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6

TECHNOLOGY

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The *media* in media studies are the technologies that mediate between those who make messages and those who receive them. Models of the communication process have long included the media, but for many years, research almost exclusively focused on message production and reception, with little attention to how messages got from here to there. The convergence of technologies that has resulted in the internet, however, has provoked a great deal of interest in just what makes one technology different from another. Today's global information infrastructure is a "pan-medium" (Theall, 1999) that combines all previous media, but differences among them still matter: Media developed earlier remain in use, many forms of communication use electronic and nonelectronic media in combination, and although technologies may have multiple meanings, and uses they are not infinitely malleable; materialities still matter. The ways we use media and the policies we make for them are, in the end, always local and therefore technology specific.

This chapter opens by distinguishing among different classes of technologies and between stand-alone technologies and technological systems, looks at characteristics of technologies that make certain choices more or less appropriate in particular circumstances, examines how new technologies appear and come into use, reviews the technological features of the contemporary global information infrastructure that provides the context and conduit for the media, and concludes by looking at media themselves as technologies.

♦ *From Tool to Meta-Technology*

Across the long course of human history, the invention of new kinds of tools and technologies had such an impact on the nature of society that we distinguish between the premodern, modern, and postmodern periods by dominant type of technology. The ancient tools of premodernity, the industrial technologies of modernity, and the informational meta-technologies of postmodernity differ in the degree and kinds of social coordination they require, the materials they process, and the range of types of processes they enable. The specific features of meta-technologies go far toward explaining why the current period is also described as an information society (Braman, 1993).

The word *technology* has its roots in the Greek *techne* (making), referring to what both art and engineering have in common. This linguistic root has given rise to three different ways of *making:*

1. *Tools* can be made and used by individuals working alone and make it possible to process matter or energy in single steps. The use of tools characterized the premodern era. Although it is easy to think of examples of ancient tools for other things that people do, such as planting seeds or starting a fire, because communication is an inherently social act, it may only be when marks are made for the purposes of individual memory can it be said there are communication tools.

2. *Technologies* are social in their making and use; that is, they require a number of people to work together. They make it possible to link several processing steps together in the course of transforming matter or energy, but there is only one sequence in which those steps can be taken, only one or a few types of materials can be processed, and only one or a few types of outcomes can be produced. The shift from tools to technologies made industrialization possible, and the use of technologies thus characterizes the modern period. The printing press and the radio are examples of communication technologies.

3. *Meta-technologies* vastly expand the degrees of freedom with which humans can act in the social and material worlds. Meta-technologies involve many processing steps, and there is great flexibility in the number of steps and the sequence with which they are undertaken. Meta-technologies can process an ever-expanding range of types of inputs and can produce an essentially infinite range of outputs. They are social but permit solo activity once one is operating within the socially produced network. Their use characterizes the postmodern world. Meta-technologies are always informational, and the internet is a premiere example of a meta-technology used for communication purposes.

There are four dimensions along which tools, technologies, and meta-technologies can usefully be distinguished: the degree to which they are social, the complexity of the processes they enable, their autonomy, and their scale. The movement from tool to technology to meta-technology is marked by an increase on each of these dimensions.

Buckminster Fuller (Fuller & Applewhite, 1975) introduced the notion of the social nature of technologies when he discussed writing as the first technology. The social coordination required for the use of technologies and meta-technologies explains why it is so important to agree on both technical standards and protocols for their use. It also explains why their use has such an impact on society, for each requires (or enables) the development of specific types of coordination and interaction.

Marshall McLuhan[1] drew attention to the second feature, complexity, when he noted that both tools and technologies change the field of possibilities and therefore of practice. French philosopher of technology Jacques Ellul (1964) offered a more detailed way of thinking about this when he defined *technique* as "a complex of standardized means for attaining a predetermined result." The complexity of each single step must also be taken into account, for the more complex, the more flexibility and creativity are possible (Novak, 1997; Scazzieri, 1993)—though an increase in complexity does not always mean a better technology. The only limits to the complexity of digital meta-technologies are those of mathematics and our imaginations.

Concern over the autonomy of technologies appeared first in the 11th century in the Golem stories that later inspired the novel *Frankenstein.* These tales of a creature made out of clay to serve human needs always concluded with the Golem becoming destructive because people were unable to be sufficiently detailed and accurate in their instructions. The notion of machinic autonomy as technological activity beyond the limits of human control thus appeared very early in the transition from tools to technologies. Economic historian Alfred Chandler Jr. (1977) pointed out in his seminal work, *The Visible Hand,* that beginning with the automation of production lines in the 19th century, society began turning its decision making over to machines, thus granting machines a second type of autonomy. In the digital world of meta-technologies, a third type of machinic autonomy has appeared in intelligent agents that roam the networks finding information, making decisions, and conducting transactions of their own on behalf of humans. It may go even further: There are now autonomously evolving nonhuman intelligences in the network that may well be making decisions and acting on their own behalf. George Dyson (1997) points out that machinic intelligence may now be operating autonomously in ways that humans cannot even perceive because the logics may be so different from what we know.

Other features of technologies also distinguish the modern from the postmodern era. Belief that technological development was always "progress" was a hallmark of modernity, but in the postmodern world, there is growing concern about its risks. Technologies used to be viewed as stand-alone objects, but today, it is understood that each is inextricably part of a system. We used to apply the term *technology* only to material objects, but now use it to refer to ideas and ways of doing things as well. And despite the modern fancy that technology and culture have little to do with each other, by now it is clear that each deeply informs—indeed, creates—the other.

While keeping the distinction between tools, technologies, and meta-technologies in mind, for ease, the remainder of this chapter will use the term *technology* to refer to all three.

♦ *Technologies and Technological Systems*

The difference between perceiving technologies as stand-alone and as embedded in systems is important for economic analysis, policymaking, and effects research. There are four types of technological systems.

1. *Mutually dependent systems.* There are systems that come into being because the use of one type of technology is dependent on the use of another, as use of the printing press required the technologies that make ink and paper. These relationships are significant because when there is a change in one of the technologies involved, it may require changes in others. When the printing press sped up as a result of electrification, for example, paper manufacturers started producing rolls of paper rather than sheets, and the quantities produced went up by orders of magnitude. An example of an indirect policy intervention possible with this type of technological system is the use of restrictions on access to paper as an effective way of preventing materials from coming into print without direct censorship.

2. *Linked systems.* In a linked technological system, individual technologies must

actually be linked with each other to be functional. Physical linkages, such as the couples between railroad cars, are one way of linking technologies in this way. Electronic networks are another. The telephone network is an example of a linked technological system in the field of communication. The internet is made up of many interlinked telecommunications networks, so we refer to it as a *network of networks*.

3. *Analytical systems.* A third type of technological system develops when social and technological forms are combined for the purposes of strategy and analysis. A good example of this from the perspective of information policy is the European use of the concept of the *filiere electronique* to refer not only to the telecommunications network but also to the organizations that exist only within and because of the network. The filiere electronique, rather than the telecommunications network by itself, has thus become the unit of analysis for economic and policy purposes.

4. *Personal systems.* A fourth sense of technological system is the information environment built and used by specific users as they choose particular technologies, networks, and interfaces for their own use. We refer to the entire world of communication and information technologies from which we choose those we will use as the *information environment*. Those we actually bring into our lives create a personal *information ecology*. Because the technological potential only becomes actual through such choices—and the effects of technologies can only be understood within this context—this type of technological system is of growing interest to researchers.

All of these types of technological systems lead to path dependency, the principle that each technical decision reduces the subsequent range of possibilities within its system by either making alternatives impossible or raising their cost so high that they are no longer economically feasible. An interesting consequence of path dependency is that it makes "leapfrogging" possible—societies that do not have certain technologies or find themselves blocked by those who control those technologies can circumvent existing power relations by taking up another. When Britain used its complete control over the global telegraph network to punish its political enemies during World War I, for example, other countries turned to the radio as a way of operating beyond British control (Headrick, 1990), and although it was long believed that every society had to repeat the stages of technological development seen in the United States and Western Europe, many countries have skipped the stage of ubiquitous wired telephony and moved directly into the wireless environment. Another implication of path dependency is that although the number of people who use a new technology early on will be relatively small, it is important to study their uses because they will play particularly influential roles in shaping the paths along which those technologies will develop (Winner, 1990).

♦ *Characteristics of Technology*

Within each class of tool or technology, additional critical distinctions are of fundamental concern to users and to policymakers. The features of any given technology are not inherent but depend instead on the context in which they are used. One of McLuhan's (McLuhan & McLuhan, 1992) "laws of media" is that information technologies can simultaneously yield contradictory effects. When the printing press came into use in Western Europe, for example, it both made it easier for an institution such as the Catholic Church to maintain control and, at the same time, made it easier for those who resisted that control, the Protestants, to develop their ideas and to organize (Eisenstein, 1979).

FUNCTIONAL VERSUS DYSFUNCTIONAL

Not every technology makes things easier, more efficient, more cost-effective, more pleasing, more aesthetic, or more healthful—or even does what it is intended to do. A technology may at times even be regressive. Capabilities can be lost, as when children who watch a lot of television fail to develop fine motor skills or organizations that take up new technologies find their productivity reduced. Dewdney (1998) uses the phrase "technological Maginot Line"[2] to describe those situations in which older technologies conquer newer ones, citing as an example the ability of Iranians to use ancient Persian rug-making techniques to piece together by hand pieces of paper shredded by the CIA at the time of the overthrow of the Shah. Osama bin Laden's reliance on transmission of information by word of mouth to avoid electronic surveillance after the terrorist attacks on September 11, 2001, is another example, as is the widespread practice known as *halawa* of using family ties rather than banks to manage and move money.

Some ideas just aren't very good at all. One example, from Lawless's (1977) wonderful book on communication policy proposals that were never implemented or that wildly failed: Before satellites came into use for communication purposes, the government seriously considered a proposal to put a belt of steel needles, each several inches long, in orbit around the Earth against which to bounce radio signals. The project was finally shelved only after numerous scientists and engineers pointed out that the needles would ultimately drop out of the sky, resulting in a rain of lethal projectiles moving at high speed as they hit the ground and anything or anyone in their way.

Sometimes ideas are good but the timing is wrong. The French minitel project provides a classic example. In the early 1980s, the then-new Socialist government in France took the dramatic decision to devote itself to development of a "dumb"[3] terminal so cheap to produce that the government could provide one free to every household in France, as a way of promoting the development of the service industry in that country while simultaneously increasing the media literacy of its citizenry and defining for itself a niche in the global information economy. Unfortunately, the plan didn't quite work out: It took much longer to get the terminals into distribution than originally projected, leading to a loss of political faith in the project. Tens of thousands of new services did appear that could be advertised and/or distributed through the minitel, but the majority involved the sex industry. And although it was a courageous guess that, with this product, France could both serve its own domestic market and offer a strong export product, by the time the minitel was fully available, personal computers had taken off, and there was little interest in dumb terminals (K. Dyson, 1988).

Because of the fundamental modern belief that more technology is better technology, it has been difficult for decision makers to acknowledge that it is possible for technologies to be dysfunctional or damaging. This, in turn, undercuts the possibilities of a rich public discourse about technological choice by leading to polarization—when those who question whether taking up a particular technology is in their own or society's best interests find that they have no way of bringing their concerns into decision-making processes, they are often left believing that resistance is their only alternative.

APPROPRIATE VERSUS INAPPROPRIATE

A technology may be ideal for one situation but disastrous in another. The experience of technology transfer—in which technologies are introduced into developing societies via aid or loans—has led to a great deal of discussion about the appropriateness of technologies. They may be too costly, as when cheap transistor radios go unused in the developing world because the batteries needed to run them are too expensive. They may be impossible to repair because they are in such poor condition upon arrival that they are irreparable, require maintenance knowledge or materials not available locally, or are so obsolete that the knowledge and/or materials needed aren't available anywhere. Technologies may not function at all within the material conditions of a particular environment, as when blowing sand and heat bring down telecommunications networks in desert areas. They may work on the wrong scale, as when wireless communication systems needed to extend service to unwired rural areas rely on technologies that have utility only in densely populated urban areas. Or they may be culturally inappropriate (Forsyth, 1990; Mansell & Wehn, 1998; Reddi, 1986); North American tribal groups, for example, are encouraged to move group decision making to an online environment when traditionally, the most important decision makers are silent in group meetings.[4]

It is not that it is impossible for cutting-edge technologies to be valuable in the maintenance of traditional cultures. The telephone has enabled families to keep in touch even when employment disperses individuals geographically (Hudson, 1984). Australian Aboriginal peoples use contemporary technologies to enter the global art market as a way of generating the funds needed to sustain traditional ritual practices (Michaels, 1994). And tribal peoples in North America, like other historically marginalized groups, find that the Web provides the opportunity they've had to reach a mass audience with their stories in their own voices.

Within the developed world, technologies may be inappropriate if they require too much energy (computers use a *lot* of energy) or if their use endangers the health of the user or others (as is the case with the sensitivity of fetuses to radiation emitted from the back of computers and, as many claim, with the increased incidence of brain tumors among heavy mobile telephone users). Technologies may put in place information flows of a kind that conflict with personal or communal goals or values (Overman & Cahill, 1994; Overman & Loraine, 1994). When computer manufacturers, for example, move away from including disk drives that permit stand-alone use of databases and software in disk form in favor of forcing users to remain linked to a network for functionality, it may be "appropriate" for marketers but not at all so for those users who wish to protect their privacy, operate off the grid, or spend as little money on their computing operations as possible.

POTENTIAL VERSUS ACTUAL

Engineers, policymakers, and techno-enthusiasts often describe the most recent and sophisticated inventions as the "state of technology," but there are always great differences in access to technologies within and across societies. Many technologies are never available, except in the most specialized and well-resourced contexts. The result is a gap always exists between the cutting edge of technology, as it may be available under ideal conditions with unlimited resources and before restrictive choices have been made (the potential state), and the level of technology actually available to most people with ordinary resources is enormous (the actual state). Many factors contribute to the latter, including level of knowledge, physical access, economics, and policy choices.

INCREMENTAL VERSUS DISRUPTIVE

Some innovations are incremental, involving minor changes in one technology that do not require changes in others within its technological system. The development of a new color of printing ink, for example, is not likely to require alterations to the printing press or to paper. Other innovations are "disruptive" or "radical" because their use demands transformations of other technologies with which they are involved and, often, of the organizations and societies that use them. The switch from the use of stand-alone manual typewriters by journalists and their editors to reliance on Web-based computers would be an example because it has completely changed the nature of journalistic practice. Disruptive innovations may come about as a result of the gradual accumulation of many small incremental changes over time, or they may appear as the result of the joint appearance of several radical innovations at once (Dosi, 1988). Some use the terminology of micro-inventions and macro-inventions to make this same distinction (Mokyr, 1992; Mowery & Rosenberg, 1989).

LOW- VERSUS HIGH-INFORMATION INTENSITY

Information intensity is the degree to which information itself has been used in the development of a particular technology. The information intensity of a technology is often invisible to the user. Very few are aware of the widespread embedding of artificial intelligence into objects of daily use, for example. An increase in information intensity does not always make a technology more difficult to use or require more training; indeed, it may make a technology easier to use. It does, however, affect the ways individuals experience their relationships with the environment (de Cauter, 1993; Wilson & Dissanayake, 1996) as well as with each other (Smith, 1990). Within organizations, technologies and organizational structure interact with each other to achieve the desired level of information intensity (de Landa, 1991; Demchak, 1991; Pondy, 1969).[5] The relative importance of information intensity for economic competition in today's environment is formalized in the concepts of "invisible assets" (Itami, 1991) or "intellectual capital" (Stewart, 1994), which refer to the edge that corporations must maintain between their own information intensity and that of their clients. Governments are inherently information intense (Fletcher & Foy, 1994), and a vast increase in the information intensity of the nation-state is one of the demarkers of governance in the modern era (Giddens, 1984). In turn, governments increasingly recognize manipulation of information intensity as a policy tool in and of itself (Forecasting and Assessment in Science and Technology [FAST], 1983), as in support for the research and development (R&D) required for technological innovation (Kanter, 1992; Mokyr, 1992).

The relationship between information intensity and level of technological development, however, is not simple. The rate of innovation was slower than it might have been for much of the modern period because practice-oriented craft knowledge was kept away from knowledge-intense people in most societies for class reasons (Pearton, 1984). In addition, because the number of times information is processed is an indicator of information intensity, traditional bodies of knowledge as expressed in story cycles and cultural practices are very rich, whether or not they involve technologies. Recognition of the transformation to an information society, however, is an acknowledgment that the ever greater reliance on information technologies in turn increases the information intensity of society itself.

LOCAL VERSUS GLOBAL

One of the ways of distinguishing among technologies historically was by looking at how their users related to space, with the difference between local and global technologies appearing as a particularly important distinction. Local technologies produce specialized products to meet the needs of particular populations or places, usually rely on local materials as inputs, and operate on a small scale. Because they are usually labor intensive, many individuals in a particular locale are involved in their use. Global technologies, on the other hand, produce standardized products for world markets and are produced and used by large corporations. Because they replace labor intensity with information intensity, very few individuals in a particular locale in which the products are found may actually be involved with their production. Metatechnologies, however, make it possible to combine the two, producing small-batch or even one-off goods to meet very particular local needs when desired.

TRIVIAL VERSUS NONTRIVIAL

Those who try to develop new technologies are very interested in the difference between those they understand (trivial) and those they do not (nontrivial) (von Foerster, 1984). Indeed, the director of a major artificial intelligence project at Honeywell in the 1980s once commented that when they understood how a piece of computer programming got the results it did, they called it software, but when they couldn't figure how the results were achieved, they called it artificial intelligence.

CRITICAL VERSUS NONCRITICAL

There is a long history of government interest in encouraging the development of technologies that will serve military ends, but it is only since the mid-1970s that policymakers in the United States have begun to think in terms of technologies that are critical for society at large as they determine policy priorities. (Policymakers in Japan and Europe made this transition earlier.) The result is a shift from a focus on technologies that are mission specific to those that have utility in multiple environments. Technologies become defined as critical when they are expected to be beneficial to the public at large but not provide enough immediate economic reward for the private sector to be able or willing to develop without governmental support (Branscomb, 1993). Digital information technologies have been defined as critical since the category made its appearance (Wiegele, 1991).

Corporations that conduct R&D on critical technologies receive a number of policy advantages that include direct funding from the government, indirect financial support through tax breaks, and exemptions from antitrust law. Critics of the practice, however, note that often those technologies defined as critical fall in line with long-established R&D interests of the firms that benefit, the criteria for selection are arbitrary, and often definitions are so abstract that they are easily turned to corporate advantage. Restrictions on the international exchange of technical knowledge about such technologies work to everyone's disadvantage.

♦ *Invention, Innovation, and Diffusion*

Technologies do not appear all at once in their final form but rather go through long periods of development that often involve repeated iterations of experimentation, refinement of ideas, and responses to user feedback. Three stages of the process by which technologies come into being are distinguished. *Invention* is the operationalization of a new idea about how to do things, *innovation* takes place when an invention becomes logistically and economically feasible on a scale sufficient for the marketplace, and *diffusion* occurs when an innovation is taken up for use by the general population.

INVENTION

Of these three stages, the least is known about invention. It is ultimately a matter of individual creativity, but societies differ in the degree to which they encourage it—Czar Nicholas I actually banned the use of the word *progress* from Russia. It is generally believed that an abundance of resources is necessary to turn an invention into a successful innovation because there must be sufficient support both to continue doing things the way they have always been done and to simultaneously try doing the same things in a new way, but a lack of resources can inspire invention when materials or goods intended or habitually used for one purpose must be turned to another end. High labor costs or other barriers to the growth of capital present challenges that can tempt inventors (Mokyr, 1992). Societies in which the dominant religion asserts human dominance over nature have been more technologically inventive than those that stress the human as a part of or subordinate to nature.

Rewarding inventors economically through the mechanism of intellectual property rights is deemed to be so effective that such rights were included in the U.S. Constitution itself. Other factors that lead some individuals to be more inventive than others are a tolerance for risk and confidence that there is a safety net. Invention is often the result of sheer play (Stone, 1995) or of the desire to create something beautiful (van Creveld, 1991). There are cultures in which more time is spent decorating a tool than will be spent in its use. Personal frustration can also play a role—James Watt invented the steam engine after his workshop was closed down because he hadn't served an apprenticeship (Pearton, 1984).

There have been experiments in trying to design environments in which creativity will flourish, but it is difficult to determine all of the pertinent factors. The isolation of research parks is often not particularly successful, apparently because they lack the stimulation of urban environments (Massey, Quintas, & Wield, 1992). Invention is triggered when individuals with different types of knowledge come together to solve common problems, as happened notably with the printing press and is happening again with the internet. There has been a lot of experimentation with "technology incubators" as a means of stimulating innovation by providing a technology-intensive working environment, but these are rarely successful, perhaps because this approach puts the working tools ahead of the problem to be solved or the idea to be implemented. One successful innovation can either enable—or require—further invention to cope with changes in the technological system (King & Cushman, 1995). Although the historical image of the lone inventor retains its rhetorical power, today invention is most often the product of teams (Dosi, 1988). When the same invention appears almost simultaneously in places that are far apart, as happened with television, it provides evidence of the fact that new ideas always rest on the ideas of others. The development of the scientific method stimulated technological creativity by providing a way of systematically breaking a problem down into its parts.

INNOVATION

Because economic thought developed before industrialization, technologies were not included among the factors of production considered to be of economic value (Blaug, 1978). This situation didn't change until the 1930s, when Schumpeter (1939) argued that innovation was responsible for launching long cycles of economic growth. There was an immediate response because his ideas were seen as offering a clue as to how to bring the worldwide Depression to an end (Dodgson, 1993). By the early 1980s, innovation had become an identifying characteristic of several information industries,[6] with some even arguing it should be its own subfield within economics (Hepworth, 1989).

Innovations affect the operations of the market because they present structural breaks (Kogut, 1993) through the alteration of technological systems. They offer the corporations that control them temporary monopolies that can be of enormous economic value (Dollar & Wolff, 1993; Hills, 1992). Because such monopolies are *only* temporary, however, corporations are encouraged to continually innovate. The sharing of knowledge that leads to innovation among networked firms is one of their important sources of value (Antonelli, 1992). A number of different inventions may appear in response to the same social or technical problem. It is a sign of movement to the innovation stage when there is rivalry between systems based on different inventions (Williams, 1975). "Standards wars,"[7] which pit different technical solutions to the same problem against each other, have been seen in media industries as diverse as television, mobile telephony, and computer operating systems.

Bringing people together is as important for innovation as it is for invention. Silicon Valley is a premiere example of the role of physical proximity in creating an "island of innovation" (Hilpert, 1992). It is for this reason that cities are increasingly described as information processing centers (Sassen, 1991), governments have sought to link geographically dispersed researchers via the network that became the internet (Abbate, 1999), and corporations form alliances to facilitate knowledge sharing and information flow (Antonelli, 1992). It used to be assumed that the invention-innovation-diffusion cluster was a linear process, but it is now acknowledged that invention and innovation can take place at any stage and that users can play important roles in product design (Greenstein, Lizardo, & Spiller, 1997).

DIFFUSION

The study of the diffusion of technologies has been an important stream of research in media studies since the 1950s. The findings of thousands of such studies have been synthesized by Everett Rogers (1983), who defines diffusion as "the process by which an innovation is communicated through certain channels over time among members of a social system" (p. 5). Diffusion may occur either through deliberate campaigns or through spontaneous "contagion" (Valente, 1995).

There are five steps in the diffusion process: (a) knowledge—learning about an innovation and how it functions, (b) persuasion—forming a positive attitude toward an innovation, (c) decision—making the choice to experiment with an innovation, (d) implementation—experimenting with the innovation, and (e) confirmation—making a commitment to either take up the innovation permanently or reject it. Features of an innovation that influence individual and collective decisions include relative advantage (Is it better than that it will replace?), compatibility (Will it work with other technologies already in use?), complexity (Is it difficult to use?), trialability (Is it possible to experiment with the innovation before committing to it?), and observability (Are the results of one person's experimentation with the technology visible to others?). Individuals may be free to make adoption decisions on their own, or they may be dependent on the decisions of their community or organization. One of the features of networked technologies is that they generate a binary condition in which one is either in or out of a circle of activity, which encourages adoption.

Thousands of studies in many different societies have shown that there are consistent differences in the rate at which individuals will take up innovations. Innovators (about 2.5% of the population) are those who take an invention and bring it into use; they may be marginal to society as a whole but have resources, a sense of adventure, tolerance of ambiguity, and a willingness to experiment. Early adopters (13.5%) tend to be well-educated and upwardly mobile individuals with some ambition and a capacity to cope with uncertainty and risk; they often play leadership roles in their communities as individuals whose actions are watched by others. The early majority (34%) are those who have observed the successes of early adopters but make their own decisions with some deliberation. The late majority (34%) start with skepticism but ultimately are convinced. Laggards (16%) are more traditional and may never take up an innovation, even if it is widely used in their communities.

Media tend to diffuse very quickly. It took only 50 years for the printing press to spread across Europe (Eisenstein, 1979), 20 years for the telegraph to develop into a global network (Headrick, 1990), and 10 years for television to appear in almost every home once it had been commercialized following World War II. A text-only internet became available to early adopters outside of the initial research community (though still confined to academia) in the 1980s, and it was with the inventions that led to the graphical and hypertextual features of the Web that the early majority began to develop in the mid-1990s. Because socioeconomic, political, or cultural factors often impede access to the Web—*adoption* in diffusion terms—the difference between those communities in which the late majority group has appeared and those in which it is still at an early adoption stage is often described as the "digital divide." Such differences are not new with digital information technologies, however. The same phenomenon in the print and broadcast environments was referred to as the "knowledge gap."[8]

♦ *The Contemporary Global Information Infrastructure*

The biggest single machine that has ever been created is today's global information infrastructure (GII), a medium that makes it possible to use one technological system for all the kinds of content and uses handled by multiple media in the past. The features of this infrastructure as a medium are so different from those of earlier media that it is worth examining them in some detail.

These differences begin with the shift from a technological to a meta-technological system. The global information infrastructure is best described as a "network of networks" (Noam, 1994), for what we experience as a single network is really made up of numerous networks that are owned and managed by different organizations and countries. Through the important regulatory mandate of interconnection—the rule that networks must connect with each other so that information can flow seamlessly through them—these networks pass messages along without user involvement, but the multiplicity of networks actually involved makes the legal and economic issues raised by the information infrastructure quite complex.

Although digitization of national infrastructures has proceeded at variable rates, it was in 1980 that it could be said that the system became global. In that year, the Consultative Committee for International Telephony and Telegraphy (CCITT), a specialized committee of the International Telecommunications Union (ITU) with responsibility for decisions regarding technical standards for telecommunications, decided that innovation had reached the stage at which it was possible to begin discussing global standards that would make it possible to transmit any kind of information anywhere via a single network that one could plug into as easily as one plugs in a telephone. The set of standards developed was called the ISDN, for the Integrated Services Digital Network. As an early participant in the development of those standards noted, the ISDN was a turning point that simultaneously served as an ideal type, a project goal, a specific set of standards, and a system put into place on the ground (Rutkowski, 1983).

THE CONVERGENCE OF TECHNOLOGIES

This network came into being as a result of what is known as the "convergence of technologies," meaning the convergence of computing and communication technologies. Technological convergence of this kind was made possible by the shift from analog to digital modes of transmitting information, discussed in more detail in Chapter 7 (this volume). Throughout the 20th century, these technologies were moving toward convergence as each underwent significant innovation, but World War II provided a great stimulus. The first legal problems arising from this convergence—which brought intelligence into the telecommunications network, thus vastly expanding its capabilities—arose in the 1950s (Pool, 1983). In the 1960s, it was widespread enough that its effects were beginning to be felt society-wide, and regulatory agencies such as the Federal Communications Commission (FCC) began to consider how the new technological systems should be regulated, undertaking a series of "computer inquiries" over a couple of decades to help the agency decide just what to do. By the early 21st century, the network of converged technologies is ubiquitous across the globe and used by millions on a daily basis.

This type of convergence appears within a long human history of finding ways to do more with media by bringing them together with other types of tools and technologies. The first medium of language converged with the material world when writing systems came into being about 6,000 years ago. Writing converged with industrial technologies with the printing press in the mid-15th century. Media converged with electricity in the mid-19th century, first producing the telegraph and then the electrified (and thus vastly more productive) printing press, the telephone, and finally the radio, marking the first stage in the history of the information society. And since the convergence of computing and communication technologies under discussion here, media are also converging with the human body.

The convergence of computing and communication technologies brought with it functional convergence, but it must be remembered that patterns of using particular technologies were themselves choices out of a wider array of potential uses with which there had been experimentation. The telephone, for example, provided a means of communal storytelling and singing in the rural Midwest—particularly valuable in the winter—as long as party lines[9] made that possible, and in the late 19th century in Hungary, the telephone was used as a news medium (Boettinger, 1976; Brooks, 1976; Casson, 1910; Pool, 1977; Pound, 1926). Social and cultural dimensions of convergence are referred to as globalization. Clearly, the type of information infrastructure that technological convergence brought about has made it easier for political convergence to take place in two senses: First, regional governance has grown in relative importance, as with the North American Free Trade Agreement (NAFTA) and the European Union (EU). And second, it has become easier for nation-states to harmonize their regulatory systems with each other and to enhance the transparency of the activities of each to each other (Florini, 2000).[10] Economically, the new technologies have also made it possible for corporations to grow larger in size and thus have contributed to convergence in the form of a reduction of competition in favor of oligopolies.

CHARACTERISTICS OF THE NET

A first global information infrastructure was built in mid-19th century with the telegraph system, but use of that infrastructure was limited because there were relatively few points of access, technical expertise was required, the length of messages was limited, only text messages could be sent, and it was expensive. Today's digital and broadband global information infrastructure exhibits very different characteristics.

Ubiquity. With the appearance of wireless means of accessing the internet, the system has become genuinely global, and the advent of the community wireless movement[11]—in which everyone within a community has free access to the internet if they have a wireless connection, itself rapidly dropping in cost—will go far toward enabling ubiquity within community as well as across it. Print had the potential of ubiquity, but transport of messages from one geographic region to another was slow, costly, and difficult. The ease of achieving global reach affects the scale at which Web-based operations may unfold in ways that are being seen in the nature of organizational form, the growing oligopolization of the mass media, and the social, political, and cultural aspects of globalization. Shifts in scale are one of the most important ways in which technologies differ from each other (Abu-Lughod, 1984). Of course, ubiquity is only a *potential*—actual use patterns depend on the many dimensions of access.

Accessibility. Although *access* is usually referred to as if it is a singular concept, in reality, a number of different factors are involved in determining whether there is *effective* access. Being within the technological reach of the network, now ubiquitous through wireless technologies but not nearly so with wired, is only one dimension of access. To actually use the network, one must also own or have the right to use a technology that interfaces with the network, the economic means to support an internet connection, training in how to use the interface, and knowledge of the benefits to be accrued through use. Language, culture, and literacy requirements can also be barriers to access.

Some of these dimensions of access are susceptible to policy interventions, such as the universal service mandate of the U.S. Telecommunications Act of 1996, that there must be internet access in schools, libraries, and medical facilities in an effort to ensure that everyone in the United States has a publicly available interface with the internet. Some barriers to access are less amenable to policy but do respond to individual-, commercial-, and community-level efforts, as seen in the proliferation of language translation software, the posting of Web sites in multiple languages, and development of Web resources in languages that serve relatively small communities. Cultural and personal preference *not* to use the internet, however, will—and should—remain; studies show that even at the highest levels of income, 2% of the population consistently chooses not to have a telephone in the home.

Potentially Nonhierarchical. Broadcasting and telecommunications historically were always organized hierarchically, whether through the material design of a system (as with wired telephony) or through the organizational structure through which decisions regarding content and distribution were made (as with over-the-air broadcasting). It is popular to describe the internet, in contrast, as nonhierarchical, but it is important to remember that a *potentially* nonhierarchical environment can go either way and that it is possible for some areas within the internet to be organized hierarchically, while others are not.

There is no doubt that the internet was deliberately developed as a decentralized structure to serve the defense need for a communication system that could survive attack because there was no "center" and because there were myriad paths through which messages could get from here to there (Abu-Lughod, 1984). Huber (1987) uses the term *geodesic* to refer to this characteristic of the internet, after Buckminster Fuller development of geodesic architecture in which load and stress on a system are dispersed equally throughout rather than being focused on certain points. Although it has been discovered that certain patterns of information flow are repeated at every level of the structure—Huber describes this feature as "fractal," after the mathematics of self-repeating patterns—it is still possible for some of those patterns to be rigidly structured, but others are not, and for pockets of nonhierarchical uses to remain even within rigidly defined structures.

The degree to which the physical aspects of the infrastructure are hierarchically designed and the degree to which the organizational and communicative aspects are treated in this manner are two different things. Although the technological aspects of the infrastructure remain essentially nonhierarchical, the modes of control and use are becoming less so in response to several factors: With commercialization of the internet in the early 1990s, it was suggested that billing internet-based activities would require centralization (MacKie-Mason & Varian, 1994), although models have developed for doing this virtually without affecting the degree to which other internet-based activities might be bound by a hierarchical structure. The internet is often imaged as a diffuse crowd, but access to the internet is managed by internet service providers (ISPs) that themselves provide a structure and more regulation of speech than is permitted in the mass media in the United States under the First Amendment (Braman & Lynch, 2003). Many national governments would like to restrict the content to which their citizens have access and thus build firewalls that add structure to filter content. The most important factor reducing the nonhierarchical experience of using the internet, however, is the concern over national security that has spiked since September 11, 2001, which has provided a justification for centralized surveillance of personal, interpersonal, and public uses of the internet.

Interactive. However aggressively, the audience participates in determining for themselves the meaning of messages, television, and radio. Print can be two-way but is highly asynchronous when it is so. Telephony is interactive, but there are limits to the number of people who can be involved in any given conversation. One of the most important features of today's information infrastructure is that it enables group interactivity, making interactivity in effect a medium in itself.

Most games, hypertext narratives, and database interfaces claim to be interactive but actually offer only branching pathways, the content of each of which is predetermined. Stone (1995) identifies several characteristics of real interactivity: mutual and simultaneous activity on the part of both participants (usually working toward the same goal, but not necessarily), mutual interruptibility (each participant must be able to interrupt the other, mutually and simultaneously, so that the goal of a conversation may change as the conversation unfolds), graceful degradation (it must be possible to handle unanswerable questions in such a way that it doesn't halt the conversation), limited look-ahead (both parties must be interruptible, so that there is a limit to how much of the shape of the conversation can be anticipated by either party), no default (there must be no preplanned path for the conversation, which develops fully only in the course of interaction), and the impression of an infinite database (there is no limit to the information and types of responses each side may experience from the other).

♦ *Media as Technologies*

Analysis of the effects of use of media began to arise in the mid-19th century, once electrification began to change the scale, speed, and intensity with which they were experienced. It was not until the early 20th century, however, that the media began to be examined as technologies per se.

Over time, theories of the media have displayed increasing sensitivity to the difference the technologies make to media effects. A second trend has been a shift from seeing technology as unnatural to understanding it as a natural extension of the human body and environment.

TECHNOLOGY AS BARRIER TO EXPERIENCE

The first discussion of media as technologies was offered by scholars associated with the German Frankfurt school. Theodor Adorno, Max Horkheimer, and Walter Benjamin were concerned about the industrialization of culture, made possible by technologies such as the electrified printing press, the radio, and the camera that could produce multiple copies of works that, in more traditional media, were created in single copies ("one-offs") or in limited numbers. With the production of multiples came the wide distribution and commoditization that, these authors argued, led to a loss of creativity and of the critical power of art. There was also a concern that the reproducibility of culture with these technologies meant that it was no longer the expression of authentic experience, exacerbating the alienation that was a consequence of all forms of industrialization and voiding the human capacity for making meaning through ritual (Negt, 1978; Ronell, 1989).

Frankfurt school analyses also saw technology as destructive of political experience, for without authenticity, it was believed to be no longer possible to have the kind of genuine public sphere envisioned by Habermas (1991) as the space in which public discourse about matters of public concern could take place separate from the state. The notion of the public sphere was predicated on the idea that an autonomous class politics could exist only with autonomous production of discourse—and such production was no longer possible because the media operate as a closed institution devoted only to commoditization.

Through contemporary eyes, it can be seen that these authors were educated in a "high" or elite art tradition and were reacting in large part to the development of popular culture forms that are now seen as creative and potentially critical in their own way. Their negative analyses of technology were also driven, however, by the experience of witnessing perhaps the most dangerous and destructive technologization of social life the world has seen, for Frankfurt school scholars had to flee the Nazis to save their jobs and, very soon, their lives.

Many of their insights were profound, and they have had an enduring impact on the development of critical theory (Held, 1980) both in North America and in Europe. The notion that commoditization vacates cultural forms of their fundamental human value has been further elaborated; Hyde (1983), for example, argues that once a gift is sold, it can no longer function as a gift. Whether the reproducibility of culture has led to standardization remains an open debate (Enzenberger, 1992; Forgacs, 1990). James Carey (1989), who was also influenced by the work of Innis and McLuhan (discussed below), characterized the kind of communication developed by the culture industries as transmission rather than ritual. Contemporary thought about the loss of authenticity includes identifying originality (Dewdney, 1998) and attention[12] as scarce resources.

TECHNOLOGY AS SHAPER OF EXPERIENCE

The next stage of theorization about media as technologies took the position that they did not prevent but *shaped* experience. Lewis Mumford (1934) first presented the idea that civilizations are formed in ways determined by the medium that dominates. Harold Innis (1951) elaborated on this idea at some length in his investigations of the way in which media technologies shaped the Canadian experience of time and space. These ideas launched a stream of work that has become known as medium theory, devoted to analyzing the ways in which society is affected by changes in the technologies used to communicate. Medium theory is distinguished from other approaches to the study of media effects because it focuses on the technologies involved rather than message content. Examples of its application include both micro-level studies of individual relations with their immediate locales (e.g., Meyerowitz, 1986) and macro-level examinations of the impact of media technologies on international relations (e.g., Comor, 1996; Deibert, 1997).

TECHNOLOGY AS EXPERIENCE

Innis's work on entire technological systems and society writ large inspired his student, Marshall McLuhan, to turn to the impact on the individual human body. McLuhan's famous phrase "the medium is the message" summarized his insight that each communication technology extends a particular human sense—radio, for example, extends the capacity of the human ear; photography extends the eye; and the computer extends the central nervous system and the brain. It is for this reason, he argues, that human relationships are so deeply affected by the media technology through which communications take place.

McLuhan was writing during the period in which self-awareness of the transformation to an information society was taking place, and he was very much the theorist of the first "multimedia" experiences of the 1960s. Responding to the first experiences of global sharing of television content—with the President John F. Kennedy assassination and then with the Muhammad Ali boxing match—he suggested that electronic media were creating a situation of a "global village."[13] Both words in this phrase carried important meaning: The globalization he envisioned has undeniably become the dominant feature of social life at the beginning of the 21st century. The word *village,* with its premodern connotations, was important to McLuhan because he believed that the linear logics promoted by print would be disrupted by the aurally oriented electronic environment in ways that would encourage the development of social forms more akin to the premodern than the modern. Of course, we have not and cannot return to the world as it was experienced thousands of years ago; Ong (1982) describes the change McLuhan was talking about as "secondary" orality, necessarily different from the kind of orality experienced before there had been any exposure to print. However, McLuhan's work presaged much of postmodern thought as well as discoveries by cognitive psychologists about changes in the ways that people process information, depending on the dominant technologies in their environment.

McLuhan deeply influenced a generation of media scholars who were young during the 1960s, even though his work was ignored in academia for many years. The failure to immediately pick up McLuhan's ideas as a basis for research was probably due to the way in which he presented his thoughts. It was McLuhan who first broke up the rigidities of the printed page to produce books in which type ran in every direction, type and images were interspersed or overlay each other, and multiple texts were presented simultaneously so that their content interacted. The texts themselves had more in common with poetry than with scholarship. After his death, McLuhan's son made an attempt to systematize the work (McLuhan & McLuhan, 1992), but it may well have been the maturation as scholars of those who were influenced by his work in youth that has finally brought scholarly attention to McLuhan's work. Today, an entire stream of literature, referred to as work on media ecology,[14] has grown up around his oeuvre.

TECHNOLOGY AS REALITY

With postmodern theory, attention has turned away from the impact that media technologies have on our experience of reality to the argument that the world they create *is* reality. Baudrillard (1983) uses the concept of "hyperreality" as a way of talking about the use of media technologies to communicate about the symbolic rather than the material world. In the contemporary electronic environment, those symbols are agents that can actually make things happen. Hookway (1999) thus uses the term *demons* to describe the way in which many operations in our daily lives are triggered electronically, drawing on the medieval concept of agency that is neither human nor divine.

Although McLuhan talked about media technologies as extensions of human senses, today, increasingly, the biological and technological are literally merging in the "cyborg" (Haraway, 1991). The U.S. Department of Defense has issued calls for research on the codesign of humans and weapons, using biotechnology for the first and digital information technologies for the second. Meanwhile, artists are experimenting with use of their bodies as permanent roving cameras, computer chips have been implanted into animals for tracking purposes and into researchers who are experimenting with the consequences, and scientists are developing ways of linking silicon directly to the neural cells of our brains.

TECHNOLOGICAL DETERMINISM

The theories presented in the previous section all suggest that technologies shape the world in which we live. In its extreme form, this is the position of technological determinism, but this position is only one along a spectrum of positions in the direction and strength of causality between technologies and society. Differences in position matter because they suggest differences in attitude toward technology and, therefore, in its uses and in the analysis of risks, as well as opportunities taken into account during policymaking for technology (Kroker, 1984). None of the thinkers discussed here are extreme technological determinists. The opposite position is that society completely determines technology.

The position taken here lies midway along the spectrum. Theoretical pluralism is necessary to fully analyze any specific event or process, as each is always unique to its historical conjuncture and results from the intersection of multiple causal forces. Thus, although it is true that technologies can have structural effects on society as well as on individual cognition, it is also true that it is society that determines just how technologies will be used. And although it is true that technologies have changed human history at many points in the past, it is also the case that the continuity, speed, and ultimately radical nature of technological innovation over the past century and a half have made technological change of particular importance at this point in history.

Technomancy—projecting the future from technologies—is a variant on technological determinism that provided the basis of technological forecasting from the beginning of the 20th century (Schiffer, 1991). The phrase "neo-technological determinism" has been coined to refer to driving policy choices in service to the development and diffusion of technologies themselves rather than to social goals (Ferguson, 1986). Technological determinism in any form is damaging to policy processes because it makes critical work impossible (Rowland, 1986) and suggests that all problems can be solved. We can thus speak of "doing" infrastructure as a social process because of the mutually causative nature of the development of technological systems (Star & Ruhleder, 1996).

♦ *Notes*

1. Marshall McLuhan's prolific thinking about the effects of new information technologies stimulated numerous lines of theoretical exploration and research; among his books from the 1950s through the 1970s either still or back in print and thus easily available are *The Gutenberg Galaxy: The Making of Typographic*

Man (1962), *The Mechanical Bride: Folklore of Industrial Man* (2001), *The Medium Is the Massage* (with Quentin Fiore; 2001a), and *Understanding Media: The Extensions of Man* (1994).

2. The Maginot Line was the use of the ancient technique of building holes in the ground as a defense against new technologies such as airplanes during World War I.

3. A "dumb" terminal has no intelligence of its own but only provides an interface with another computer, enabling the user to access that computer's intelligence from afar.

4. Cultural tensions raised by moving communications to the internet are often the subject of discussion in meetings of the National Association of Media, Arts, and Culture (NAMAC) and the Association of American Cultures (TAAC).

5. When the level of information intensity within an organization is dependent on the extent to which it is networked, it is referred to as "network densitity" (see Hagedoorn, 1993).

6. Fritz Machlup (1980) was the first to distinguish among specific industries in the information sector of the economy in the early 1980s; research and development (R&D) was one solely devoted to innovation, and others required innovation as an input.

7. "Standards wars" have taken place with almost every new information technology (see, e.g., Cerni & Gray, 1983; Crane, 1978; Kahin & Abbate, 1995).

8. Rural sociologists Donohue, Tichenor, and Olien (1975) developed the knowledge gap hypothesis and pursued it for decades. The powerful concept has provided the foundation for influential research programs by many others, including the following: Viswanath and Finnegan (1996), Ettema and Kline (1977), and Kwak (1999).

9. A party line was a telephone line shared by multiple households, each of which had a different ring so that a family could tell when a phone call was for its household. For most purposes, only a single party would respond to a telephone call, but communal purposes could be served by having everyone get on the party line at the same time.

10. The concept of "transparency" is a driving principle in international relations today; for a succinct synthesis of the literature on the subject, see Florini (2000).

11. The "community wireless movement" is the name given to the early 21st-century move by a rapidly growing number of cities in the United States that are in the process of providing free access to the internet through a community-wide wireless network provided by the municipality through a wireless hub.

12. The term *attention economy* was coined in the 1990s by Alan Froomkin, but the same concept is explored in treatments of social aspects of time in the work of authors such as Appadurai (1997) and Nowotny (1990).

13. The notion of the global village appeared in a number of Marshall McLuhan's writings of the 1960s and are newly accessible in republications of several of his books (e.g., McLuhan & Fiore, 2001b).

14. In addition to work by authors already discussed here such as McLuhan, Innis, Carey, Ong, Postman, Mumford, Eisenstein, Meyrowitz, Postman, and Ellul, other works that fall into the category of media ecology include Bolter (1984), Boorstin (1961/1992), Goody (1977), Havelock (1982), and Sontag (1977/2001).

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