash, et al., 1992). Although we have progressed toward open architectures, we still have a long distance to travel. Moreover, as we become dependent on information from outside the organization, a new set of information islands appear on the seascape. Electronic data interchange (EDI), for example, permits one company to exchange electronic information with another. But these exchanges remain problematic. Many firms years before developed proprietary standards that now set them apart. Others have adopted industry standards that may not be consistent with other industries in which they compete or otherwise interact. Even the U.S. standard is not fully in compliance with the international EDI standard. Furthermore, inconsistencies and monopolistic pricing still is the order of the day in many of the world's telephone systems, thus fueling additional frustrations.

A valued but often archaic legacy of software and computer architectures that the industry must drag along behind it further impedes progress. Too frequently mainframe-based system users tumble into a nest of impossible-to-decipher error messages that lurk deeply hidden in operating systems designed in a preuser-friendly era. More modern graphical user interfaces often sit on top of, and fail to completely conceal, far less friendly foundation operating systems and application programs. This, along with the increasing complexity of these systems

and the bevy of components now available for them, forces us to turn to the equivalent of medicine's general practitioners when something goes wrong or if we wish to add some new feature to our system. Unfortunately, the bedside manner of these young computer doctors can leave a great deal to be desired. Their training, interest, and genetic disposition usually favors the idiosyncrasies of Novell, C++, and DOS/NT rather than empathy, understanding, patience, and a "please the customer" point of view. Also, their technical expertise is usually narrow in scope. If they embrace workstation and local network skills, then they are unfamiliar with problems of the mainframe where most of the corporate data still exists. There is yet another, although diminishing, problem in marrying communications technology with information technology. Today we still conceive these technologies separately. For example, at GPS we saw management begin to draw a distinction between common systems for consistent and, presumably, less expensive processing of standard business transactions versus communication pathways that can facilitate less predictable but critically important facilitation of shared expertise such as Jose Mueller.

We have also implied throughout this article that distant, but real-time, interactions among network participants can pay rich dividends. Although we believe and have seen these benefits captured, our enthusiasm is not without its caveats. First, as with the videoconference at GPS, time zone differences play havoc with attempts to bring together a group from around the world. There also are still significant bandwidth limitations that impede the quality and/or inflate the costs of videoconference sessions. Videoconferencing can be effective, but it remains a far cry from an in person interaction.

Many years ago Alan Turing, a brilliant participant in the early years of computing, proposed a test to demonstrate a computer's ability to reason like a human. A human seated in one room at a computer terminal would carry on a dialog through a communication hookup with either a computer or a human in the next room. The participant could ask whatever questions it wanted and judge its partner by the nature of the responses. If the computer fooled the participant into believing it was a human more than was possible by chance alone, then, according to Turing, the computer's reasoning was equivalent to that of a human. A simple analog of the Turing test can be proposed for communications: Separate two rooms by a large glass window. Encourage participants

in one room to carry on a conversation with what they imagine to be the person in the next room. They would instead be speaking to someone on the other side of the world, their image displayed on a screen behind the window.

But even environments that could pass this test will remain unequal to personal contact. You can not yet shake someone's hand, take them out for lunch, share a beer, or smell their perfume. Without those personal contacts, at least occasionally, it will be difficult to build trust, confidence, and rapport that are usually necessary for know-how or expertise to be transferred. Indeed, an executive from the auto industry, and a heavy user of videoconference technology, told us recently that he has had considerable success convening groups to work on development of worldwide business processes. But, he confessed, "we only begin to really make progress in identifying shared processes when, after a nice meal, I bring them into my living room and start up a roaring fire and pour a round of brandy." Occasional personal contacts will continue to be important.

A Market for Information

The network organization assumes a free flow of information. Some envision future information stores as not unlike the public library—a common good available at little or no cost to the public. Of course, the library is but one outlet for book and journal publishers. If, as with popular works of fiction, there are other revenue-generating outlets for the book, the cost to the library, taxpayer, and book author (in lost sales) will remain relatively small. But, it is impossible to imagine, for instance, a publisher and an author being willing to sell at today's book store rates a single copy of a book to, say the Library of Congress, if that book could then be accessed at no cost by every household in the country. It is equally improbable that the Library of Congress would be willing to pay a price for the book that reflects the lost revenues and then distribute it free of charge to the public. But, in the future our economy will increasingly be driven by knowledge-based products and services that are distributed in such a manner. Although these will be distributed instantaneously anywhere in the world at little cost, their producers will still need to be rewarded. Assuming nonmonopolistic distribution channels and mass market appeal, prices will be low, but these products will rarely be free. Exceptions, of course, will occur for information

created by the government or, as with access to university card catalog systems, by reciprocal exchange of services in kind.

Elaborate pricing schemes must evolve to deal with this new marketplace of information and knowledge. Today, online information is often priced based on connect time, a flat subscription rate, or the number of transactions downloaded. These measures appear highly inappropriate for pricing information that is embedded in expertise such as Jose Mueller's. Future pricing algorithms will likely need to reflect the age of the information, the value added to potential users, the popularity or credibility of the source, or even the number of other users who have already seen and used the information. As information is used as a substitute for personal inspection or contract negotiation, rich mechanisms will need to be developed to describe and guarantee products for sale. Given that information can be easily duplicated, stored, and retransmitted—often without the knowledge of the owner— equally elaborate safeguards will be required to protect the value of the knowledge resource. And, as was recently demonstrated in the electronic banking industry (Riordan, 1993), there will be vast fortunes made by the individuals who invent new mechanisms to price, charge, or secure information resources.

Personal Freedom

CNN cameras helped ignite Boris Yeltsin's last-ditch stand against the coup. Fax machine feedback on coverage of the Chinese rebellion appearing in the Western press fueled the resolve of demonstrators in Tiananmen Square. Many such examples illustrate the spotlight of freedom that modern computer and communications technology can shine into the dark holes of despotism. Indeed, one condition for China to retain its most favored nation status with the United States is permitting its citizens to receive broadcasts from abroad. Similarly, technology in the form of personal cellular telephones, home security systems, crib monitors, and medic alert buttons can provide individuals with a more secure environment and greater personal freedom.

But the kinds of network systems we describe here also have considerable potential to limit personal freedom and privacy. Annoying cigarette smoke may have vanished from your favorite restaurant, but your dining companions may now be armed with equally annoying cellular telephones, beepers, and notebook computers. Envisioning the

future, Andrew Grove, CEO of Intel, predicts, "We'll all be able to work ourselves to death—because ubiquitous computers mean that our work will always be with us. And, our competitors will always be working too" (*Fortune*, June 14, 1993, p. 70). But it is more than just access and competitive pressures that will spur long hours. Four assembly workers working for 30 hours each can essentially do about the same amount of work as three workers working for 40 hours. This is not true for knowledge workers where requirements for interpersonal communications and the time to walk up the learning curve tend to promote the use of smaller teams working longer hours. As the work will often be interesting and the extra hours put in in the privacy of one's home, the exploitation may only be apparent to the real victims—the worker's family.

And, as organizations carry outsourcing to its logical lowest common denominator, people like Jose Mueller will spin off as independent engineers serving multiple clients. Although the short-term rewards may be lucrative, the responsibility for health care, retirement, reskilling, and the vagaries of business cycles will fall from the shoulders of corporations on to those of individual workers and the broader society.

CONCLUSION

Within this paper we first studied with admiration the network organization that many envision as critical to tomorrow's success. This new organization form is anticipated to take advantage of computer and communications technology so as to provide greater personalized service, extend global reach, and meet the needs for faster and faster product and process innovations. This organizational form, or its variants, will replace the traditional functional, divisional, or matrix organizations, which will prove to be ineffective structures for dealing with the increased turbulence organizations face and for taking advantage of the high-bandwidth, any time, anyplacee information systems that are emerging.

The key competency of the network organization will be continuous generation and dissemination of knowledge, stitched together from information and human expertise. Increasingly the necessary

information and expertise will be acquired from outside the firm. Organizations will strive to develop knowledge-based core competencies and rely on the core competencies of others for a wide range of ancillary knowledge and services. The buying and selling of expertise and information can, over time, supplant physical goods as the basis of developed nations' economies. Instantaneous, worldwide, and low-cost distribution systems have the potential to make knowledge accessible to a far greater number of potential customers, thus significantly reducing the costs for everyone while dramatically lowering the time for knowledge to diffuse.

After examining the promise of the network organization we used a fictitious firm, GPS, to demonstrate that today's corporations with their legacy of top-down direction and control will have a difficult, and perhaps impossible, time reshaping themselves into this new form. The currently fashionable practice of organizational reengineering is intended to help organizations overcome the inertia of their existing outdated business processes. We suggest, however, that reengineering as it is practiced today is not yet focused on the processes that will need to be redesigned to effectively support a knowledge-based organization. In particular, firms must ensure that processes are in place for identifying unique problems and opportunities, connecting with value-adding knowledge nodes, solving problems, and developing teams.

But even if these reengineering efforts are targeted at these processes, organizations will still face a variety of significant barriers to change. Among those discussed were: (1) an organizational legacy deeply mired in hierarchical thinking, (2) inadequate management of information technology, (3) an emerging, but as yet unsophisticated, marketplace for information, and (4) threats to personal freedom engendered by information technology.

The promise of the network organization is indeed compelling. But the pitfalls faced in transform: g a traditional hierarchical organization to a network structure are plentiful and deep. We predict that today's giant corporations with their legacy of top-down direction and control will have a difficult, perhaps impossible time restructuring themselves. We anticipate therefore, a massive transformation of industry fueled by entrepreneurial new entrants.

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ENDNOTES

1. To become knowledge, information must be embedded in expertise. Expertise combines the experience of the past with the judgment of what's possible in the future.

2. Bandwidth refers to the amount of information a communications channel is capable of carrying. Narrow-bandwidth channels can transmit only a small number of characters per second, while broad- (or high-) bandwidth channels permit rapid movement of video images containing hundreds of thousands of bits of information.
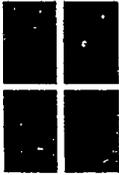
THE PROMISE OF A NEW WORLD INFORMATION ORDER

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The information superhighway is here to stay, but its promised benefits may not substantially materialize. Technological innovations have already produced a revolutionary "little bang" in the mixture of technical capabilities, government regulations, and competitive strategies that constitute the world information order. Now the task is to facilitate powerful hybrids of computer, communications, and entertainment capabilities. The result could be a further "big bang" in the deployment and use of digital information technology that would restructure opportunities ranging from business to education. However, the economic dislocations caused by such changes may prompt coalitions of business and governments to retard innovation. And the superhighway—the new political slogan for what's to come in global information technology—may be later and less fruitful than imagined.

The traditional world information order was deeply anticompetitive and slowed technological progress. The "little bang" upset this order during the past two decades, but Japan, Europe, and the United States still have very different approaches to introducing the information age.

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Europe still hopes phone companies can champion change, Japan relies on managed competition, and the United States favors competitive innovation. Their clashing philosophies could deadlock necessary new reforms.

This paper shows how to achieve a "big bang" revolution. We disentangle the policy choices confronting the world community by emphasizing four building blocks for the world information order. Perhaps the most important is whether or not policy encourages market competition. A second building block is the approach to controlling and sharing ideas. Regulations governing the creation of technical standards and the rights of owners of intellectual property are especially important. A third is the priorities of government research and development policy. Does policy focus on stimulating new hardware or creating new uses for technology? A final building block is the strategy to improve global equity. How does policy address the needs of the poorer countries? To promote the "big bang" we urge a mix of increased competition, streamlined arrangements for setting standards and protecting intellectual property, research priorities focusing on the demand side of the market, and a program for developing countries that blends more reliance on the market with targeted assistance from international institutions.

THE OLD WORLD INFORMATION ORDER

Until the 1970s, the world information order treated international telephone and telegraph traffic as a luxury good—expensive items sold in small volumes. Virtually every country had a national telephone monopoly at home (usually government owned) and international phone traffic was a service jointly provided by the two national monopolists. As one might imagine, prices were very high.

Policy also discouraged mass broadcasting from spilling over national boundaries. Countries allowed only a small number of television networks and radio stations; in most places the key licenses were in the hands of government broadcast companies. Broadcasting systems largely served only national markets. While programming did cross national borders—reruns of American shows were a global staple—most countries favored national broadcasters emphasizing local programming

whenever possible. One reason for this cultural protectionism was that in a world of limited media outlets and mass audiences only the products of the biggest and most powerful countries could attract attention in the world media market. So, many countries concluded that freedom of movement in programming would only serve the strongest nations.

The computer industry was a more globally competitive business than communications or broadcasting. But Europe and Japan both had policies to restrict competition in order to protect local champions against American firms, especially IBM. And until the 1980s computing largely consisted of expensive mainframes and minicomputers. This style of computing made steady impressive increases in power and productivity, but computing was still a very specialized and expensive undertaking until the desktop breakthrough. So, it was not surprising that large companies that could afford mainframe computers helped to pioneer the information revolution. Less obviously, technology also made households into the leader of a massive shift in the broadcast market.

The old world information order collapsed when technology created market demands and options to supply them that defied the old ways of regulating and doing business. The network demands of global financial markets far exceeded the capacity of traditional phone companies. A state monopoly on television had diminishing returns if viewers switched to VCRs for programming alternatives, or to fax machines tied to the outside world for information during a political crisis.

THE "LITTLE BANG"
AND THE WORLD INFORMATION ORDER

By the 1960s most industrial countries had established nearly universal, basic telephone services. While the quality of national phone services widely varied, the biggest general problems were limited capacity for international services and the burgeoning age of computer networking.

The structure of the traditional telecommunications industry rested on a maze of cross-subsidies. Monopoly telephone companies subsidized their equipment suppliers (e.g., such political powerhouses as Siemens and NEC). Long-distance services subsidized local ones on the

theory that local service was not profitable. (Of course, bloated staffing levels at lucrative wages significantly inflated local costs.) International services—where profit margins of several hundred percent were not uncommon—subsidized everything else.

This pyramid scheme was susceptible to collapse if some services started to respond to competitive market forces. This is precisely what happened. The revolution began when national phone companies could not meet the needs of the computer networks created by multinational corporations in the 1960s. So, phone companies reluctantly agreed to allow new service providers (such as General Electric Information Services) to supply computer networks over communications circuits leased from the telephone companies.

The new computer networks greatly improved on existing pricing and performance, but both prices and network reliability left much to be desired. The monopolistic and parochial cultures of communications companies were slowing progress promised by the cosmopolitan and competitive world of computing. Moreover, long-distance phone bills were a growing burden for sophisticated customers. Multinationals began a successful campaign to win the right to rent private telephone lines to tie together communications between their global offices. By the early 1980s many companies operated their own internal telephone networks; Citibank, for example, had a bigger global network than some countries.

At the same time, another commercial battle was unfolding because a media revolution was under way. Cable firms were challenging established television networks. Videocassette recorders were providing yet another alternative. Meanwhile, cable companies and phone companies recognized their potential rivalry.

The United States partly resolved these tensions by introducing competition for all but local telephone and cable television services in 1984. This kept entertainment and communications on distinctive commercial tracks, but allowed communications and computing to mingle. The subsequent dramatic drop in prices for long-distance telephone calls and the increased array of options for data networking caught the attention of the commercial world. Japan and the United Kingdom were the two other leaders in global financial trading, the most information-intensive industry of the 1980s. They soon followed the United States in switching to competition in providing telecommunications.

These national regulatory revolutions set off demands in other countries for more competition. They also created a crisis for the existing world information order. If the three largest national markets no longer supported monopoly arrangements for telecommunications and information networking, how could the existing world information order survive? The answer was clear: It could not. Two sets of changes created the "little bang": competition in the *conduit* of information systems and oversight of the *content*.

Opening the Conduit

One set of changes involved the *conduit* of the information system—the companies and networks that provided the communications infrastructure and network services. The United States blended intense trade negotiations with evangelical proselytizing on behalf of competition to foster a new regulatory framework. Communications and information service industries are becoming subject to free trade agreements, like those that traditionally govern the markets for manufactured goods, thereby liberalizing world commerce significantly.[1] Industrial countries agreed that all forms of domestic and international communications services except for basic telephone services and the underlying physical network would be subject to competition. They also agreed that consumers should have substantial freedom to own and attach their own preferred equipment for computing and communications to the telephone networks. At the same time, the world's oldest international organization, the International Telecommunications Union, effectively had its mandate rewritten. Instead of reinforcing monopoly and codifying slow changes in technical standards, its new mission is to speed technological innovation and accommodate competition.

The changes went beyond new international agreements. Privatization became a popular policy. Many governments preferred to reap a profit from selling the phone system rather than issue new government debt to finance a race to modernize telecommunications networks. While there is no international agreement to liberalize ownership of national media systems, the pressures of cable, VCRs, and new communications satellites led most governments to privatize parts of the broadcast system. Some accepted limited foreign investment. U.S. regional Bell operating companies (RBOCs) bought cable

television systems in the United Kingdom and France (even though they could not do so in the United States).

These changes swept the industrial world in the 1980s. They slowly crept into developing countries even though privatization and competition looked at first glance to be irrelevant to countries lacking the basics of modern telephony. Nonetheless, by the late 1980s privatization was viewed as a way of improving access to foreign management skills and investment capital. Limited competition might also stimulate financial trading services vital to supporting an internationally oriented economy, including homegrown financial centers. Perhaps most importantly, some strategists recognized that traditional monopoly phone companies had not noticeably advanced the goal of social equity. For example, political pressures drove the phone companies to spend their funds largely on urban areas. Privatization, limited foreign investment, and some competition tied to performance targets set by the government might prove a better route to success.[2]

New Rules for Content

There was also an evolution in the rules governing the *content* of information systems. Governments had to decide whether they were willing to permit the competitive provision of information data bases on a global basis. They also had to rethink their policies concerning the provision of broadcasting. And, most importantly, they had to consider the meaning of intellectual property in a digital age.

An early outcome of computer networking was the creation of a market for information services. For example, attornies began to rely on such remote data bases as Lexus to research case law because these services reduce the need for comprehensive private law libraries and provide faster access to the newest rulings by courts. Other information services coordinated the shipping and logistics information of many rail and cargo lines in order to improve the handling of freight. However, because these information services rested on powerful global computer networks, they faced many restrictions from monopolistic phone companies which were trying to preserve their communications prerogatives. Moreover, a lively debate emerged over the tradeoff between rights to privacy and freedom to transport data.[3]

As computer networks opened the possibility of running credit files on Europeans from U.S. computers, for example, governments worried

about protecting the privacy of citizens as data moved outside national borders. Reinforcing this concern was the none-too-subtle worry that jobs in the service industry would flee to other countries. As a result. many early regulations on transborder data flows in the name of privacy took a highly protectionist turn. Pressures from global companies eventually persuaded most countries to roll back the most patently protectionist rules. By the mid-1980s governments also agreed to legalize competition in the provision of information services across national boundaries. Still, the core issue of privacy rights remained and the tension between individual privacy and global information access continued to color the public policy debate.

At the same time global information services spread across national borders, the creation of new media outlets increased the pressure to provide new programming. often from foreign sourcing. The United States was the obvious reservoir but new entrants, like CNN. were no longer content to peddle rights to reruns. They wanted to become global broadcast services. Sourcing also grew more diverse as audiences fragmented. The information explosion made it easier to popularize the culture of the developing nations globally. "World music" was an early example. International networks specializing in language groups became a strong possibility: Mexican television programs became a staple in some U.S. cities.

If the "little bang" was internationalizing the supply of information and media. it was also threatening to weaken the traditional policy foundation for stimulating innovation, the granting of intellectual property rights. The coming of desktop computers and inexpensive consumer recording devices for video and sound posed significant challenges to traditional rights of intellectual property. Suddenly. copying movies and music recordings or computer codes was much easier. The software industry and entertainment companies were particularly strong proponents of an aggressive approach to addressing these issues. Losses to original producers through unauthorized copying were costing tens of billions of dollars in lost sales every year. But the problem of copying also concerned manufacturers because a rapidly growing share of the value-added in products ranging from computer chips to autos was in specialized software.

The ease of copying juxtaposed with the difficulty of enforcement against copycats spawned an entirely new field of computer and tech-

nology law. The result, however, was an evolution rather than revolution in legal protection. Relying on age-old concepts, including patent rights enshrined in the U.S. Constitution, the courts struggled to fit the new technologies within the framework of traditional intellectual property law—patent, copyright, and trade secrets. The result, at least in the United States, has been a flexible and evolving set of rules governing even the most intangible and abstract concepts and inventions.

Because intellectual property rights are, largely, national rights, the United States also pursued an aggressive course of sanctioning countries that refused to implement enforcement mechanisms. This led to detailed trade agreements governing intellectual property rights in countries ranging from Brazil to Taiwan. This intellectual diplomatic campaign made significant progress, but many companies have decided that even more intensive enforcement is necessary. They have formed industry trade associations that investigate problems worldwide, press for enforcement by private legal action in addition to diplomacy, and fund public information campaigns to show why such protection serves everyone's interest in the long term. Significantly, although many developing countries complain that intellectual property simply hinders their access to technology, some companies in developing countries are now becoming supporters of the campaign as they become exporters of electronics and software programming.

In sum, by 1990 there was a "little bang" that revolutionized the world information order, but it fell well short of the information revolution in the United States. Monopoly in conduit was out for all but basic telephone services and the underlying network infrastructure. Alternative routes to delivering and organizing mass media entertainment and information were undermining the franchises of the established media giants. The provision of new information services was becoming a global industry. And new rules for intellectual property reinforced incentives to create and disseminate software, information, and entertainment properties globally.

In all revolutions the question is, When does the era of great change end? The pace of policy innovation during the 1980s seemed formidable, but the "little bang" was only a belated response to technologies spawned in the 1970s and early 1980s: the intersection of mainframe computer technology with telephone networks, and the collision of broadcast media with the first generation of such alternatives as VCRs.

The 1990s are about the advanced fruition of digital technology that threatens every information company's core business with competition from other segments of the information business. This instability will erode the policy compromises under the "little bang."

Many policy differences over how to foster the new information age among the United States, Japan, and the European Community reflect conflicts of interest among the industrial countries. The question is whether their differences will block the fruition of digital information technology.

THE NEW FORCES OF CHANGE

Technological innovation is a political Pandora's box. The fundamental driving force is the intersection of the microprocessor and software revolutions that is leading to dizzying increases in computational and communications capacity at plummeting prices. Video, computing, and communications technologies are intersecting in new and unpredictable ways.

It is hard to forecast which services will truly become important, or the mix of technologies that will deliver them. Important technologies change what we want and our notions of what types of organizations can deliver them. New channels on cable networks and movies on home VCRs undercut the major American television networks at a breathtaking speed because it became economically feasible to pinpoint small audiences for programming. Less than 10 years ago, Federal Express spent large sums installing high-capacity fax machines in its offices to provide two-hour letter delivery when overnight service was too slow. It disastrously assumed that fax technology would remain relatively expensive and there would be few fax machines. Instead, technology reduced the costs of machines, faxes became a substitute for many phone calls and letters, and people discovered that fax machines are most valuable when they are very close at hand, not at a distant Fedex office. Similarly, companies spent millions on new information systems with little change in productivity until they recognized that information networks allowed the restructuring of basic functions, not simply automating current tasks. Benneton is an example of creating a new way of global production and distribution. It can update its changing mix of

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fashion offerings from independent manufacturers on a daily basis because it ingeniously standardized color, design, and ordering information on a global computer network linking its sales terminals to design studios and factories.

We can imagine that 10-year-olds in Seattle and Tokyo will recreate the dinosaur special effects of Jurassic Park on school computers, tap the resources of university libraries to explain their images, and then dial into a global network to splice their software animation into a composite class project on evolution. Microsoft will deliver some future generation of operating system, say DOS 10.0, instantly to all computers by a modem. CNN will not only deliver the images of the next war or political protest, but viewers will use remote controls to choose their preferred camera angles and background information from the CNN coverage feed. Even relatively small firms will be capable of engaging design, manufacturing, and marketing capacity on a global basis virtually overnight because of computer-integrated design, manufacturing, and marketing networks. And digital technology can permit use of existing storehouses of imperfectly integrated information in new combinations. For example, the medical history of patients will be on computers, and teams of physicians in different locations can teleconference to provide group diagnoses while using past histories and concurrent remote telemetry of the patient.

Technology makes all these options conceivable, but no one knows which services are going to appeal at what prices. If phone companies had created a special premium tariff for faxes—say at $3.00 per page—would they be as popular?[4] It is great to think of children in Tokyo and Seattle working together on making their documentary, but simple phone service between the two cities during evening hours is almost 80 cents per minute. The communications bills for the titanic capacity demands of interactive video for our students could pay a teacher's salary for a month unless rates change dramatically.[5] Yet international rates are dropping more slowly than domestic prices. Moreover, no one knows which technologies are most appropriate for particular services. Will data be delivered over cellular radio or fiber-optic cables?

Companies like Microsoft make no bones that such a technological explosion would create many losers.[6] IBM fell from grace because it relied too long on mainframe computers. IBM's story will be repeated frequently in many segments of the world information market. Will the

television or personal computer be the first window to the interactive world for the mass public? Movie studios, television and cable networks, computer and telephone companies, and even talent agents (like CAA's Michael Ovitz or ICM's Jeff Berg) are scrambling to secure the high ground in a digital world. A world with 100-gigabyte memories on personal computers by 2001 (about twice the size of the entire corporate capacity of American Airlines today), tied together by comparatively inexpensive networking systems, could make many uses of traditional telephone networks largely obsolete. This is one reason telephone companies are so urgently exploring new markets.

The situation is even murkier when the challenge becomes global delivery of advanced information capabilities. No one is certain how to organize the global network of the future. British Telecom recently purchased 20 percent of MCI in order to integrate its international services. In comparison, AT&T bought all of McCaw Cellular because it judged partial equity ownership too inefficient to respond to changing markets. Which company is right?

POLICY APPROACHES AND POLICY CHOICES

Change implies displacement, not just additions. If understood simply as hardware (including computers and consumer electronics), communications services and software, and publishing and media, the global information industry could exceed $3 trillion by the end of this decade.[7] But of course the use of information technology is also critical to the fate of such industries as global financial services, transport and cargo services, and avionics products.

The huge economic stakes alone would make the industry politically sensitive. It is even more controversial because the United States, Japan, and Europe have very different approaches to blending competition and government oversight. These approaches reflect their particular technological strengths and their traditions of government and business. The U.S. faith in heightened competition contrasts sharply with Europe's hope to use phone companies as the architects of the information age and Japan's reliance on government-managed competition. These differences further extend to policies for protecting intellectual property and promoting new technology.

The United States

The United States remains the Wild West of information technology and policy. Its approach to the computing, communications, and media industries has emphasized new competitive entrants, stimulation of the market through price cutting to fuel innovation, and aggressive protection of new forms of intellectual property.[8] Silicon Valley's relentless assault on the dominance of old-line computer firms was the counterpart to the breakup of AT&T. The wrestling between equipment and software companies for the upper hand in defining the information architecture of the future has forced frantic experimentation.

Competition and innovation have meant that unlike Europe and Japan, the United States could not provide policy support for a massive consumer electronics industry that can successfully move over into advanced information technologies. However, competition has made consumers into big winners because of lower prices and greater ranges of choice. Data transmission and long-distance services costs in Europe average two to four times those in the United States because of restricted competition. Although the margins are smaller the same holds true in Japan. Similarly, the prices for Japanese cellular telephones are much higher in Tokyo than in New York because regulations allowed Japanese phone companies to require rental of their equipment.

Besides encouraging new entrants and price competition, the United States has stimulated creativity by rapidly updating intellectual property rules to reinforce property rights concerning software, trade secrets, and copyrighted creative materials. With the exception of a sui generis protection statute for computer chips, the U.S. approach has adapted both traditional concepts (e.g., trade secrets) and statutes (e.g., patents, copyrights, and trademarks) to protect the various aspects of computer programs.

Although the legal developments are not always wholly rational or predictable, a general but flexible framework of protection has emerged which is rooted in traditional concepts. The difficulty has not been in defining protected rights, but in enforcing them. Enforcement actions are expensive and in cases like mass-market software, the pool of potential infringers is virtually limitless. At the same time, given the delicate interplay between intellectual property and the options for competition. U.S. competitors cannot consider the protection of intel-

lectual property without addressing the concern of government over the use of intellectual property to restrict competition.

The public policy tension between fostering innovation and promoting competition knows no bright line. These innovations sometimes reinforce the market position of a dominant market player, as in Intel's property rights to the design of microprocessors. But over the long term they speed up and diversify the pool of potential market entrants by providing incentives to commercialize good ideas and innovations.

On balance, measured by pricing of equipment and services, size of information service markets, competitiveness in computers and software, and overall leadership in computer networking and advanced general networking equipment, the U.S. approach has been very successful. The biggest weaknesses of the U.S. approach are the by-products of its successful cult of innovation. For example, the user-driven experimentation of the United States has created computer communications protocols that dominate much of global networking even while official global organizations for standards still ponder the alternatives. However, decentralized policies for setting standards may also leave the United States with two standards for the next generation of cellular telephony.[9] Moreover, there are problems in sharing know-how and intellectual property among the many participants in the market. The tensions over standards setting reflect the inability of the U.S. industry to take stock of its technological capabilities and work collab-oratively to fill in the gaps.[10] Some analysts worry that America's lead in complex data networking applications is in private corporate networks that do not share their learning easily with their rivals. Thus, there may be rapid experimentation in corporate America, but data standards for networks tying GM and its suppliers may be incompatible with those of IBM and its suppliers.[11] Moreover, the efforts to secure intellectual property in a world of digital replication and sharing of knowledge may impede new information products. For example, small innovative creators of new information products, such as the multimedia Voyager "books," complain that they are frozen out of licensing opportunities, or must engage in endless negotiations to use intellectual property.

The European Community

In contrast to the U.S. approach, the politics of European policy emphasize building unity. In the United States, the necessary compro-

mises precluded stronger support for lower prices and new entrants. Instead, the European Community (EC) encouraged higher investment, greater sharing and integration of know-how of the suppliers of services and equipment and only incremental efforts at more competition.

The Europeans believed that innovation by the major public phone network was the key to bringing the information age to small businesses and households. A mix of monopoly and liberalization would spur more digital switching and fiber optics plus the introduction of innovative public services that would bring the information revolution to households and small businesses.[12] In theory, the comfortable margins from monopoly phone services financed modernization of the public network while selective liberalization of equipment, computer networking, and cellular service markets blunted the worst effects of monopoly. The same mix applied to media. The EC urged careful liberalization of provision of the mass-media (e.g., cable) infrastructure and programming, but it did not challenge many restrictions on foreign programming.

The EC wanted to promote Europe's global competitiveness by breaking up rigidities inside the European market created by national monopolies and protectionism. Its strategy for research, setting technical standards, and creating intellectual property rights emphasized integration of the European market. However, when trying to coax traditionally protected firms to support European integration, the EC often acceded to cooperation over competition. For example, it promoted a massive European R&D program for telecommunications equipment and services to rationalize cooperation among European firms by building links across national borders and among firms from different parts of the information industry. The program pumped the bulk of its funds into the traditional giants of European electronics. The setting of EC technical standards also encouraged more permissive cross-licensing of key technologies than in the United States while speedily setting common standards for the European infrastructure. But it also sometimes tilted toward approaches that reinforced traditional market leaders.[13]

Intellectual property rules in Europe broadly paralleled the direction of U.S. innovations, but, unlike the United States, the EC chose to write specific directives on software and data bases to address key technology issues, rather than simply adapt preexisting principles. The

directive approach has the virtue and vice of being innovative but is narrower and less flexible in some circumstances. For example, the EC has strict rules on patent and know-how licensing that limit the restrictions that can be imposed on licensees. And the EC's detailed regulatory regime for the guidance of privacy issues is criticized by the business community as an unfair impediment to moving data as freely as in the United States.[14]

By 1992 a blue-ribbon commission reported to the EC that Europe had been slow to advance in the distributed computing revolution in part because limited competition was not working in the communications sector.[15] So, the EC decided to permit competition in the provision of long-distance voice services by 1998 to speed the pace of innovation and cost cutting by the phone companies. But the EC did not challenge the monopoly on network infrastructure and thereby still gambled that the traditional phone companies could become effective advocates of the information age for home and small business. This predisposition may continue to limit effective competition in the next generation of information technology.

Japan

Japan relied on detailed regulatory oversight over competition to balance benefits and stimulate investment. The traditional Liberal Democratic Party political leaders did not wish to change the winners and losers in the marketplace radically when it introduced competition to the telecommunications industry and began to privatize Nippon Telegraph & Telephone (NTT), the dominant phone company. Policy still favored suppliers over residential consumers. Heavily managed competition in phone services and equipment tried to give something to everyone by slicing and dicing the market into carefully regulated pieces. New phone companies entered the landscape, but everyone was subject to detailed regulation. NTT could not provide international services nor enter cable television services. Newcomers could not compete with each other on price. They also could not provide both long-distance and local phone services, or both domestic and international services.

Who won? For one, large commercial users, such as the Japanese trading companies, improved their mix of services and pricing by becoming partial owners of new telephone and computer network

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companies. These new firms effectively rebated part of their revenues to their owners. The government also used proceeds from the sale of NTT stock to finance experiments with new uses of communications and information technologies in selected cities (so-called teletopias).

Competition also redistributed benefits among hardware companies by allowing more entry into equipment markets by Japanese firms (e.g.. Mitsubishi) that did not traditionally supply NTT. But administrative guidance still slowed foreign competitive entry and kept up profit margins for both computing and communications hardware. During most of the 1980s this helped Japan's drive to sweep the information equipment market by leveraging progress in mass-market products to leadership in advanced information technologies. Equipment and new service suppliers also benefited from government guidance to assure common technical standards and careful attention to installing some powerful network capabilities.[16] Neither the United States nor the EC have matched the Japanese ability to use modest R&D programs plus jawboning to establish common standards for production processes for new technologies. This is why Japan dominates the component market in many parts of information technology even though the United States is ahead in selling the end system (as in personal computers).

The complex regulatory scheme for administered pricing and market segmentation ultimately proved too clever by half. NTT miscalculated about such network technologies as cellular services and intelligent network routing. Moreover, just like the U.S. RBOCs. NTT complained that it could not afford to deliver fiber optics to households without permission to enter cable television and international services. The regulatory strategy also seemed to be slowing cost rationalization and innovation at NTT.[17] Most importantly, the carefully managed domestic market in Japan was a poor predictor of trends in the critical American market. The most glaring example was Japan's sluggish advance into desktop computing and the networking of information systems.[18] Data suggest that interactive on-line information services in Japan are far less advanced than in the United States.[19]

Another example is the slow pace of the media revolution in Japan. This came as a surprising reverse for Japan. Just a few years ago the situation looked bright. Nintendo and Sega were Japanese giants in the burgeoning mass market for computer games. Sony and Matsushita

bought control of two of the major Hollywood studios to get program-ming for their new generation of electronic devices, especially high-definition television. Today, Japan is lagging in innovation at home. Its chosen technology for high-definition television is a bust. The rest of Asia is bustling with satellite delivery of new pan-Asian media services, but regulations forbid new Japanese entrants in satellite services from serving the rest of Asia with their extra capacity. Nintendo is relying on the chips of an American computer firm (Silicon Graphics) for produc-ing the next generation of its game equipment and services. Why? The American firms responded faster to a market favoring the devolution of computing power to desktop networks that share powerful graphics modeling (such as computer-aided design packages).

Ironically, just as it is stumbling in choosing technological win-ners, Japan is accelerating its production of new patents and other intellectual property. It has been heading in this direction for 20 years and, as a result, it has adopted a rather traditional framework to protect intellectual property. For example, Japan has settled on granting computer software protection in all the forms employed by the United States. But, the implementation often favors local firms at the expense of the rest of the world and Japanese ministries exercise great discre-tion in applying the rules to manage the market. The United States has consistently complained in trade discussions about discriminatory treatment of foreign firms when they seek to secure intellectual property rights in Japan. Moreover, Japanese companies do not face the practical restraints of private antitrust actions in regard to intellec-tual property and the Japanese Fair Trade Commission has taken no significant action in this arena. Perhaps the best example of the difference is that the United States and the EC have pondered antitrust actions against Microsoft because of its alleged market domination of operating systems for computers, while a much more proprietary lock on operating systems in Japan by NEC remained unchecked.

By 1993 both NTT and the computer industry were arguing that a more market-driven approach was necessary in Japan. But no one challenged the premise that government will continue to offer guidance by means of "visions" for priorities in information industry technolo-gies and extensive efforts to promote advanced uses of information. The question was what distinctive spin on the world information order would emerge from Japan's mix of competition and managed markets.

PREFERENCES FOR THE WORLD INFORMATION ORDER

The lucrative economic stakes of the world information order tempt further fiddling by governments. Indeed, no point in the triad is happy with its policies. The question is whether the adjustments will be sufficient to force the "big bang." We think that the outcome depends on decisions about: (1) competition; (2) setting standards and government research and development; (3) intellectual property and transborder data issues; and (4) bringing the global network to the developing countries.

Competition

This choice most sharply divides nations even if a clear trend toward more competition is developing. The United States and Japan already permit competition in voice and data services, but both have restrictions that run smack into the digital revolution. The Japanese confronts tougher choices than those remaining in the United States. Both are in a better position than the EC.

The United States is already dropping the remaining competitive barriers as RBOCs receive permission to enter cable and video-on-demand services. Cable systems will be in local phone service in at least selected markets. Wireless communications services will become far more competitive and technologically powerful alternatives to the terrestrial network. Meanwhile, as the distinctions among computers, telephones, and televisions are changing, programming for all three will have more crossovers ranging from data bases through games.

The United States encourages fragmentation in markets and rapid technological experimentation. But this strategy is going to run head-first into problems in the global marketplace. The name of the game for global leadership is the introduction of equipment and services that are useful on a global scale. Yet American information technology companies may face a much tougher time internationally if they cannot deploy networks that emphasize cost cutting and flexible design of software and equipment mixes. So increasing global competition has to be an American priority, and it is this patent self-interest that causes other governments to suspect American praise of competition.

Nonetheless, this is one case where self-interest and the public interest coincide. Digital technology can change price-performance

relationships radically and reorganize how we employ information. This is what a flexible competitive market does best, as Japan and the European Community are slowly accepting.

In the long term more competition will arrive on a global scale. But the means and the timing could slow technological progress. Europe's understandable concern over keeping a viable information industry sometimes drives its policy into the hands of entrenched incumbents. This could hamper technologically innovative newcomers both within Europe and from abroad. Similarly, Japan could delay the deployment of advanced wireless services for data until its firms make up lost ground. And consumers everywhere could suffer if the prices for international communications services don't plummet sharply enough to allow interactive data, video, and voice services on a global scale. Consumers also need the right to use flexible mixes of equipment, software, and communications services to achieve their objectives. The United States cannot relent on advocating new options for deploying global information technology.

The United States could make a special contribution by providing imaginative responses to new regulatory problems under competition. For example, a major challenge is coming in the pricing of telephone services. It may require something like a small value-added tax on communications services to protect universal service. At some point competition may make it impossible to use cross-subsidized pricing to finance the small part of the population whose service is at risk under market pricing.[20] The United States could set the terms for this global discussion by innovations at home.

Technical Infrastructure: Setting Standards
and Government Research and Development

In contrast to competition, the United States has much to learn from Japan and the EC with regard to government programs for creating technical standards and directing government R&D. The most important objectives are to speed up standards encouraging the interconnection of open systems while stimulating experimentation with new uses of networks.

Technical standards are essential to interconnecting the pieces of the information landscape. Major regions of the world often had incompatible standards, and this is still occurring (e.g., high-definition

television standards). There is a brisk business in products to bridge incompatible standards. Nonetheless, interoperable global standards are crucial for tapping the digital revolution effectively. The question is how to do it.

The setting of standards has sped up considerably. It has also fragmented as ad hoc industrial coalitions have often usurped the role of formal intergovernmental exercises. This is a very American approach. However, the dispersion and acceleration of the process raise issues of accountablity to public policy. One necessity is transparency so that closed-door exercises do not shut foreign competitors out of the market, as was often the case in Japan. Another requisite is timely action to achieve consistent regional standards. Here the EC has proven quite innovative. It has created schedules of work for critical Europe-wide standards tied to EC research programs that encourage timely action and discourage idiosyncratic national approaches. In contrast, the United States' federal system has sometimes stalled on a comparable schedule of work. The U.S. weaknesses could hinder American firms in global competition and weaken its influence in setting the benchmarks for information technology in the future.

Research and development programs are the complement to setting standards. A U.S. R&D program, Internet, is arguably the single most successful example of government-sponsored innovation in the information industry. It completely subsidized the long-distance transmission capacity of a computer network that was accessible to, and governed by, the evolving community of university computer users. This wildly successful exercise in subsidized anarchy has created a rapidly growing global information community and is now attracting corporate users and complementary commercial services. Its communications protocols dominate much of global networking, but Internet's software applications lag the commercial world in many respects.

An explosion in use is necessary to finance the next generation of information networks. This is why phone companies are so eager to provide movies on demand to millions of ready-made customers. But entirely new classes of demand and types of major users are also necessary. Japan has made particularly imaginative efforts to use R&D to find new uses for information technology in the public sector. Today, some Japanese analysts suggest that Japan should become the innovator in finding a user-friendly interface for the Internet system. The Euro-

pean Community is also slowly shifting its research program toward funding experiments with new ways of using information technology for rural regions, small business, and public services. And the clear thrust of the Clinton administration's program for the information superhighway is in this direction rather than subsidizing investment in network infrastructure.

The shift in direction for R&D is very encouraging. But there is a missing link. It is the global dimension. Except for Internet, these experiments remain largely national or regional. The next challenge is to push for experiments in global use of information technology to stimulate new applications in both industrial and developing countries. Finding an appropriate venue is going to be a challenge. International research collaboration can be very productive, but it also has a dismal record of many efforts lost in international bureaucratic morasses.

Intellectual Property and Transborder Data Flow

National systems for protecting intellectual property are unlikely to converge. The goal should be to harmonize practices to the extent necessary to achieve substantial recognition and enforcement of intellectual property rights while letting each country forge specific practices appropriate to its traditions and needs. In practice, trade agreements for the protection of intellectual property are likely to be the principal vehicle for such efforts. If the GATT round succeeds, it will produce a significant code on intellectual property. Nonetheless, bilateral negotiations are going to be necessary to fill in the practical meaning of broad GATT principles.

Some adaptations should be evolutionary, as in the American efforts to expand on traditional forms of legal protection. However, the United States should consider favorable responses to some forms of sui generis rules that would address some of the most novel implications of the information technology. Issues concerning data bases, privacy, and transborder data flows may fit this category.

Three innovations would help intellectual property rules promote the "big bang" revolution. They are a mix of adaptive evolution and sui generis innovation.

Achieve global harmonization of fair competition laws. Maintaining strong intellectual property rights also creates the potential for

anticompetitive actions. Such disputes are going global. Microsoft is subject to complaints in the United States and Europe. Some American firms are grumbling about licensing practices of Japanese firms as the Japanese patent position becomes much stronger. Japanese and American companies sometimes complain about licensing rules in Europe. Both the U.S. government and the EC have supported the principle that they can apply their fair competition laws to activities in other countries.

These developments suggest the desirability of efforts to increase the international harmonization and coordination of antitrust and fair competition practices in regard to intellectual property. The Organization for Economic Cooperation and Development (OECD) is already discussing ways to harmonize antitrust practices globally. This should be a special priority for its talks.

Establish new mechanisms for dispute resolution. Companies have actively urged their governments to become their champions for intellectual property enforcement. But governments can easily politicize and escalate these disputes. At some point, the rapid changes in information technologies are going to overwhelm government avenues for action. A constructive alternative would create specialized mechanisms for private firms to achieve fair, economic, and speedy resolution of their technological disputes. While nonjudicial solutions, known as alternate dispute resolutions, are gaining acceptance, the global complications of competition and intellectual property pose special challenges. Specialized private mediation and arbitration forums, perhaps sponsored by the OECD or another international organization, could achieve this goal.

Create new technologies and principles for sharing intellectual property. Some experts argue that protecting intellectual property is a hopeless task in a digital information world. Copying is already easy, and will become more so. Even with a sound framework of protections many forms of infringement will go unchecked. Global information networks will support millions of on-line bulletin boards to service many different types of users. Inevitably, software programs and digital music and video recordings will spread rapidly. However, as Roger Noll's essay in this volume explains, retaining some form information protection is important for stimulating innovation. So the question is how to adapt.

Unless we are prepared to impose really cumbersome encryption keys for these programs or abandon all forms of payment for use of intellectual property, is there any way to prevent the information networking explosion from getting bogged down in countless negotiations over how to make payments for intellectual property use? This is one case where imaginative technological fixes and simple regulations might clear things up.

The model for intellectual property could be ASCAP (American Society of Composers, Authors and Publishers) fees. Thousands of radio stations, for example, keep a log of recordings that they play and automatically pay a set fee for playing copyrighted recordings to a clearing house operated by ASCAP. ASCAP handles all pooling and payments to individual copyright holders for use of the recordings, and it monitors stations to see if they are complying.[21] Similarly, government R&D programs could create new software tools for information networks to do automatic billing and forwarding of funds for use of registered intellectual property. Any holder of intellectual property would include its fee and registration information in its software, recording or video property. The bulletin board operator would obtain the billing software module for free from the government and, as a condition for operation, install the module on the bulletin board. From the viewpoint of the operator there would be no additional burden because the payment for use would be an automatic operation of the bulletin board software system. From the viewpoint of owners and users of intellectual property it would greatly facilitate the licensing of use of intellectual property.[22]

Developing Countries

For all the promise of a new world information order, many worry that an explosion in the information capabilities of the industrial world will worsen the lot of poorer countries. Many developing countries complain global competition will reduce whatever limited equity exists under the cross-subsidies given to developing countries through the profits earned from international phone services.[23] Considerations of international equity, however, do not justify substantial restrictions on competition for three reasons.

First, expanded information capabilities in the industrial world do not hurt developing countries by substituting for Third World products or services. Instead, boosting wealth and productivity in industrial

countries opens market opportunities for developing countries.[24] For example, the introduction of computer technology in the OECD region did not mean less output in developing countries. There were no adding machine exporters in India going out of business. To the contrary, computing technology has opened up new pathways to becoming sophisticated value-added manufacturers of computer components (e.g., the Asian corridor anchored around Singapore) and exporters of software (e.g., India) and engineering services (e.g., Brazil).

More generally, the incredible improvements in price-performance measures for digital technologies are delivering ever more powerful capabilities to developing countries on more favorable terms. The costs of digital technology are sinking much more rapidly than the prices of developing country exports.

Second, cross-subsidies from international services are not essential to modernization. As we noted earlier, some countries have already concluded that their worst problems result from inappropriate domestic policies. Moreover, high international rates and limited global competition can harm developing countries, not just subsidize them. A few examples can explain why.

Several Caribbean countries gave their national phone franchises to Cable and Wireless of the United Kingdom. Cable and Wireless rapidly integrated them into a global fiber-optic network using digital switching. It significantly cut prices on these international services to induce an explosion in demand. The revenue streams then provided funds for upgrading domestic services, which in turn bolstered demand for international services. Just as significantly, the strategy allowed them to upgrade their interconnections to global reservations networking to make them attractive partners to global service suppliers in what many countries now call the new TTT (travel, transport, and tourism) nexus of growth. These networks allow the developing country to earn much higher returns than the old systems of massive discounting to standard group tours provided.[25] The strategy also made them attractive sites for the creation of entry-level positions in supplying global information networks. (Back offices for information systems, like those of American Airlines, are located in these countries.)

Similar strategies for the TTT and advanced manufacturing industries are emerging in countries like Thailand. Thailand is introducing competition in new technologies, like cellular, to try to induce techno-

logical innovations that may bypass gaps in the traditional wire-line infrastructure. It also manages its international telephone rates to encourage foreign production in the country, including software programming and computer equipment components. And it participates in such new media experiments as the Star satellite system that is introducing a blend of pan-Asian news, education (an Asian Open University), and entertainment services.

A particularly interesting experiment involves the Trade Point Networks being sponsored by United Nations Conference on Trade and Development's (UNCTAD) Trade Efficiency Initiative. These networks allow all national participants in foreign trade transactions—especially small and medium-sized firms—to have one electronic contact point to handle tasks like customs, freight forwarding, and banking. The Trade Points are not service monopolies; they are simply a forum for ready interconnection. The 40 new Trade Points also permit experiments with how to facilitate global commerce and provide an efficient gateway for interconnection to global networks for local firms. The returns on the Trade Points are high enough to induce infrastructure investments by public and private funds. As research and development programs take on an international dimension, governments should give a high priority to finding other innovative applications for information networking in developing countries.

To be sure, there is also a strong case for increased lending assistance by the World Bank to reformed national telephone companies. These are attractive infrastructure investments that greatly benefit the national economies. The International Telecommunications Union issued an important report in 1993 by global business leaders that endorsed a special lending facility for telecommunications infrastructure in developing countries that embraced sound commercial management techniques.[26] This innovation would properly balance concerns over international equity with the adjustments necessitated by the revolution in the world information order.

CONCLUSION

The world information order has changed dramatically since the 1970s. Larger changes ought to occur. The objective should be to tap the

potential of a revolution in digital information technology for consumers and producers in the private and public sectors.

This technological revolution is going to upset many traditional market positions and practices on a global scale. It is not simply a matter of new winners and losers, although these will be very numerous, or of changing national advantages in global competition. Change also implies the reordering of many public and commercial institutions as we discover new ways of doing things and new goals to be fulfilled.

We believe that even more competition is essential for the experimentation and innovation required to seize these opportunities. This requires continued significant changes in international regulatory practices. But markets alone cannot suffice. Government has to play a strong role in facilitating open interoperable standards for the next generations of information and communications technologies. It also needs to stimulate innovations in whole new applications for information technologies; the opportunities are particularly great for new educational, social, and public uses. The shift of government R&D toward stimulating new uses is a commendable new development.

Innovation also requires appropriate incentives for the creation of intellectual property. Yet intellectual property protection also creates problems. These difficulties could be ameliorated by the global coordination of fair competition laws, provision of more effective avenues for the private resolution of disputes, and facilitation of licensing and billing for the use of intellectual property.

Even as governments stimulate innovation they have to remember that a large part of the world has yet to enter the age of traditional telephony. It is in no one's interest to see a large share of the world's population outside the information technology revolution. The traditional world information order could not solve the problems of the developing world. It is time for governments to show that a mixture of markets, technological innovation, and judicious assistance can make this revolution truly global, not just the province of the wealthy.

ENDNOTES

1   The agreement to govern communications and information services will be part of the General Agreement on Tariffs and Trade. If the current Uruguay Round should

not succeed, bilateral agreements will still create these trade rules. Peter F. Cowhey and Jonathan Aronson, *Managing the World Economy: The Consequences of Corporate Alliances.* New York: Council on Foreign Relations Press, 1993.

2. Typically, a privatization that permits foreign investment has performance requirements involving installation of infrastructure, pricing, and quality.

3. George B. Trubow, "The European Harmonization of Data Protection Laws Threatens U.S. Participation in Trans-Border Data Flow," *Northwestern Journal of International Law and Business,* 13, Spring/Summer 1992, pp. 159–76.

4. Even at current phone rates Xerox estimates that one global oil company slashed its faxing costs by more than $800,000 per year by simply switching to faster fax machines that cut the transmission time from 24 to six seconds per page.

5. The early pioneers of classroom networking can use subsidized government transmission networks. As volumes grow, the subsidy will be less available.

6. Presentation by Bernard Vergne, *Proceedings of the Conference on the Networked Economy, 1993.* Paris: Communications Week International, 1993.

7. Presentation by John Sculley, *Proceedings of the Conference on the Networked Economy, 1993.* Paris: Communications Week International, 1993.

8. The triumph of the principle of competition shows up most powerfully in the partial exceptions. The RBOCs could not enter into information services, cable, or equipment markets while they still held a monopoly on local phone services. But few disagreed that they should be allowed to enter new markets as their monopoly disintegrates. Similarly, the government decided to license personal communications services with the goal of breaking up the duopolies in cellular wireless markets.

9. Some believe that investment in modernizing the network has also suffered, but this is a highly controversial argument. Jonathan Aronson, "Telecommunications Infrastructure and U.S. International Competiveness," in *A National Information Network: Changing Our Lives in the 21st Century,"* Annual Review of the Institute for Information Studies. Queenstown, MD: Institute for Information Studies, 1992.

10. To see the difference from Japan see Martin Fransman, *The Market and Beyond— Information Technology in Japan.* New York: Cambridge University Press, 1990.

11. Francois Bar, Michael Borrus, and Benjamin Coriat. *Information Networks and Competitive Advantage.* Vol. 1. Paris: Organization for Economic Cooperation and Development, 1989.

12. France Telecom's Minitel terminals for home information services exemplified this effort to bring innovative data services to the home by cross-subsidizing new subsidies from old profit centers. There is considerable controversy over the viability of Minitel as a business model.

13. A pointed warning on the dangers of the EC process is in Carl Malamud, *Exploring the Internet: A Technical Travelogue.* Englewood Cliffs, NJ: Prentice Hall, 1993.

14. The text of the International Chamber of Commerce statement is reproduced in "International Business Criticizes EC Data Protection Proposal," *Transnational Data and Communications Report* 15, January/February 1992, pp. 37–42.

15. European Community (DG XIII), *Perspectives for Advanced Communications in Europe.* Vol. 2. Brussels, 1992, Sections 3.2–3.3.

16. For example, the next generation of wireless communications services, the so-called personal communications services (low-powered cellular telephones), is benefiting from certain types of software that the Japanese government insisted on for regular network switches.

17. The regulators face cross-cutting pressures. The Ministry of Finance wants to keep up NTT margins because it owns a large part of its stock. The Ministry of Post and Telecommunications is under pressure from political leaders to keep down prices and increase services to the politically prized farm vote. Roger Noll and Frances Rosenbluth, "Telecommunications: Structure, Process and Outcomes," in Peter Cowhey and Matthew McCubbins, eds., *Structure and Policy in the United States and Japan*, New York: Cambridge University Press, forthcoming.

18. In the winter of 1993 the price of a personal computer in Japan was almost double its equivalent U.S. counterpart. About 70 percent of U.S. office workers had a terminal while only about a quarter of Japanese office workers did. *The Economist*, February 20, 1993, pp. 64–7.

19. Japanese firms are highly competitive in fiber optics, satellite stations, and terminal equipment. They are behind in most other segments of network equipment or computer network equipment (e.g., routers and workstations).

20. Eli Noam, "Beyond Liberalization: Past Performance and Future Direction," in William Drake, ed., *Governing the Global Information Economy: Challenges for the United States and the World*, Twentieth Century Fund, forthcoming.

21. Needless to say, the operations of ASCAP and its counterparts are far more complex than this thumbnail example. Our purpose is only to highlight how this system could serve as a model for other uses of intellectual property. The details of our recommendation are less important than the general approach.

22. These solutions require complementary adaptations in the marketplace. For example, some companies may slash prices to make copying less attractive. Other firms may emphasize more specialized sales channels (discounts for site licenses to use software) and provide more customized after-sales services that are available only to registered owners. Needless to say, many companies would not be willing to authorize preset fees for the use of specialized intellectual property, but many firms would build commercial strategies built around the premise of inexpensive mass licensing.

23. Most international calls involving developing countries originate from industrial countries. Under current global rules, for example, AT&T shares half the revenue of a phone call to Ghana with that country's phone company. This is a tidy source of profits for Ghana.

24. Put differently, some people having more does not mean others have less. It may well mean that others also get more, but not as much more. Whatever the theoretical merits of emphasizing absolute versus relative living standards, the international community operates most effectively when it concentrates on raising absolute levels of living standards.

25. Bruno Lanvin, ed., *Trading in a New World Order: The Impact of Telecommunications and Data Services on International Trade in Services*, Boulder: Westview Press, 1993.

26. "ITU Plans a Global Coalition to Fund the Developing World," *Telecom Markets*, No. 228, August 5, 1993, pp. 6–7

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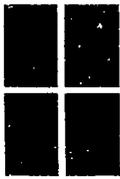
Technology, Information, and Social Behavior

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Hi, all,

I am sure I'm not the first to ask this question but I can find no help in Quest [on-line data base of previous questions and replies] so I'm asking the world [the company] to see if I can get any answers.

I have a number of 2311's [computer terminals] (50+) installed at ABC Co. and many of them are starting to get too dim even at the max brightness setting. Is there any way to increase the brightness on these monitors or is the solution a replacement?

Any info would be greatly appreciated.

Regards, Nadia

> *E-mail memo to 9,000 employees. She received seven replies in four days from people in three countries.*

As social scientists exploring how the nature of information is changing, we come to questions of how information is traded and used, who controls information, and the impact of information on those who do and do not have access to it. Even so-called scientific facts and technical procedures are embedded in the social context, depend on social behavior, and in turn influence social behavior. Thus in the e-mail message quoted above, the technical answer to the employee's question

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depends on (and influences) her behavior (asking strangers for help), on others' behavior (how they trade know-how to learn from one another about "max brightness," and why they give information away to someone they don't know), and on the culture of the organization (that does or does not promote good citizenship). Asking these questions surfaces larger issues of the organization of work, the distribution of power and control, privacy, and the mobilization of resources. In this article, we draw from empirical research on computer networking to discuss how new information technologies change the social aspects of information, and how these changes in turn affect behavior and the relationships among groups and individuals.

SOCIAL ASPECTS OF INFORMATION

From ancient times, new technologies have increased the durability and portability of information. When information is durable and portable, ideas in one person's head can live and travel beyond that one person. The portability of information changes the distribution of information: who knows what. The distribution of information is important because people learn from others, particularly when they do not have recourse to direct observation or to objective measures such as yardsticks and weights. What people believe is real constitutes their social reality. Does understanding of how disease spreads reside just in doctors and faith healers or does a community learn about disease by watching TV? People cannot see germs, so medical disease is a social reality created or influenced by television.

The distribution of information also influences the credibility of information, its further spread, its impact on social behavior. When most of the community believes that germs cause disease, germs are both less arcane and more sacred. Knowing about germs sends villagers to seek Western medicine and incidentally exposes them to urban values.

The durability and portability of information affects not only the distribution of information but also the distribution of social relationships—who knows whom—and the form and quality of these social relationships. For instance, the sender of the e-mail message quoted above sent that message to hundreds of strangers. Each of those who replied also made copies of their replies available in a computer archive

to everyone else in the firm. Now employees have more in common with one another and can draw on that information in the future. More generally, computer-based communication technology seems to increase the number of weak social ties and to reinforce existing strong social ties. There is historical precedent for this effect of communication technology. For instance, the telegraph made it possible for officials in Washington to make frequent contact with their ambassadors in foreign countries. The significance of this change was not simply that Washington could obtain foreign news quickly, but that Washington could keep tabs on its envoys. Through the exchange of reports, the capitol exerted greater authority over ambassadors' behavior.

The distribution of relationships affects future information exchange, since people seeking information tend first to share news with, and seek out, those whom they know. Further, when people get to know one another across lines of time, geography, and group, an influx of new opportunities and ideas crosses social boundaries. These opportunities and ideas can increase individuals' mobility and their groups' innovativeness. On the other hand, as in the case of ambassadors, greater access to others can be used to control others or even to mobilize against them. It is easier to monitor others or spy on them with satellites and radio receivers and telephones than without them.

Talk about information technology and resulting social change pervades professional and scientific discourse and the popular media. Frequently *computers* and *revolution* appear in the same sentence. Some have forecast widespread unemployment and the impoverishment of social life; others have promised a world in which everyone is a well-paid, well-educated "information worker." That information technology can lead to social change is largely undisputed. Historic and antecdotal evidence suggests that using technology as a means of organizing, protecting, manipulating, and distributing information leads to, or at least can be used in the service of, changes in social relationships in organizations and in society. But in actuality, information technology has not caused a revolution in society nor has it altered human nature. Its social effects are far more subtle and are still evolving. There is much dispute about the true role of information technology in social stability and change, and scholars have different conceptual frameworks for thinking about technological change. Below we offer one framework for doing so.
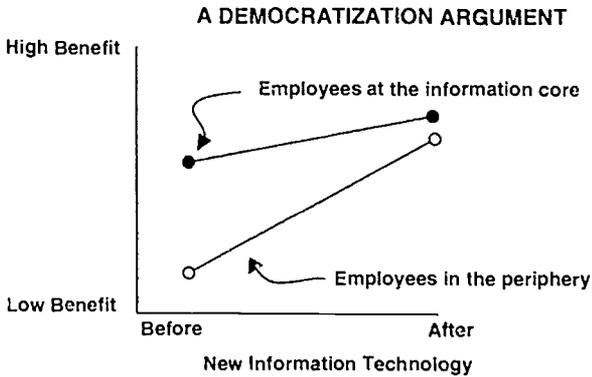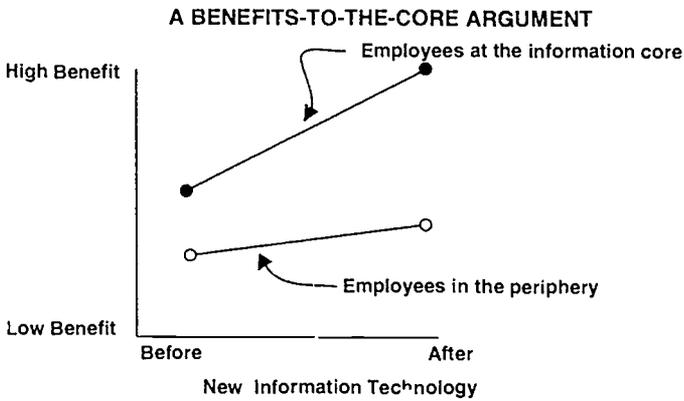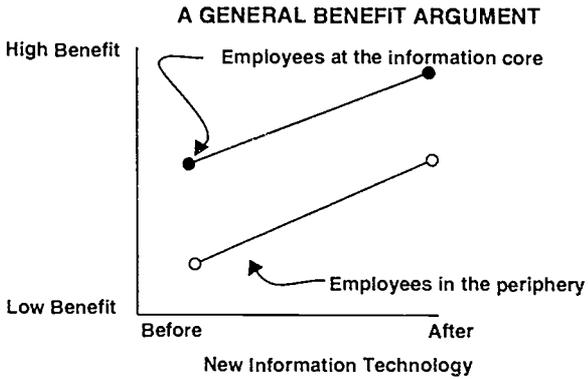
FRAMEWORK FOR THINKING ABOUT
INFORMATION TECHNOLOGY IMPACT

Our framework for thinking about information technology and social change separates two kinds of change. The first kind of change is a general effect, fairly immediate, on organizations or society. This general change could take many directions. One direction is a positive one, where technology leads to increases for everyone in productivity, efficiency, reduction of energy usage, effectiveness, or quality of life. Another is a negative one, where technology leads to bad effects such as pollution or crowding or war. We are going to assume here that the net effect of technology is a generally positive one, and consider a second kind of change. This second kind of change is a differential effect on different social groups. This effect is frequently hard to predict and measure but also can be ultimately just as important as the second kind of change. For example, although the telephone was intended as a business tool, it became even more important in personal usage and had far-reaching effects not only on organizational forms such as the branch office, but also on rural life, on families, on teenagers, and on parents.

Many scholars are concerned with the differential impact of information technology in society. Who really benefits the most? Who is the "loser?" At least three arguments are made. The first says there is no important differential effect of technology, that only the first kind of change is important. In Figure 1, we can see this argument modeled in the "General Benefit" graph. A second argument is that the elite of society or those at the technical or administrative core of organizations invariably benefit from technology much more than the have-nots, than marginal members of groups, or than people at the periphery of organizations. A third argument is just the reverse: that have-nots, marginal group members, and employees on the periphery of organizations, or distant from their technical and administrative core, really benefit most from new technology. This is the democratizing argument for technology.

Figure 1 shows how the three arguments predict general and differential benefits and losses from new information technology in large organizations. In these graphs we oversimplify greatly by dividing the organizational world into two groups. One group consists of those at the authority, technical, and information "cores" of the organization,

Figure 1 The Differential Impact of Information Technology in Society

A GENERAL BENEFIT ARGUMENT

High Benefit

Employees at the information core

Employees in the periphery

Low Benefit

Before After

New Information Technology

A BENEFITS-TO-THE-CORE ARGUMENT

Employees at the information core

High Benefit

Employees in the periphery

Low Benefit

Before After

New Information Technology

A DEMOCRATIZATION ARGUMENT

High Benefit

Employees at the information core

Employees in the periphery

Low Benefit

Before After

New Information Technology

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such as those who have high managerial status, or those who are technically experienced, or those who are located in the technical center of the organization. The other group consists of those who are more "peripheral" by virtue of their lesser access to information and influence, such as those in branch offices far from the technical core. By peripheral we do not mean unimportant. For instance, peripheral employees may be sales people at the interface between the organization and its customers. They are essential but we call them peripheral because of their poorer access to information and to others. We also simplify by depicting the graphs in a form respresenting a generally positive effect although our discussion considers examples of less beneficial outcomes.

Within the framework of our analysis, different arguments can be made as to how those at the core and those at the periphery of organizations are influenced by new information technology. The general-benefit and general-loss arguments are that that each group benefits about the same degree from new technology. For example, technologies like central air conditioning blow cool air on everyone in a building from the president on the top floor right down to the mail room clerk in the basement. All benefit. Somewhat the same argument could be made for many inexpensive entertainment technologies, such as the Walkman radio and videotaped movies. Although we can take such an overall positive posture toward information technology, an overall negative posture is also possible. For instance, we can argue that air conditioning is harmful to all because it emits toxins and fluorocarbons. Because air conditioning generally reaches all people equally, there is no reason to believe that those in the core suffer any more or less than the people at the periphery.

The benefits-to-the-core argument is that those who already have access to information and power also control new technology, and typically use technology in their own interest to gain further benefit. The Egyptian scribes kept the distribution of papyrus and writing implements to themselves. In the 19th century, governments did in fact use the telegraph to tighten control over their ambassadors to foreign countries. In the 20th century, business developed and adapted paperwork technology—memoranda, filing systems, typewriters—toward greater control of work and employees. Memoranda and reports reinforced a hierarchical system of authority. Today managers in big companies buy tech-

nologies for the benefit of management and hardly would be expected to invest in those that would undermine their control.

Another version of the benefits-to-the-core argument is based on the observation that competency multiplies. Those who are at the technical core of the organizations are usually the most skilled and knowledgeable members of the organization, and are the ones who have the most exposure to new generations of technology and gain most from them and from new ideas and knowledge. One example of such an effect in the larger society is seen in the relative impact of the television show *Sesame Street:* Children of wealthy, educated parents learn more from *Sesame Street* than do children of poor, uneducated parents. Whereas both groups learn (benefit) from *Sesame Street,* the gap between rich and poor increases. When the overall impact of technology is negative, the core might lose least. Hence, suppose technology increases information overload, the speed of work, and psychological stress on workers. By virtue of their ability to buffer themselves from stress with secretaries, faster computers that automate routine tasks, two-martini lunches, and so forth, those at the core, one could argue, suffer less the ill effects of technology.

The democratization argument is that information technologies, often unintendedly, equalize groups by giving peripheral employees (or citizens) increased access to resources, information, and influence that those at the core already have. Hence the invention of the tractor, refrigeration, and electrification of the farm made it possible for more people of moderate income to eat fruits and vegetables in the winter, somewhat narrowing the gap between rich and non-rich. This argument is a motivating philosophy and political argument for nonprofit organizations and government investments in new communication and computer technology. The basic argument is that new technology—computers in the schools, medical technologies, public television, and the National Research and Education Network (NREN)—will provide to peripheral groups (the technically ignorant, the poor, the young, the old) and organizations (high schools, community agencies, small businesses), information resources that previously were enjoyed mainly by elite individuals and organizations.

The democratization argument suggests that the negative impact of information technology might be less severe for those at the periphery, hence narrowing the gap between the core and the periphery despite the

overall negative impact of technology. For example, suppose information technology reduces employees' or citizens' privacy and their exposure to public ridicule. Because those at the core have more transactions and are more visible to others, they probably experience a greater loss of privacy than those at the periphery. (When Michael Jackson or Bill Clinton gets a strange haircut or befriends someone, television and cable TV ensure the country knows about it instantly.)

The arguments described above have stimulated much research on new information technology. We next review some of this research.

EVIDENCE ON THE SOCIAL IMPACT
OF INFORMATION TECHNOLOGY

The earliest literature about computer-based information technology was largely speculative, for there were few computer information systems to study in the 1950s and early 1960s. Writers took established theories of organizations as rationalistic bureaucracies or as economic task systems dominated by a legitimate managerial hierarchy and deduced from these images how computing should change the firm or the society. These early reflections on the effects of information technology often polarized around extreme versions of general change arguments described above. They had utopian or Orwellian visions of organizational change, both visions assuming the changes would be unidirectional and uniform—the same for all organizations, for all kinds of computerized information systems, and for all groups. Over the years, researchers have collected evidence to test these notions. Here we review some of that evidence in three areas: changes in skill requirements on the job, shifts in control and influence, and structural changes in organizations.

Skill Requirements

General-benefit theorists have argued that information technology will absorb the most routine of manual tasks, leaving all jobs rich in higher-order and cognitive skills. An intense debate has existed between them and the benefits-to-the-core school that views workplace technologies as instruments for subordinating workers by replacing skilled craft-like jobs with narrow deskilled jobs. Subsequent empirical re-

search on information technology in diverse workplaces has revealed flaws in both of these arguments. First, the impact of computing on skills, although widespread, has varied. Changes in clerks' work look very different from changes in professionals' or managers' work. In some cases, as in libraries that put in cataloging and search systems, the same kinds of people were either deskilled or upskilled: Some librarians became computer information professionals and some administrative clerks. Almost identical computer systems applied to similar clerical work forces have affected work in dramatically different ways in different companies.

This research has led to a thorough reworking of theories of information technology and skill change. Skill changes, although triggered by the adoption of a technology, less reflect the technology itself than they are outcomes of setting up and putting in technology, and of the structure of the workplace and work groups into which the technology is deployed.

Control and Influence

Many stories about extensive benefit from computer networking for both peripheral and core employees have come from the computer industry. There, even novice computer professionals have high value to firms, which treat them well. These employees have enjoyed perquisites including free and extensive access to computers and networks. In these situations, everyone from the top echelon to the bottom of the organization generally benefits somewhat equally from the technology.

Other firms use technology to reinforce control. A 1990 study by Rule and Brantley showed how supervisors at a burglar alarm company used new computer-based data from alarms to check whether field inspectors assigned to machines had given them their periodic manual servicing. Computerized analyses of sales were another common vehicle for increased control by managers. One employee said of a firm that fabricated steel parts and entered every order into the computer:

> The President gets a copy of every order and the order lists the profit margin and dollar profit for every order. Before computers, he simply got the dollar total made on the order (and he got it much later). Now, he is much tougher on the sales people when he sees a low margin. Since he often sees this before the

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bill has gone out. he will often change the price. He usually gets the customer to pay that price. Before computers, by the time he saw the dollar profit on each order, the invoice had probably gone out already. He didn't want to issue an additional bill because the customer wouldn't pay it. Also, since he only saw total dollar profit, he might think an order that made $1,000 was a good order without realizing that the profit margin was only 3 percent. Now, he sees both dollar and percentage and this leads to keeping better tabs on the sales and salesmen.

The benefits-to-the-core school also can point to evidence on the role of hierarchy in networks and electronic communication technology. Hinds and Kiesler (1993) recently did an analysis of employees in seven departments of a large telecommunications firm. Newer electronic communication technology (voice mail and e-mail) was used more by those at higher levels of authority, and was used for hierarchical communications more than for communications among peers. And across departments, those whose respondents engaged in more communication up and down the hierachy also were the departments making greater use of new electronic communication technology.

When researchers look at interdepartmental or interorganizational communications, however, they find evidence of democratization. An experiment illustrating democratization effects was conducted by Tora Bikson and J. D. Eveland at Rand in 1988. They formed two task forces in a large utility firm, each assigned to analyze employee retirement issues and produce a report. Each task force had 40 members, half who had recently retired from the company and half who still worked but were eligible for retirement. The primary difference between the two groups was that Rand provided one group with networked computer terminals and software. Both task forces created subcommittees, but the networked task force created more of them. Also, unlike the task force without electronic communication, the networked task force assigned people to more than one subcommittee. The networked task force also organized its subcommittees more complexly in an overlapping matrix structure. That task force added new subcommittees during its work. It also decided to continue meeting even after its official one-year life span had ended. Finally, retired people who were members of the networked task force were much more influential, headed more subgroups, and

became closer to other members of the task force than retired people who were members of the task force that was not networked.

Research shows that computer networks can be a participatory vehicle for peripheral employees. Senior managers and key professionals usually have good connections and are "in the know" in their organizations and profess' ...ui communities. Employees who are less central by virtue of geographic location, job requirements, or personal attributes have generally had fewer opportunities to make contact with others. Reducing the impediments to communication across both physical and social distance is therefore likely to affect the influence peripheral employees have, and their feelings of connection, more than that of central employees. In the Hinds and Kiesler study, electronic mail provided a vehicle for lower-level employees in the firm to be in contact with those at higher levels. In another study, Huff, Sproull, and Kiesler found that employees who used electronic mail extensively reported more commitment to their jobs and coworkers than employees who did not use the network much. But this correlation was much stronger for shift workers who, because of their jobs, had fewer opportunities to see their coworkers than regular day workers did.

As many firms diversify and become global, many employees become peripheral geographically. Despite the global nature of their firm, these employees will mainly lead local lives at work. They will spend most of their time in one physical location—the office and its immediate environs. They will talk mostly to people like themselves—their immediate coworkers, clients, or customers. They will participate in a few workplace groups—their primary work group, perhaps a committee or task force, and possibly an informal friendship group. New information technology, however, is encouraging employees in some dispersed firms to become much more cosmopolitan. Using computer networks, these employees transcend their local environs and communicate easily with people around the world. They "talk" with distant employees, customers, and suppliers, many of whom they have never met in person, as easily as they talk with someone in the next office. They participate in groups discussing company policy, new product design, hiring plans, or last night's ballgame without ever physically meeting with the other group members.

Research conducted in laboratory experiments suggests that electronic "discussions" are likely to be more egalitarian than those held

face-to-face in the same organizations. One reason for this phenomenon is that networking technology allows for conversation absent social-context cues and reminders, and therefore people are less constrained in what they say and who they talk with. Due to the openness of responses on networks, organizations are finding that many group activities are being done at long distance on computer networks people did not think would be possible. These range from group discussions of sex to health counseling to training new employees to huge electronic project groups. But just as an electronic message is not merely a fast letter or a transcribed conversation, an electronic group is not just a traditional group whose members use computers. For example, electronic groups tend to be much, much larger than nonelectronic groups created for similar purposes.

Reviewing the research on control and influence in organizations suggests that the impact of new information technology depends greatly on the policies of managment and design of the technologies. Management can use information technology to increase control and influence from the top down. In cases where managers have invested in networks but encouraged employees to use them creatively to increase their productivity or in cases such as the Internet, which grew exponentially without much social control, influence and control seem to have been increased more democratically.

Structural Changes

Benefits-to-the-core theorists have long predicted that new information technologies would reinforce existing social structures. They argue that, historically, elites have aggrandized whatever instrumentalities of social control are provided by new technologies, and suppressed or hobbled those consequences of the technologies working against their interests. On an opposing side are general-benefits and democratization theorists who argue that prevailing organizational structures are artifacts of existing limits to information, cognition, and control. Therefore, new information technologies eventually will change conditions in striking ways. Some democratization theorists have heralded new information technologies as powerful enabling instruments for "delayering" organizations, meaning that they allow significant increases in effective spans of managerial control, and thereby reduce the need for layers of middle management. Some have gone so far as to

forecast the era of the flat organization, consisting essentially of a single level of hierarchy beneath a very small leadership core.

There is an irony in this predicted change. On the one hand, a thorough delayering of organizations and great widening in span of control would effectively centralize organizations by decreasing the distance between loci of decision rights. Conceivably, this could enable total centralization of even very large organizations by placing all decision rights in the hands of a single manager who is able to supervise each and every subordinate directly through computer-assisted technologies for communication, surveillance, analysis, and so on. On the other hand, these new technologies are often promoted as powerfully decentralizing and empowering of subordinates, because the numbers of middle managers are reduced and the amount of effective decision autonomy granted to workers can be increased as long as ultimate corrective authority resides with the residual managerial core.

The irony has led to a shakeup of social scientists' concept of centralization. The concept traditionally has been tied to decision authority structure in circumstances where there was no practical ability to leave large amounts of discretion to local actors while retaining sufficient surveillance and interdiction capability to intervene in a "wrong" decision before organizationally negative consequences occurred. Local actors either had decision rights or they did not, making it easy to declare the prevailing organizational structure as centralized or decentralized. But with such surveillance and interdiction capability in place, we face a dilemma in labeling situations where, for example, the decisions of local actors are watched and could be interdicted by higher authority, but in fact, they never are interdicted because they are always "right." Does centralization reside in decision authority principle or in decision authority practice?

THE SOCIAL CONTEXT

Research on the social impact of information technologies sometimes supports general effects arguments, sometimes the benefits-to-the-core argument, and sometimes the democratization argument. The social context often determines the nature of these effects of informaton technology. Researchers such as Attewell, Westin, Barley, and others

have identified important contextual factors related to specific outcomes. These include: (1) the prior history of labor relations and managerial philosophy in a firm; (2) the size and clerical intensity of the firm; (3) the growth rate and competitive situation of the firm; (4) the scarcity of the labor pool; (5) the introduction of the system (e.g., top down versus bottom up); and (6) the intrinsic dullness of work.

A rule of thumb from research on social context is that for all to benefit (or for all to lose) from information technology, all must have access to the technology and control of the ways they want to use it. Utilization will be biased in the direction of those in control. Therefore, if the core maintains control over access to and utilization of the information technology resource, technology effects are more likely to fulfill the predictions of the benefits-to-the-core school. If the technology is equally in the hands of core and peripheral people, the needs of the periphery will be addressed and there will be more evidence for general effects or for democratization.

NEW SOCIAL ORGANIZATIONS

The discussion above focused on the impact of information technologies on existing organizations. New technologies also might create social organizations or new kinds of groups with characteristics and behaviors not seen before.

The appearance of nationally and internationally accessible computer-based communication networks has changed not only individuals, but groups. Paramount among these changes are the strengthening of existing distributed work groups and the creation of new such groups. In some cases, these groups have become sufficiently powerful and influential to exert significant and concentrated pressure on established organizations and institutions. In a few instances, these distributed groups have evolved features of size, hierarchy, and operating norms common to organizations. These are fundamentally new kinds of social organization, not anticipated or explained by existing social theory. Moreover, they show promise of being a major form of social organization in the coming years.

The central feature of these groups is that they exist completely within computer-based telecommunication networks, and their mem-

bers usually function as members of one or more formal organizations at the same time they are active participants in the electronic groups. A common situation is that of a university faculty member or a researcher in a corporation with access to one of the major national/international networks (e.g., Bitnet or Internet). While individuals have normal organizational duties and responsibilities in the organization of their employment, these duties can extend through the networks to individuals in other such organizations with whom they have work-related needs for discourse and discussion. Collaboratively authored documents flow back and forth through the networks, residing in different versions here or there in various host machines, eventually wending their way to dissemination or publication. Also, there can be extensive discussion via private person-to-person electronic mail, "broadcast" electronic mail from one person to many, or via "posting" to public bulletin boards or news groups.

The astonishing growth in use of computer networks, as measured by both numbers of users and message traffic, is crude but powerful testimony to their significance among their users. At minimum, they are a great convenience for communication among the professional actors with access to them. There are suggestions, however, that the import of these networks goes far beyond that of just another way of communicating. Among other things, these networks have been used several times as instruments for mobilization of major social actions by distributed and institutionally disconnected individuals.

> Hi, World,
>
> Could you please measure and send me the dimensions of your office? Our manager wants to move us into smaller office space. I don't think I can get any work done in a closet. If you e-mail your stats ASAP, I will have some ammunition to use with our boss's boss. . . .
>
> *E-mail broadcast to all members of a firm.*

Political mobilization is particularly effective in one electronic news collective called USENET, available through various networks such as Internet and Bitnet. No one knows exactly how many people read USENET news groups, or how often, but current estimates place the number of organizations with access to USENET at more than

50,000 and the number of people reading at least one newsgroup at nearly 2 million. Two instances of USENET activity for social organization are worth noting.

One instance was during the Tiannanmen Square confrontations in June 1989, in which the USENET newsgroup soc.culture.china became a highly interactive communications device among Chinese students in the United States and Europe for sharing information and plans for action in response to the crisis. This was not simply an electronic version of Tom Paine and the pamphleteers; it was a powerful organizing modality that permitted nearly real-time mobilization and coordination across vast distances. The fact that postings to this newsgroup could not be anonymous meant that participants identified themselves as protesters in a way not common to mass physical demonstrations. Records of the transactions were lasting and widely available.

Another incident occurred in 1991, with extensive discussion of the new Lotus Development Corporation's product Households—a "profile" advertising data base—on the USENET comp.risks newsgroup. This discussion began when an individual close to the development of the product but not working for Lotus "leaked" a detailed description of the product to his own company's bulletin board. This was read by another person, and "reposted" with a few keystrokes to the comp.risks bulletin board with its thousands of readers. The subsequent discussion on comp.risks precipitated an electronic protest message writing campaign directly to the e-mail address of Lotus CEO Joe Manni that produced thousands of e-mail messages decrying the new product. It is reported that this message campaign had a pronounced effect on the Lotus leadership, who subsequently scuttled the product.

In quite a different vein, these networks have been used to conduct professional work among widely distributed actors concerned with common issues. Some of these activities are discrete and one-time-only. For example, mathematical computer scientists at Bell Communications Research and Digital Equipment Corporation used the network as a coordinating mechanism for organizing a distributed work project to factor a very large prime number, Fermat's 9th Number. In this case, the distributed computing resources of many organizations were contributed to the project using the network as the analytical coordinator. In other cases, the collaborations are ongoing and have become embedded work routines of whole cadres of professionals. For example, physical

oceanographers have been using electronic network distribution lists to coordinate large projects, such as the World Ocean Current Experiment. The network is used to report results to colleagues, to solicit advice and help for doing the work of the experiment at various locations, and to obtain access to large data bases. These activities all occurred in oceanography before networks were available, but use of the network has significantly increased participation overall and by those scientists in remote locations.

These networks raise important intellectual and theoretical questions about how individuals join and leave groups, how groups establish and maintain group cohesion, and how individuals build their allegiances and connections to multiple, disparate groups through the network modalities. They also constitute an important and controversial crossing of the boundary between individuals' various group memberships and commitments, and between the worlds of work and leisure. Participation in these networks is often enabled by and supported through an individual's primary employment, but network activities often go far beyond employment responsibilities to include social discourse and entertainment uses that employers could hardly justify in strict economic terms. These modes of communication are creating a fertile ground of controversy over fundamental notions of free speech, privacy, proprietary rights to intellectual discourse, and liability that simply has not been seen before.

CONCLUSION

As we explore the nature of information, it is as important to study people as to study the technologies that create, change, store, transmit, or manipulate information. The nature of information rests on how people use, trade, and react to it. We are continually being faced by new information technologies—new means of dealing with information. Although extensive planning goes into the development of the technical features of these new technologies, their real impact wil' come from the ways that people use them, particularly the unexpected or unintended uses.

The research cited in this paper shows that general benefits or loss arguments, benefits-to-the-core arguments, and democratization arguments all can be valid in different contexts. A context-free technology

is just as rare as teacher-proof classroom learning. The design and implementation of a technology, and policies for its regulation, or avoidance of regulation, are critical in determining the nature of the social impact—and ultimately changes in the nature of information. Recently, the White House issued an announcement that it would help democratize politics by setting up computer network linkages between the public and White House staff and Congress. Much of the design planning for this network assumed that the most important activity in the network would be messages flowing from the public to public officials, and the most important function of the technology would be to speed up or increase such communications. Since public officials already receive thousands of communications from the public, it seems unlikely the network will have impact either on society or on the nature of information. Compare that with a network that over the last decade has vastly improved the qualitative ability of people (including children) to find people and create new groups, where members talk with one another on any subject they want to discuss (including politics). This network is the Internet, whose thousands of "newsgroups" talk about music, the environment, legal issues in art and child care, and hundreds of other topics. The emerging "network community" seems a truly interesting phenomenon which changes both people's relationships and the nature of information. The Internet was developed over two decades, sheltered from the public eye and with little interference by commerce or government, except for financial and technical support through the Department of Defense. Engineers and scientists, educators, and students, especially technical graduate students, built the Internet for themselves. The Internet is a wonderful reminder that the effects of technology are unpredictable and often surprising, and always involve people's behavior.

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NETWORK LITERACY IN AN ELECTRONIC SOCIETY: AN EDUCATIONAL DISCONNECT?

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> We're all connected by communications miracles. It's the people, still fumbling with the Switch Hook Flash who are stuck in the Stone Age
>
> *Gleick, 1993, p. 26*

The skills required to use the switch hook flash on one's telephone pale in comparison to the skills and knowledge that are needed to use resources and services in the evolving National Information Infrastructure (NII) and the Internet/National Research and Education Network (NREN). While some people begin and others expand and refine their network skills and competencies, the vast majority of the public has no skills related to using these new communications technologies and many live in fear of a passing thunderstorm that might force them to relearn (again) how to reset the LCD time displays on their VCR or microwave.

There is an educational disconnect between the rapidly developing communications technologies and information resources available to the public, and the public's ability to use these resources. An elite few, typically academics, researchers, technology enthusiasts, and "network junkies," are network literate. While the gulf between these network literate "cybernauts" and those who are not continues to widen, the education system continues to be largely oblivious. Individuals in this emerging electronic society primarily learn on their own to be productive in and empowered by this new environment, or they are left behind.

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Significant changes in the communications infrastructure are affecting the very fabric of society. Information technologies in telecommunications, cable television, wireless satellite transmissions, the Internet/NREN, and others now provide an incredible and seemingly endless array of information resources and services. Experts knowledgeable about these technologies tell us that future uses and applications are limited only by one's imagination ("The Info Highway," 1993). Network literacy, the ability to identify, access, and use electronic information from the network, will be a critical skill for tomorrow's citizens if they wish to be productive and effective in both their personal and professional lives.

The NII, an amorphous term for the collection of these information technologies and the infrastructure that supports them, appears to be taking shape (U.S. Congress, 1993a). We are moving toward establishing a ubiquitous electronic network that connects different information technologies to endless streams of digital data throughout the country and the world. Indeed, the "network" is an evolving term that includes these various computer, telecommunications, cable TV, and other technologies.

Meanwhile, the telephone, telecommunications, and cable television companies are battling for the rights (and the profits) for wiring individual homes into a massive array of information providers, resources, and services (Stix, 1993). But while the battle for connecting individual homes to this evolving information infrastructure is still developing, it is clear that the Internet/NREN already provides a great deal of connectivity throughout the country and will have a significant impact on society. Indeed, the "networked society" is already taking shape.

While the technology developments related to networking are significant and draw much attention, there is also an infrastructure that supports these technologies. The nontechnological aspects of the infrastructure include the human resources, political, and social processes; organizational support; and the tools (both physical and attitudinal) that people need to use the new technologies. The technological infrastructure that supports the Internet/NREN continues to grow at a much faster rate than our knowledge about how to use the network—to say nothing of the switch hook flash—the network's impacts, its uses, and its effects on organizations and individuals.

Despite the traditional role of libraries in providing a range of information resources and services to the public, federal policy and planning have been inadequate to assist libraries transition to the networked environment. Nor has there been adequate planning or assistance to the public in learning how to use and access these electronic resources. Making these resources available to the public, learning how to communicate and use the network, and ensuring network literacy among the population are critical to the success of the NREN and to the people in the networked society.

In our fascination with the new information technologies, we have given inadequate attention to how society will migrate to this networked environment. Will the networked society result in excluding a range of services and opportunities to those who are unable, for whatever reason, to move to the networked environment? Who will be responsible for educating people to use the networking technologies and take advantage of the wealth of resources currently available and yet to be developed? How will the public participate in decision making about technology applications that will affect the fabric of their society if they are network illiterate?

The purpose of this paper is to explore educational and societal issues related to network literacy. How we address and resolve these issues will have a significant impict on how society evolves, how notions of literacy and a literate society evolve, and the degree to which social equity can be enhanced in this country. The country must develop strategies to develop the Internet/NREN as a vehicle for (1) "reconnecting" different segments in our society, (2) promoting a network literate population to ensure a social equity, and (3) enhancing the role of libraries and the education community to accomplish these objectives.

NETWORKED INFORMATION RESOURCES AND SERVICES

The term *networked information* applies to a vast range of electronic information and services now available through the Internet. It is not the purpose of this paper to review the extent and nature of these resources and services since others (LeQuey, 1993; Krol, 1992) already have done so. There are thousands of discussion groups; data bases and

sources to access information from governments, commercial providers, and other individuals; sophisticated scientific applications; books and journals in digital format; electronic card catalogs of many libraries throughout the world; weather reports and restaurant guides; and much, much more.

Information that has been networked, i.e., made accessible via one of the over thousands of worldwide networks comprising the Internet, puts new dimensions on the impacts and uses of information (see following section). But uses and applications of the Internet have gone far beyond ordinary electronic mail (e-mail). To cope with the vast amounts of information available over the network new communication techniques and information resource discovery tools are available and being used (Brett, 1992), including:

- *Listservs and discussion groups:* Users who share a common interest in a particular topic can subscribe to a "listserv," where a message posted to that list will be sent automatically to everyone subscribing to that list. There are thousands of such lists on every conceivable topic imaginable. For example, there is a PUBLIB listserv in which individuals exchange information related to public library activities. Someone can post a note to such a listserv and immediately have it sent to thousands of other people interested in that topic.

- *File Transfer Protocol (FTP):* Individuals and organizations have placed vast amounts of information on file servers at many different sites around the world; using FTP, users can log in to a remote computer system, identify a particular file, and retrieve that file directly into their computer. For example, a file containing *Alice in Wonderland* at Project Guttenberg can be FTP'd to an individual's personal computer to be read whenever desired.

- *Telneting:* Once an address is known for a particular data base, the user can log in to a remote data base and search that data base for information; for example, users from around the world can log in to a data base at the Library of Congress and determine the current status of legislation.

- *Gophers*: This technique identifies files on the Internet by keyword searching, connects the user to the desired file, and the identified file then can be searched and downloaded (if desired) directly into their computer. For example, within a gopher program, users might search on the term *environmental pollution* locating 12 different data bases covering that particular topic, users can select one they wish to search and be seamlessly connected to that data base.

- *Wide Area Information Server (WAIS)*: A WAIS is similar to a gopher in that both identify and access remote data bases; a WAIS, however, ranks the likelihood that a particular data base has the information one needs and can do full-text searching of multiple data bases.

These, of course, are only some of the services and techniques that people can use to identify, access, search, and obtain a wealth of information over the Internet. Krol (1992) and Kochmer and Northwest Net (1993) are two of the best guides currently available for how to use and search the Internet.

This environment promotes a very pluralistic albeit constantly changing and chaotic approach for accessing and using information in a networked setting. And while there is still much need for more user-friendly programs and services over the network, and while some of the issues related to privacy, intellectual property rights, pricing of services, and acceptable use of the Internet (to name but a few) remain thorny and contentious, growth and use of the Internet proceeds exponentially.

For example, one recently developed service is called AskERIC, which is an Internet-based question-answering service for teachers, library media specialists, and the education community. It is supported by the Department of Education through the ERIC Clearinghouse at Syracuse University ("AskERIC: ERIC and the Internet Continued," 1993). By sending an e-mail message over the Internet with the request for information to <askeric@ericir.syr.edu> users can obtain a response, usually within 24 hours, about virtually anything related to education. In addition, the librarian answering the question at the ERIC Clearinghouse may direct the user to additional Internet resources,

provide digital information from the ERIC data base, or attach a range of additional information in his/her electronic response to the user.

The impacts of having access to and use of the Internet are extensive. One business executive (Levin, 1993) commented:

> The Internet gave us the power to do something significant and the ability to do it quickly. In business terms its a first-quarter success. We can work quickly with experts around the world and we can get rapid feedback on early revisions. It improves our customer support, which increases our income from sales.

Another example of impact comes from a television manager in Omaha, Nebraska (Stix, 1993, p. 105):

> My daughter was scheduled for surgery in October of 1991 for correction of scoliosis (curvature of the spine). In late summer of that year, I decided it was important to learn more about scoliosis. A library catalogue search over the Internet led me to discover that another daughter had symptoms that could mean our family was affected by a serious hereditary disorder. . . . I used a specialized Internet service, WAIS, that let me search multiple databases. The bibliographies led me to physicians who knew how to diagnose and treat it. *The Internet may have saved my daughter's life!* [author's emphasis].

Health care delivery over the evolving NII is another area where rapid changes will occur. The Consumer Interest Research Institute concluded that (1993, pp. 12–15):

> Powerful new information technology applications are emerging which can make home based health care surprisingly effective:
>
> • *Computer-based medical records.* Computer based medical records are a "foundation technology" that will make possible a wide range of new applications. They will record and store patient information including patient problems, test results, orders submitted, treatment plans, X-rays and other images.

- *Health information and communication systems.* Easy consumer access to health information will be crucial for making a disease prevention/health promotion strategy work. Consumers will have greater health information available to them at home including clinical advice about specific diseases, information on their own conditions, access to their own medical records, disease prevention/health promotion information geared to their individual health status, etc.

- *Diagnostic and therapeutic expert consultation.* By 1995, expert systems are likely to be used increasingly on physicians' workstations for consultation and quality control. . . . In the late 1990s they will be linked to the electronic medical record and knowledge bases that will advise the practitioner on the logic and medical literature supporting specific decisions.

These experiences and visions—as well as thousands of other "success stories"—dot the Internet landscape. The new communication techniques and the resources and services available over the Internet will continue to change the way we work and live. Those not connected or unable to use the Internet, however, may find themselves increasingly disadvantaged in the workplace, in dealing with daily issues, in being an informed citizen, and in living a quality life.

A POLICY PERSPECTIVE ON THE INTERNET/NREN AND LITERACY

Although the intent of this paper is not to provide a policy analysis of the Internet/NREN and of literacy, it is interesting to juxtapose a brief overview of these two areas. There have been few efforts to consider relationships between these two policy areas. Yet the successful development of the NII will require both a new expanded information policy system and network literacy throug' 'ut society.

Internet/NREN Background
The Internet is a currently existing, operational network of networks. The NREN is a program, a concept, and a vision of an intercon-

nected future. The Internet was not created at a single point in time but has been an evolving structure since the late 1960s. The term NREN is often used as shorthand for a ubiquitous, national network connecting computers, people, data bases, digital libraries, and a host of other resources residing on the network.

Projects underwritten by the Defense Advanced Research Projects Agency (DARPA) in the mid- to late 1960s resulted in the ARPANet, an experimental packet-switched computer network that began in 1969. ARPANet provided both operational functionality as well as an opportunity for further research into advanced networking technologies. The Transmission Control Protocol/Internet Protocol (TCP/IP) emerged from the research in the ARPANet environment. These protocols allowed the concept of the Internet, a network of interconnected computer networks of all sizes—from local area networks (LANs) to wide area networks ('VANs) to become a reality. Lynch and Preston (1990) and McClure, et al. (1991) provide overviews and history of the Internet.

In the mid- to late 1980s, the National Science Foundation (NSF) funded several supercomputer sites to serve as national supercomputer resources and developed a high-speed backbone network (NSFNet) to connect them. This initiated the second phase in national network development. NSF also coordinated a tiered structure of interconnected computer networks by funding the establishment of regional, or mid-level, networks. These regional networks interconnected educational and research organizations, institutions, and their individual computer networks, and they provided access and connection to the NSFNet backbone. The NSFNet backbone is one of several federally funded backbone networks, connected together through the Internet.

The Internet is not only a United States computer network but a truly global network, connecting an estimated 12–14 million users on thousands of networks. In recent years, the Internet has shown tremendous growth in number of users, networks connected, and traffic. Rutkowski (1993) details this tremendous growth and predicts that exponential growth of the Internet, in terms of users, connected networks, network hosts and registrations, and traffic will continue for the foreseeable future.

Now in the early 1990s, the Internet is in another transitional stage. The NSF has been reducing its subsidies to the regional networks in recent years and is guiding the Internet toward privitization and com-

mercialization. Privitization means that the federal government will no longer directly subsidize network services and connections. Commercialization will allow the lifting of current restrictions on traffic flowing over the network and acceptable use of the network will not be limited to network traffic supporting research and education. The direction and character of the moves toward privitization and commercialization have sparked widespread debate within the networking community (DeLoughry, 1993).

As a federally funded, multiagency initiative, the principal goals of the NREN program are: establishing a gigabit network for the research and education community and fostering its use; developing advanced networking technologies and accelerating their deployment; stimulating the availability, at a reasonable cost, of the required services from the private sector; and serving as a catalyst for the early deployment of a high-speed general purpose digital communications infrastructure for the nation. Despite these goals, the NREN means different things to different people. The policy debates will continue, but network literacy issues have yet to be raised and receive adequate attention.

Current and Proposed Internet Policy Instruments

The High Performance Computing Act of 1991 (P.L. 102-194) authorized the creation of a National Research and Education Network. After several years of legislative action, the Act was signed into law in December 1991. McClure, et al. (1991), provide a comprehensive legislative history of the Act and related legislative initiatives. In the Act, the NREN is one of several components in a high-performance computing and communications program. In the fiscal 1993 proposed budget for the high performance computing program by the Office of Science and Technology, only 15 percent of the funds are allocated to the NREN. The majority of the funds are targeted at the high-performance computing systems and the advanced software technology and algorithms components.

Section 102 of the Act describes the NREN, and section (b) specifically discusses "access" to the network:

> Federal agencies and departments shall work with private network service providers, State and local agencies, libraries, educational institutions and organizations, and others, as ap-

propriate, in order to ensure that the researchers, educators, and students have access, as appropriate, to the Network. The Network is to provide users with appropriate access to high-performance computing systems, electronic information resources, other research facilities, and libraries. The Network shall provide access, to the extent practicable, to electronic information resources maintained by libraries, research facilities, publishers, and affiliated organizations.

While public access is prominently mentioned in this section, the sense of this section is severely compromised by phrases such as "as appropriate," "with appropriate," and "to the extent possible."

The Clinton administration has expressed commitment to advancing the information infrastructure and increased deployment of information technology in the cause of education, research, and national competitiveness. A February 1993 policy statement states (Clinton and Gore, 1993):

Public investment will be provided to support technology that can increase the productivity of learning and teaching in formal school settings, in industrial training, and even at home. New information technologies can give teachers more power in the classroom and create a new range of employment opportunities. Schools can themselves become high-performance workplaces [p. 14].

Regarding the importance of "Information Superhighways":

Access to the Internet and developing high-speed National Research and Educational [sic.] Network (NREN) will be expanded to connect university campuses, community colleges, and K–12 schools to a high-speed communications network providing a broad range of information resources. Support will be provided for equipment allowing local networks in these learning institutions access to the network along with support for developing of high performance software capable of taking advantage of the emerging hardware capabilities [p. 35].

The policy paper goes on to discuss the importance of using the new information technologies and the national network for enhanced economic competitiveness; making a range of government information and services available to the network; and expanding access to the NREN.

In spring 1993, Representative Boucher (Virginia) introduced H.R. 1757, the High Performance Computing and High Speed Networking Applications Act. The bill was renamed the National Information Infrastructure Act of 1993 when it passed the House in summer 1993. Section 2 (3) states:

> High performance computing and high-speed networking have the potential to expand dramatically access to information in many fields, including education, libraries, government information dissemination, and health care, if adequate resources are devoted to the research and development activities needed to do so.

Section 2 (5) states:

> The Federal Government should ensure that the applications achieved through research and development efforts such as the High-Performance Computing Program directly benefit *all Americans* [author's emphasis].

And Section 305 (b) states that the program will:

> train teachers, students, librarians, and state and local government personnel in the use of computer networks and the Internet. Training programs for librarians shall be designed to provide skills and training materials needed by librarians to instruct the public in the use of hardware and software for accessing and using computer networks and the Internet.

This bill is important since it includes language supporting training issues for networking, extending the role of libraries and the education community in developing and operating the national network, and promoting the development of networking applications and demonstration projects. The bill recognizes the importance of helping individuals

to move into the networked society successfully. As of August 1993 the bill has passed the House and awaits Senate action.

Literacy Policy Perspectives

Policy instruments related to literacy have evolved from a number of agencies and initiatives. For example, the Adult Education Act (P.L. 89-750) promotes the development of a range of basic literacy programs to adults; the Library Services and Construction Act (P.L. 88-269) provides for Department of Education grants to states for public library services such as literacy programs; the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-148) amends the Adult Education Act to provide literacy programs and amends the Education for Economic Security Act to authorize mathematics and science education programs.

In general, however, these initiatives provide support and funding for the individual states to create and run a range of "literacy" programs. It is unclear how successful these efforts have been. Some have argued that there is no accountability from the states regarding these programs and that the results have been mixed at best (Bishop, 1991). Moreover, these efforts typically concentrate on (1) improving adult reading skills, (2) promoting math and science education, and (3) job training—not on network literacy or information problem solving skills.

For example, one of the National Education Goals that resulted from the meeting between President Bush and the state governors in 1992 (U.S. Department of Education, 1992), was that by the year 2000:

> Every adult will be literate and have the knowledge and skills necessary to compete in a world economy and exercise the rights and responsibilities of citizenship.

Currently, it is estimated that there are some 30 million functionally illiterate Americans in this country. Thus, how this goal will be accomplished is unclear. How these adults will be "literate" in a networked society and what might constitute such literacy is also unclear.

Probably the most important recent policy instrument related to literacy is P.L. 102-73, The National Literacy Act of 1991. A major thrust of this law is its creation of the National Institute for Literacy. Section 102 (3) states:

> A national institute for literacy would (a) provide a national
> focal point for research, technical assistance and research
> dissemination, policy analysis, and program evaluation in the
> area of literacy; and (b) facilitate a pooling of ideas and
> expertise across fragmented programs and research efforts.

The Institute can also award action grants to be given to volunteer
groups that provide literacy training. Because the Institute is still in its
infancy, it is unclear how successful it will be in dealing with the
plethora of literacy problems and policies.

Literacy policy and support at the federal level is uneven, at best.
Recently, in spring 1993, the Clinton administration proposed the
elimination of $8 million in literacy projects from the Library Services
and Construction Act, Title VI. For fiscal year 1993, that program
accounted for some 250 awards, administered by state and public
libraries. In the overall scheme of the U.S. federal budget, $8 million
may be trivial. But in terms of support for dealing with literacy issues,
$8 million is significant.

In perhaps the best recent analysis of policy issues related to literacy,
the U.S. Office of Technology Assessment (1993, pp. 127–28) concluded:

> The Federal response to the problem of adult illiteracy consists of
> many categorical programs—at least 29, perhaps many more,
> depending on the definition used—that in some way aid adult
> literacy and basic skills education. Although the individual
> programs have solid records of accomplishment, together they
> create a Federal role that is complicated, fragmented, and insuffi-
> cient, and which, by it very nature, works against development of
> a coordinated Federal adult literacy policy.

Federal policy instruments related to literacy issues are limited to a very
traditional interpretation of "literacy." Overall, the literacy policy
framework can be best described as one that has been given much
rhetoric but has received very limited direct support.

Assessment

Until the Clinton administration, the federal policy framework for
creating the Internet/NREN has emphasized the development of new

networking technologies and creating a "level playing field" for the private sector to develop the network. Inadequate policy exists supporting public-sector uses of the Internet/NREN. The library and education community had minimal input and impact on developing the NREN plan. The policy framework has promoted the use of the Internet/NREN among researchers and scientists working primarily on "grand challenges" rather than developing it as a "public right" to which all citizens are entitled. This may change with Clinton administration policy initiatives and the introduction of H.R. 1757 in March 1993.

Moreover, development of the Internet/NREN is uneven. Gigabit transmission speeds are being developed while the typical American classroom has no telephone line to connect to the network; some individuals have free (often subsidized) use of the Internet and others must pay significant fees; the gulf between network literacy and illiteracy continues to widen; and overall, large segments of the population appear likely to be bypassed as the networked society evolves. How society will migrate to this networked environment is unclear.

Interestingly, the Department of Education has limited involvement in the deployment and planning of the NREN or the NII. Despite some recent activities for promoting literacy and the passage of P.L. 102-173, there is only beginning understanding of literacy in an electronic age or for the networked society. Inadequate thought appears to have been given to the educational roles of national networking or how the network could be used to enhance the country's educational institutions.

Federal policy related to literacy is very decentralized and dependent, to some degree, on a host of private initiatives and local efforts—all largely uncoordinated. In addition, literacy policy is best characterized as developing basic reading and writing skills. Moreover, "OTA finds that technology is not a central consideration for most literacy programs" (Office of Technology Assessment, 1993, p. 15). Literacy in terms of information literacy, information problem solving skills, or network literacy are not considered in the existing policy framework.

Apparently, the belief is that public uses of the network will occur naturally with little or no federal, state, and local planning and support. Either the private sector will provide for public uses and educational applications, or the library and education community will marshall the resources needed to move the population into the networked environ-

ment. *Somehow*, *someone* or *some institution* will assist the country to move to the networked environment and provide access to information resources, services, and holdings in an electronic format.

INFORMATION IN A NETWORKED ENVIRONMENT

There is considerable discussion and debate about what networked information is, how its access or lack of access affects a range of societal activities, and how information can be best managed to improve societal productivity. Generally, information is considered as data or signals that affect the uncertainty state of an individual. That is, for something to be considered as information it must either make the individual more or less uncertain about a particular situation or phenomenon (Whittemore and Yovits, 1973, p. 222).

As a resource, information is unique in that it has a number of characteristics that separate it from traditional types of resources (adapted from Yurow, 1981, p. 54):

- the information is not used up by being used,

- the information can be possessed by many persons simultaneously,

- it is difficult to prevent persons who wish to do so from possessing particular parts of information or acquiring information without paying for it,

- the value of information for a particular consumer often cannot be determined until the information is disclosed to that user,

- information can become obsolete, but it cannot be depleted,

- frequent use of information does not wear it out, and

- the technical units of measurement of information, e.g., bits, packets, etc., lack meaning and fail to carry meaning for the consumers of that information.

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Thus, information fails to adhere to traditional aspects of a "resource," making it difficult to develop policy for how best to acquire, manage, and use it in a basic market economy such as that in the United States.

This description of information, then, raises the issue of the degree to which it might be best considered as a public good. Some information might be best seen as "public," that is, belonging to the public at large (e.g., much of the government information produced by the U.S. federal government); other information might best be seen as "private," that is, owned by an individual and either kept for that person's own use or sold if a market price can be determined.

More recently, the notion of "value added" has been applied to information as a conceptual approach for better understanding its characteristics (Taylor, 1986). In this model, a range of different value-added services and processes can be added to information as a means of enhancing its usefulness. For example, an author writes a book; to add value to that book she hires someone to produce an index for the book; a publisher adds value to the book by having it copyedited, and so forth.

Understanding these basic attributes of information is important if we are to understand educational issues and concerns related to information in a networked society. One significant change from traditional notions of information to information in a networked environment is less emphasis on information as affecting the uncertainty state of the individual and more on information as an empowering tool. Such an empowerment tool, when properly managed, and when appropriate value-added process are attached to the information, can assist an individual to make better life decisions and contribute to the overall productivity of a society.

NETWORKED INFORMATION AND THE NEW LITERACY

The term *literacy* means many things to different people. In recent years, different types of literacies have been proposed and defined. Introducing the term *network literacy* into this already confusing array of terms and definitions requires some discussion of the various terms and how they are being used.

Types of Literacies

With the range of services and resources available over the Internet, what constitutes literacy given this evolving networked society? P.L. 102-73. The National Literacy Act of 1991, Section 3, states:

> The term "literacy" means an individual's ability to read, write, and speak English, and to compute and solve problems at levels of proficiency necessary to function on the job and in society, to achieve one's goals, and develop one's knowledge and potential.

This notion of literacy is the traditional view—and one that is increasingly out-of-date.

Computer literacy, for example, is an additional extension of traditional literacy, requiring that individuals can complete basic tasks on a computer such as word processing, creating and manipulating data on a spreadsheet, or using other types of software. The notion of *media literacy* recently has been introduced and is described as follows (Aufderheide and Firestone, 1993, p. 1, v):

> Media literacy, the movement to expand notions of literacy to include the powerful post-print media that dominate our informational landscape, helps people understand, produce and negotiate meanings in a culture made up of powerful images, words and sounds. A media literate person—and everyone should have the opportunity to become one—can decode, evaluate, analyze and produce both print and electronic media.

Thus, media literacy is a step beyond traditional notions of literacy although it does not specifically mention computing skills or skills/knowledge related to locating, processing, exchanging, and using information in a networked environment.

Probably the most encompassing notion is *information literacy*. The Association for Supervision and Curriculum Development stated in a 1991 resolution (Breivik, 1992, p. 7):

> Today's information society transcends all political, social, and economic boundaries. The global nature of human interactions

> makes the ability to access and use information crucial. . . .
> Information literacy, the ability to locate, process, and use
> information effectively, equips individuals to take advantage of
> the opportunities inherent in the global information society.
> Information literacy should be a part of every student's educa-
> tional experience.

Although it might be assumed within this definition, the resolution could be strengthened to make clear that information literacy includes an "ability to locate, process, and use information effectively" *regard-less of delivery mechanisms and the type of format in which that information appears;* that is, to be literate, one must be literate with both print and electronic formats.

Hancock (1993, p. 1) provides additional detail describing informa-tion literacy, concluding that "education systems and institutions must take seriously the challenges of the Information Age. This includes restructuring the learning process to reflect the use of information in the real world, [and] changing the role of the teacher from presenter of prefabricated facts to facilitator of active learning." Information literacy thrives in a resource-based learning environment rich in a variety of print and electronic information.

Ochs, et al. (1991) provide an excellent literature review of infor-mation literacy. Figure 1 describes a very useful set of goals and objectives related to developing information literacy skills. The goals and objectives

Figure 1   Information Literacy Program Goals and Objectives

A. Understand the role and power of information in a democratic society. Students can describe and understand:

- how scholars and researchers use information and keep currently informed;
- how practicing professionals use information and keep currently informed;
- how the use of information can improve the quality of scholars' and professionals' work;
- the commodity nature of information: who generates, controls, and uses information—in particular, the role that governments play in the dissemination and control of information;
- the costs of misinformation; the possibilities of abuse and its consequences.

B Understand the variety of the content and the format of information. Within their discipline, students can:

- distinguish popular from scholarly treatments of a subject;
- distinguish between primary and secondary sources;

- define various standard formats for the storage of scholarly information. e.g.. print, microform, optical, floppy and compact disk, and magnetic tape;
- evaluate the quality of information and the usefulness of the content and format of a particular information tool based on relevant criteria.

C. Understand standard systems for the organization of information. Within their discipline. students can:

- define types of data bases and their organization. e.g.. records, fields, and the retrieval function/process;
- recognize that different types of reference sources lead to various forms and formats of information;
- define standard terms such as bibliographic citation. periodical index, abstract, and citation index;
- differentiate between the types of materials typically represented in a library's catalog and those that are not;
- determine the index structure and access points of print or computerized information resources.

D. Develop the capability to retrieve information from a variety of systems and various formats. Within their discipline students can:

- construct a logical plan to organize their search for information;
- describe the difference between controlled vocabularies and keywords and use both efficiently in their search strategy;
- effectively use logical operators (e.g.. and. or, not) to link their search terms and intersect concepts in various electronic information systems;
- understand and apply the concepts of truncation and field qualification in various electronic information systems;
- describe and use appropriate services which are available to assist them in locating information;
- successfully navigate within the libraries they use;
- accurately interpret bibliographic citations from print and computerized information resources and locate the materials they represent;
- operate a standard personal computer, develop mastery of certain programs/software. and maintain a working awareness of others.

E. Develop the capability to organize and manipulate information for various access and retrieval purposes. Within their discipline. students can:

- use a bibliographic file management package to organize downloaded citations and personal files of references;
- conduct their own needs assessment. based on relevant criteria. to identify suitable software packages appropriate to a given application;
- use electronic spreadsheets to reformat and analyze numeric data which has been either downloaded or manually entered into the package.
- use a word processing package to format papers. reformat downloaded references and construct bibliographies;
- write correct bibliographic citations for books. journal articles. and conference reports

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were developed in the context of undergraduate student skills and knowledge, but they are useful in expanding our thinking toward network literacy skills. Moreover, the objectives on this list suggest the importance of such skills in not only higher education, but as basic skills for leading a productive life in a networked society.

Although the objectives listed in Figure 1 tend to be "library oriented," they offer an excellent perspective on what types of generic skills we need to be teaching the public if they are to be productive in a networked environment. But at the core of the notion of all the various literacies is the idea of information problem-solving skills.

Literacy and Information Problem-Solving Skills

These skills, or the "Big Six Skills," as described by Eisenberg and Berkowitz (1990), suggest that people should successfully solve problems and make decisions by being able to engage in six key information problem-solving activities (see Figure 2). People involved with the Internet recognize the importance of such skills in training and education programs. What they sometimes fail to recognize, however, is the importance of developing Internet skills within the contexts of (1) real need and (2) the overall information problem-solving process.

The first context is real need: curricular, life, or work. While it is certainly possible to learn skills in isolation, practice and research confirm that people learn best when the use and purpose are clear. Students can probably learn to communicate via e-mail or to access a NASA data base, but they will eagerly engage and internalize these skills if they see how they directly relate to their school assignments, personal interests, or work requirements.

The second, and often overlooked, context is information problem-solving process itself. Computer and telecommunications technologies are supposed to extend our abilities to solve problems. That sounds fine in the abstract, but what does it really mean? Again, practice and research tell us that when people understand how specific skills fit into an overall model or process, the power and usefulness of the specific skills are expanded.

Task definition is step one of Eisenberg and Berkowitz's Big Six approach to information problem-solving. Electronic communication is also a powerful tool for consulting with others about the best strategies for seeking information (step 2), to locate and access the information

Figure 2 Internet Capabilities in an Information Problem-Solving Context

The Big Six Skills	Internet Capability	Application
1. Task Definition		
1.1 Define the problem	E-mail	to seek clarification from teachers
1.2 Identify information requirements of the problem	E-mail Discussion/interest groups (listservs,news-groups)	to consult with group/team mems. to share and discuss concerns/ questions/problems with persons in similar settings or with experts
2. Information seeking		
2.1 Determine the range of possible sources	Electronic libraries, data centers, resources	to be aware of options, to determine possible and priority sources
2.2 Evaluate to determine priority sources	WAIS, Gopher, various Internet resource guides	to determine possible resources, to search for types of files and data bases available
	Use of AskERIC, NICs	to consult on resources, files, data bases
	E-mail Electronic discussion groups (listservs, news-groups)	to consult with group/team mems. to request recommendations from persons in similar settings or from experts
3. Location and Access		
3.1 Locate sources (intellectually, physically)	Archie, Veronica	to search for the location of spe-cific files or data bases
3.2 Find information within sources	WAIS, Gopher Telnet, remote login, ftp	to search by subject within/across sites to obtain remote access to com-puters and electronic libraries
4. Use of information		
4.1 Engage (read, view, listen)	Download and file transfer, ftp	to get the relevant information from a remote computer to your own
4.2 Extract relevant info		
5 Synthesis		
5.1 Organize information from multiple sources	E-mail Listservs, newsgroups	to share drafts and final communi-cations to share papers, reports, and other communications
5.2 Present information	Electronic journals Ftp and Gopher sites	to present papers and reports to archive reports, papers, products
6. Evaluation		
6.1 Judge the product (effectiveness)	E-mail	to gain feedback
6.2 Judge the process (efficiency)	Listservs, newsgroups	to gain feedback

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itself (step 3), to extract relevant information (step 4), to present the results (step 5), and to seek reaction to your work (step 6). Therefore, it is essential to design and deliver Internet and technology training within the overall problem-solving context.

The two contexts, need and process, provide the necessary anchors for meaningful technology training—and increasing network literacy. This is true regardless of whether those receiving the training are students gaining their first glimpse of the Internet, unemployed workers involved in retraining programs, or corporate executives seeking to stay on top of emerging technologies. Figure 2 offers examples of how Internet capabilities can be placed in the Big Six information problem-solving context. These are, of course, just some of the options. The chart is easily modified as new Internet functions and resources are made available or as teachers and students find new ways to apply existing capabilities.

Notions of information problem solving and the Big Six Skills can be used to enhance our conceptualization of various types of literacies and how they are related to each other. Of concern are (1) we cannot wait until college for such skills to be obtained, (2) how those who have not gone or do not intend to go to college wou... obtain such skills, (3) the degree to which members in the education and library community have such skills and could impart those skills on others in the general public, and (4) a range of additional skills, unique to the network, need to be added to the list.

Recasting Notions of Literacy

Recasting information literacy notions into the networked society are mind boggling. Project Literacy U.S. estimated that as many as 23 million adult Americans are functionally illiterate, lacking skills beyond the fourth-grade level, with another 35 million semiliterate, lacking skills beyond the eighth-grade level (White House Conference on Library and Information Services, 1991). It must be remembered that these numbers consider literacy in a print-based society and not in a networked society.

Figure 3 suggests a possible approach for thinking about literacy in a networked society. At one level, an individual must be able to read and write— traditional notions of literacy. At another level, the person must be technically literate, e.g., be able to operate computer, telecommuni-

cations, and related information technologies. At a third level, people need media literacy; at yet another level they need network literacy. All of these types of literacies can be cast in the context of information problem-solving skills.

Papert (1993) explores the importance of redefining literacy in a networked society. He discusses "knowledge machines" that provide children with interactive learning opportunities that include virtual reality and an ability to have freedom to explore and interact in an electronic knowledge arena:

> School will either change very radically or simply collapse. It is predictable (though still astonishing) that the Education Establishment cannot see farther than using new technologies to do what it has always done in the past: teach the same curriculum. . . . I would go further; the possibility of freely exploring worlds of [electronic] knowledge calls into question the very idea of an administered curriculum.

Figure 3 Thinking about Literacy Concepts
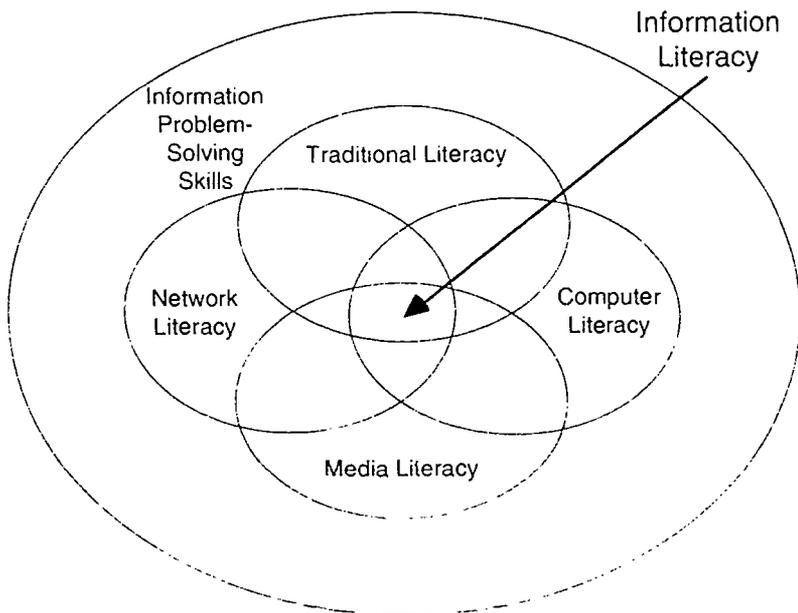
But what Papert does not tell us is what, specifically, are the skills and knowledge that these children will need to be literate in this networked environment, and how they will be taught these skills.

A beginning discussion piece for the knowledge and skills that might comprise network literacy for the general public includes:

Knowledge
- awareness of the range and uses of global networked information resources and services;

- understanding of the role and use. of networked information in problem solving and in performing basic life activities;

- understanding of the system by which networked information is generated. managed, and made available.

Skills
- retrieve specific types of information from the network using a range of information discovery tools;

- manipulate networked information by combining it with other resources, enhancing it, or otherwise increasing the value of the information for particular situations;

- use networked information to analyze and resolve both work- and personal-related decisions and obtain services that will enhance their overall quality of life.
  -

Such knowledge and skills cannot be seen as "supplemental" to traditional literacy, but rather as part of a reconceptualized notion of literacy in an electronic society.

These skills and knowledge are targeted at the *general* public for *network* literacy. Likely as not, they will require other "literacies" to already be in place (see Figure 3). Additional knowledge and skills certainly can be included in this beginning list. But even these knowledges and skills listed above, while seemingly basic and rudimentary to the already network literate, will require national commitment and a range of programs if they are to become commonplace in society.

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Answers to what constitutes network literacy and how network literacy relates to other types of "literacies" requires immediate attention and research. But as more information services and resources are networked, those individuals who, for whatever reason, cannot access and use them will be severely disadvantaged in society. They may be unable to obtain good jobs; they may not be able to communicate effectively with governmental units; they may not be able to exploit a range of self-help or entertainment services available over the network; and they may become disenfranchised from mainstream societal goals and values. Implications from such a widening gulf between the network literate and the illiterate are significant and require our immediate attention.

INFORMATION IN THE EVOLVING
NETWORKED SOCIETY

Even those who are creating the networked society cannot predict how it will evolve. It is still too early to determine how the public can best be connected, which applications will be most useful to the public, which types of services should be made publicly available and which will be costed, and what might differentiate roles among the government, the public sector, and the private sector in developing and operating the Internet/NREN.

What we do know, however, is that information in this evolving networked society may have different characteristics than information in the prenetworked society. The following aspects of information in a networked environment will require us to rethink educational programs to ensure network literacy.

Pervasiveness of Electronic Information

Increasingly, information is in a digital, electronic format. Currently, information tends to be (1) created in electronic format and then, if necessary, transferred into a paper format, or (2) created in electronic format and never migrated into a paper format. The vast majority of Bureau of the Census data, climate and weather data beamed down from satellites, and a range of research data will never be migrated into a paper format. Thus, increasingly, users of information will either

have to identify and access information in electronic format or they will be unable to use it at all.

Convergence of Information Technologies

The computer that sits on my office desk is (a) a computer, (b) a CD-ROM reader, (c) a fax machine, and (d) a worldwide telecommunications node! To refer to this machine as a "mere" computer is an insult! Increasingly, it has become almost impossible to determine where a telecommunications technology, a computer technology, and other information technologies begin or end. Mergers among cable TV companies, computer companies, software producers, and telephone companies testify to the fact that the new information technologies will be multi-tasked and seamlessly combine many technologies into one package.

Transferability of Digital Information

Related to the convergence of information technology is the transferability of digital information. Once information is in a digital format, it can be transferred, manipulated, edited, revised, and sent through endless transmitters and receivers. A digital picture of the Mona Lisa can be enhanced, changed, "brushed up," or otherwise manipulated, sent over a network, downloaded and "brushed up" again with existing software. Once information is digital, it can go anywhere, to anyone, at any time. Society will be in a sea of information and only those information services and products that meet real needs, offer true user-friendly software, and make life easier (as opposed to more difficult) will prosper.

Information for Electronic Services Delivery

To date, emphasis has been placed on delivery of electronic information rather than delivery of electronic *services*. Dumping gigabites of data on the network is not the same as providing services to successfully use that information in one's daily life. The ATM machines at local banks are only the beginning. Increasingly government services, for example, will be delivered through a range of electronic kiosks and directly to the home (McClure, et al., 1992). Shopping, financial services, entertainment, public education, and other services will be commonplace on the network. Individuals unable or unwilling to take advantage of these electronic services—especially government services—will be increasingly disadvantaged.

New Information Navigation Skills

In the short term, people will be forced to "drink from firehoses" as a glut of information resources and services overwhelm them. New information navigation skills on the network will be a prerequisite for successful use. Already, it is clear that if individuals cannot use a "gopher," a WAIS, or "telnet" to an "FTP site," they will be hopelessly swallowed in a sea of information and resources—drowned, as it were, in information. Traditional navigational tools such as the card catalog at the library, the Sunday newspaper listing of television programs, or reliance on one or two "key" newspapers or journals will be grossly inadequate to identify and retrieve networked information.

"Bottom-Up" Information Services Development

Due in part to some of the above characteristics, individual info-preneurs have it in their power to develop, test, market, and distribute a range of information products and services. Such services and development efforts have been largely in the domain of large companies. No more. The nature of the information technology allows amoeba-like developments by individuals with curiosity, perseverance, and good ideas. The rapidly expanding community networking movement is a good example of this phenomenon (Civille, 1993). Individuals who wish to take advantage of the new technologies, who know how to operate them, and see possible applications can develop these services from their home—either to enhance the quality of their life or for economic gain.

Filtering and Synthesizing Information

With the glut of digital information, filtering and synthesizing that information and determining which information is needed in what situations will be a critical concern for individuals in the networked society. The only way to deal with such large amounts of information is to develop mechanisms to filter and synthesize it. Such information retrieval techniques will have to be uniquely individualized in their design. "Profiles" of the information needs of individuals will be converted by "know-bots" that scan the network for specific types of information of interest to the individual, synthesize that information, and report it in a timely and organized fashion. Knowledge management will be much more important than information management.

Information in Search of People

In the past, it has been extremely difficult for individuals to "publish" their ideas or make them widely available to a large audience. In the future, the problem will be the reverse. There are thousands of messages posted on Usenet discussion groups today that are never read; endless papers and articles posted on the network that are ignored; and hundreds of unread e-mail messages deleted from reader files every day. The network has made it easy to produce and send information; the problem is to get people to read or review the information service or product sent them. The tyranny of information overload, despite sophisticated filters and synthesizing devices, is likely to be resolved by ignoring most information.

Privacy Protection

Because of many of the characteristics outlined above, the networked environment will increase the difficulty of protecting individuals' privacy. The Privacy Act of 1974 (5 U.S.C. 552a) and the Computer Matching and Privacy Protection Act of 1988 (P.L. 100-503) provide a number of important safeguards to ensure that the government, or others, do not divulge certain information about individuals. The success of these policies in the networked environment, however, is unclear.

New information technologies, and the increased use of authentication devices to confirm transactions between sender and recipient (especially for certain personal services e.g., social security information) will strain our ability to keep private information about ourselves to ourselves. Without adequate policy and enforcement, governments and commercial firms can easily maintain files of "personal data" linked to specific individuals that can be matched to other files to produce, for example, composite "buying patterns" that include specific types of purchases by specific individuals, demographic information about a person's household and income, and other types of information.

ISSUES AND IMPLICATIONS

Literacy in, and for, an electronic society will require a major overhaul and rethinking. As the educational system currently operates,

it is ill-prepared for the challenges it faces in migrating individuals from a print-based society to a digital, network-based society. There are a number of issues that will need to be addressed if we are to move successfully into a networked society where all members of society have a level playing field to be empowered by the network.

Increasing Awareness of the Importance of Network Literacy

The first issue that must be addressed is increasing the awareness of government policymakers (at all levels of government) and the public at large that notions of literacy have changed, and will continue to change in the future. Literacy cannot be defined simply as the ability to read and write at a fourth-grade level. It includes a range of technologically based skills as well as information problem-solving skills.

Increasing awareness is linked to demonstrating the importance of networked literacy and the impact of network literacy on:

- the individual's ability to operate successfully in a networked environment;

- society's ability to empower the individual to be a productive member of society;

- the economic productivity of the country and the ability of the United States to compete successfully with a knowledgeable and technically skilled workforce.

Such impacts will have a significant effect on how well this country will maintain leadership not only in industry, but in health care, manufacturing, delivery of services, and the individual's pursuit of happiness.

Reaching Agreement on What Constitutes Information and Network Literacy Skills and Knowledge

A major impediment to developing programs for increasing networking literacy in this country is that we have been unable to operationalize skills, competencies, and knowledge that could constitute "network literacy." Debate continues about how best to define and measure traditional notions of literacy—to say nothing of networked

literacy. Yet, until we can operationalize the term *network literacy*, we certainly will not be able to teach it and determine the degree to which individuals have gained such skills.

And as suggested by the opening quote to this paper, the existing level of knowledge and skills of most people in this country (to say nothing of those worldwide) in dealing with the new information technologies is abysmal. The reality is that if you cannot read, you cannot use the network. Reaching agreement on what literacy skills are essential for the public will require much coordination among federal, state, and local governments, private foundations, and others. Unfortunately, many of these same individuals themselves are unfamiliar with what the network is and how it works.

Revising the Federal Policy Framework

The brief overview of policy related to the Internet/NREN and literacy suggests that a significant disconnect exists. Not until the proposed H.R. 1757, the High Performance Computing and High Speed Networking Applications Act, has there been some linkage between development of the Internet/NREN with education and training concerns. While the linkage between the development of the network with education is laudable, H.R. 1757 still does not address literacy issues, i.e., educating the general population, or in some cases, retraining the population to be able to work and live in "Cyberspace" (Communications, Computers and Networks, 1991).

A federal policy initiative that has as its objective to develop a program that will train or retrain—or even make available—network literacy skills to the population is essential. Such a policy could also coordinate and organize the efforts for developing network literacy at state and local governmental levels. Such a policy framework would need to bring together the efforts of a number of federal agencies such as the Department of Education, the National Commission on Libraries and Information Science, the Agriculture Extension Service, and the National Literacy Institute—to name but a few.

In addition, a revised policy framework for this area needs to recognize the importance of libraries in promoting network literacy and serving as a vital link between networked resources/services and the public. Recent research suggests that the library community is beginning to redefine its roles and responsibilities to move more

effectively into the networked society (McClure, Moen, and Ryan, 1993). But a clear mandate by federal policy to coordinate the education and library community to work together in this area is essential.

Reinventing Education and Libraries for the Networked Society

There has been considerable discussion about "reinventing" a range of services and institutions in this country. The Clinton administration, for example, is attempting to reinvent government. Education and libraries are additional institutions desperately in need of being reinvented. *A Nation at Risk* (U.S. Department of Education, 1983) identified a raft of problems with the American education system. Now, in 1993, there is general consensus that those problems still exist, and if anything, have only become worse. Many libraries lack infrastructure, public support, and leadership in visioning their role in the networked environment (McClure, Moen, and Ryan, 1993).

Hughes (1993) notes that the intensified commercialization of the network, the lack of attention to public uses of the network, and our inability to confront issues related to educating the public for the networked society will result in

> an acceleration of the decline, or in some places the death, of the public education system. It simply won't be able to compete for the attention of students. And those parents who want a decent education for their kids will get it—commercially. Including offerings over the infotainment net. And then will act to stop or reduce taxes for a broken public system. Which will further decline. And in the long run be reduced to educational welfare for the have nots.

Schools and libraries may not be able to continue what they have always done in a networked environment since the networked environment is substantially different from the traditional school and library environment. These two institutions need to be reinvented, they need to rethink their roles and services in a networked society, and they need to determine their responsibilities for transitioning the public into the networked society in a way that individuals are empowered and advantaged.

Libraries can serve as an electronic safety net for the American public to ensure basic access to electronic information. Public libraries are especially well-suited to assume this role as they already serve such a role in a print-based society. Not only can they provide access to electronic information and provide connectivity for those otherwise unable to link to the network, they can also provide training and education to the public at large in how to access and use networked information. Despite the lack of federal policy supporting libraries to move into this area, there is evidence that this can be accomplished with adequate planning and resource support (McClure, et al., 1993).

Creating a Level Playing Field between Public and Private Interests

Increasingly, development of the Internet/NREN appears to be a commercial venture. The Bush administration promoted commercial development of the Internet/NREN, and it appears that the Clinton administration will continue this policy—although with some restrictions and modifications (U.S. Congress, 1993b). Investment from the private sector in the national information infrastructure certainly is welcome and appropriate. Such an investment, however, cannot be made without also supporting public and educational uses and access to the network.

We cannot afford the development of a national network that provides unlimited access to entertainment, home shopping, and other commercial activities—with hundreds of interactive multimedia channels that are all pay-per-view or pay-for-access (Hughes, 1993):

> TCI, US West-Time-Warner, AT&T and the MCI's of the world are now falling all over each other in the race to push the pipe in your front room, entertain you to death, interactively.... This administration is urging these "private companies" on as a way to build the infrastructure.... But, with the tidal wave of entertainment/home shopping interactive telecom via fiber, ISDN, cable about to wash over the U.S., the "serious" Internet is going to look like a tiny mountain rivulet in comparison. I think we [the United States] are in for some gigantic problems.

Commercial applications cannot be developed to the exclusion of public applications and uses of the network. Public service and

educational applications on the network for the nation's elementary, secondary, and vocational schools, as well as independent learners, must be nurtured and promoted.

There are, however, areas where both the public and private sectors have mutually supportive goals. The goal of educating the public to be network literate certainly can be supported by all. From the public sector perspective, network literacy will be a prerequisite to operate effectively in society. From the private sector perspective, there must be a network-literate population or there will be no market to purchase the new and innovative gadgets that continue to be introduced. These and other common goals must be recognized so that partnerships between the two groups can be formed.

Promoting Research

A range of research initiatives related to educational matters is needed to facilitate the transition into the networked society. Research initiatives in the following areas are needed:

- *Policy research.* Two key thrusts can be identified in this area. First, we need a comprehensive analysis of existing policy in the areas of Internet/NREN development, literacy. electronic privacy. and related policy instruments. Second, we need to develop and assess policy options that have as an objective the provision of educational initiatives to prepare individuals to be productive members in the networked environment.

- *Applied research.* A range of social and technological topics related to educating for the networked environment remain to be addressed. To what degree are those who are network literate more or less productive on what types of tasks? What variables affect the development of network literacy in individuals? Would cost savings result from delivery of networked government services, for example. if we had network-literate individuals in society?

- *Descriptive studies.* Baseline data is needed that describes the number and types of users of the existing network. What are the demographic characteristics of users and nonusers of the net-

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work? What trends can be identified in terms of the use of the network among the various population segments?

- *Program development.* Currently, it is unclear what types of, how many, and which sponsoring agencies and institutions will be needed to educate and retrain the population to be productive members in the networked environment. Further, we have yet to understand how best to marshal the new information technologies to help us promote network literacy in our schools, workplaces, and homes.

The above topics are intended to be suggestive, not comprehensive. What government agencies, foundations, or other organizations will be able to take leadership in this area for promoting such research? At the moment we are woefully ignorant about topics related to how information can be best managed and used in a networked environment.

THE NEED FOR VISION

Probably the most important challenge for exploiting information in a networked environment is extending our horizons of what is possible and developing new visions. A vision is a dream of what the network should be in the future and how people and institutions will use the network. A vision statement is a description of a possible future state or set of functions for developing a network literate society. Getting the "vision thing" right requires that it address:

> [people's] physical and economic well-being, their social need to be treated with respect and dignity, their psychological need to grow and develop, and their spiritual need for meaning and significance (Lee, 1993, p. 28).

Vision statement development requires us to make explicit our assumptions about the future and to envision a future state of the networked society in light of these assumptions and in light of societal goals and resources.

A primary purpose of such visioning is to describe and explore *visions* of what constitutes educated individuals in a networked society. In terms of strategic planning we need to develop a range of possible visions, identify those that are most important and would benefit society the most, and then take appropriate steps to ensure that the vision evolves as defined. A vision statement provides a target we can move toward and a vision of what we would like to occur, and suggests resources needed to reach that vision.

In the policy process vision statement development is a precursor to setting mission, goals, objectives, and tasking programs to accomplish the objectives. It is essential that this development precede the traditional activities of strategic planning to ensure the development of visions, to encourage stakeholder groups to think in terms of new opportunities, and to define possible states of being that would be especially appropriate for the networked society.

In thinking about developing a vision for the education and library community, stakeholders need to:

- state societal assumptions on which the vision is based,

- identify societal assumptions on which the vision is based,

- identify institutional assumptions on which the vision is based,

- recognize impacts, benefits, constraints, and limitations of the vision for individual segments of the society,

- consider resource needs to realize the vision, and

- produce draft vision statements for public debate and discussion.

Group processes among a broad range of stakeholder groups regarding these points are essential as they encourage policymakers to consider factors that will affect the success of the network in the future and possible services that should be provided given changing environmental conditions, and to better identify and accomplish educational objectives.

For example, one vision of education in the networked society is to have all public libraries connected to the national network. Any person could access the array of information resources and services simply by using the "network room" in the library. Students could work interactively on lessons, adult learners could tap into instructional tools and persons providing support to use those tools. Virtual learning communities (Schrage, 1990) could form and grow.

Electronic resources of all types and forms would be publicly available for those who cannot connect from the home. Librarians and educators would serve as electronic intermediaries, navigators, and instructors—being actively involved in assisting people to best use the network. Parents, students, adult learners, educators, and others could work interactively and interdependently on projects and activities that we can only begin to imagine now. The public library, as a nonpartisan publicly supported institution with strong local community ties, is well-suited to serve in this role.

This, of course, is just one of many possible visions. Minimally, the key stakeholder groups that need to participate in such a discussion are information providers from the commercial and public sectors, government policymakers, educators, librarians, parents, and individuals and firms that design instructional materials and equipment. Constructive policy debate among these groups (and possible others) in terms of visioning has not occurred. Discussions about how the network *should* evolve, how people *should* be able to use the network, and how individuals will be *empowered* by using the network (as opposed to entertained) are essential.

RECONNECTING SOCIETY

Maintaining the status quo for network development will ensure an ever-increasing gulf between the network literate and illiterate. Those disempowered from using the network, those without access to a network "safety net," and those who simply are bypassed by the network will be increasingly disadvantaged and unable to lead productive work or professional lives. As suggested by the recent report resulting from White House Conference on Libraries and Information Services (1991, p. 6):

> As dependence on information grows, the potential increases
> for emergence of an Information Elite—the possibility of a
> widening gap between those who possess facility with in-
> formation resources and those who are denied the tools to
> access, understand, and use information. . . . Today, now
> more than ever, information is power. Access to it and the
> skill to understand and apply it—increasingly is the way
> power is exercised.

To not be on the network, to not be able to use networked information,
and to not take advantage of a range of networked information services
and resources will ensure second-class status in this society.

But "information gaps" in our society are widening. Increasingly,
various population segments are disenfranchised from accessing infor-
mation due to race, gender, family income, geographic location, and a
host of other reasons. A report issued by the Freedom Forum Media
Studies Center states (Pease, 1992, p. 8):

> Neglecting the needs of minorities and others who may be
> underserved [in the networked environment] would only ex-
> acerbate their disenfranchisement from the information mar-
> ketplace, said Julius Barnathan, senior vice president for tech-
> nology and strategic planning of Capital Cities/ABC, Inc.
> "There's no concern for the minority, for the people who live
> in rural communities," he said. "We find that education and
> illit-eracy are getting worse, not better. So we need an infor-
> mation system to do one thing: educate. We've got to educate
> people so they can use these devices."

Disparities between the richest and poorest segments of society con-
tinue to widen, and social equity issues, i.e., the degree to which all
people may legitimately make the same claims on social resources, are
exacerbated by the evolving NII (Doctor, 1993).

Moreover, to the degree that information in the network is avail-
able to some and not to others, we may witness the development of a
hyperpluralistic society. The hyperpluralistic society is one that is
composed of thousands of small-interest groups that know only limited
pieces of information and are unable to understand and assess larger
societal concerns. They typically are interested in only one or two

issues or topics and develop skills—either in the print or in the network world—to support those interests. Making it easier for like-minded people to maintain communication, as suggested by Cleveland (1991, p. 40) can exacerbate this hyperpluralistic society.

Such impacts from the networked environment are difficult to predict, but require thinking and debate *now*. Information in a net-worked society takes on characteristics and impacts that we are only now beginning to identify and recognize. There is an educational imperative to assist individuals—be they in school, in the work force, or at home. They need to know much more than how to use the "switch hook flash" on the telephone. They must learn how to use the network and to exploit the digital information for personal growth, work force advancement, and national economic productivity. Development of formal policy and programs to support this retooling of American society is essential.

Technology in general, and the development of the NII in particular, must be seen as a dynamic social and cultural phenomenon. As Winner (1993) notes, one view of technological change is as a pump for economic development. But it can also be seen as loom from which the fabric of society can be reweaved. He argues that policy-makers thus far have inadequately considered "what Walter Lipp-mann called the public philosophy—a vision of the purposes that bring us together in society in the first place." Network literacy, re-connecting society, and ensuring social equity in an electronic society are parts of this public philosophy that still require attention. public policy debate, and resolution.

This challenge is one that we cannot ignore. If we fail to act, fail to accept this challenge, the various segments of our society will become increasingly disconnected and intolerant of each other. It is a challenge that will require long-term program and resource commit-ment. But perhaps most importantly, it will require a commitment to *people*, a commitment to provide equal opportunity to all members of society, and a commitment to promote the self-worth and individual productivity of *all* members of society.

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THE ROLE OF TECHNOLOGY IN AN INFORMATION AGE:
TRANSFORMING SYMBOLS INTO ACTION
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THE ECONOMICS OF INFORMATION: A USER'S GUIDE
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COMPETING WITH INFORMATION:
EMPOWERING KNOWLEDGE NETWORKS
WITH INFORMATION TECHNOLOGY
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THE PROMISE OF A NEW WORLD INFORMATION ORDER
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TECHNOLOGY, INFORMATION, AND SOCIAL BEHAVIOR
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NETWORK LITERACY IN AN ELECTRONIC SOCIETY:
AN EDUCATIONAL DISCONNECT?
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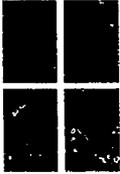
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