

HANDBOOK  
*of*  
NEW MEDIA

Social Shaping and  
Social Consequences of ICTs

*Updated Student Edition*

*Edited by*  
LEAH A. LIEVROUW  
and SONIA LIVINGSTONE

 SAGE Publications  
London • Thousand Oaks • New Delhi

---

# New Media Design and Development: Diffusion of Innovations v Social Shaping of Technology

LEAH A. LIEVROUW

Across many literatures technologies are described as having trajectories, stages, cycles and growth curves; they diffuse, transfer, are 'pushed' and 'pulled', and evolve. Many current observers agree that 'technology' includes not only the built devices themselves, but also the practices and knowledge related to them and the social arrangements that form around those devices, practices and knowledge (Dierkes and Hoffmann, 1992; MacKenzie and Wajcman, 1999; see also the Introduction to the First Edition (2002)). Thought of this way, technology is dynamic, even fluid: 'The interaction between material and nonmaterial components and coupling of technical and social components can be captured in the concept of technology as a project' (Rammert, 1992: 63). New media technologies are no exception. They develop in dynamic environments where users, designers, manufacturers, investors, regulators, distributors and others work out their interrelated and competing interests, cultural assumptions, desires and visions.

This chapter has two main purposes. The first is to review and compare two major bodies of research on technology and society that have been particularly influential in new media

research. *Diffusion of innovations theory* (Rogers, 1995) and the *social shaping of technology (SST)* perspective (Mackay and Gillespie, 1992; MacKenzie and Wajcman, 1999; Williams and Edge, 1996) are sometimes characterized as competing or even antithetical approaches to technological change. They might also be classified as 'mediated impact' and 'shaping' explanations of technological development, respectively (Boczkowski, 1999, 2004). While the two perspectives differ in important respects, they also share common concerns and theoretical grounding.

The comparison of diffusion and SST is illustrated by two examples. Electronic mail and videotex originated at about the same time in the 1960s and 1970s; e-mail was eventually adopted in universities, workplaces and homes, while videotex never found a 'niche' in the US and encountered considerable consumer resistance elsewhere. Both cases have been studied extensively, and the present discussion draws on those studies to show how diffusion and SST would frame the cases differently.

Based on the comparison of SST and diffusion and the two case studies, the second

purpose is to characterize the development and use of new media technologies as a process that involves a constant tension between *determination* and *contingency*, that is, between the imposition of order and uncertainty. It is argued that determination and contingency are interdependent and iterative, and that this relationship can be seen at several key junctures or 'moments' in new media development and use. The chapter closes with a discussion of determination and contingency as common threads in both theoretical traditions.

### THE DEVELOPMENT OF NEW MEDIA TECHNOLOGIES

As with other technologies, new media development is not just a matter of engineering or optimal solutions to technical problems; it can be characterized as a *sociotechnical* phenomenon (Bijker, 1995; Bijker and Law, 1992; Suchman, 1996). It brings together engineering specifications (such as interoperability, ergonomics, human factors, interface design, navigation, system implementation) and media production values (such as visual or sound quality, post-production techniques or style) in the changing social, institutional, economic, cultural and policy context of everyday reception and use.

It is often tempting to focus on the origins of technology, on design, invention or innovation, and to give designers or inventors priority in the process. But this can be a misleading approach because 'Technologies are created not by lone inventors or geniuses working in a social vacuum, but by a combination of social forces and processes' (Mackay and Gillespie, 1992: 688; see also McMillan and Flichy, in this volume). Bucciarelli explains that technology design is a fundamentally communicative process that brings objects, actions and social relationships together: 'design is best seen as a social process of negotiation and consensus, a consensus somewhat awkwardly expressed in the final product' (1994: 20–1).

Moreover, some observers argue that technology design continues in use (Suchman, 1987;

Suchman and Jordan, 1997). 'Design and use mutually shape one another in iterative, social processes' (Brown and Duguid, 1994: 29). Technology design has been said to lie somewhere between a technology-driven, science-influenced 'one best solution' approach, and claims that design simply responds to human 'needs' or markets (Bucciarelli, 1994). For new media, the idea of design-in-use suggests that development encompasses both channels and content. As formerly distinct forms and genres of content based on particular media technologies (for example, feature films, personal letters, pop music albums, radio programmes, printed books) have converged into a single digital bit stream that can be retrieved via different types of terminal equipment (wireless phones, PDAs, satellite-based multichannel systems), artists, designers and consumers alike have devised new ways to create, manipulate and capture those content streams.<sup>1</sup>

New information and communication technologies may be designed and intended from the outset to fulfil particular needs or purposes. However, we need only consider the histories of the telephone (Fischer, 1992; Umble, 1992), radio (Aitken, 1985; Sloten, 1995), computing (Abbate, 1999; Ceruzzi, 1998; Edwards, 1996; MacKenzie, 1991) or the typewriter (David, 1985; Knie, 1992) to find that some are likely to have open and unanticipated uses or consequences, while others become firmly – perhaps prematurely – entrenched. Other apparently good inventions never succeed.

### COMPARING DIFFUSION AND SST

Two seminal social science research perspectives have sought to capture the complexity of the relationship between society and technology, including media technology. *Diffusion of innovations* theory and the *social shaping of technology* perspective have enjoyed widespread influence in studies of technology and social change. Both SST and diffusion study the origins and uses of new technologies. Both address the evolution and rate of technological development. Though they differ in emphasis, both

contextualize technology relative to human action, social relationships and culture. Both examine the choices people make about technologies and, to differing degrees, both are concerned with the consequences of technology adoption and use. They also focus on information flows and communication relationships that foster new ideas and ways of doing things.

SST and diffusion also share theoretical roots in nineteenth-century European social thought and the interactionist tradition associated with the Chicago School of sociology.<sup>2</sup> Along with its close relative, structural or social network analysis, diffusion traces its foundations to the work of Georg Simmel. He conceptualized society as a fundamentally interactive and intersubjective 'web of affiliations' rather than a static, separate superstructure overshadowing human action (Emirbayer and Goodwin, 1994; Rogers, 1995; Rogers and Kincaid, 1981). Simmel's theories were a major influence among Chicago School sociologists in the 1920s and 1930s, particularly for Robert Park and Charles Cooley (Hamilton, 1996), who taught succeeding generations of social network researchers (for example, Fischer, 1982). Mitchell notes that the social network approach, given its focus on communication among network members and the meanings they attribute to their relationships, 'converges with that of the symbolic interactionists' (1975: 20, note 2). And Wellman (1988: 25) notes the 'Simmelian sensibility' that characterizes network or structural analysis, the premise that the structure of social relations determines the content of those relations, including norms and values.

In the SST tradition, too, scholars have been influenced by concepts and methods from Chicago School sociology. The social construction of technology perspective, discussed later, reflects many of the assumptions and empirical orientations of social interactionism and ethnomethodology. Simmel's 'pioneering sociology of consumption' (Holton, 1996: 45), which examined the effects of the emotional and aesthetic aspects of life on a society's popular culture, resonates with the SST emphasis on the 'consumption' or shaping of technology by its users (Mackay and Gillespie, 1992).

Despite these common influences and concerns, however, SST and diffusion have divergent histories, disciplinary roots, theoretical assumptions and methodologies. Their differences have given them windows with distinct views of technology and society.

### **Social Shaping of Technology**

Several areas of theory and research coexist under the umbrella of social shaping of technology, but they all share a basic theoretical commitment: that technological determinism is an inadequate description or explanation of technological innovation and development, or of social change more generally (MacKenzie and Wacjman, 1999; Williams and Edge, 1996). Technological determinism has been a prominent theme in accounts of modernity and social progress; the idea is neatly captured in the motto of the 1933 Chicago World's Fair: 'Science Finds – Industry Applies – Man Conforms' (Rydell, 1993: 98–9). In contrast, SST emphasizes the importance of human choices and action in technological change, rather than seeing technology as politically and ethically neutral, an independent force with its own inevitable logic and motives, or as a mysterious black box that cannot be analysed socially. From the SST point of view, to talk about the 'impacts' of technology on society, as though technology is the hammer and society the nail, is to accept implicitly the basic premise of technological determinism.

In the 1960s several prominent critics began to question the prevailing assumption that technology drives social change (McDermott, 1969; Mumford, 1964, 1970). More recent critiques have also helped to discredit the deterministic view (for example, Winner, 1977, 1986). Despite nearly 30 years of SST research, however, deterministic assumptions and language continue to dominate popular culture in technologically advanced societies, to the distress of some observers (MacKenzie and Wacjman, 1999). Still, the critique of technological determinism has been a powerful influence in social science research about technology, and indeed in engineering. Many prestigious American engineering

schools (including MIT, Georgia Tech, Virginia Tech, Cornell and the Rochester Polytechnic Institute), as well as prominent departments at Amsterdam, Delft, Paris, Sussex and Edinburgh, have courses and degree programmes in science, technology and society that incorporate the SST perspective.

SST takes a particular philosophical view of the nature of knowledge and its manifestations in society, specifically that knowledge and its products (including science and technology) are essentially social phenomena. The *sociology of scientific knowledge* or SSK has identified critical points of contingency in the process of scientific research when events (such as data collection, explanations, discoveries) could have gone differently, that is, when the people involved showed 'interpretive flexibility'. By conducting historical studies and ethnographic fieldwork, many sociologists of knowledge have concluded that scientists' own beliefs, opportunities and relationships are as important in the establishment of scientific facts or truths as the natural phenomena that they study (Knorr, 1981; Latour and Woolgar, 1986).

Despite the intense anxiety of some scientists who object to science and technological innovation being treated as objects of study in themselves (Gross and Levitt, 1994), anti-determinist and constructivist researchers in SST do not seek to deny or undermine the benefits of science and technology. Rather, the stated aim of SST is to formulate policies to guide technology development so that its benefits are more 'human-centred', usable, equitable, appropriate and responsive to everyday culture and practice (Williams and Edge, 1996).

The *strong programme* of SSK has provoked some of the greatest worries among scientist critics of SST. The strong programme is often identified with historian and philosopher David Bloor (1991) and his colleagues at the University of Edinburgh. He proposes that the creation and acceptance of *all* knowledge claims (including those of SSK) must be explained 'in social terms, rather than by reference to the natural world' (Williams and Edge, 1996: 869). Furthermore, its proponents say, this method should be applied equally both to knowledge that is considered factual and that which is

considered biased, mistaken or fraudulent. The *weak programme* of SSK, on the other hand, examines only the social conditions of knowledge growth or the sources of biased or distorted knowledge, and not the 'rational acts of apprehending inferences and evidence' as facts, truths or errors (Bloor, 1992: 494).

Both the strong and weak programmes of SSK have influenced social studies of technology. Notably, the *social construction of technology* (SCOT) approach (Bijker and Law, 1992; Bijker et al., 1987) has borrowed the idea of interpretive flexibility to examine the choices available to designers, developers and users in the course of technological development. Given their focus on the social context of innovation and change, SCOT analyses have much in common with the weak programme of SSK.

Several research fronts employ the SCOT framework. For example, studies of *large technical systems* (LTS) (Hughes, 1987; LaPorte, 1991; Mayntz and Hughes, 1988; Summerton, 1994) have applied SCOT principles to the analysis of extensive, complex technologies such as electrical power grids (Hughes, 1983), supercomputing (MacKenzie, 1991) and videotex and telephone systems (Galambos, 1988; Mayntz and Schneider, 1988; Schneider, 1991, 1994, 2000). Also, the growing field of *social informatics* (Kling, 1996, 1999) has combined a broad SCOT approach with methods from industrial and organizational sociology to study the evolution of information systems and computing (see Kling and Scacchi, 1982; Star, 1995; Star and Ruhleder, 1986; Suchman, 1996). Leigh Star has elaborated a particular aspect of interpretive flexibility to argue that a given technology, for example computers, may be understood and used very differently by different social groups. They become 'boundary objects' whose forms and uses are negotiated among groups (Star and Griesemer, 1989; see the chapter by Flichy in this volume).

By emphasizing the influence of society on technology, rather than the reverse, SST has attempted to understand the complex society-technology relationship. Researchers have tried to transcend 'one-way' or linear accounts of technology and society that imply that progress

is irreversible. However, in recent years SST's adherents have recognized that while they might have reversed the direction of causality, the hypothesis that society shapes technology remains an essentially linear explanation (MacKenzie and Wacjman, 1999).

One of the most compelling bodies of SST research, *actor-network theory* or ANT (Callon, 1986; Latour, 1993; Law and Hassard, 1999), shares many of the assumptions of SCOT but attempts to overcome the problem of linear causality. ANT rejects both strong technological determinism, on the one hand, and the strong social constructivist argument, on the other. Its proponents (including Bruno Latour, Michel Callon and their colleagues at the Centre de Sociologie de l'Innovation of the École Supérieure des Mines in Paris) consider people, technologies and institutions alike as 'actants' that have equal potential to influence technological development (Callon et al., 1986; Hughes, 1986). Neither technology 'push' nor market 'pull' can fully account for the shaping of technology, they argue; technologies and people alike should be thought of as interrelated nodes in constantly changing sociotechnical networks, which constitute the forms and uses of technology differently in different times and places for different groups. Furthermore, according to ANT, technologies are not infinitely flexible or negotiable; they tend to become embedded and stabilize within institutional and social structures and influence or even determine subsequent technological choices.

### Diffusion of Innovations

As its name suggests, diffusion of innovations theory describes how new ideas or practices are introduced and adopted in a social system, with a special focus on the communication relations and information flows that promote adoption (Rogers, 1995). Diffusion is a specialization of communication research that combines theories of personal influence and persuasion with the analytical techniques and theories of social structural or network analysis in sociology (Blau, 1982; Wellman and Berkowitz, 1988). Diffusion of innovations is also a key construct

in the economics of information and technology transfer (Antonelli, 1991a, 1991b; Dosi et al., 1988; Griliches, 1988). Though diffusion processes are studied in many social contexts and disciplines (Valente, 1995), the diffusion of new ICTs has been studied most extensively in sociology, communication research and economics. Sociological/communication studies tend to emphasize social relations and interaction in the diffusion process, while economic studies stress industry and market structures and economic motives for adoption, such as profitability.

Diffusion theory models the dynamics of technology adoption, including the rate of adoption and the eventual spread of the innovation in a social system. A new technology (or other innovation) is introduced in a social group (community, organization, nation, market, industry), often by a change agent with an interest in promoting it (private firm, public agency or influential individual). Typically, a few actors are the first or early adopters; the success of the innovation often depends on their social status or influence. Other members of the group, who are either directly acquainted with or share similar interests with the early adopters, may be persuaded to adopt the innovation, and they in turn influence others. Successive waves of adoption continue until the innovation reaches a saturation point or *ceiling* that varies depending on the characteristics of the innovation and the social system. Important concepts in diffusion include the adoption *threshold*, the number of adopters necessary to induce one more actor to adopt an innovation (Valente, 1995), and *critical mass*, the point at which enough actors have adopted an innovation for it to succeed, based on the rate or momentum of adoption (Allen, 1983; Mahler and Rogers, 1999; Markus, 1987; Rogers, 1995).

The sociological/communication and economic traditions of diffusion research frame technology somewhat differently. Sociology and communication have a long-standing interest in the development and use of technology in particular social contexts (Rogers, 1995). On the other hand, in neoclassical economics technology has usually been treated as

an exogenous factor, like 'manna from heaven' in Christopher Freeman's phrase (1991: 303; see also Antonelli, 1991; Dosi et al., 1988). Economists have tended to view technology as a 'black box' that could be an economic input or output, but not a component of the economy itself (Rosenberg, 1982).

However, difficulties arose with neoclassical analysis as economies shifted toward services and information technology in the 1960s and 1970s. Information technologies were no longer ancillary to the 'real' productivity of the manufacturing and extractive sectors, but had become the very centrepiece of developed economies. Critics argued that mainstream economics could not meet the analytical challenge (see Lamberton in this volume). In the 1970s and 1980s, Freeman and his associates, influenced by the early work of Joseph Schumpeter, called for a new economic approach to understanding technological innovation and development (Dosi et al., 1988; Henten and Skouby in this volume). They argued that, analogously to the paradigm shifts in science described by Thomas Kuhn, societies may undergo shifts in *sociotechnical paradigms* that have profound economic consequences.

Economic and sociological/communication diffusion studies share a fundamental theoretical and analytic focus on network structures and dynamics. In sociological network analysis, this emphasis has been called the 'anti-categorical imperative' (Emirbayer and Goodwin, 1994). That is, network analysts, including diffusion researchers, assume that the relationships or links among social actors explain more about their actions than does the conventional procedure of classifying actors according to their individual traits or characteristics, and then predicting action based on that classification. Action, network scholars say, must be considered within the context of complex and changing social relations that are directly observable, and not as the result of individual values, motivations or other psychological states that are difficult or impossible to observe.

Network analysis and diffusion studies have a generally holistic, inclusive orientation. Wellman and Berkowitz (1988) argue that the network approach is consistent with

a late-twentieth-century intellectual shift in the sciences and social sciences away from atomistic, reductionist and cumulative explanations, and toward explanations of complexity in which parts are defined by their interactions. Likewise, economists of information and technological change contend that by definition networks have a high degree of complementarity, compatibility and strong interdependence among network elements (people, innovations, firms, etc.).

Another key concept is *network externalities* (see also the chapter by Star and Bowker in this volume). Sometimes called a 'snowball effect' (Bodet et al., 1991: 310), the idea is that the value of a network to a given member increases with the size of the network. Katz and Shapiro (1986: 146) have pointed out that 'This effect has long been recognized in the context of communications networks such as the telephone and telex ... the more subscribers there are on a given communications network, the greater are the services provided by that network' (quoted in Antonelli, 1991: 18, note 15). Ironically, analysts say, early adopters of a technology receive less of a benefit than later adopters do; in fact to some extent they subsidize the benefits of later adopters.

A basic axiom of network analysis and diffusion is that 'Networks structure competitive and collaborative activities to secure scarce resources' (Wellman, 1988: 46). Large, stable networks (those with greater externalities, to use the economic term) tend to maintain the resource or value status quo, and can actually impede the introduction and diffusion of innovations and create barriers to entry of new ideas or techniques (similar to the 'embeddedness' of some technologies noted by actor-network theorists). Technological development, especially in telecommunications, tends to have 'high levels of lock-in effects' (Antonelli, 1991: 12). Antonelli argues that since network externalities can inhibit technological change, network economics must balance competition and cooperation, in contrast to the exclusive focus on markets and competition in neoclassical economics (see also Flichy in this volume).

Both sociological and economic diffusion research have been criticized, often for similar

reasons. Critics charge that diffusion theory is technologically deterministic because it treats innovations as given and focuses more on the effects or impact of innovations in social systems. Rogers (1995) calls this the 'pro-innovation bias' of diffusion theory. The perceived pro-innovation bias has led critics to question the impartiality of diffusion research because it seems to ally the interests of researchers with those of change agents or technology proponents. In economic diffusion research, the determinist tendency emerges in its treatment of technology as exogenous, though this has been modified somewhat by the growing emphasis on sociotechnical paradigms. Economists have also called for greater attention to the creation and development of the innovations themselves, along the lines of some SST studies (Dierkes and Hoffmann, 1992). However, most accounts of diffusion continue to depict the process as linear, for example by using the classic S-shaped diffusion curve to illustrate the rate of adoption or by describing technology use in terms of industry 'push' versus market 'pull'.

Diffusion is also criticized on the grounds that it assumes that technologies and other innovations are unitary, stable phenomena throughout the diffusion process. However, most sociologists, communication researchers and economists acknowledge that technological innovations are rarely singular inventions. Rather, they are constellations or 'clusters' of interrelated or complementary innovations (Freeman, 1991; Perez and Soete, 1988). Rice and Rogers (1980) have demonstrated that technologies are *reinvented* as they diffuse, creating a kind of punctuated equilibrium alternating between rapid growth and plateaus in the rate of diffusion, rather than a single S-curve. Koontz (1976) has characterized innovations as either tightly or loosely bound bundles of subinnovations. Tight bundles may diffuse more slowly, while loose bundles diffuse quickly because they allow users to adapt their components more flexibly. Freeman (1991) has distinguished between radical and incremental innovations, which produce different diffusion patterns. As Perez and Soete put it: "There are plenty of reasons for expecting both the

innovation and its surrounding economic environment to change as diffusion proceeds' (1988: 462). Freeman concurs: "diffusion" is seldom if ever a simple process of replication by unimaginative imitators' (1991: 305).

To recap some of the main points about SST and diffusion, SST is based in constructivist epistemology and rejects technological determinism. Diffusion derives from theories of social influence and persuasion and asserts that networks of relationships and shared meaning shape social action, including the adoption of technology (Rogers and Kincaid, 1981). Both struggle to transcend linear models of causality, with varying success. Diffusion is frequently associated with institutions that sponsor innovations and promote technological development; SST emphasizes the consumption side and the everyday use of technology. Diffusion research analyses adoption patterns of successful and unsuccessful innovations to formulate models that allow the prediction of future trends. SST advocates intervention in the development of technologies before they are 'pushed' into society.

### Two Cases: E-mail and Videotex

Two brief case studies are offered here to illustrate the similarities and differences between SST and diffusion. Electronic mail and videotex are 'tele-matic' technologies, that is, they merge data processing/computation with telecommunications systems. Originally, e-mail required an expensive and esoteric technical infrastructure and served a very small community of highly specialized scientists and engineers. Today, however, e-mail has been adopted widely throughout the world. Videotex, on the other hand, merged computerized information databases with widely available broadcast and telephone systems, and provided broad-based news and community information for general audiences. Nonetheless, it never really found a niche in American households or business, and was adopted very slowly elsewhere. Even in France, where it has been most successful, videotex use has declined sharply in the face of competition from similar services available through the Internet.

### *Electronic Mail*

By most accounts electronic mail arose accidentally as a by-product of the US Defense Advanced Research Projects Agency's ARPANET. The ARPANET project began in the late 1960s as a means to share data processing facilities at universities, military bases and other DARPA-funded research sites, via satellite and telecommunications networks. The system allowed researchers to move data files among sites and gave them access to remote computing facilities when local systems were unavailable or insufficient to handle a given job. The centrepiece of the system was the sabotage-resistant technique of packet switching, which divided files or data processing jobs into small chunks called packets. Packets were sent separately through any available network links, and reassembled into their original form at the destination computer. Packets could be moved through any open route among networked computers, even if some links or nodes in the network were damaged or unavailable. The ARPANET grew rapidly, from 11 nodes in 1970 to almost 90 in 1985; each node connected many computers to the network (Abbate, 1999; Ceruzzi, 1998; Jennings et al., 1986; Newell and Sproull, 1982).

Once the ARPANET was running in the 1970s, researchers at member sites quickly realized that they could use the system to exchange messages with colleagues at other sites as well as to exchange files or data processing jobs. E-mail 'emerged soon after the first few nodes were working' (Ceruzzi, 1998: 298). Specialized software was developed that performed most of the e-mail functions still used today, such as saving or responding to messages, or sending a message to a list of recipients. Soon, messaging overtook other uses, and computer scientists took note of what was perhaps the first 'killer app':

The value of electronic mail came as a surprise to the developers of the ARPANET, who expected the network to be used principally for computer-to-computer communication for resource sharing but found instead that the dominant use was mail. (Newell and Sproull, 1982: 848)

ARPANET was used less as a tool for sharing remote computational resources than it was for sharing information. The major lesson from the ARPANET experience is that information sharing is a key benefit of computer networking. (Jennings et al., 1986: 945)

However, network access was distributed unevenly from the outset; technical and administrative barriers slowed the spread of electronic mail for nearly 20 years. Given the esoteric nature of the research and the security constraints of defence projects, the designers of the ARPANET had always intended the system to link a relatively small, elite group of scientists and engineers. Therefore,

ARPANET also had the negative effect of creating a have-have not situation in experimental computer research. Scientists and engineers carrying out such research at institutions other than the twenty or so ARPANET sites were at a clear disadvantage in accessing pertinent technical information and in attracting faculty and students. (Jennings et al., 1986: 945-6)

Other observers 'sensed a growing split in the community between those with ARPANET access and those without it' (Comer, 1983: 747-8), which included access to resources, facilities and scholarly interaction with colleagues at other institutions. To help alleviate the widening gaps, the National Science Foundation established NSFnet, which linked researchers at many US campuses to NSF super-computer centres through the ARPANET (Comer, 1983; Jennings et al., 1986). A confederation of non-ARPANET computer science departments created CSNET in the early 1980s to connect with their colleagues at ARPANET sites (Comer, 1983).

As networked computing grew other barriers arose, particularly between scientists and engineers and other university-based scholars and researchers who recognized the potential benefits of high-speed asynchronous messaging for their own specialties, but did not have access to the network. 'In general, the existing ARPANET connections are in departments of computer science and electrical engineering and are not readily accessible by other researchers' (Jennings et al., 1986: 946). With the help of IBM, a consortium of non-ARPANET colleges and universities using IBM mainframes established BITNET (Because It's There Net) in 1981, with the first link between the City University of New York and Yale University (Abbate, 1999: 202; Ceruzzi, 1998). By 1985 BITNET connected about 600 computers in 175 institutions: 'It is not limited to specific

academic disciplines, and may be used for any academic or administrative purposes' (Jennings et al., 1986: 947).

Abbate (1999) gives a detailed account of the transformation of the ARPANET into an NSF-supported 'backbone' that became the core of the Internet, and how separate networks like BITNET eventually were connected to the Internet. However, for a time interconnection between Internet and BITNET sites was often awkward; some scholars and researchers maintained both Internet and BITNET e-mail addresses to reach colleagues in different disciplines or institutions. There was also a persistent sense of a two-class system associated with BITNET, with Internet addresses (major government and research institutions with plenty of extramural funding) having more cachet than their BITNET counterparts. (Network address status distinctions resurfaced in the 1990s with the .edu, .org, .gov, .mil and .com domains of US Internet addresses, and continues in ICANN debates about the allocation of domain names.) Nonetheless, BITNET opened e-mail access to an unprecedented number of researchers and students, and established electronic mail, bulletin boards and discussion lists as a routine mode of communication throughout American academia.

At about the same time in the 1970s and 1980s, public data networks were being developed in Europe, Canada and the US for clients prohibited from using the non-profit research networks. These networks, such as Telenet in the US, were expensive; they conveyed files and data via dedicated transmission lines, much like a long-distance telephone call. Instead of the TCP/IP networking protocol used in the ARPANET, which connected many diverse computer networks, public data networks employed the X.25 protocol developed by national postal, telegraph and telephone ministries (PTTs) and adopted by the Consultative Committee on International Telegraphy and Telephony (CCITT) (Abbate, 1994). The framers of the X.25 protocol assumed that a uniform standard for computer networks would eventually emerge, such as the reliable, high-speed Ethernet local area network developed at XeroxPARC (Abbate, 1994; Ceruzzi, 1998).

Therefore another barrier was created, this time between the (mainly American) non-profit research- and university-based Internet on the one hand and (US and international) public data networks and private-sector organizational 'intranets' on the other. This barrier endured until the late 1980s, when moves began to privatize the Internet and so open it to commercial and entertainment uses (Abbate, 1999). The distinction virtually disappeared in the mid 1990s, when the hypertext transfer protocol (HTTP) for the World Wide Web, combined with the client-server network configurations that had originally been designed for Xerox's Ethernet, effectively bridged the TCP/IP and X.25 standards (Abbate, 1994).

As networked computing and the use of electronic mail spread from high-level, DARPA-funded research sites to computer science and engineering more generally, then throughout academia, and finally to the private sector, e-mail and the Internet became increasingly taken for granted as communication media, with all the social expectations and difficulties of other media. For example, users found that the style of interaction among computer scientists and engineers was not always appropriate in other contexts. Early ARPANET users – often students, using UNIX-based research workstations – had created news or discussion groups in which members posted messages and expressed their opinions on a wide range of topics. Writing in 1982, two prominent computer scientists observed that 'electronic mail has come to be used in an informal way ... messages have the informality of speech, perhaps because the sender views the message as an alternative to a telephone call' (Newell and Sproull, 1982: 848). E-mail and bulletin board discussions often became heated and lengthy, in part because members would use aliases to avoid being identified as the source or target of an often brutal, *ad hominem* style of criticism called 'flaming'. Flaming and aliases were understood and accepted within the relatively small, closed world of computing research, but were foreign to newcomers from other disciplines.

As computer networks proliferated, the Internet shifted to the private sector, and e-mail

attracted more diverse users, social scientists had more opportunities to study the uses of e-mail and other computer-mediated communication (CMC) technologies (Garton and Wellman, 1995; Rice, 1980; Steinfield, 1986; see Rice and Haythornthwaite in this volume). E-mail users began to develop and enforce consensual rules of 'netiquette'. They cultivated a more civil style of interaction to limit the rhetorical excesses of the engineers' 'flame wars'.

Today, it can be argued that e-mail development has entered a new phase of consolidation and control. E-mail users must often adapt their work and communication patterns to established systems, and are prohibited from modifying systems to suit their own needs. While the technology has been adopted widely in private-sector work settings, managers routinely control e-mail content as well as access. E-mail records are routinely subpoenaed in legal actions. The original 'acceptable use policy' imposed by DARPA and the NSF, which restricted uses of the ARPANET and Internet to non-profit research and teaching activities, has given way to a flurry of organizational use policies that can severely restrict what users may or may not say about their workplaces, corporate sponsors or other private firms, or even about the provider of the Internet service being used. Voluntary 'netiquette' has given way in many organizations to strictly enforced, top-down controls on expression and the surveillance of employee messages by management. In a recent study by the Pew Internet and American Life Project (2002) nearly 70 per cent of survey respondents said that their e-mail use at work was monitored by employers. According to survey data gathered by the American Management Association, the percentage of major US firms that monitor employee e-mail increased from about 15 per cent in 1997 to 60 per cent in 2004 (American Management Association, 2001, 2004). Today, e-mail is a routine, and perhaps the most routinely monitored and sanctioned, form of interpersonal communication in the US and elsewhere.

### *Videotex*

Though unfamiliar to most Americans, videotex information systems are common in other

parts of the world, including Canada, Japan, Europe and the UK. Videotex systems link users' television sets or a specially dedicated terminal (or in more current systems, their PCs) to computerized information databases via telephone or cable lines. (A similar system, teletext, provides the same type of information over the air as part of the television broadcast signal.) Subscribers use a keypad device, such as a specially modified remote control channel changer or keyboard, to call up 'pages' of information that are displayed on the television screen. Pages incorporate text and very simple graphics; content ranges from news, sports scores and weather reports to telephone directory information, want ads, rail and airline schedules, stock prices and gardening tips. Early systems connected subscribers to a single centralized database; later systems incorporated networked computers and distributed databases. In some ways videotex can be seen as a precursor to today's World Wide Web, where users call up web pages from any one of millions of databases on demand.<sup>3</sup>

The first videotex system, Prestel, was introduced in the UK in 1979 by a division of the British Post Office (now British Telecom). By the mid 1980s the Bundespost in the Federal Republic of Germany had started the Bildschirmtext system, based on Prestel technology; the Canadian government had launched its Telidon project; and in the UK Prestel was joined by the BBC's teletext service, Ceefax. The French Télétel service, based on a hybrid videotex/teletext platform called Antiope, was developed by the Direction Générale des Télécommunications section (DGT) of the French PTT ministry (now France Télécom). Télétel was distinctive because it displayed pages of text on small, specially designed terminals called minitels instead of television sets. The developers of all these systems envisioned them as 'information utilities' and anticipated rapid, widespread adoption in households and workplaces (Greenberger, 1964).

However, videotex got off to a slow start. In Britain, Prestel never grew as quickly as planners predicted. At its most extensive, the system attracted fewer than 100,000 subscribers; these numbers were soon surpassed

by the BBC's Ceefax. The German Bildschirmtext system experienced similarly slow growth until Deutsche Telekom (the successor to the telecommunications branch of the state Bundespost) modified the system in the 1990s to be PC accessible via the Internet. Facing early consumer resistance, the operators of both Prestel and Bildschirmtext shifted their focus from households to business and professional users. In Canada, Telidon offered a technically superior system with better graphics, but the system never attracted enough subscribers to get past the trial stage.

In France, Télétel was the only real videotex success, owing partly to the free distribution of millions of minitel terminals to households and business telephone customers between 1983 and 1990 (Schneider, 2000). The French public was slow to adopt PCs in the 1980s, and minitels gave them access to basic French-language information and messaging services similar to those available in English over the Internet. Originally, the system provided only telephone directory assistance, but it was soon expanded to include personal messaging and bulletin-board-type services, for example 'erotic "conversation" groups' (Schneider, 2000: 320) called *messageries roses*. Students even used minitel messaging to organize nationwide protests in the 1980s. Since the mid 1990s, however, minitel use has declined as PC adoption and Internet use have grown in France.

In the US, videotex encountered even bigger problems during the 1980s. Information services similar to those offered on videotex systems were available online to subscribers with PCs and modems, including H&R Block's CompuServe, the Dow Jones Information Service, The Source from Reader's Digest, and later, IBM and Sears' Prodigy system and America Online (AOL). Several major media firms conducted videotex trials in selected US markets in the 1980s using Canadian, British and French technologies (Case, 1994; Mosco, 1982; Rogers, 1986). Knight-Ridder introduced the Viewtron system in Miami/Coral Gables, FL; the Times-Mirror Company built the Gateway system in Orange County, CA; IBM, Sears and CBS joined forces in the Trintex project; CBS and AT&T ran an experimental

system in New Jersey; and Time/Life planned a trial as well. Besides these firms, a number of others were involved in the design and development of terminal equipment, information services and system infrastructures (Mosco, 1982).

Despite millions of dollars spent on the various American trials, however, sponsors soon abandoned videotex systems because they attracted so few subscribers. Though media companies were involved in many of the trials, critics charged that they were never really interested in developing services that would rival their existing operations in publishing, broadcasting or online services. The trials, it was alleged, were virtually designed to fail, offering general-interest content that was readily available elsewhere and charging high prices for terminal equipment and connection time. Because most trials were conducted in affluent suburban neighbourhoods, there were doubts about the general appeal of the services. By the late 1980s hopes for American videotex services delivered to television sets or dedicated terminals had faded, though several providers (including online newspapers) migrated their services to be available online via personal computers.

Most accounts of videotex history cite several reasons for its difficulties in the US and elsewhere. First, videotex was a top-down phenomenon, depending more on industry and government push than on consumer pull. It tended to be most successful where state agencies and national telecommunications monopolies sponsored and built systems along the lines of other telecommunications services such as the telephone. In the late 1970s, national monopolies were searching for new uses for their rapidly expanding bandwidth, and state industrial policies promoted national champions (e.g. British Telecom, French Télécom, Deutsche Telekom) in international markets for telecommunications and computing equipment and services. Videotex systems were promising on both counts. It is notable, for example, that many American videotex trials employed foreign technologies. Though a consortium of US players developed the North American Presentation Level Protocol Syntax (NAPLPS) protocol in the early 1980s, AT&T lobbied the FCC to accept a modified version

of Canadian Telidon technology as the US standard, while CBS advocated the French Antiope system. However, where no state or monopoly interest was willing to underwrite the startup and maintenance costs of such large distributed systems – as in the US – videotex stalled.

Others cite problems with the technology itself, particularly the cost, complexity and relatively unsophisticated display capabilities of specially adapted television sets or dedicated videotex terminals. In a sense, these platforms were 'closed' in that they did not give subscribers access to content or services beyond the provider's system. Videotex adapters could add hundreds of dollars to the price of a TV; keypad codes could be arcane and difficult to remember; and (with the exception of the Telidon system) page displays were often limited to a few lines of ragged text and crudely rendered graphics. As more users called up pages, the slower page retrievals became. And many systems that made large initial capital investments got 'locked in' to early technical standards and could not afford to upgrade later.

Furthermore, videotex was introduced in the US at about the same time as personal computers and modems, which provided access to similar rival information services like CompuServe. PCs and modems had the advantage of being a more 'open' platform: users could subscribe to whatever services they chose, and were not restricted to one provider or source of information. Furthermore, almost any computer screen could produce better graphics and more readable text than videotex, even before graphical user interfaces like the Macintosh desktop or its derivative, Windows, became common. Videotex-adapted television sets could hardly compete with PCs in terms of speed, flexibility and power. To some extent, then, videotex enjoyed greater popularity where markets for personal computing had not yet developed. Once PCs and the Internet became widely available, existing videotex systems had to go online to survive, or be replaced by Internet-based services and eventually the World Wide Web.

Another reason for videotex's poor showing may be ideological (Case, 1994). Videotex

evolved during a period dominated by expansive new visions and rhetoric heralding the emerging 'information society', in which information would be the new commodity and communication the new market. Access to information services became a staple of US urban policy in the 1970s, for example, as planners envisioned 'information utilities' that would provide information services to poor and underserved neighbourhoods via cable television technology (Greenberger, 1964; Light, 2003). This faith in the new technologies may have created unrealistic or premature expectations among key players for videotex and similar services. Many believed that the new hybrid technological infrastructure, which combined computing and telecommunications (and gave rise to awkward neologisms like 'compunications' and *télématique*, or 'telematics' in English) would break down institutional and national boundaries, reduce or eliminate the costs of labour, materials and transportation, and deliver information and services to consumers instantly and transparently at a fraction of the previous cost. These new 'information utilities', including videotex, would create new markets in information and, indeed, in bandwidth itself (Dordick et al., 1981). Industries were particularly interested in the potential for transaction-based services such as home shopping, banking and financial transactions, electronic document delivery, and other on-demand, so-called 'interactive' services (Greenberger, 1985; Institute for the Future, 1970; Tydeman et al., 1982). Such transaction-based services promised new sources of profit for the private sector and a revival for stagnating national economies (Nora and Minc, 1981; Sigel, 1980).

With the benefit of hindsight it seems clear that while videotex delivered via television sets or dedicated terminals may have failed as a particular technological platform, the essentially commodified and transactional vision of telematics and information utilities lives on in recent market enthusiasms for e-commerce, electronic publishing, online trading and auctions, and 'end user information services' (Case, 1994). Still, information delivery and commercial transactions have never been as compelling to consumers as the opportunity

for interpersonal interaction online. Survey research shows that people use the Internet far more frequently for electronic mail and related services like real-time messaging or chat rooms than for shopping, banking or document retrieval (Pew Internet and American Life Project, 2005). Distinctions have emerged between 'content' uses of new media where every mouse click represents potential revenue (such as shopping; music, video or electronic book downloads; Web browsing; travel booking), and 'community' uses (e-mail, chat, instant messaging) which tend to be less lucrative. The early vision of telematics, focused on information delivery and commercial transactions, was the primary influence on videotex design and implementation. But users seem to have expected more.

#### DETERMINATION AND CONTINGENCY

The preceding cases illustrate that the new media development process entails design and use, negotiation and consensus, engineering specifications and market demands, channels and content, the material and the social. More generally, these dualities can be recast as a dynamic relationship between determination and contingency. *Determination* is the effort to specify conditions or 'impose coherence' in a situation with the intent of achieving some desired outcome (Schön, 1988, 1990). *Contingency* is the existence of many possible conditions in an uncertain situation. Complete certainty is never fully achieved, so in a sense there is no final design 'solution' for a given technological problem.<sup>4</sup> Rather, designers contend with contingency by making choices from among existing conditions or by creating new ones. In turn, these choices create new conditions and uncertainties that prompt further specifications or choices, and so on. Technology design and development can therefore be relatively 'loose' or 'tight' depending on the prevailing tendency at any given point toward contingency or determination, respectively.

Diffusion and SST can be thought of as having differing profiles in terms of the determination/contingency framework. For example,

diffusion might be said to tend more toward determination *vis-à-vis* the origin of technologies, the actors involved, and dynamics and distributive mechanisms, though it leans more toward contingency regarding choice and consequences. SST, on the other hand, seems to align more with contingency on almost all counts, though some scholars (especially actor-network theorists) also recognize that technological change often leads to closure and irreversibility when innovations are widely adopted. Interestingly, frameworks like actor-network theory and sociotechnical paradigms could both be placed near the middle in terms of determination and contingency. They both emphasize the networked interrelationships among individuals, technologies and institutions, and the barriers to innovation brought about by technological 'embeddedness', standardization, network externalities, or prevailing technological regimes ('paradigms').

#### Moments of Technology Development

Furthermore, the e-mail and videotex cases suggest that determination and contingency are played out at several critical points or 'moments' in development. Moments in this context are not specific points in time, but rather notable or conspicuous elements having the potential to move development in one direction or another. They do not necessarily follow in the linear order that the following list suggests; moments can and frequently do overlap or relate in other ways. Table 12.1 gives examples of how the moments can vary depending on the prevailing tendency toward determination or contingency.

##### *Origin*

In the first moment of the development process new ideas are generated and tried out. Origins may be responses to specific problems or situations, or may arise more spontaneously, when an idea is proposed just because it is possible or interesting. Origin is principally a creative moment; it can be intensely active or may take the form of a simple conceptualization. Origins may involve whole

Table 12.1 *Determination versus contingency in moments of new media development*

Moments	Determination ←	→ Contingency
Origin	Institutional sources of innovation Innovation pre-defined by R&D process	Innovation is open, reflexive
Actors	A few controlling interests Human or organizational actors	Many players, no signal interest Institutions, technologies and people can all act, have influence
Dynamics	Slow, stable, organized, linear Dominant groups create barriers to entry Externalities, irreversibility	Rapid, volatile, reversible, disorganized or self-organizing systems
Choice	Few choices	Many choices
Formal properties	Established styles, forms, genres Existing forms constrain new ones	Experimental, recombinant, temporary forms
Distributive mechanisms	Centralized, restricted access, few channels	Decentralized, open access, multiple channels
Consequences	Closure, stability, standardization, barriers to entry, monopoly	Lack of standards, 'churn', proliferating forms and users, competition

teams of people sharing and negotiating ideas, or individuals trying to solve problems in a new way. In the economics of technology, Schumpeter distinguishes between 'invention' and 'innovation' (Freeman, 1991): invention corresponds to the generation of a new concept, while innovation involves its communication or transfer beyond the originator(s).

### Actors

The second moment is the *actors* involved in new media development. Actors include anyone who makes choices that affect the subsequent uses or forms of the technology, including professionally trained specialists. Sonnenwald (1993) argues that there are many types of actors involved in design, each with different (sometimes conflicting) interests, requirements and expectations.

### Dynamics

The third moment is complex and extends throughout the development process. *Dynamics* involves the movement and momentum of a new technological idea, its expression, and its adoption and use. Development dynamics may be volatile or stable, fast or slow, may move ahead easily or be impeded or encounter resistance, or even be reversed. Technologies may

become standardized (that is, undergo closure), or standards may break down. Dynamics is illustrated by the concept of critical mass in diffusion theory, technological trajectories in the economics of technological change (Dosi, 1982; Nelson and Winter, 1977, 1982), and momentum in SST (Hughes, 1987).

### Choice

The fourth moment is closely related to dynamics, and also operates more or less constantly throughout the development process. Contingency is characterized by a wide variety of *choices*, while determination forecloses or limits choice. More 'durable' technologies constrain subsequent choices (Latour, 1991).

### Formal Properties

Expressions or physical forms of a technology emerge as it develops. Form may be influenced by ergonomic or aesthetic considerations or by the usability of the technology. In diffusion theory, the *formal properties* of an innovation make it observable by potential adopters. Style or production values can be important aspects of form.

### Distributive Mechanisms

The sixth moment involves the means by which new ideas, things or practices spread.

*Distributive mechanisms* include interpersonal networks, existing media technologies, markets, and organizational or institutional structures. Fairness or equity of distribution is an important consideration (for example, as governed by universal service regulations for telephone service). Distribution is often highly politicized because different actors may have relatively more or less power to influence or benefit from distribution. Access to technology is one outcome of particular patterns of distribution.

### *Consequences*

The final moment involves the effects, 'impacts' or other outcomes of a technology, whether intended or unanticipated. *Consequences* may emerge early in the development process and 'feed forward' to affect later phases, or may not become apparent until the technology is widespread. Consequences affect subsequent development; for example, a successful technology is likely to generate a whole group of imitators or similar works (perhaps creating a genre with particular formal properties). An unsuccessful technology may discourage further experimentation or creative uses of related ideas.

### **Determination and Contingency in E-mail and Videotex**

In retrospect, though e-mail succeeded and the original videotex platform did not, both demonstrate the interrelationship between determination and contingency in the moments of media development. Videotex seems to have been the more determined technology, especially at the outset. Fewer actors were involved, typically in alliances between PTTs and national monopolies, or among corporate media firms. Technical standards were established early, which had the effect of locking in relatively unsophisticated graphics and interfaces, at least in some systems. The first operators had clearly defined markets in mind, though their subscription projections were generally overoptimistic. Consumer resistance slowed the initial momentum of videotex development; operators tried to rekindle interest by reorienting the services from household to business customers, but this strategy was not

much more successful. In France, videotex was more flexible, offering messaging and chat as well as information services, and the state/PTT alliance made much larger initial investments and subsidized the service heavily for nearly a decade. The system was inexpensive for consumers and the number of subscribers grew steadily. But as more information services went online and more households and businesses adopted PCs and modems, videotex lost much of its appeal in France, as it had elsewhere.

E-mail also began as a highly constrained system. The underlying ARPANET infrastructure, including packet switching, was institutionally commissioned, paid for and controlled by ARPA. As with videotex, very few actors were involved at the outset and access to the system was strictly limited, but unlike the sponsors of videotex ARPA provided little institutional 'push' that would move the technology beyond its original base in federally funded computer science research.

In fact, e-mail itself – an unanticipated use of the system that demonstrated users' 'interpretive flexibility' – shifted the dynamic of networked computing toward proliferation and contingency. The ARPANET was transformed by 'user activism' that began with electronic mail (Abbate, 1999: 90). E-mail opened up collaborative possibilities far beyond the file sharing and distributed data processing originally envisioned by ARPA project directors. Perhaps unwittingly, computer scientists with ARPANET access played the role of 'early adopters' in the diffusion sense, modelling the benefits of e-mail for colleagues in computer science and eventually throughout academia. E-mail had immediate intuitive appeal; user 'pull' rather than industry push helped accelerate the trend toward networked computing and 'internetworking' among major institutions. Eventually the same model was reproduced all the way to the desktop with the Internet, PCs, modems (later, broadband) and wireless networks.

Certainly, technical and administrative barriers to networking and e-mail arose at each step in its development and diffusion. It took about 25 years for e-mail to move from DARPA researchers, to computer science at large, to other disciplines in major research universities and large corporate organizations, to smaller

universities and colleges, and finally to most American businesses and households. But along the way, networked computing as a medium, including e-mail, transformed expectations about interpersonal communication, written discourse, privacy, workplace life, organizational forms and hierarchies, as well as the access to information and entertainment that videotex was supposed to provide. Today, e-mail is virtually ubiquitous in education, business and government and most households in developed nations, and use is rising around the world.

From an SST perspective, we might say that videotex developers misunderstood potential users and their everyday needs for information. Systems were complex and expensive, and offered information and services that could readily be obtained elsewhere. System sponsors seemed to have a deterministic, 'build it and they will come' faith that the availability of the technology itself would compel subscribers to change their information-seeking habits – and pay for the privilege. There was little opportunity for subscribers to modify or adapt the system for their own purposes, except in France, where impromptu bulletin boards and chat groups developed. The transaction-based platform precluded real interpersonal interaction in most systems. For e-mail, on the other hand, the developers themselves were the original users, and had some latitude to design the system according to their needs and preferences. The system was also 'free' to most individual users in the early stages, in the sense that it was subsidized by large research grants, and later underwritten by the research universities, government and private firms. (Users would later assume more of the costs of connect time, software and hardware.) A system originally intended for file sharing and distributed data processing (transactions) was adapted to permit interpersonal communication. In the process it became, and still is, the 'killer app' of networked computing.

From the diffusion perspective, the roles of system designers and innovators, the influence of opinion leaders on later adopters, the social ties and persuasive interactions among system users, the presence or absence of critical mass, adaptation or reinvention, and the network effects or externalities of system growth are all clear in both cases. The diffusion curve of most videotex

systems never achieved critical mass or 'takeoff', while the curve for e-mail has something of a punctuated equilibrium shape, with alternating phases of growth and stability. Videotex was a relatively stable innovation, while e-mail's features evolved as new groups of users adopted it. For example, the simple text format of e-mail messages remained more or less unchanged until business users added features like document attachments and links to calendars and spreadsheets and a friendlier graphical interface.

## CONCLUSION

To conclude, in this chapter I have attempted to provide a general conceptual overview of the development of new media technologies. It is a complex, multilayered process that involves many different groups and their interests, but one way to understand it is to consider shifts between determination and contingency at different moments or steps in the development process. I have focused on two important perspectives on technology and social change that have been widely influential in new media research, to show how they incorporate determination and contingency in their analyses. Diffusion of innovations and social shaping of technology have different disciplinary and philosophical foundations and different orientations toward technology and action. Yet both provide useful tools for observing and describing the technology development process.

I reviewed the development of two media technologies, videotex and electronic mail, to identify instances of determination and contingency in each case. I also briefly compared the two technologies from the viewpoints of diffusion and SST, to demonstrate how the two perspectives might analyse them differently while still incorporating moments of determination and contingency. The cases presented here are necessarily brief; more extensive historical analysis might reveal important details or themes that have been overlooked here. Similarly, the descriptions of diffusion theory and SST would benefit from a more comprehensive literature review highlighting significant theoretical refinements and empirical studies. Readers are

encouraged to review the main works cited here for additional background.

However, despite this limited treatment the determination–contingency framework, organized around the moments of technology development, may offer a means for future studies to compare and triangulate theoretical approaches as well as the media technologies themselves.

## NOTES

I would like to acknowledge the research and editorial assistance of Marjorie Rauen on the original version of this chapter. Pablo Boczkowski also provided invaluable comments and suggestions, particularly regarding the section on videotex.

1 With worrisome consequences for content regulation and intellectual property rights, as Verhulst points out in the present volume.

2 I thank Donald Case for this insight.

3 For more background about the development and history of videotex, see Case (1994), Mayntz and Schneider (1988), Mosco (1982), Rogers (1986), Schneider (2000), Schneider et al. (1991), and Tydeman et al. (1982). This section draws primarily from these works. Also, see Boczkowski (2004).

4 Though as Latour (1993, 1996) emphasizes, some solutions – we might think of books or broadcast television – may become so durable that they powerfully constrain any subsequent developments

## REFERENCES

- Abbate, J. (1994) 'The Internet challenge: conflict and compromise in computer networking', in J. Summerton (ed.), *Changing Large Technical Systems*. Boulder, CO: Westview. pp. 193–210.
- Abbate, J. (1999) *Inventing the Internet*. Cambridge, MA: MIT Press.
- Aitken, H.G.J. (1985) *The Continuous Wave: Technology and American Radio, 1900–1932*. Princeton, NJ: Princeton University Press.
- Allen, D. (1983) 'New telecommunications services: network externalities and critical mass', *Telecommunications Policy*, 12 (3): 257–71.
- American Management Association (2001) *2001 AMA Survey: Workplace Monitoring and Surveillance*. Available online: [http://www.amanet.org/research/pdfs/ems\\_short2001.pdf](http://www.amanet.org/research/pdfs/ems_short2001.pdf)
- American Management Association (2004) *2004 Workplace E-mail and Instant Messaging Survey*. Available online: [http://www.amanet.org/research/pdfs/IM\\_2004\\_Summary.pdf](http://www.amanet.org/research/pdfs/IM_2004_Summary.pdf)
- Antonelli, C. (ed.) (1991) *The Economics of Information Networks*. Amsterdam: North-Holland.
- Bijker, W.E. (1995) *Of Bicycles, Bakelites and Bulbs: Toward a Theory of Sociotechnical Change*. Cambridge, MA: MIT Press.
- Bijker, W.E. and Law, J. (eds) (1992) *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press.
- Bijker, W.E., Hughes, T.P. and Pinch, T. (1987) *The Social Construction of Technological Systems*. Cambridge, MA: MIT Press.
- Blau, P. (1982) 'Structural sociology and network analysis: an overview', in P.V. Marsden and N. Lin (eds), *Social Structure and Network Analysis*. Beverly Hills, CA: Sage. pp. 273–9.
- Bloor, D. (1991) *Knowledge and Social Imagery*, 2nd edn. Chicago, IL: University of Chicago Press.
- Bloor, D. (1992) 'Strong programme', in J. Dancy and E. Sosa (eds), *A Companion to Epistemology*, London: Blackwell. p. 494.
- Boczkowski, P.J. (1999) 'Mutual shaping of users and technologies in a national virtual community', *Journal of Communication*, 49 (2): 86–108.
- Boczkowski, P.J. (2004) *Digitizing the News: Innovation in Online Newspapers*. Cambridge, MA: MIT Press.
- Bodet, C., Joram, D. and Lamarche, T. (1991) 'Savoir-faire and telecommunication market structure: cooperation, domination and competition', in C. Antonelli (ed), *The Economics of Information Networks*. Amsterdam: North-Holland. pp. 301–24.
- Brown, J.S. and Duguid, P. (1994) 'Borderline issues: social and material aspects of design', *Human–Computer Interaction*, 9: 3–36.
- Bucciarelli, L.L. (1994) *Designing Engineers*. Cambridge, MA: MIT Press.
- Callon, M. (1986) 'The sociology of an actor-network: the case of the electric vehicle', in M. Callon, J. Law and A. Rip (eds), *Mapping the Dynamics of Science and Technology: Sociology of Science in the Real World*. London: Macmillan. pp. 19–34.
- Callon, M., Law, J. and Rip, A. (eds) (1986) *Mapping the Dynamics of Science and Technology: Sociology of Science in the Real World*. London: Macmillan.
- Case, D.O. (1994) 'The social shaping of videotex: how information services for the public have evolved', *Journal of the American Society for Information Science*, 45 (7): 483–97.
- Ceruzzi, P.E. (1998) *A History of Modern Computing*. Cambridge, MA: MIT Press.

- Comer, D. (1983) 'The computer science research network CSNET: a history and status report', *Communications of the ACM*, 26 (10): 747-53.
- David, P.A. (1985) 'Clio and the economics of QWERTY', *American Economic Review*, 75 (2): 332-7.
- Dierkes, M. and Hoffmann, U. (eds) (1992) *New Technology at the Outset: Social Forces in the Shaping of Technological Innovations*. Frankfurt and New York: Campus.
- Dordick, H., Bradley, H. and Nanus, B. (1981) *The Emerging Network Marketplace*. Norwood, NJ: Ablex.
- Dosi, G. (1982) 'Technical paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technological change', *Research Policy*, 11: 147.
- Dosi, G., Freeman, C., Nelson, R., Silverberg, G. and Soete, L. (eds) (1988) *Technical Change and Economic Theory*. London: Pinter.
- Edwards, P.N. (1996) *The Closed World: Computers and the Politics of Discourse in Cold War America*. Cambridge, MA: MIT Press.
- Emirbayer, M. and Goodwin, J. (1994) 'Network analysis, culture and the problem of agency', *American Journal of Sociology*, 99 (6): 1411-54.
- Fischer, C.S. (1982) *To Dwell Among Friends: Personal Networks in Town and City*. Chicago and London: University of Chicago Press.
- Fischer, C.S. (1992) *America Calling: A Social History of the Telephone to 1940*. Berkeley, CA: University of California Press.
- Freeman, C. (1991) 'The nature of innovation and the evolution of the productive system', in *Technology and Productivity: The Challenge for Economic Policy*. Proceedings of a conference sponsored by the Technology/Economy Programme, OECD. Paris: Organization for Economic Cooperation and Development. pp. 303-14.
- Galambos, L. (1988) 'Looking for the boundaries of technological determinism: a brief history of the US telephone system', in R. Mayntz and T.P. Hughes (eds), *The Development of Large Technical Systems*. Frankfurt and Boulder, CO: Campus and Westview. pp. 135-53.
- Garton, L. and Wellman, B. (1995) 'Social impacts of electronic mail in organizations: a review of the research literature', in B.R. Burleson (ed.), *Communication Yearbook 18*. Thousand Oaks, CA: Sage. pp. 434-53.
- Greenberger, M. (1964) 'The computers of tomorrow', *Atlantic Monthly*, 213 (5): 63-66.
- Greenberger, M. (ed.) (1985) *Electronic Publishing Plus*. White Plains, NY: Knowledge Industry.
- Griliches, Z. (1988) *Technology, Education and Productivity*. New York: Basil Blackwell.
- Gross, P.R. and Levitt, N. (1994) *Higher Superstition: The Academic Left and Its Quarrels with Science*. Baltimore, MD: Johns Hopkins University Press.
- Hamilton, P. (1996) 'Systems theory', in B.S. Turner (ed.), *The Blackwell Companion to Social Theory*. London: Blackwell. pp. 143-70.
- Holton, R.J. (1996) 'Classical social theory', in B.S. Turner (ed.), *The Blackwell Companion to Social Theory*. London: Blackwell. pp. 25-52.
- Hughes, T.P. (1983) *Networks of Power: Electrification in Western Society, 1880-1930*. Baltimore, MD: Johns Hopkins University Press.
- Hughes, T.P. (1986) 'The seamless web: technology science, etcetera, etcetera', *Social Studies of Science*, 16: 281-92.
- Hughes, T.P. (1987) 'The evolution of large technical systems', in W.E. Bijker, T.P. Hughes and T. Pinch (eds), *The Social Construction of Technological Systems*. Cambridge, MA: MIT Press. pp. 51-82.
- Institute for the Future (1970) *Potential Demand for Two-way Information Services to the Home 1970-1990*. Menlo Park, CA: Institute for the Future.
- Jennings, D.M., Landweber, L.H., Fuchs, I.H., Farber, D.J. and Adrion, W.R. (1986) 'Computer networking for scientists', *Science*, 231 (28 February): 943-50.
- Katz, M.L. and Shapiro, C. (1986) 'Product compatibility choice in a market with technological progress', *Oxford Economic Papers*, November (supplement): 146-65.
- Kling, R. (ed.) (1996) *Computerization and Controversy: Value Conflicts and Social Choices*, 2nd edn. San Diego, CA: Academic.
- Kling, R. (1999) 'What is social informatics and why does it matter?', *D-Lib Magazine*, 5 (1). Available online: <http://www.dlib.org:80/dlib/january99/kling/01kling.html>
- Kling, R. and Scacchi, W. (1982) 'The web of computing: computer technology as social organization', *Advances in Computers*, 21: 1-90.
- Knie, A. (1992) 'Yesterday's decisions determine tomorrow's options: the case of the mechanical typewriter', in M. Dierkes and U. Hoffmann (eds), *New Technology at the Outset: Social Forces in the Shaping of Technological Innovations*. Frankfurt and New York: Campus. pp. 161-72.
- Knorr, K. (1981) *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science*. Oxford: Pergamon.
- Koontz, V. (1976) 'Determinants of individuals' knowledge, attitudes and decisions regarding a health innovation in Maine'. Unpublished doctoral dissertation, University of Michigan, Ann Arbor, MI.

- LaPorte, T.R. (ed.) (1991) *Social Responses to Large Technical Systems: Control or Anticipation*. Dordrecht and Boston: Kluwer.
- Latour, B. (1991) 'Technology is society made durable', in J. Law (ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination*. London: Routledge. pp. 103–31.
- Latour, B. (1993) *We Have Never Been Modern*. New York: Harvester-Wheatsheaf.
- Latour, B. (1996) *Aramis, or the Love of Technology*. Cambridge, MA: Harvard University Press.
- Latour, B. and Woolgar, S. (1986) *Laboratory Life: The Construction of Scientific Facts*, 2nd edn. Princeton, NJ: Princeton University Press.
- Law, J. and Hassard, J. (eds) (1999) *Actor-network Theory and After*. Oxford: Blackwell.
- Light, J.S. (2003) *From Warfare to Welfare: Defense Intellectuals and Urban Problems in Cold War America*. Baltimore, MD: Johns Hopkins University Press.
- Mackay, H. and Gillespie, G. (1992) 'Extending the social shaping of technology approach: ideology and appropriation', *Social Studies of Science*, 22: 685–716.
- MacKenzie, D. (1991) 'Notes toward a sociology of supercomputing', in T.R. LaPorte (ed.), *Social Responses to Large Technical Systems*. Dordrecht: Kluwer. pp. 159–75.
- MacKenzie, D. and Wajcman, J. (eds) (1999) *The Social Shaping of Technology*, 2nd edn. Philadelphia, PA and London: Open University Press and Taylor & Francis.
- Mahler, A. and Rogers, E.M. (1999) 'The diffusion of interactive communication innovations and the critical mass: the adoption of telecommunications services by German banks', *Telecommunications Policy*, 23 (10–11): 719–40.
- Markus, M.L. (1987) 'Toward a "critical mass" theory of interactive media: universal access, interdependence and diffusion', *Communication Research*, 14: 491–511.
- Mayntz, R. and Hughes, T.P. (eds) (1988) *The Development of Large Technical Systems*. Boulder, CO: Westview.
- Mayntz, R. and Schneider, V. (1988) 'The dynamics of system development in a comparative perspective: interactive videotex in Germany, France and Britain', in R. Mayntz and T.P. Hughes (eds), *The Development of Large Technical Systems*. Boulder, CO: Westview Press. pp. 263–98.
- McDermott, J. (1969) 'Technology: the opiate of the masses', *New York Review of Books*, 31 July.
- Mitchell, J.C. (1975) 'The concept and use of social networks' (1969), in J.C. Mitchell (ed.), *Social Networks in Urban Situations: Analyses of Personal Relationships in Central African Towns*. Manchester: Manchester University Press, for the Institute for African Studies, University of Zambia. pp. 1–50.
- Mosco, V. (1982) *Pushbutton Fantasies: Critical Perspectives on Videotex and Information Technology*. Norwood, NJ: Ablex.
- Mumford, L. (1964) *The Myth of the Machine*. Vol. 1: *Technics and Human Development*. New York: Harcourt Brace Jovanovich.
- Mumford, L. (1970) *The Myth of the Machine*. Vol. 2: *The Pentagon of Power*. New York: Harcourt Brace Jovanovich.
- Nelson, R. and Winter, S. (1977) 'In search of a useful theory of innovation', *Research Policy*, 6 (1): 36–75.
- Nelson, R. and Winter, S. (1982) *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.
- Newell, A. and Sproull, R.F. (1982) 'Computer networks: Prospects for scientists', *Science*, 215 (12 February): 843–52.
- Nora, S. and Minc, A. (1981) *The Computerization of Society*. Cambridge, MA: MIT Press.
- Perez, C. and Soete, L. (1988) 'Catching up in technology: entry barriers and windows of opportunity', in G. Dosi, C. Freeman, R. Nelson, G. Silverberg and L. Soete (eds), *Technical Change and Economic Theory*. London and New York: Pinter. pp. 458–79.
- Pew Internet and American Life Project (2002) *Email at Work*. Washington, DC: Pew Internet and American Life Project. Available online: [http://www.pewinternet.org/pdfs/PIP\\_Work\\_Email\\_Report.pdf](http://www.pewinternet.org/pdfs/PIP_Work_Email_Report.pdf)
- Pew Internet and American Life Project (2005) *Internet Evolution: The Mainstreaming of Online Life*. Available online: [http://www.pewinternet.org/pdfs/Internet\\_Status\\_2005.pdf](http://www.pewinternet.org/pdfs/Internet_Status_2005.pdf)
- Rammert, W. (1992) 'Research on the generation and development of technology: the state of the art in Germany', in M. Dierkes and U. Hoffmann (eds), *New Technology at the Outset: Social Forces in the Shaping of Technological Innovations*. Frankfurt and New York: Campus. pp. 62–89.
- Rice, R.E. (1980) 'The impacts of computer-mediated organizational and interpersonal communication', *Annual Review of Information Science and Technology*, 15: 221–49.
- Rice, R.E. and Rogers, E.M. (1980) 'Reinvention in the innovation process', *Knowledge: Creation, Diffusion, Utilization*, 1 (4): 499–514.
- Rogers, E.M. (1986) *Communication Technology: the New Media in Society*. New York: Free Press.
- Rogers, E.M. (1995) *Diffusion of Innovations*, 4th edn. New York: Free Press.

- Rogers, E.M. and Kincaid, D.L. (1981) *Communication Networks: Toward a New Paradigm for Research*. New York: Free Press.
- Rosenberg, N. (1982) *Inside the Black Box: Technology and Economics*. New York and Cambridge: Cambridge University Press.
- Rydell, R.W. (1993) *World of Fairs*. Chicago, IL: University of Chicago Press.
- Schneider, V. (1991) 'The governance of large technical systems: the case of telecommunications', in T.R. LaPorte (ed.), *Responding to Large Technical Systems: Control or Anticipation*. Dordrecht and Boston: Kluwer. pp. 19–42.
- Schneider, V. (1994) 'Multinationals in transition: global technical integration and the role of corporate telecommunication networks', in J. Summerton (ed.), *Changing Large Technical Systems*. Boulder, CO: Westview. pp. 71–91.
- Schneider, V. (2000) 'Evolution in cyberspace: the adaptation of national videotext systems to the Internet', *The Information Society*, 16 (4): 319–28.
- Schneider, V., Charon, T., Graham, J.M., Miles, I. and Vedel, T. (1991) 'The dynamics of videotex development in Britain, France and Germany: a cross-national comparison', *European Journal of Communication*, 6: 187–212.
- Schön, D.A. (1988) 'Designing: rules, types and worlds', *Design Studies*, 9 (3): 181–90.
- Schön, D.A. (1990) 'The design process', in V.A. Howard (ed.), *Varieties of Thinking: Essays from Harvard's Philosophy of Education Research Center*. New York: Routledge. pp. 110–41.
- Sigel, E. (ed.) (1980) *Videotext: The Coming Revolution in Home/Office Information Retrieval*. White Plains, NY: Knowledge Industry.
- Slotten, H.R. (1995) 'Radio engineers, the Federal Radio Commission, and the social shaping of broadcast technology: creating "Radio Paradise"', *Technology and Culture*, 36 (4): 950–86.
- Sonnenwald, D.H. (1993) 'Communication in design'. Unpublished PhD dissertation, Rutgers University, New Brunswick, NJ.
- Star, S.L. (ed.) (1995) *The Cultures of Computing*. Oxford: Blackwell.
- Star, S.L. and Griesemer, J.R. (1989) 'Institutional ecology, translations and boundary objects: amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–1939', *Social Studies of Science*, 19: 387–420.
- Star, S.L. and Ruhleder, K. (1996) 'Steps towards an ecology of infrastructure: design and access for large information spaces', *Information Systems Research*, 7 (1): 111–34.
- Steinfeld, C. (1986) 'Computer-mediated communication systems', *Annual Review of Information Science and Technology*, 21: 167–202.
- Suchman, L. (1987) *Plans and Situated Actions: The Problem of Machine-human Communication*. Cambridge: Cambridge University Press.
- Suchman, L. (1996) 'Supporting articulation work', in R. Kling (ed.), *Computerization and Controversy: Value Conflicts and Social Choices*, 2nd edn. San Diego, CA: Academic. pp. 407–23.
- Suchman, L. and Jordan, B. (1997) 'Computerization and women's knowledge', in P.E. Agre and D. Schuler (eds), *Reinventing Technology, Rediscovering Community*. Greenwich, CT: Ablex. pp. 97–105.
- Summerton, J. (1994) *Changing Large Technical Systems*. Boulder, CO: Westview.
- Tydemann, J., Lipinski, H., Adler, R., Nyhan, M. and Zwimpfer, L. (1982) *Teletext and Videotex in the United States: Market Potential, Technology, Policy Issues*. New York: McGraw-Hill.
- Umble, D.Z. (1992) 'The Amish and the telephone: resistance and reconstruction', in R. Silverstone and E. Hirsch (eds), *Consuming Technologies: Media and Information in Domestic Spaces*. London: Routledge. pp. 183–94.
- Valente, T. (1995) *Network Models of the Diffusion of Innovations*. Cresskill, NJ: Hampton.
- Wellman, B. (1988) 'Structural analysis: from method and metaphor to theory and substance', in B. Wellman and S.D. Berkowitz (eds), *Social Structures: A Network Approach*. Cambridge: Cambridge University Press. pp. 19–61.
- Wellman, B. and Berkowitz, S.D. (1988) 'Introduction: studying social structures', in B. Wellman and S.D. Berkowitz (eds), *Social Structures: A Network Approach*. Cambridge: Cambridge University Press. pp. 1–13.
- Williams, R. and Edge, D. (1996) 'The social shaping of technology', *Research Policy*, 25: 865–99.
- Winner, L. (1977) *Autonomous Technology: Technics-out-of-control as a Theme in Political Thought*. Cambridge, MA: MIT Press.
- Winner, L. (1986) 'Do artifacts have politics?', in *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago, IL: University of Chicago Press. pp. 19–39.