Invisible Infrastructure:
Packet Networking Standards,
1968-1976

by

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Master of Arts

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“Invisible Infrastructure: Packet Networking Standards, 1968-1976”

submitted by Simon C. R. Cheesman, B.A.
in partial fulfillment of the requirements for
the degree of Master of Arts

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Abstract

This thesis investigates the creation and competition of packet-switching standards between 1968 and 1977. In particular it investigates the development of the ARPANET's Network Control Protocol, IBM's System Network Architecture and the telephone carriers' X.25 standard. It treats compatibility standards as a powerful and under-examined form of governance – a means of creating and reproducing particular technical-economic-regulatory structures of practice. It places this form of governance in the context of larger shifts in business and regulatory practices described as a period of transition from industrial to an 'information' society. This thesis seeks to problematize historical narratives of the Internet that draw a clear, unbroken path from the ARPANET to the modern Internet. Rather than autonomous technical trajectories, inherent technical characteristics and homogenous organizational will, it emphasizes the historical contingency of technical development and the “unity of opposing structures” that composes every apparently stable system of practice.

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Donnybrook.

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List of Acronyms

ANSI	American National Standards Institute
ARPA	Advanced Research Projects Agency
AT&T	American Telephone and Telegraph
BBN	Bolt, Beranek and Newman Inc.
BEMA	Business Equipment Manufacturers Association
CBEMA	Canadian Business Equipment Manufacturers Association
CCCTF	Canadian Computer/Communications Task Force
CCITT	International Telegraph and Telephone Consultative Committee
CIPOM	Committee on Computers, Information Processing and Office Machines
CNCP	Canadian National/Canadian Pacific Telecommunications Inc.
CPU	Central Processing Unit
CRTC	Canadian Radio and Television Commission (later the Canadian Radio-television Telecommunications Commission)
CSA	Canadian Standards Association
CTCA	Canadian Telecommunications Carrier Association
DCE	Data Circuit Equipment
DOC	Department of Communications (Canada)
DOD	Department of Defense (US)
DTE	Data Terminal Equipment
EDP	Electronic Data Processing
EFTS	Electronic Funds Transfer System
EPSS	Experimental Packet Switch System

ESS	Electronic Switching System
FCC	Federal Communications Commission
HDLC	High-level Data Link Control
IAB	Internet Architecture Board
IBM	International Business Machines
IEC	International Electro-technical Commission
IETF	Internet Engineering Task Force
INWG	International Network Working Group
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunications Union
LU	Logical Unit
MCI	Microwave Communications Inc.
NCP	Network Control Protocol
NTT	Nippon Telephone and Telegraph
NWG	Network Working Group
OECD	Organization for Economic Cooperation and Development
OSI	Open Systems Interconnect
PCI	Packet Communications Inc.
PSTN	Public Service Telephone Network
PTT	Postal, Telegraph, and Telephone
RCP	Réseau Commutation par Paquets
RETD	Red Espanol Telecomunicacion de Datos

RFC	Request for Comments
SCC	Standards Council of Canada
SDLC	Synchronous Data Link Control
SDO	Standards Development Organization
SNA	Systems Network Architecture
SSCP	System Services Control Point
TC	Technical Committee
TCP/IP	Transmission Control Protocol/Internet Protocol
TCTS	Trans-Canada Telephone System
USASI	United States of America Standards Institute

Introduction

This thesis investigates the creation and competition of packet-switching standards between 1968 and 1977. It treats compatibility standards as a powerful and under-examined form of governance – a means of creating and maintaining particular technical-economic-regulatory structures of practice.

The period in question marked the first serious clash over control of the development of data networks, not simply between competing actors, but between established and formerly autonomous industrial sectors: telecommunications, commercial computing, and military/academic research and development. This struggle was central to larger shifts in business and regulatory practices that have been described as a period of broad transition from an industrial to post-industrial society and economy. The 1970s clash over packet networking was played out in the social, political and economic arena of standards development. The results would determine important characteristics of a technology resting at the base of cause-and-effect arguments regarding technology and social/economic change.

The contenders: NCP, SNA and X.25

Packet-switching technology emerged in North America within three overlapping domains: the military/academic R&D community, the commercial computing industry, and the telecommunications sector. Technical frameworks emerged from each sphere of activity, intended to establish a formal or *de facto* standard for packet-switched networking. Beranek and Newman Inc. (BBN) developed its Network Control Protocol (NCP) on behalf of the U.S. Department of Defense's Advanced Research Projects Agency (ARPA) in 1969. IBM released its first System Network Architecture (SNA)-

compatible products in 1974. And the X.25 protocols received the International Telegraph and Telephone Consultative Committee's (CCITT) formal approval in 1976, although Bell Canada and other national carriers were operating prototype X.25 networks as early as 1974. The development and deployment of these early packet-switching standards form an important, but rarely told pre-history of the Internet.

Historical narratives of the Internet's development typically concentrate on the rise of packet-switching technology within the *first* of these spheres – the military/academic R&D community. A narrow focus is kept on the Advanced Research Projects Agency's experimental ARPANET initiative, leading to the modern Internet's much later emergence into the commercial sphere. The effect is not only to draw a linear path from the development of ARPANET to the Internet, but to also equate the packet-switching *concept* with the technical characteristics of a particular standardized *implementation* of it, and in turn with the system of practices characterizing the operation of the Internet today. These narratives, aside from creating a false picture of the Internet emerging out of the hermetically sealed confines of the Pentagon's research department, also obscure 'internal' ruptures in the ARPANET's own development. For example the replacement of the ARPANET's original protocols with the TCP/IP suite represented a radical, and in some senses an oppositional, departure from NCP in terms of network operation and control. But this protocol shift is consistently downplayed or characterized as a natural evolution of the original technology. Emphasized are autonomous technical trajectories, inherent technical characteristics and homogenous organizational will. In contrast, I wish to emphasize the historical contingency of technical development, the characteristics with which technologies are imbued in the process of arriving at standardized versions,

and the “unity of opposing structures” that composes every apparently stable system of practice.

Where technical compatibility is essential to a sphere’s operation, the way technical standards are worked out lies at the heart of the process by which that domain is defined and reproduced. A sector’s system of practice, its standards process, and the technologies it produces are homologous and reinforcing. Technical standards influence and naturalize the way a technology is deployed, controlled and developed over time. Control over the standards process bears a direct relation to control over the domain for which the standardized technology serves as an enabling infrastructure. Technical standards don’t simply reflect the interests of dominant stakeholders, to use Gramsci’s language, they reflect the hegemonic logic that regulates the entire system of practices and defines the sphere of activity. Technical standards reinforce the essential structure of the sphere as a whole, including the degree to which power and control is distributed or concentrated among particular players. The process by which new technical standards are developed is a key aspect of this distribution of power. In short, compatibility standards can be said to reflect the conditions of their production, and technologies based on those standards tend to favour the reproduction of those conditions.

Prior to the 1970s, the industrial practices of both the telecommunication and commercial computing sectors were characterized by the creation, maintenance and protection of large-scale, monolithic systems. Telecommunication carriers in Canada and the US owned and operated expansively defined infrastructures over which they were granted exclusive access and end-to-end control. Complementing this ‘internal monopoly’, potential competitors were also prohibited from building (or ‘overbuilding’)

a second infrastructure within the same service area as an existing licensed carrier. In contrast, the electronic data processing (EDP) industry was characterized by free-market competition. Yet, by the 1960s, the sector bore a remarkable resemblance to the telecommunications sector: dominated by a single corporation (IBM), providing large-scale, highly integrated machinery. Although not protected by a regulatory licensing regime, IBM (as well as other computer hardware manufacturers) focused on the “monopolization” of their customers and their own computer systems through contractual service and maintenance bundles, and technical integration.

Although held up as polar opposites in terms of industrial practice and technical approach, the telecommunications and commercial hardware industries of the late 1960s were both paragons of the Fordist model of business practices and technical implementation. But over the course of the 1970s, these practices came under increasing pressure, both from general shifts in the political-economic environment, as well as particular technical and competitive challenges from within their respective industries. “Teleprocessing,” in particular, challenged the technical, regulatory and service assumptions that underlay the monolithic-systems model that defined both the computing and telecommunication spheres by stimulating heterogeneous development at the ‘peripheries’ of both systems. Plug-compatible terminals and ‘foreign attachments’ challenged the ability and right of stakeholders in both industries to enforce the closely guarded ‘integrity’ of their infrastructures. *Packet switching*¹ emerged within the context of this larger attack on the monolithic-systems paradigm. The ARPANET was designed

¹ “A communications paradigm in which packets (messages or fragments of messages) are individually routed between nodes, with no previously established communications path. Packets are routed to their destination by the most expedient route (as determined by some routing algorithm). Not all packets travelling between the same two hosts, even from a single message, will necessarily follow the same route” (*Free Online Dictionary of Computing*, <http://foldoc.doc.ic.ac.uk>, 1999-03-30).

as a means to share computing power and applications using an independent “sub-network”² of mini-computers to carry out networking functions independent of the host computers connected to the network *and* the switching equipment of the telephone companies. From the perspective of the telephone carriers and IBM, the NCP protocols potentially posed a threat to the existing business and technical models of both industries *and* effectively displaced their technologies from playing any meaningful role in a largely undefined, but rapidly expanding industry.

Regulators in Canada and the US worked to establish frameworks for computer communications to flourish. In each country, legacy technical and service models articulated with national self-interest (influenced by current economic theories) to create unique regulatory approaches. The challenge was to define technical, regulatory and industrial interfaces between incumbent and novel services.

The SNA and X.25 packet-switching standards represented attempts to respond to these technical, regulatory and competitive threats, while extending their dominant positions into the new territories opened up by data communication services. SNA and X.25 protocols capture many of the innovative aspects of packet switching, while preserving the practices and power structures that defined their respective domains. Rather than a monolithic machine, the IBM and the telcos pursued a technical and strategic model based on a network architecture that would embrace technical heterogeneity and competition at its periphery, but position proprietary equipment and protocols at the network’s conceptual ‘centre,’ defining and providing essential data-

² The ARPA *network* consisted of host computers that performed applications for end-users. The *sub-network* refers to the interconnected minicomputers that carried out the communication functions involved in routing packets and controlling network activity.

transport services. IBM and the telcos pursued these similar visions in a competitive race to establish their technology as the *de facto* compatibility standard in the emerging commercial marketplace for data communications. Establishing their technical protocols and hardware as the critical network component would place IBM or the telephone companies in the privileged position of establishing the pricing and service models most compatible with their existing business practices. More importantly, *it would wed future technical innovation and service development to the standards process conjoined with a particular set of industrial boundaries*. Technical innovation would be confined to the ‘migration path’ defined by the industrial logic of the existing sector.

Thesis Outline

My research demonstrates that established regimes of technical standardization are an important means of incorporating environmental change – such as technological and regulatory changes - into an existing status quo. Standards naturalize a particular formulation and use of technology. *Successful* standards rely on broad acceptance and the cooperation of numerous stakeholders but ultimately reinforce particular hierarchies. Thus, I find Gramsci’s notion of hegemony to be a useful concept to organize my analysis.

I begin by reviewing existing literature on standards and the process of standardization in the IT and telecommunication industries. The literature is organized by theoretical approach, thus helping to distinguish my own approach and analytical framework. Many of the authors, regardless of their particular perspective, have become caught-up within the larger thesis of the ‘information’ or ‘post-industrial’ society. This larger intellectual movement has had a sweeping effect on how economic and regulatory

ideals are imagined, and thus the role standards should play in achieving them. This, and other limitations of these various approaches, lead me to adopt a Gramscian notion of hegemony to organize my analytical framework.

In the second chapter I outline the business practices, technological models and regulatory frameworks that characterized the telecommunications and computer hardware industries until the late 1960s. An emphasis on the distribution of scarce resources and the maximization of economies of scale corresponded with an emphasis on large scale, centralized production and control. Both industries internalized technical standardization within single corporations to the greatest extent possible, where standards could be produced within hierarchical, bureaucratic settings. Though ‘public’ standards setting was a marginal activity, especially in the US, it was thought to correspond to the actual level of demand of particular markets and commodities.

The concept of a ‘natural monopoly’ had been applied to telecom carriers in the early part of the twentieth century, a period when the computer industry consisted of a fragmented collection of specialized tabulating machine manufacturers. But by the 1960s, it looked increasingly as if the computer industry might also qualify for natural monopoly status. Aside from being increasingly dominated by IBM, the industry now seemed best described as producing sources of a generic resource similar to water or electricity: raw computing power. Time-sharing systems and packet switching emerged from the computer science community as a way to transform computer systems into computer ‘utilities’. Within this context, packet switching, and the ARPA’s NCP protocol standards reflected the priorities and principals of computer programmers attempting to efficiently distribute a scarce resource, in a manner that disrupted the technical and business

assumptions on which IBM and AT&T operated.

In the third chapter I review a series of reforms carried out in the US aimed at stimulating competition in both the computer and communication industries. These reforms were influenced by a shift in mainstream economic thought that emphasized the role played by technological advancement in the overall pace of economic growth. Computers, and the computer industry, with their rapid growth and cycles of technical development, came to symbolize the future of economic development. Government policy prized the distribution of computer technology more fully throughout business and society, and teleprocessing was seen as a key means of accomplishing this. However, the tightly integrated and proprietary standards used by both the computer and the telecommunications industries to protect their monolithic systems acted as a significant bottleneck to the development of teleprocessing services which depended on the interconnection of computers and communication systems. Seeing government oversight of standardization as a form of regulation with a negative effect on innovation, regulators refused to legislate their creation. Instead, the FCC and Justice department elected to disrupt these companies 'internal monopolies' through market structuring. Regulatory lines were drawn between technical and industrial components of formerly homogenous undertakings. The chapter closes with an analysis of IBM's SNA initiative – a system of internal standards that focused on data communications as a way to answer competitive challenges emerging from the computer marketplace and the Justice Department's anti-trust case. SNA reformed the company's strategy of controlling inviolable integrated systems, into controlling the means the components of an open system used to communicate and interoperate.

The fourth chapter contrasts the reforms undertaken in the US regarding computer communications with those undertaken in Canada. Rather than drawing a regulatory and technical divide between processing and communications, Canadian regulators sought to preserve regulatory control and economies of scale operating at the level of ‘carriage’ or ‘infrastructure’, while allowing for competition and diversity at the level of ‘content’, i.e. data and services that would be distributed by a prospective ‘national computer utility.’ This distinction led to quite a different technical picture of what a computer utility in fact was and what it signified: rather than computer power and economic impacts on business, Canadian regulators stressed the *informational* nature of its services and their wider *social* impacts. Standards too came in for quite different treatment – leading to intervention by the Canadian government on behalf of the carriers, helping to defend them against the encroachment of IBM’s SNA protocols into major networking initiatives.

The chapter closes with an analysis of the development of the X.25 packet switching protocol, an international public standard initiative undertaken by a handful of major carriers – with Bell Canada and the TCTS at the forefront of the effort. X.25 represented a compromise between a diverse number of actors, that ultimately created and reflected a vision of packet networking that reinforced the position of incumbent carriers and sought to extend it into the emerging ‘no-man’s-land’ of data networking.

Methodology

My analysis largely proceeds as a historical narrative, moving chronologically through the events of 1968 to 1977, beginning with the creation of NCP and ending with the formal approval of the X.25 standard. In each chapter I establish a political-

economic-technological context for the arrival of the protocol standard in question: NCP, SNA and finally X.25. I then attempt to demonstrate that each standard reflects a number of overlapping influences, and works to advance the interest not of a single, dominant stakeholder, but of an entire system of practice based on a hierarchy of interests.

I draw on a great deal of archival research taken from industry periodicals, especially *Datasystems*, *Data Communications* and *Canadian Datasystems*. Government policy information was drawn from official policy statements, commission reports on the issues surrounding computer communications. US policy analysis is largely based on the 1968 Presidential Task force on Telecommunications, also known as the Rostow Reports; and the FCC's first Computer Inquiry. Canadian policy analysis is based on several of the Telecommission reports, especially its study on the computer utility industry. I also draw on several studies carried out by the Canadian Computer Communications Task Force, including its final report *Branching Out*.

Chapter 1: Literature Review and Theoretical Framework

In the following discussion I review recent literature on technical compatibility standards in the spheres of IT and telecommunications, which I organize into economic, structural-functionalist, political-economic and sociological perspectives. While the latter three tend to focus on the various institutions that oversee the creation of standards, economic approaches play down their role in favour of seeing standards as the result of economic forces mediated by the actions of rational agents behaving in accordance with their imperfect informational inputs.

All of these broadly defined approaches have been profoundly influenced by ‘information society/economy’ discourses that place recent large-scale economic, political and social change into a reassuring explanatory context. Yet because the ‘paradigm shift’ associated with the emergence of an information society forms the taken-for-granted starting point for these analyses, they tend to focus on how political-economic-technological change has affected the production of “timely, high-quality standards”. Because I propose that standardization itself plays a constitutive role in the creation and distribution of the new communication technologies treated as the foundation of the ‘information society’, I require a theoretical framework able to place the rise of this dominant paradigm itself into a critical analytical context. For this reason, and a number of others articulated below, I choose Gramsci’s theory of hegemony as an organizing concept for my own analysis.

Network economics

Much of the recent academic work done on standards and standardization forms a subset of analytical work done on “network economics”. This branch of economics, as the name suggests, typically deals with economic phenomena arising in the context of

physical communication networks but also describes broader theoretical concerns.

“Networks” are a way to identify and analyze the direct interdependencies that exist between agents in an economic system other than those described by market mechanisms (that is, “where a variety of signals, besides prices, matter” (Antonelli, 1992: 15)). These interdependencies are referred to as *externalities*. The telecommunications and IT industries are extremely sensitive to so-called *adoption* and *network externalities*.

Because telecommunications is characterized by a high degree of technical compatibility and complementarity the process of introducing new technologies profoundly affects and is affected by existing technologies and the collective choices made by agents on the network. Network externalities describe the manner in which networked technologies, like fax machines and telephones, are subject to increasing utility as their number of users increases; their value ultimately depends on the adoption decisions made by other firms.

As Paul David explains:

...the functioning of any component of an integrated system cannot be evaluated in isolation, and its within-system performance can be affected by the attributes or behaviours of other components...the economic value of any technically defined variant of system design can in some degree be enhanced for those using it by enlarging the size of the user-community. *When technically interrelated components of a system are supplied by independent economic agents, both features give rise to network externalities* (cited in Antonelli, 1992: 14, emphasis added).

Once a technical component *has* been adopted into a network the value offered by a technically innovative, but incompatible, replacement must be greater than the opportunity costs involved in disrupting the smooth operation of the existing network. Those costs rise as the installed base of the incumbent technology grows. In economic terms, network members must balance the advantages of *dynamic* (value generated by innovation) and *static* (value extracted from fixed investment) *efficiencies*.

The concept of network externalities is further refined into what are called *direct* and *indirect externalities*. Direct externalities manifest themselves in the positive consumption incentives created as the size and expanse of a physical communications network grows (e.g., as the number of people a telephone owner can reach, and can be reached by, increases). Positive indirect externalities are created as the number of goods and services designed to operate using a particular durable good increases. Katz and Shapiro explain:

Network externalities are significant in many important industries where there are no physical networks. In fact most examples of network effects entail indirect externalities associated with the provision of a durable good (hardware) and a complementary good or service (software). In these cases the externality arises when the amount and variety of software available increase with the number of hardware units sold. For instance computers and programs must be used together to produce computing services and the greater sales of hardware, the more surplus the consumer is likely to enjoy in the software market due to increased entry (Antonelli, 1992: 18).

As the authors point out, these indirect externalities characterize a number of industries and technologies, from automobiles to disposable razors. But perhaps none more so than the field of computers, where the perceived power of indirect externalities to block the entry of competitors was recently demonstrated by the case carried out by the US Justice Department against Microsoft based on the dominance of its Windows operating system (OS) (Economides, 2001: 11).

While a generalization, it is fair to characterize the North American telecommunications industry prior to the 1980s as being dominated by direct network externalities and the personal computer industry by indirect externalities. Both industries were structured by an underlying monopoly. But the dominant position of incumbent exchange carriers was based on their ability to provide the infrastructure for a single,

largely undifferentiated service (telephony) virtually ubiquitously. IBM's dominant position on the other hand, was maintained by supplying a single widely-available platform used to deliver access to many software applications. However, as the importance of sharing digital information and services between individuals and organizations grew, so did the pressure on carriers to deliver a greater variety of communication services and on computer vendors to provide compatibility applications. The growth of teleprocessing in the 1970s created complementary needs for innovation in an industry characterized by stable homogeneity and stability in an industry characterized by constant innovation. Neither industry structure or regulatory regime ("regulation" is used here in its broadest sense, and includes forms of self-regulation and intra-industry organization) were entirely appropriate.

Of particular concern to network economists is the development and distribution of new technologies into markets where legacy technologies hold sway. The term 'externalities' refers to the fact that these particular market forces are not adequately 'communicated' in the form of prices. Network economies heighten the need for additional informational inputs in order for agents to make rational choices and to maximize overall market efficiencies. The mix of inter-organizational cooperation *and* competition demanded by the networked economy aren't seen as achievable by either a purely individualistic, interest-driven marketplace or a managed monopoly. Antonelli reiterates:

Traditionally markets have not proved to be the appropriate organizational framework to achieve the necessary levels of coordination in managing telecommunications networks. Monopolies based on vertical integration however have performed very poorly in attaining the desired levels of introduction of technological and organizational change (Antonelli, 1992: 14).

Network economists attempt to theorize new forms of inter-firm organization and regulation to create a system that allows for an “appropriate” balance of risk-taking and stability. Because technical compatibility and complementarity are a key characteristic of network economies, technical standardization plays a central role in these concerns. Standards regimes are seen as a key instrument by which the increasingly converged industries of telecommunications and IT can be “regulated” – a meeting ground between market and government forces. Antonelli again:

The trade-off between static and dynamic efficiency is in fact the trade-off between Market and Organization. Markets are likely to provide the maximum of opportunities for dynamic efficiency. Organizations are vice versa likely to be able to provide the necessary levels of compatibility and coherence at the expense of low rates of introduction and diffusion of technological and organizational innovations.

The elaboration of complex intermediate institutional solutions, such as Networks based on the interpenetration between Markets and Organizations seems an opportunity to blend the advantages of both systems (Ibid: 24).

Forming “intermediate institutional solutions” is seen as a rational reaction by firms attempting to internalize and control a number of otherwise unpredictable externalities, including technical standards (Angereau, 1999). Referred to as *clubs*, these alliances facilitate a degree of cooperation between competitors in order to share information and coordinate activities.

Network economics and the information society

The academic currency of network economics has advanced in step with the broader concept of the “information society” and “information economy”. Networks and information have become something of a theoretical touchstone for many of the social sciences in the last decade, economics being no exception. Paul David reflected in 1992

that, "...economists have been participating in a broader semantic trend that has seen the flowering of 'the network' as the favoured metaphor to be invoked when conceptualizing complex systems of production and social organization" (David, 1992: 103). The importance of direct and indirect network externalities, first recognized in the context of telecommunication networks, has come to be recognized more broadly throughout the economy as, according to Peter Monk:

[e]conomic activity is increasingly dominated by the production, distribution and consumption of information, both in its own right and as an adjunct to physical goods and services...new technologies which process information, rather than physical resources, now provide the means for a radical expansion of 'knowledge industries' in an 'information economy' (Monk, 1989: 36).

The 'information economy' concept arguably reached popular critical mass in the early 1990s, but can be traced back years earlier to work such as Marc Porat's nine-volume *The Information Economy*, published by the US Department of Commerce in 1977. Porat's initial claim that an information economy was emerging from the remnants of an industrial-based economy was mainly grounded on a quantitative analysis of corporate and government data. Explaining his findings in an article written the following year, Porat claimed that "informational activities engaged more than 46 percent of the work force, which earned over 53 percent of all labour income. On the strength of these findings, we call ours an 'information economy'" (Porat, 1978: 4). Frank Webster has criticized such quantitative definitions of an information economy/society for not taking into account the *qualitative* nature of information and the uses to which it is put. Porat's evidence fails to demonstrate any fundamental shift in the social/economic order of things (Webster, 1995: 10-13). Network economic theory has been used to fill the gap left by quantitative evidence: network economics highlights the qualitative change in

economic activity brought on by the increasing use and central role of IT in the marketplace. It can be argued that the play of externalities in a networked marketplace profoundly affects the dynamic of economic activity and agent behaviour. For example, business strategy since the late 1990s features such buzzwords as *co-opetition* and *value networks* (Brandenburger, 1996), and focused on strategies of *external disaggregation* in which companies develop symbiotic relationships instead of centralizing ownership and control over all aspects of their business (Day, 1998). Further, the new kinds of informational inputs required for rational decision making in a networked economy, and the ability of IT to digitally store, transmit and manipulate information combine to commoditize information in a much more fundamental manner than ever before. Network economics, as a heuristic device, draws out these very sorts of observations, observations that lead network economist Peter Monk to conclude that the information society represents “a period of radical economic change [which] calls for equally radical developments in ideas about how the economy operates and about how innovation can occur” (Monk, 1992: 35). Some authors have pointed directly to standards development as a key area for this new form of cooperative/competitive development to take shape (Rutkowski, 1995).

By the early 1990s, the profound influence of network economics on the analysis of topics central to the information economy was apparent. In 1991, for example, as part of its ongoing series on *Information, Computers and Communications Policy* (started in 1979), the OECD published a report on the economics of technical standards which echoes a great deal of the theoretical premises forwarded by the network economics school of thought. The following quote echoes Antonelli’s description of “intermediate

institutional formations”, as well as his concern for balancing static and dynamic efficiencies:

Market and committees, as alternative (informal and formal) modes of coordination, are agents of a static concept of efficiency. This concept focuses on the exploitation of network externalities on the basis of the maintenance of previously established critical masses. Dynamic efficiency, on the other hand, could be supported by “new forms of organisation” (OECD, 1991: 51).

Such analyses have provided governments and businesses with analytical and conceptual tools to ground strategic action in an unfamiliar economic environment. The “information society” provides a theoretical framework for conceptual tools like network economics to emerge. Paul David points out that the rise of the network metaphor to describe economic activity within an information society displaced the previously dominant metaphor that characterized the economy as a machine or engine, used during the reign of the industrial economy (David, 1992: 103). David Harvey’s well known work, *The Condition of Postmodernity*, explores in some detail the linkages between economic regimes and their accompanying dominant worldviews or, as he calls them, “myths”:

The myth [of modernity] either had to redeem us from the ‘formless universe of contingency’ or, more programmatically, to provide the impetus for a new project for human endeavor. One wing of modernism appealed to the image of rationality incorporated in the machine, the factory, the power of contemporary technology, or the city as a ‘living machine.’ ...a host of cultural producers...set out to impose rational order (‘rational’ defined by technological efficiency and machine production) for socially useful goals...(Harvey, 1990: 31)

These myths and metaphors help to constitute large-scale change as more than the product of instability and historical accident, instead appearing as the natural product of an evolutionary process. The metaphorical pattern in this case is clear enough – if the

industrial economy was like an engine, the informational economy is like a network.

The information society is as much a theory about the exhaustion of the industrial society as it is about the foundation of a new one. Porat's work, for example, was written at a time of profound economic recession, corporate restructuring and the apparent failure of the Fordist and Keynesian approach to economic management. As Harvey explains:

The sharp recession of 1973, exacerbated by the oil shock evidently shook the capitalist world out of the suffocating torpor of 'stagflation' (stagnant output of goods and high inflation of prices), and set in motion a whole set of processes that undermined the Fordist compromise (Ibid: 145).

Harvey's "Fordist compromise" refers to the collection of scientific managerial strategies, state powers and civil institutions aimed at stabilizing the capitalist system of exchange until their failure in the early 1970s. Porat's "information society" helped to recast this period of decline as a period of transition.

Schumpeter's theories of economic growth also play a central role in the information society paradigm. Schumpeter proposed that the ideal character of an economic system is not described by stability and equilibrium, as held by classical economics, but rather by a series of historical epochs instigated by clusters of key technological innovations which drive activity and create opportunity for a finite period of time. Eventually the dominant status quo is replaced by a novel set of technologies implemented by a new wave of motivated entrepreneurs, thus starting a new cycle of *creative destruction* in which the economy is remade in the image of these new technologies.³ These ideas have been applied, especially of late, as a kind of theoretical rationale for the emergence of an information society, centred on communication and information technologies. *The*

³ New School University's *History of Economic Thought* online resource provides an overview and collection of academic articles on Schumpeter and his influence: <http://cepa.newschool.edu/het/schump.htm>

Economist provides a somewhat simplified, technologically-determinist example of Schumpeterian economic theory in a 1999 article titled “Catch the Wave”:

By the time Schumpeter died in 1950, the third cycle of his “successive industrial revolutions” had already run its course. The fourth, powered by oil, electronics, aviation and mass production, is now rapidly winding down, if it has not gone already. All the evidence suggests that a fifth industrial revolution – based on semiconductors, fibre optics, genetics and software – is not only well under way but even approaching maturity. This may explain why America shrugged off its lethargy in the early 1990s and started bounding ahead again, leaving behind countries too preoccupied with preserving their fourth-wave industries (*Economist*, 1999).

Webster points out that a number of somewhat less boosterish analyses have also adopted a “neo-Schumpeterian” approach to change, contending “that IT represents the establishment of a new epoch. This new ‘techno-economic paradigm’ constitutes the ‘Information Age’ which is set to mature early in the next century” (Webster, 1995: 8). Specifically Webster notes the work of economists Christopher Freeman, Carlota Perez, Peter Hall and Paschal Preston. Eli Noam employed network economic theory to describe the inherent long-term instability of public telecommunication systems, specifically citing Schumpeter to characterize his approach (Noam, 1992: 110).

Theoretical limitations

The economics of information networks focus on how agents can manipulate and benefit from processes of local and large-scale change and economic disruption. Antonelli describes network economics as a unique means of fusing the domains of micro and macro economics by “incorporating into the microeconomic tradition the study of consequences of externalities on the behaviour of agents who are strategically aware of the role played by externalities in their decision making” (Antonelli, 1992:17). The theory is, in fact, inextricably bound with strategic interest from the perspective of

economic agents operating in a competitive marketplace, and as such has a number of built-in biases in terms of acting as a lens through which to view the process of technical standardization.

First it tends to intertwine two naturalized processes as interdependent engines of progress: technology and the economy. Webster is particularly critical of most versions of what he calls the ‘information society’ thesis, as implicitly subscribing to a theory of social transformation powered by engines of change that *transcend* society, especially in the case of technological innovation (Webster, 1995:10). Such underlying assumptions are evident in many analyses of technical standardization that draw on network economic theory as well. The OECD, for example, argues that:

[t]he early development of standards in information technology followed models set for earlier, major technological infrastructures...The roots of change are in the development of the stored-program, digital computer, with its inherent characteristics of recursion...This chain of developments describes a new standardization trajectory which challenges established approaches and represents a major diversion from the previous control-oriented, paradigm. In other words, major restructuring as a result of the growing integration of information technologies into communications, an integration that challenges the foundations of central control to reflect the enormous range of stakeholders and actors (OECD, 1991: 18).

The passage makes reference to the vast array of “stakeholders and actors” involved in the process of structurally integrating IT and telecommunications, but portrays them as having no hand in the apparently spontaneous process of technological integration.

According to this perspective, technology (e.g. the telegraph) defines the paradigm of operation (e.g. central control and closed networks) which determines the regulatory environment (e.g. regulated monopoly). A change in the first element leads to changes in the others. Standardization regimes are included as part of the overarching regulatory environment - technology then, to some extent is being said to determine its own mode of

standardization.

A second limitation of using network economics to theorize changes in regimes of technical standardization is the limited degree to which the theory can explain group formations. Group formation is the logical result of individual firms acting in their own self-interest, by both improving their access to pertinent information and to control environmental factors stemming from the network externalities created by group behaviour (Antonelli, 1992: 16). Angereau's recent investigation into determining the role network externalities play in the adoption of competing technical standards provides an appropriate example. The development of inter-organizational alliances is based on gaining strategic advantage in the marketplace and minimizing financial risk by reducing uncertainties, such as market acceptance of particular technical standards (Angereau, 1999). Angereau locates her empirical study entirely in the private realm to better isolate the effect of network externalities, and limit the effect of externalities other than those created by the 'consumption' of particular technical standards. Thus, the activities of government actors, formal standards development organizations (SDOs) and other non-private entities are absent from the study. Network externalities are essentially produced by rational agents acting in their own self-interest within the context of a competitive marketplace, making it a difficult concept to theorize actors other than private self-interested individuals, and any actor working outside of the marketplace.

Finally, network economics is bound to a strong *normative* project regarding the *proper* means of regulating technical standards. Network economics identifies a particular dynamic within the competitive marketplace affecting the diffusion of new technologies. But it goes beyond that identification to prescribing a re-balancing of

dynamic and static efficiencies by pushing the regulation of telecommunications and IT in general away from the typical bifurcation of competitive versus government activity and towards what it defines as a ‘middle ground’ of self-regulatory models of cooperation between firms. The programmatic elements of network economics, and the information economy, work on behalf of (and, as already pointed out, from the strict perspective of) the open marketplace itself. Larger priorities and other domains of activity are disregarded.

The fact that the importance of network externalities is concomitant with the rise of the ‘information society’ thesis suggests an embrace of a Schumpeterian vision of long waves of economic expansion based on the rising and falling crests of technical paradigms. The economic ideal is thus diverted from achieving unbroken equilibrium to embracing a degree of healthy economic churn, as the institutions and corporations of the past era are washed away by the rise of another. An article from *Fortune* magazine sums up this perspective on the “new economy”:

It's a messy business, this new economy. And despite what our leaders say, all the turmoil is actually good for us...Disequilibriums [are] not passing anomalies, Schumpeter asserted, but rather the very crux of the capitalist process: an entrepreneurial business--Microsoft, Nucor, Southwest Airlines--enters a market with a technological or organizational innovation, destroys the oligopolistic equilibrium, and siphons off wealth and jobs from the hegemonic giants. In that model of constant disequilibrium, the entrepreneur is the central economic protagonist, the fount of economic progress and quality-of-life improvements (Useem, 1997).

In this context, the primary job of regulators is to ‘get out of the way’ of emerging technologies and avoid ‘coddling’ businesses. As the OECD standards article states, formal standardization bodies are primarily institutions that preserve already achieved critical masses – and are thus a bottleneck for new ‘waves’ of technological innovation.

Structural-functionalist models

Despite the increased interest in the economics of standards, they were until recently considered by most to be a strictly bureaucratic entity. Standards were in an important sense simply defined *as the product of particular bureaucratic regimes* (Cargill, 1995; Branscomb, 1995). Cargill reflects on the level of scholarship devoted to formal standardization before the late 1980s:

The standards process, as it is generally described...details the rules for actually writing a standard, balloting that standard, and then having it approved. This is the arena in which many theorists concentrate their research...This flow chart shows the entire stream of activities involved in ensuring that a standard reaches consensus and follows all of the ANSI rules about being open to all possible participants. It includes 18 significant milestones along the way. This is, for many standards participants, “as good as it gets” (Cargill, 1994: 80).

Formal Standards Development Organizations (SDOs), like the International Organization for Standardization (ISO)⁴, remain particularly focused on developing a highly structured and regimented approach. Neilsen, who undertook an analysis of SDO ‘culture’, found that “There is a sharp focus on rules and procedures in the formal environment. Formality matters; rules are important.” (Neilsen, 1996: 124) This formalized process of consensus building lies at the centre of what was once a taken-for-granted system of industrial practice. Within each industrial sector (e.g. computers or telecommunications) a great number of fundamental decisions surrounding standards had already been agreed upon: industrial boundaries, when standards should be introduced into the market, the function they primarily served, who the primary stakeholders were and who should be involved in the formal process of drafting standards. Within this web

⁴ ISO is not an acronym, but a standardized ‘nickname’ for the organization, thus avoiding the problem of multiple acronyms corresponding to different translation’s of ISO’s proper title (e.g. IOS in English, OIN in French). ISO is derived from the Greek word *isos*, meaning ‘equal.’

of established precepts the practice of establishing consensus around particular technological choices appeared to be strictly a technical practice. And in this context, technocratic issues concerning due process tended to dominate.

Much of the more recent literature (within the last decade) dealing with formal standards procedures has focused on the need for, and ongoing process of, SDO reform. Institutional reforms, and the flood of written commentary and analysis it has produced, has been in response to a number of significant changes in the larger standards-setting environment which began to materially impact SDOs in a number of ways by the late 1980s.

First, the success of Internet protocols at the expense of formal SDO initiatives, in particular the spectacular failure of the Open Systems Interconnect (OSI) project, soured many participants on organizations such as ISO and the CCITT. OSI was one of the largest standards efforts in the history of formal standardization and sought to reproduce many of the functions offered by the TCP/IP protocol suite. OSI occupied both the CCITT and ISO for more than a decade, but by the mid-1990s most countries had adopted Internet protocols instead of OSI-approved technologies. This broad adoption of TCP/IP focused attention on the Internet community's own standardization procedures and institutions, such as the Internet Architecture Board (IAB) and the Internet Engineering Task Force (IETF) (Branscomb, 1995: 6).

Second, technology stakeholders began to divert time and resources into alternative standardization organizations, primarily privately run standards consortia. Carl Cargill describes the trend from the perspective of a long-time participant in the IT standards process:

During [1993], X3's⁵ active membership declined from over 3000 members to slightly less than 2000. The rationale given by X3 members for the decline was that companies could not afford to fund the activities, that there was an economic downturn, and that major areas of interest were completed. In reality, the same companies that were decommitting from X3 were continuing to fund standardization consortia.

Approximately one major new consortium per quarter is being created. (A major consortium is defined as a consortia which costs over \$50,000 per year to join; minor consortia appear even more quickly.) That creation rate continues today (June 1994). One must wonder why major corporations were pouring money into these consortia if the "interesting" things were done and if there was an economic downturn (Cargill, 1994: 84).

The standardization field in the US and elsewhere has continued to fragment with the creation of new formal and private SDOs as well – a great number of which, although not formally concerned with IT, "began to preempt some of the territory previously considered the domain of IT standards" (Cargill, 1994: 85).

Third, regulatory change opened clefts between SDOs' mandate, membership rules, and their traditional participants. For example, the ITU remained primarily an inter-governmental organization at a time when the telecommunications industry was quickly entering the private sector. The ITU's bureaucratic architecture was designed to accommodate organizational relationships that were quickly becoming obsolete (MacLean, 1995: 182).

A number of authors have focused on improving the standards process as it now exists, ranging in their focus from "micro-practices" (particular day-to-day activities involved in standards development) to a more "macro" perspective that seeks to reform larger organizational policies. Many of their articles and reports are the result of SDO-sponsored research. In a 1995 report, Spring et al focus on "the human dimensions of standards development (e.g. behaviour, skills, group dynamics)...The data was analyzed

⁵ X3 is the largest national IT standards committee in the US.

to find mechanisms for improving management skills and personal characteristics through training” (Spring 1995: 225). Using different methodology, Neilsen has taken a similar approach (Neilsen, 1996). Morell and Stewart offer a number of incrementalist strategies for improving the SDOs process, focusing on training chairpersons to better lead technical committees, committee selection and improving rules of procedure (Morell, 1995). Carl Cargill has written extensively on standards reform, having developed one of the first analytical models of standardization that looks beyond the formal consensus process; his well-known “five segment model of standardization” has been the center of a great deal of constructive commentary and elaboration (Cargill, 1995). These studies lie behind many of the SDO reforms that have been implemented over the last ten years or so. The CCITT, for example, initiated a process of reform that resulted in a major restructuring of the organization (including its renaming as the ITU-T) and shedding its rigid four-year publication cycle so that new standards could be ratified and distributed upon completion (Irmer, 1994). Many SDOs developed “fast track” procedures to reduce unnecessary overlap between SDOs by adopting work already done on standards at the domestic or international level (Besen, 1990). Following the lead of Internet standards organizations, the use of electronic communication to negotiate and distribute standards were also discussed and initiated by SDOs by the mid-1990s in hopes of creating a faster, more open and inclusive standards environment (Amy, 1994).

Some writers have framed their analysis within an attempt to discover the core competencies of each type of standards organization and by doing so help to rationalize and coordinate their efforts. The underlying assumption is that the arrival of private consortia and Internet standards bodies signals a change in the standards environment,

and new organizations have arisen in response to the needs of that environment. As Nak writes:

These [private consortia] are emerging to meet the immediate needs of the marketplace with temporary solutions. Attempts are being made to pass these interim solutions to the accredited standards bodies for refinement, consistency and thoroughness. This “competition” is providing motivation for standards bodies to expedite their work and provide timely and effective solutions (Nak, 1994: 73).

These writers combine a free-market model of standards development with functionalist logic that assumes the presence of different types of SDOs is evidence of a changing environment that requires new organizations, and inter-organizational relationships to maintain equilibrium within the larger standards-making environment. Morell and Stewart (1995) note that the process of carefully filtering out “irrelevant” standardization efforts from the overworked SDOs is now a critical part of the standards development process. Essentially this means that there has been a shift in the criteria used to green-light a standardization effort from technical to economic grounds. With increased competition, decreased tolerance for vendor lock-in⁶ (and thus higher expectation of standardized products from consumers) and the need of interoperability between computer products, standards have been firmly placed in the domain of business innovation and marketing, a job purportedly better placed in the hands of private industry. Their recommendation is for private standards consortia to be responsible for choosing technologies to standardize, and for SDOs to act as a kind of clearinghouse for their work: “to begin developing more standards through industry consortia, and to use the work of those consortia to define and validate both proposed work items and

⁶ *Vendor lock-in* refers to the state of dependence consumers of computer services find themselves in when the cost of converting data and services over to a new, incompatible infrastructure makes leaving a current hardware or software vendor economically difficult or impossible.

standards” (Morell, 1995: 218).

Organizational metaphors: from efficient machine to flexible network

The analyses cited above, focusing on the need and means of institutional reform, mirror larger trends in theories of organizational efficiency and the appropriate role to be played by public bodies with regard to private enterprise.

Bureaucracy, particularly in the ideal sense given to it by Weber and subsequent analyses, is seen as the quintessentially modernist embodiment of rational and secular authority. As a system of rules enforced within an organization as a matter of principle they take on a self-legitimizing and impersonal character. The supra-personal nature of these rules gives them the quality of a concrete object; Weber saw bureaucracy as a sort of *machine* in its own right, an engine of *production*. As Weber wrote:

The decisive reason for the advance of bureaucratic organizations has always been its purely technical superiority over any other kind of organization. The fully developed bureaucratic mechanism compares with other organizations exactly as does the machine with the non-mechanical modes of organization (cited in Elwell, 1996).

The mechanistic imagery associated with this managerial approach has an intuitive complementarity with the Fordist-era means of production which, as Harvey points out, typically relied on large fixed investments balanced by efficient and regular production (Harvey, 1990). However, along with the economic downturn during the 1970s and the rise of the information society thesis, the appeal of the mechanistic metaphor to describe economic activity began to seriously wane. Like Fordist production itself, bureaucratic management was criticized for both its inflexibility and tendency to spend an increasing level of energy preserving its own organizational hierarchy and status quo rather than the external goals it was originally assembled to achieve (e.g. ‘goal displacement’ was

described in Robert Merton's "Bureaucratic Structure and Personality" as early as the 1950s (Merton, 1957: 195-206)).

Writing on the "New Public Administration," Kaul relates the sea-change in administrative theory and practice to the same changes in the global politico-economic environment identified by Harvey:

The general collapse of the centrally planned economic systems underscored the poor performance of government services worldwide. This collapse demonstrated that the solutions to the problems of poor public services not only required a managerial re-think in all government operations, but also dictated a reassessment of the fundamental responsibilities of government in economic management and delivery of public service.

The upsurge in liberal market economic policies and in liberal democratic political philosophies led to a new and narrower definition of the role of government, the new institutional economics, combined with a wave of private business-style management practice breaking across the government ensuring that public services were structured and managed very differently (Kaul, 1997: 13).

Reductions in staff and resources have been coupled with a complementary administrative rationale that calls upon government to act as an overseer of policy goals, as a *facilitator* rather than a *producer* of outcomes. As Kaul sums up, "As government moves from a concern to do towards a concern to ensure that things are done, the managerial focus has increasingly been directed away from formal processes towards results" (Ibid: 14). This shift places emphasis on the role of government to provide guidance in the form of information, to play the role of honest broker and to influence outcomes such that they forward long term economic and social goals. The result is to refashion government from a policy machine to a forum for mediating private and public interest groups; public administration is no longer the engine but the infrastructure for policy creation and implementation. As in economic theory, the ruling metaphor has

shifted from machine to network.

The corresponding result in standards literature has been a shift in emphasis towards formal SDOs' role as a 'clearinghouse' for standards produced by private standards consortia. This has been accompanied by attempts to create more flexible, inclusive processes to accommodate a wider range of stakeholders and proceed at a less regimented pace.

Theoretical Limitations

This body of literature provides necessary, detailed insights into the internal operation of SDOs that, until recently, dominated the standards-setting process within telecommunication and computing spheres (e.g. the CCITT and ISO at the international level, respectively). But aside from descriptive information, this perspective's ability to discuss change is limited to reactive prescriptions regarding how to reform organizational practices to better meet stakeholder expectations. Its analytical norms strongly tend toward self-preservation (especially as the writers are often themselves SDO 'insiders'); no matter how 'radical' or deep-seated the suggested reforms may seem they do not include disbanding organizations or phasing out formal standards altogether. To the extent they are included at all, explanatory accounts point uncritically to large-scale environmental change affecting the needs of standards stakeholders. New entities such as the IETF and industry consortia are symptoms of change, in the form of competition provoking SDOs to do their job (i.e., producing "timely", "high quality" standards) better or to focus their efforts on performing a particular role within the changed standards-making environment.

Political-economic models

A number of authors (Egyedi, 1999; Irmer, 1990; Van Rooij 1992) have pointed to an increase in the characterization of standards, and standards organizations, as tools of corporate strategy and political statecraft. Egyedi claims that:

...a shift appears to have taken place from a style of standardization predominately based on technological considerations towards a process with strong political and economic overtones. It is now more or less understood that economic and political interests determine the outcome of negotiations in standards committees. Studies of standards processes buttress this view...(Egyedi, 1999: 355)

In stark contrast with the last body of literature, which tends to focus on the formal aspects of drafting standards in an attempt to eliminate particular 'corporate interests' from corrupting a standard (Spring, 1995), political-economic analyses treat SDOs similar to private consortia, as a means to mediate stakeholder interests on behalf of particular industries. Egyedi continues:

More often, what seems to be a formal technical discussion turns out to be the negotiation of interests. Non-technical interests are translated into an institutionally legitimate type of reasoning, that is, a technical type of reasoning. The conclusion of these studies is clear: technological knowledge is predominantly a resource for strategic action, and not a decisive factor in itself (Ibid).

The increasing appreciation for the political and economic significance of IT and telecommunication standards corresponds with a number of developments in those industries.

First, an increase in the number of technologies that involve both computer and telecommunications SDOs has led to a greater appreciation for the manner in which particular organizations serve the strategic interests of their members. The OSI effort, in which the ISO and CCITT organizations were formally joined in 1983-4, underlined the structural and cultural differences between these two organizations and the fact that each

represented separate and competing group interests.

Lehr demonstrates how firms negotiate standards on behalf of their self-interest both within particular SDOs, but also between them. Firms negotiate over venue selection in order to improve the likelihood that emergent standards will benefit their market position. In contrast with the functionalist explanation for SDO reform, which stresses the need for greater efficiency in the face of competition from new standardization fora, Lehr uses “a game theoretic model to explain the increased controversy regarding the effectiveness of standards setting practices...” His case study reveals how the conflict between telecommunication and computer vendor interests has led to standards “venue shopping” in an attempt to influence “the future evolution of data networks” in such a way as to provide strategic advantage (Lehr, 1992: iv).

Second, the emergence of so-called anticipatory standards into the competitive commercial sphere has also played an important role of focusing analytical attention on the strategic rather than technological aspect of compatibility standards (Cargill, 1989; Bonino, 1999; Branscomb, 1995). Standards within the competitive computer industry, where innovation and being “first to market” provide important competitive advantages, tended to be introduced for technologies considered to be mature and ready to be “commoditized”, that is where *price* rather than value-added *innovations* would be the major competitive ground. Standards were defined as something that came *after* technological invention, and as rules intended to *limit* rather than spur innovation. In the telecommunications industry however, in which competition was much less a factor, and where interconnection and interoperability were much more important, standards in some cases preceded the commercial implementation of technologies (Hummel, 1985).

However, as the communicative aspects and interoperability of computers grew in importance, as did the competitive value of “open systems” in general, so called anticipatory standards were seen as a prerequisite to building markets for new computer services and technologies. Branscomb and Kahin characterize the emergence of non-formal standardization as a response to the failure of traditional SDO’s to successfully develop anticipatory standards – a failure epitomized by the OSI effort (Branscomb, 1995: 8). Bonino and Spring suggest a “theory of standardization” that would, among other things, treat standards as “change agents in the information technology market”, a radical repositioning from their earlier use for computer technologies past their prime and ready for commoditization. This has led some writers to equate standards with corporate strategy:

What is needed is a shift of the paradigm away from viewing standards as created in a technological and economic context. Thinking about standards needs to be steered towards the more productive model that reflects their potential for functioning as change agents in the business market setting (Bonino, 1999: 285).

A third trend is also drawing standards to the attention of political economists. The broader perception of the role standards play in maintaining industrial configurations and practices, providing competitive advantage within and between industrial boundaries, and setting courses of future competitive activities through anticipatory standards have inspired recent interest in the role governments should play in the process of standardization, as well as the potential of SDOs to operate in a more formal regulatory capacity.

The role of government in the sphere of compatibility standards has only recently emerged as a more coherent policy area in the face of a number of technological,

regulatory and economic trends. The technical and industrial convergences between formerly distinct spheres of activity – in particular telecommunications, broadcasting and computers – have highlighted the role of standards that now cut across all three industries and the differences between the manner in which each industry managed its own standards regimes (Branscomb, 1995). For example, whereas in both France (Crane, 1979) and the US regulators (Neil, 1995; Head, 1990) have acted directly to use broadcast and television standards to shield their domestic electronics industries from foreign competition, the US at least has maintained its policy of non-intervention in the realm of IT standards.

Internationally, trade liberalization promoted and enforced by organizations such as the WTO and trade agreements like NAFTA, have put nations under increasing pressure to eliminate non-tariff trade barriers (especially post-Tokyo round WTO negotiations (Trebilcock, 1999: 140-141)), including technical barriers such as compatibility standards. This too has highlighted the attention they receive as a necessary element in the process of trade liberalization (OECD, 1992: 13). This trend of course is complemented by the growing importance of telecommunications and data services as an issue of international trade (Trebilcock, 1999: 299-305).

But while the political significance of compatibility standards has grown, the ability and willingness of governments to act directly to legislate them has diminished. Instead, especially in the US, standards are treated as a means of facilitating the development of technologies from a pre-competitive stage to the marketplace. This vision depicts private and public technology stakeholders working in unison to bring technologies from a “pre-competitive” state to their successful “commoditization”:

The test [of a standard] lies in the market response to the standards process and...in the further response of the standards process to the market. The challenge is to determine how this process can effectively bootstrap the evolution of a technology, from conceptualization and innovation to commoditization (Branscomb, 1995: 4).

Branscomb and Kahin argue that the standards process should be pictured less as a set of institutionalized procedures leading to the production of technical specifications, and more as a flexible system mediating between private and public interests, comparable (and complementary) to the legal regime of intellectual property laws – “a system to promote investment and a body of public knowledge” (Ibid: 23).

Schoechle has gone as far as to argue that domestic SDOs should play a strong and largely independent role from the government in developing and implementing public policy. He argues that their independence from government and emphasis on due process allow (US) SDOs to serve as the kind of “public sphere” described by Habermas:

Standards making can be seen as a form of discourse ethics within the context defined by Habermas...The essence of discourse ethics is that universal ethical principles and the relation between the justification and application of norms can be socially constructed from rational discourse based on language. In this model, Habermas extends the enlightenment project, committing to the proposition that negotiated norms of truth and good can be determined through consensus and group will, especially if procedural principles of rational discourse, which include what he calls “ideal speech,” can be adhered to (Schoechle, 1995: 1).

Aside from accomplishing technical compatibility, SDOs could settle questions regarding the technical aspects surrounding privacy, the environment, safety and health, and consumer-rights issues. Although Schoechle’s analogy between SDOs and the public sphere quickly breaks down under closer scrutiny (for example, SDO participants are typically representatives of corporations, with vested economic interests in the outcome), it helps illustrate how policy-making is becoming increasingly equated with a simple

process of interest-mediation rather than serving some larger “public interest”.

Theoretical Limitations

The political-economic perspective sees SDOs’ organizational form and function as embedded within a larger system of power and influence which mediates the activities of self-interested groups. Formal procedures are treated as functional components, serving the interests of elites within a particular sphere of activity. Although both organizational structure and technological trajectories can be acknowledged as having significant material impact on actors and outcomes, they are ultimately subordinate to the pursuit and maintenance of self-interest, defined in rational economic terms.

Within a political-economic perspective it is the concepts of power and interest that become the transparent basis for the rest of its penetrating analysis. But for the purposes of this thesis, I am particularly concerned with how ‘interest’ is itself contingent and constructed. First, as I have tried to highlight throughout this chapter, shifts in theoretical movements – network economics or the ‘new’ public administration, for example – tend to evolve along parallel lines within larger meta-narratives defined by a central metaphor or metaphors. Since the 1970s the metaphors used to characterize social, economic and governmental activity have shifted away from ‘the machine’ and towards ‘the network.’ Within this meta-narrative ‘interest’ – the long-term interest of capital – has been redefined in ways compatible with the narrative itself *as has the activity of ‘self-interested’ agents*. In order to investigate the role standardization plays in regulating the relatively stable power structures of state-industrial configurations, and the role it played in the transitional period between them, I require a theoretical perspective that can show *how material practice articulates with idealized accounts of that practice and how the*

process of standardization facilitates that articulation.

Second, the political-economic perspectives cited here assume that agents and organizations within the standards process *simply* operate as peons of larger powers, that standards participants *only* participate by, knowingly or unknowingly, translating economic interests into technical jargon. This view equates standards *as* strategy and while successfully avoiding the treatment of technological progress as singular, transcendent and inevitable, it discounts the idea that certain technological trajectories, defined by their own internal dynamic, influence the standards process at all. Thus, it creates a significant blind spot with regards to the arrival of the IETF and the development of the Internet and its protocol suite whose pioneers acted largely outside of the commercial sphere. The ‘interests’ uniting and motivating this community are more appropriately defined sociologically and technologically than economically.

The process of ‘consensus building’ includes but goes beyond both the institutional structures that contain it and the economic interests that pressure it. In short, what is required is a theory able to demonstrate how larger economic interests articulate with the particular sociological understanding these groups have of themselves and their activities.

The Sociology of Standards: Egyedi’s *Shaping Standardization*

Egyedi’s *Shaping Standardization* goes beyond a simple ‘sociological’ analysis of standards making. Neilsen, for example, has produced a lengthy analysis of how the culture and working styles of different SDOs can affect the outcome of the standards process. Within her analysis institutional structures interlock with the culture and community produced within. While providing excellent insight into the processes of standardization within various kinds of SDOs, Neilsen’s work is limited by the degree to

which it remains an internal analysis of standards qua standards (Neilsen, 1996).

Egyedi, on the other hand, specifically seeks to link the internal logic of standards groups, their institutional contexts and the larger political-economic environment in which standards are utilized. Towards this end, she splits her object of study into three integral components: “Here, standardization refers to three features: the standard, the standards process and the political meaning of standardization” (Egyedi 1996: 1). Her approach is to analyze a technical standard, the institutional environment in which it was produced, and the larger political environment in which the institution itself operates. Each of these three aspects of the standard is matched with its own analytical lens: the socio-cognitive, the institutional and the political.

At the first level, Kuhn’s concept of scientific *paradigms* is used to explore how the established conceptual framework of a technical community strongly determines the shape of technological innovation within that community. Paradigmatic features are reproduced in the creation of new technology (and their standards), excluding other approaches and techniques. In the development of technological standards, Egyedi claims that paradigms provide a more basic and inclusive explanation for outcomes than either technical trajectories or the negotiation of economic interest. *Interest* and *innovation* are, to a large extent, concepts defined within particular paradigms (Egyedi, 1996: 8).

Egyedi describes her use of the term paradigm as “roughly corresponding” to Kuhn’s: “a set of technology-related cognitions which structure and focus the behaviour of practitioners in a field of technology” (Egyedi, 1999: 356). Out of these cognitions come shared “methods, heuristics and rules”, as well as “exemplars” (achievements which serve as a common point of reference and model for future activity):

These and the beliefs and expectations of the practitioner community structure actions. These actions can be understood in terms of structured search processes and follow patterns of 'normal' problem solving (Egyedi, 1999: 356).

Importantly, Egyedi does not conceptually isolate cognitive structures on the one hand, and material circumstance and interests on the other. Rather they become interdependent within her definition of paradigm:

Technological heuristics develop in interaction with their operational environment. Practitioner communities in the field of telematic services, for example, assess the developments in service demand differently, take the turnover rate of business equipment in their ideas, favour different architectural design, etc. depending on the market segment they operate in. Especially in applied fields of technology, paradigms embody operational and economic heuristics (Egyedi, 1999: 372).

Whereas critical political-economic analysis might seek to demonstrate how standards are used by power elites to protect a particular techno-industrial status quo through coercive and ideological means, Egyedi proposes that such a status quo itself is part of a larger 'conceptual' status quo: *the paradigm*. Within the field of standardization then, individual agents are not primarily negotiating on behalf of their employers' economic interests, but their own cognitive 'self-interest':

Stability is in the interest of practitioners as changes in the operational environment could demand a change of paradigm, and paradigms are not easily discarded. Paradigm adherents will do what they can to maintain the status quo and will oppose changes. In other words; interest negotiation in standards committees is partly to be understood as a means to preserve the operational trajectory which supports the paradigm-based technological trajectory (Egyedi, 1999: 372).

Perhaps because the notion of a paradigm is so closely associated with scientific and technological knowledge, Egyedi does not apply it to either of her next two 'layers' of analysis. The institutional contexts in which the development of standards takes place are analyzed in terms of their *formal procedures* and *ideology* (one, Egyedi points out, is

often modified independently from the other). The political context is defined as a series of *actor networks* defined by geography (national, regional and international) and their functional proximity to standardization itself (formal core, operational and political). While the developments in each layer are seen as having significant impacts on the activities and outcomes of the others, they are not seen as necessarily homologous to each other. Her goal is to identify and analyze the stable configurations at each of her analytically distinct levels rather than treating them as components of a larger configuration. And because each element of standardization is subjected to a different socio-cognitive perspective and focuses on different objects of analysis, the effect is to heighten the different dynamic and goals at work. One consequence of Egyedi's approach is to suggest, for example, that while *technological* standards are developed within preexisting paradigms, *political* standards are not.

Furthermore, Kuhn's theory of scientific paradigms suffers from significant limitations for my project's purposes. On the positive side, as previously mentioned, Egyedi's use of the term ties together the complex material circumstances of those involved in the standards process from the telecommunications and computer industries and the collective cognitions that guide their activities. Nevertheless, an important element of economic and technological determinism remains in how Egyedi *identifies* paradigms. In her main discussion of the conflict over the OSI protocols, Egyedi focuses on the debates between the two established standards communities involved: the ITU and ISO, the telecommunications and computer paradigms, respectively. Egyedi writes, "In order to avoid an unproductive theoretical discussion on paradigm identification, I focus on paradigmatic elements" (Egyedi 1999: 359). These elements act as indexes of the

“shared outlooks and orientations...relevant for standardization” (Ibid). In the case of her analysis of the OSI process Egyedi follows two leads in order to identify the opposing/cooperating groups identified for her analysis: *management domains* and *economic considerations*. With regard to management domains, Egyedi explains:

In the field of information and communication technology components, subsystems and systems can be distinguished. It depends on the angle one takes, whether an artifact is labeled a component, a subsystem or a system. It specifically depends on the management domain under consideration (Egyedi 1999: 359).

Within the management domain of telecommunications, the public network is defined as the primary system, with local and wide area networks (WANs and LANs) considered *subsystems*. Within IT, the starting point was the computers or LANs, thus distinguishing it from the paradigm of telecommunications by privileging the private management domain over the public one (Ibid: 361). The *economic considerations* Egyedi goes on to identify flow naturally from these technologically defined management domains: capital investment, service definition, bandwidth allocation, product cycles, etc. Two sweeping paradigms are thus created based on their technological underpinnings (computers versus telephones) with very little internal differentiation. The result is to reify categories and structural relationships defined by a competitive economic marketplace: telephony versus computer vendors. This, despite the fact that, in comparison with the Internet community emerging from within academic and research circles, telecommunication and computer companies were actually in fundamental agreement in their ideas regarding standards making and technological innovation. These two groups were in competition to achieve the same goal: the capture of market share. The truly oppositional nature of the Internet community, it's true exteriority to the century-old ISO and ITU processes of standards

and technological development, cannot be said to emerge from a separate, technologically-defined *management domain*, which was (like the ISO community) computer oriented. Its different economic considerations are not explained by the technological basis of their field of activity. Thus, what is required is a conceptual framework less technologically oriented and more explicitly political in its priorities.

Hegemony

Like Kuhn's paradigm, *hegemony* also describes a configuration of agents engaged in material practice and operating within a concomitant set of cognitions that form an epistemological and ontological rationale for the operational status quo. However, evolving as it does out of Marx's theory of capitalist ideology, it retains a defining emphasis on issues of power and influence, the economic and the political, and change within a large-scale holistic view of society. The notion of hegemony, as developed by Antonio Gramsci in his *Prison Notebooks*, provides a useful framework to unite an analysis of the larger social-economic environment with particular occurrences in the realm of standards making, without making the latter simply the mechanistic result of the former (Gramsci, 1971).

Gramsci used the concept of hegemony to explore the ways that a ruling class leads disparate groups within a structure of alliances maintained through a combination of "moral and intellectual leadership" and coercion. While hegemony denotes the consent and support of agents within a particular power hierarchy, hegemony manifests itself within a complex set of alliances backed up by the threat or actual use of physical force. Kurtz contrasts hegemony with a reliance on "the leadership of a single individual or any occult structuralist energy, such as a discourse, a collective conscience, deep structure or

culture” (Kurtz,1996:107) in order to explain the consent given by exploited groups to be ruled within a stable set of practices. “Hegemony” is an ideology that is the *result* of negotiations between unequal groups, not the determinant element existing outside the negotiations itself – as it is in Marx’s base-superstructure model. Kurtz explains:

Hegemony construed as an organization of agents that provide intellectual and moral leadership is the key to understanding Gramsci’s idea of hegemony and his political project, which is to analyze the role of the political-ideological superstructure in political processes. Hegemony provides the focus for *neo-Marxists*, that is Gramscian Marxists, to counteract the emphasis by traditional Marxists on the ontological primacy of the economic base (Ibid: 107).

Thus, hegemony places explanatory emphasis for any durable social and political order on the practical processes by which a common, hegemonic understanding is negotiated, formulated and distributed within groups and society.

Standards Making as a Hegemonic Order

The concept of hegemony provides a double insight into the standards process, into both the formal consensus-building activities and the way that a technological consensus is used to preserve an order of established practices. In short, hegemony provides a useful means to contextualize both the mechanics and the significance of the standards process. Hegemony places SDOs, analytically, at a central point of articulation between the naturalization of technological trajectories (often presented as self-determining and inevitable) and larger political-economic trajectories (which often point back to technology to establish their own inevitable character). In the next several paragraphs I will highlight four key theoretical advantages gained by using a Gramscian notion of hegemony in framing my analysis. The first two are characteristics of a hegemonic formation that seem especially compatible with the formal process of developing

standards and the particular case study in question: the essential dialectic between force and voluntarism, and the complex set of alliances that define a hegemonic order. The latter two help me to identify *significant* change in a period characterized by flux and transition: hegemony locates the source of change in the continual process of renewal and reassertion of authority, and defines ‘oppositional’ forces as those offering *alternatives* to an existing order, rather than simply a change in the hierarchy of its membership.

Flexibility and compromise in the formation of a ruling consensus is central to Gramsci’s notion of hegemony. Williams comments that “the decisive hegemonic function is to control or transform or even incorporate” voices of opposition (Williams, 1997: 144). And although the work of SDOs is unquestionably dominated by large industrial and political powers, the principles of inclusion and voluntarism are of the utmost importance in both the creation and implementation of technical standards. Internally, within most standards organizations, there is a great deal of procedural emphasis placed on addressing opposition to a standard: compromises must be made until a supermajority is reached (Cargill, 1995). Almost all participants eventually willingly *accept* and *feel implicated* in the final decisions that emerge. The standards produced by the ITU and ISO are nominally considered “recommendations” and “voluntary” standards but have as much, if not greater, influence than *de jure*, or officially mandated standards. These standards are of course backed up by the economic and political “force” of the dominant governmental and economic agents involved but their influence is more visibly drawn from these standards’ status as the final word on defining the taken-for-granted characteristics of technologies, both existing and as yet to be developed. In this sense, technical standards can be said to operate as a hegemonic culture, which Gramsci

describes as “the habit of connecting cause and effect...enlivened by organization” (Gramsci, cited in Kurtz, 1996: 114).

Hegemony is seen to arise out of complex alliances between subjects rather than the product of one group, or class, dominating another. This accounts analytically for dissension within subject categories at various levels of analysis, whether one is investigating an individual organization, a coalition of like-minded organizations or society as a whole. In each case, *it is the process of dealing with and allaying internal dissension from which a hegemonic order is conceived*. Gramsci tracks the formation of these alliances by focusing on the role of intellectuals. A hegemonic culture, he asserts “is personified in the intellectuals” (Gramsci, 1971: 41) as they provide “the foundation of a new and integral conception of the world” (Ibid: 9), through “active participation in practical life, as constructor, organizer, ‘permanent persuader’ and not just a simple orator” (Ibid: 10).

The standards process in general operates by drawing individual experts from key organizations over large geographic areas to form a technical consensus. These experts in many ways act as the “permanent persuaders” imagined by Gramsci. Further, because a hegemonic bloc is not a homogenous structure but rather a “unity of opposing structures”, focusing on key individuals rather than predetermined subject boundaries (such as telephone vs. computer players or public vs. private interests) it avoids creating blind spots based on categorical assumptions of identity, interest or motivation. This is especially an important point as the case study at hand, ultimately` deals with new and emerging subject categories such as “the Internet standards community”. Individual experts in their field forged a new collective perspective and identity around the use of

the TCP/IP protocols from the existing venues and networks through which they initially made contact.

Hegemony provides a theory of change and social transformation in addition to one of control and reproduction. Implicit in its focus on process over structure is an emphasis on the need to constantly renew and reassert its “moral and intellectual” authority.

Williams was particularly taken with this aspect of hegemony, writing that:

...the hegemonic has to be seen as more than the simple transmission of an (unchanging) dominance. On the contrary, any hegemonic process must be especially alert and responsive to the alternatives and opposition which question or threaten its dominance. The reality of cultural process must then always include the efforts and contributions of those who are in one way or another outside or at the edge of the terms of the specific hegemony (Williams, 1977: 113).

This perspective accounts for change, often seemingly dramatic change, within the confines of a continued dominance by a ruling group or coalition of groups. This theory of change stands in contrast to Kuhn’s theory of scientific paradigms, used by Egyedi to discuss the ‘paradigm shift’ involved in the convergence of computers and telecommunications in the realm of standardization. Kuhn characterizes such a shift as the ‘collapse’ of an older worldview in the face of a new one’s success and acceptance, signifying a scientific “revolution”, “transform[ing] the scientific imagination in ways that we shall ultimately need to describe as a transformation of the world within which scientific work was done.” (Kuhn, 1962: 6). Discussion of change in terms of paradigms tends to encourage change as the washing away of the old and ushering in the new, in bold clear strokes. This is evident in many of the popular-press uses of the term, especially when dealing with the Internet or the impact of IT on the business world (e.g. Don Tapscott’s *Paradigm Shift*). It also lends itself to the kinds of previously-discussed

Schumpeterian analyses of technological innovation playing out in waves of creative destruction, as in this *Economist* editorial:

If, as seems likely, we are already a decade into this new industrial cycle, it may now be almost too late for the dilatory to catch up...Catching the wave at this late stage will depend on governments' willingness to free up their technical and financial resources, invest in the infrastructure required and *let their fourth-wave relics go*. Failing that, latecomers can expect only crumbs from the table *before the party comes to an end – and a new wave of technologies begins, once again, to wash everything aside* (Economist, 1999).

Giddens has criticized paradigms as suffering from an exaggerated internal unity, and for their related tendency to be treated as closed systems. One result of this tendency is that continuity between ‘revolutions’, whether social or scientific, is overlooked. (Giddens 1976: 143-4). A hegemonic framework preserves such continuities by treating an established worldview as part of a lived process rather than a reified structure of cognitions. Within this process, agents negotiate and form strategic alliances in order to preserve power and competitive advantage within shifting material circumstances and concomitant ideologies. Thus, within a hegemonic framework, paradigmatic shifts are more often than not seen as strategic adaptation led by dominant agents rather than the sign of some sort of fundamental transformation.

As Williams suggests, such adaptation often takes the form of co-optation of potentially oppositional elements. But aside from identifying strategies for dealing with oppositional elements, hegemony and Marxist theory provide an important set of criteria for identifying elements as “oppositional”. As a point of contrast, Egyedi uses paradigms to investigate the practices and concepts that separate the business of telecommunications and that of IT. The two groups are placed in opposition to each other in the sense that each group competes for the same goal: to establish a systematic advantage for

themselves as they fight for market share. This led to competition between standards venues as well as in shaping the technical characteristics of shared standards, such as the OSI protocols. Using hegemony this struggle can be interpreted as a sub-set of a larger conflict with a more fundamentally oppositional group: the emerging Internet community. The primary motivation for telephony and computer vendors to develop a consensus between each other was because both groups were facing 'competition' from groups that had begun to establish a system of practice that was opposed to utilizing telecommunications and IT in a manner consistent with a system of capitalist exchange. Educational, government and R&D organizations had built self-owned and operated data networks as an ancillary activity to their own non-commercial activities; these networks were a means to an end, not as services intended for resale. The threat they posed was not initially in their ability to compete with network operators and computer vendors, but in their existence as an alternative to the commercial exchange of technology and network services altogether.

Chapter 2: Fordist Compromise and Packet Opposition

The ARPANET, and the Network Control Protocol (NCP) it used to operate, emerged from a computing environment that stressed the efficient use of scarce computing resources. 'Efficient' meant maximizing processing power within a single machine and using a linear 'batch processing' approach that dealt with one program at a time. This technical model mirrored the dominant conception of 'efficiency' described in Fordist economic and regulatory thought. The time-shared computing systems and packet-switching techniques developed within the academic and research communities proposed an approach to computing that would transform stand-alone calculating machines into networked resource-distributing public utilities. This vision opposed most of the technical assumptions on which computer systems and the circuit-switched telecommunications grid had been designed – technical assumptions that were bound up with the regulatory and economic principles on which the larger political-economic status quo relied.

NCP, as a standard, reflects the collaborative atmosphere in which it was developed, as well as the priorities of its developers, which to a large extent included end-users of the system as opposed to the service provider alone. It stands in stark contrast to the standards developed within the telecommunications and computing industries – which for the most part reflected the same Fordist economic principles of hierarchically organized and internalized decision making.

Economies of scale and natural monopolies: 'sectoral policing'

The neoclassical school of economic thought arose to prominence in the late nineteenth century, prefiguring the development of modern industrial economies in North America and Europe. Neoclassical economic theory continues to provide the orthodox picture of how market economies function, and conversely the nature of their

dysfunctions. Although it did not invent the term, it was within neoclassical discourse that the economic concept of a ‘natural monopoly’ became a regulatory category into which networked undertakings, such as the telephone and telegraph, were placed. Many of the state, corporate and labour regimes developed during the first two decades of the twentieth century would define the character of the social and economic mainstream of Canada and the US for the next six (Winseck, 1995; Ward, 1997: 214).

Neoclassical theory is preoccupied with the best means to capture and control the productive energies found in *economies of scale*. Adam Smith, on the one hand, pictured the process of capital accumulation occurring as “a self-sustaining, largely self-regulating virtuous circle of capital accumulation” (Foley, 1999: 4), based on *increasing returns to scale*. As the scale of commodity production increases, efficiencies are gained, lowering the cost of the commodity and increasing sales. As the market increases in size, the opportunities for dividing labour into specialized tasks also increase, again lowering the commodity’s production costs:

The links between the division of labor and the extent of the market create a system of positive feedbacks, in which increases in the division of labor lower costs, raise real incomes, and extend the market, thus leading back to more increases in the division of labor (Ibid: 15).

On the other hand, the *law of diminishing returns* functions as a limiting factor to Smith’s virtuous spiral of economic development: as a particular productive resource is increased, its output decreases proportionately until the marginal cost of the resource is no longer equal to its return. This principle sits at the foundation of neoclassical equilibrium theory. Market equilibrium is achieved when a commodity’s supply price (the cost of production) meets its demand price (what the market is willing to pay). Where supply and demand meet determines the market price of a commodity, as well as

influencing the size and character of the market for that commodity, *in particular the number of firms that can viably compete within it*. Alfred Marshall, a central figure of the neoclassical movement, observed that in the short run all commodities were characterized by either constant, diminishing or increasing returns to scale, and that in extreme instances the latter created conditions incompatible with free market competition:

Continued rivalry is as a rule possible only when none of the rivals has its supply governed by the law of increasing return. The equilibrium is stable only when none of them is able to drive the others out; and this is the case when all of them conform to the law of diminishing return; because then if one did obtain a temporary advantage and its use increased, its supply price would rise, and then the others would begin to undersell it. But if one of them conformed to the law of increasing return, the rivalry would soon cease; for whenever it happened to gain a temporary advantage over its rivals its increased use would lower its supply price and therefore increase its sale its supply price would then be further lowered, and so on: thus its advantage over its rivals would be continually increased until it had driven them out of the field (Marshall, 1920).⁷

A natural monopoly is defined as one of the rare instances when a competitive marketplace fails to set a price that maximizes allocative efficiency (where cost, supply and demand balance). Natural monopolies create a divergence between private and public interest, creating a need for public intervention:

It is the immediate interest of the monopolist so to adjust the production and sale of his wares as to obtain for himself the maximum net revenue, and the course which he thus adopts is unlikely to be that which affords the aggregate maximum satisfaction. The divergence between individual and collective interests is *prima facie* less important with regard to those things which obey the law of diminishing return, than with regard to those which obey the law of increasing return: but, in the case of the latter, there is strong *prima facie* reason for believing that it might often be to the interest of the community directly or indirectly to intervene, because a largely increased production would add much more to consumers' surplus than to the aggregate expenses of production of the goods (Ibid).

⁷ Marshall, Alfred. *Principles of Economics*. Macmillan and Co., Ltd. 1920. Accessed online at Library of Economics and Liberty. 2 August 2002. <<http://www.econlib.org/library/Marshall/marP34.html>>.

Under the natural monopoly thesis the most cost-effective means of providing service is through an individual firm, however this creates a catch-22 in that an unregulated monopolist will maximize profits, producing too little service at too high a price. Neoclassical theory holds that in a perfectly competitive environment a firm will charge the marginal cost of production (the cost of extending service to an additional customer). However in the case of a natural monopoly with high start-up costs and rapidly decreasing marginal costs, average marginal cost falls *below* average total costs. If the monopolist priced its services at marginal cost, it would eventually go out of business. The market failure is thus essentially reduced to a malfunction of the pricing mechanism. But despite going some lengths to define the theoretical character of the natural monopoly dilemma, Marshall doesn't provide concrete tests for, or solutions to, the problem:

One of the most interesting and difficult applications of the theory of monopolies is to the question whether the public interest is best served by the allotment of a distinct basin to each great railway, and excluding competition there...The theory of monopolies starts rather than solves practical issues such as these: and we must defer their study (Ibid).

Richard T. Ely, a US economist writing before the turn of the century, was at the forefront of the 'progressive movement' pushing for industrial reforms, and wrote influentially on the need to classify telegraphy a natural monopoly. His criteria for judging an industry a natural monopoly (taken from Farrer) are less economic and more political, aimed at not simply defining a natural monopoly but defining a case for public intervention:

- First — What they supply is necessary.
- Second — They occupy peculiarly favored spots or lines of land.
- Third — The article or convenience they supply is used at the place
 where and in connection with the plant or machinery by

- which it is supplied.
- Fourth — This article or convenience can, in general, be largely, if not indefinitely, increased without proportionate increase in plant and capital.
- Fifth — certainty and harmonious arrangement, which can only be attained by unity, are paramount considerations (Ely, 1889: 45).

Ely argues for public ownership of railroads, telegraphy and other networked undertakings which are incompatible with, but necessary to free-market enterprise. They are “undertakings which are monopolies *by virtue of their own inherent properties...super-imposed upon the world of competitive industries*, viz., agriculture, manufactures, and commerce” (Ely 1894: 294, emphasis added).

Ely is not seeking an alternative to competitive markets, but a regime to maintain their continued operation in light of the host of new industries on which the modern industrial economy depends (Ibid). He is looking for a point of compromise between stakeholders:

To the anti-socialist it may be said that what is advocated is not socialism, but something far from it. A policy which leaves to private enterprise agriculture, manufactures, and commerce is something quite different from a policy which leaves no field for private industry. To the socialist it can be said: “Let us try this reform first. You want this, and so do we. Here is a point of union” (Ibid: 303).

A regulatory framework for telecommunications

The compromise was sought in the midst of the continued uneven development of telegraphy and telephone services, and widening cleavages “between business and residential customers; urban and rural areas; large and small communities; capital and labour; federal, provincial and municipal governments; and corporate-sized versus independent providers of telephone service, etc.” (Winseck, 1995: 4). Over the first ten years of the new century both AT&T and Bell Canada pursued a strategy of consolidation

and market domination through hostile takeovers, refusing interconnection and filing litigation against competitors (Winseck, 1995: 5, 10; Ward, 2000: 168). The following decade found Bell and AT&T under increasing pressure from regulatory powers seeking to stabilize the industry, alternately threatening to nationalize or dismantle dominant firms in the telecommunications industry (Ward, 2000: 169, Winseck, 1995: 5). A compromise eventually emerged in the early 1920s, a regulatory regime in both countries that “marked the beginning of regulated capitalism, the bureaucratic state, and social welfare democracy” (Winseck 1995: 9). The solution hinged on the creation of sectoral boundaries around each undertaking that fell into the natural monopoly category of market failure: energy, transportation and telecommunications. Arms-length regulatory agencies, such as the BRC in Canada and the ICC in the US, removed natural monopolies like telephone service from both government partisanship and the competitive marketplace (Doern 1998: 110). These agencies carried out a technocratic, market-corrective mandate “to promote macroeconomic stability and growth...not to recreate markets but to compensate for their destabilizing effects” (Schultz 1998: 112).

The nature of the regulatory solution suggests the influence neoclassical theory had in defining the nature of the problem – the natural monopoly concept is a central organizing principle in the form of political governance that emerged in North America after the First World War. First, telephone service was withdrawn from certain ‘horizontal’ controls established to ensure the continued operation of competitive enterprise generally (such as anti-trust legislation) and placed within vertically defined industrial sectors. The sector boundaries prevent “destructive competition” within the sector as well as between natural monopolies and other forms of competitive industry (Ibid: 111). Second,

regulation of telecommunications has largely been restricted to pricing controls. Rate-of-return regulation aims to price services at their average total cost (CRTC, 1994), considered a second-best alternative to average marginal cost pricing recommended in neoclassical literature (total cost pricing creates the lowest level of allocational inefficiency). This has led regulators to focus on accounting principles, attempts to measure total costs, set depreciation rates, etc. Third, to maximize economies of scale the sector is structured into a few large firms operating exclusively within geographically defined service areas, providing a single, largely undifferentiated, service and vertically structured so as to extend monopoly efficiencies to all elements of the industry. In combination with a rate base regulation that emphasizes *total* costs as a means to determine a fair return on investment, the monolithic character of the firm, service and underlying technology is emphasized. The latter is especially relevant in that neoclassical theory attributes the natural monopoly character of an industry primarily to qualities of the commodity being sold. In the case of telecommunications, the commodity being ‘distributed’ is the network’s own carrying and technical capacity to connect parties for the purposes of voice communication. After the construction of the network itself was largely completed, the continuing costs of operating the network focused on the creation and maintenance of the switches in the network that established point-to-point connections between any two parties on the network. According to 1973 data, “[Switching] contributes 45% of the cost of an average telephone call; the figure is 54% for long distance calls” (Hopewell, 1973: 50). Thus the ‘scarce resource’ being distributed was the network’s switching capacity. The network was constructed in a hierarchical, centralized fashion in order to maximize the number of individual

telephones being served by a single switch – and thereby minimize the number of switches, and switching costs, in the network.

Telecommunications Standards

The neoclassical definition of a natural monopoly is essentially silent on the issue of coordinating interoperability between competitive agents within a networked industry. Although Ely lists it among his criteria for state intervention, the definition of a monopoly deals strictly with returns to scale experienced by certain commodities in a competitive market. The high up-front costs coupled with low marginal costs are the source of natural pricing advantages that bring about an industry's monopoly character. The fact that all the major examples of these industries involve the construction of large-scale networks is apparently incidental, simply a condition under which increasing returns to scale, and thus natural monopolies, arise. The combination of monopoly control and vertical integration between service providers and equipment manufacturers deals with the pricing and efficiency dilemma described in neoclassical literature, but also largely eliminates the problem of interconnecting equipment from different manufacturers in the same network. This effectively left the issue of setting technical standards as a matter of internal corporate policy. AT&T and its manufacturing arm, Westinghouse, initially used its dominant position and control over matters of interconnection as a means to drive out independent operators. As the industry stabilized, and with the creation of the FCC in 1934, interface standards began to be shared with existing independent carriers and manufacturers through various industry forums, such as those organized by the Bell-United States Telephone Association. However, AT&T remained the sole producer of new technologies and standards in the US (Lifchus, 1985:

34). In Canada, a similar system of control and distribution of standards arose – under increasing domestic control with the creation of Bell Northern Research and the Trans-Canada Telephone System (TCTS), a non-incorporated coalition of Canada's largest carriers that coordinated inter-carrier activities such as interface standards, and traffic and revenue sharing (Janisch, 1987). Essentially, telecommunication standards evolved into an exclusive and carefully guarded 'club', characterized by the circulation of standards produced by a very limited number of institutions within hierarchical, corporate settings. This model was essentially reproduced at the international level within the CCITT (Hummel, 1985).

IBM: from calculating machine to computing resource

IBM was formed from a conglomeration of companies producing electronic measuring and tabulating machines in the early part of the century. The principal firm, the Tabulating Machine Company, had established itself in 1890 with a machine designed to read and store information recorded in punch-card form, and used by the US federal government to process census results. By 1923, when the conglomerate adopted the name International Business Machines, its line was composed of an array of specialized calculators of this kind (Troppe, 1983). But over the next several decades, computers would shift away from the 'hard-wired' calculators built by IBM, towards a general-purpose, programmable, computing machine.

The dominant technical model on which computers were based by the late 1960s reflects core Fordist business principles: large, centralized, linear, hierarchical and integrated. The central 'problem' of neoclassical economic theory is to find the ideal means of distributing scarce resources. The computer provided a scarce and very

expensive resource – access to its processing power. It is not surprising then that its technical design reflected many of the core economic principles of its day. Grosch’s Law, coined in 1956 by computer scientist Herbert Grosch, fused the dominant economic and technical paradigms of the times by demonstrating that “the ratio of the power of two computers is approximately equal to the ratio of their costs squared” (Solomon, 1970: 107).⁸ This predicts that large economies of scale exist in the production of computing power. To illustrate using arbitrary numbers, if one computer is capable of executing two million instructions per second (MIPS) and costs \$5000, then according to Grosch’s law, a computer capable of 10 MIPS will cost roughly \$11000. The cost per MIPS falls dramatically (\$2500 versus \$1100, respectively). Because power rises disproportionately to cost, a large fixed investment in a single, centralized computer is seen as the best means to efficiently extract value (productivity) from the hardware. By centralizing the CPU (rather than distributing it among a number of computers or peripheral devices) the largest amount of computing power can be made available at the lowest price. “Batch processing” was the digital equivalent of the automobile production line: in order to squeeze as much productive capacity out of a computer’s central processing unit, all ‘jobs’ (programs and data) are fed to the computer and processed in sequence. The CPU’s idle time is reduced as much as possible and while being processed, a computer dedicates *all* of its computational resources to completing it (van Vleck, 1995). In a sense, batch processing continued to treat the computer as a specialized calculator – one that was ‘retrofitted’ to become specialized for each new job being run.

⁸ $A:B=(X:Y)^2$, where A is the processing power (in MIPS) of computer 1, B the processing power of computer 2, X the cost of computer 1 and Y the projected cost of computer 2.

Standards fiefdom: the IBM/360

This technical model also intermeshed with an IBM corporate and product strategy that emphasized large-scale production and integration (Duby, 1995: 2). IBM's approach to technical standardization reflected this corporate structure and strategy. Large-scale horizontal and vertical corporate integration removed the need for inter-firm standardization, leading IBM to favour proprietary, hardware-based compatibility. Given the lack of regulatory or cost boundaries to market entry, IBM's proprietary standards were expressly designed to keep customers *inside* the family of IBM products by tying them to additional IBM-produced software and hardware. This strategy was made manifest by the IBM System/360 line – released in 1964 as the first compatible 'family' of computers. It promised broad 'horizontal' compatibility between all peripheral components, as well as 'vertical' compatibility allowing customers to upgrade to newer technology without losing compatibility with older components and software. The significance of the 360's success is difficult to overstate – both to IBM as an individual firm as well as the larger structure of the computer industry. IBM invested \$5 billion in the development of an entire line of interlocking products and service. Bob Evans, the manager who oversaw the 360's development commented, "We called this project 'You bet your company.'"⁹ The 360's breadth of technically compatible components and commitment to vertical compatibility profoundly influenced the pattern of technological development and diffusion within the commercial computing sphere. Competition henceforth centered on the development and maintenance of computing 'platforms', defined by proprietary compatibility standards (Bresnahan, 1997: 4). Corporate strategy focused on developing a *migration path* for customers, and the means of creating this

⁹ <http://www.mhhe.com/cit/uit3e/pages/chap10/profile10.html>

path was through standards that wedded technical innovation with technical stability (i.e. compatibility).

IBM's System/360 represented a blending of technical and strategic trajectories that had existed since the earliest modern computers: a generic CPU designed with proprietary standards tending to bind customers to a particular model after being tailored with investments in software and hardware. The 360 simply employed both of these technical/business approaches on a large, highly integrated scale.

Public Computer Standards in the US and Canada

The 1960s saw the first substantial development of broad computer standards. The development of standards-making institutions and government policy occurred in response to the rising importance of computers as administrative tools, and rising frustration with data conversion costs and the inability to make full use of an inventory of computational power divided between various incompatible makes and models (Cunningham, 1969: 27; Brooks, 1969: 24). Despite the creation of institutional frameworks, computer standardization generally remained disconnected from end-users (Fujaros, 1975: 27; Datamation, 1969: 21); hampered by undue corporate influence, a displacement of technical by strategic concerns, lopsided participant selection and an over-emphasis on hardware issues (Bromberg, 1969: 23); and fragmentation (especially in the US) between committees and organizations with differing criteria and methodology (Ibid). Nevertheless, these problems were not seen as a *failure* of the marketplace, but rather an accurate reflection of market demand. Low standardization was equated with a corresponding high level of technical innovation (Brooks, 1969: 24; CCCTF, 1972: 1). Computer standards, and standardization fora, were seen as appearing and operating in

the manner market forces dictated:

By this time it should be obvious...that the payoff to both the producer and the user from the domestic standardization effort is money. Money saved during the production process, saved via a smaller inventory or stockpile and money saved in the employee training and maintenance operations. The producer knows that his market is larger when he can conform to agreed upon standards...In areas where cost savings were not involved, government and private standardization programs lagged far behind and encompassed inadequate *de facto* standardization (Grove, 1969: 38).

This perspective was far more in evidence in the US – where (1) standards organizations were entirely private-sector undertakings, (2) particular standards initiatives were sponsored and organized by particular private-sector stakeholders and (3) the government essentially played the role of an ‘influential and responsible’ consumer.

Institutional structures

Computer standardization activities developed within existing institutional structures for technical standards, as opposed to the specialized institutions developed for telecommunications equipment. In the United States, the USA Standards Institute (USASI) served as the main clearinghouse and coordinating body for voluntary standards until 1969, when it was reorganized into the American National Standards Institute (ANSI). USASI was a privately supported organization funded by membership fees (paid by companies, trade associations and professional societies) and the sale of published standards (Grove, 1969: 30).

Within ANSI, various Standards Boards were responsible for standardization in a particular area, and each board oversaw a number of Technical Specification Committees that prepared the standards. Each board was formed and operated by a ‘sponsor’:

It is the sponsor’s responsibility to identify the areas for standardization, attract the required number of experts, see to the financing and conduct the

business of the committees in accordance with the USASI operating procedures (Bromberg, 1969: 22).

The Business Equipment Manufacturers Association acted as the sponsor for the 'X3' standard board, overseeing the development of computer and information processing technology standards. The committee was convened in 1960 and also served as the official US representative on ISO's Technical Committee 97 (Grove, 1969: 30).

By contrast, the Canadian Standards Association (CSA) – the domestic equivalent of ANSI and USASI – was made subordinate to a government-created organization, the Standards Council of Canada, in 1970. The SCC was granted the authority by Parliament to oversee CSA's work, accredit other standards organizations and have authority over Canada's delegates to international standards associations such as ISO and the International Electro-technical Commission (IEC). The CSA continued to carry out the administrative work involved in standards making. Funding came from dues, publications and certification services. The CSA's Standards Policy Board oversaw the development of standards, and was composed of Sectional Committees carrying out standards-making in particular technical areas. The Sectional Committee on Computers and Information Processing was formed in 1965.

In 1969 it was replaced with the Sectional Committee on Computers, Information Processing and Office Machines. CIPOM's activities were controlled by an Executive Committee appointed by the CSA and made up of representatives from manufacturers, the National Research Council, the Defense Research Board, and universities. CIPOM's mandate included work in computer science *and* office equipment standards – a mandate divided between the X3 and X4 committees in the US, and TC 95 and 97 at ISO (CCCTF, 1972 vol. 6).

Government standards activity

Canadian SDO's operated under the ultimate authority of a government agency, the SCC. The US government, alternatively, played a far more active role as a *participant* in the standards process itself. It also moved quickly to create an internal standards policy for governmental computer use, to act as an *influential consumer* of computer equipment and services. Not only was the US government by far the largest consumer of computer resources in the world, but also possessed an unusually wide array of models and types, reflecting the 'division of powers' (low central coordination) approach that still characterizes US political structure (Brooks, 1969: 24; Cunningham, 1969: 27). The exacerbated need for standards to enable the pooling of computer resources and sharing of data spurred the development of the 'Brooks Bill,' introduced in 1963 (passed in 1965), mandating the Secretary of Commerce to "make appropriate recommendations to the President relating to the establishment of uniform automatic data processing standards" (CCCTF, 1972: 12). The Center of Computer Sciences and Technology of the National Bureau of Standards coordinated and encouraged the participation of federal government employees in standards-making activities (Ibid). By 1972, no equivalent specialized agency oversaw the development of computer standards within the Canadian government.¹⁰ The 'responsible consumer' approach taken by the US held less sway in Ottawa. The majority of computer hardware standards were *de facto* standards created by private companies (Fujaros, 1975: 27; Bromberg, 1969: 22), and without exception these companies were American (Glinski, 1969: 71). Thus the opportunities to serve Canadian economic interests were more directly served in a policy setting, rather than applying

¹⁰ Intra-governmental technical standards were drafted and administered by the Canadian Government Specifications Board, which also participated in CIPOM.

consumer pressure on branch-plant producers operating in Canada. Essentially, technical standardization was treated as an issue escaping the pressures of the market place, a form of market failure requiring, in the final instance, government oversight.

Computer Science Opposes the Status Quo

The dominance of IBM, and its share of the EDP market increased, increased faster after the release of its System/360. Competition developed, major computer firms in the US and the UK challenged IBM with their own series of integrated, proprietary computer series (Control Data and Ferranti being the two highest-profile examples in each country), but failed to capture more than a small percentage of the market. Despite rapid technical change within the computer industry, and new markets for computing developing throughout the economy, competing platforms failed to achieve more than a foothold in anything but specialized niches. The switching and conversion costs involved in changing computers helped keep existing customers loyal to IBM. The increasing momentum of IBM products distinguished the development of the computer industry from, for example the auto industry, where many of the same production strategies had been employed. However, while the auto industry had become a stable oligopoly, the computer industry had developed into a clear monopoly.¹¹ A Canadian survey estimated that IBM represented over 70% of installed systems in 1964 (Glinski, 1969: 72). Control Data Corporation (IBM's largest competitor) estimated that IBM had installed between 70-76% of the \$4.2 billion worth of computer equipment purchased worldwide in 1967 – a steady *increase* over the previous two years. Control Data had installed less than 6% of 1967's hardware purchases (Datamation, 1969: 79).

¹¹ Admittedly, market share measurement was a contentious issue by the late-1960s due to the threat of anti-trust action by the Justice Department and the multiple civil suits brought against IBM by its competitors.

Time-sharing techniques emerged out of an academic context, based on a perspective that broke with the view of computers as calculating machines, and explicitly treated them as sources of a new kind of generic commodity: computing power. Time-sharing allows for virtually simultaneous, real-time access to a computer's CPU by multiple users. Early time-sharing systems consisted of multiple 'dumb terminals' connected to a central computer over ordinary phone lines. Each end-user was provided with what appeared to be online access to his or her own private computer facility. Time-sharing was explicitly attached to the concept of the *computer utility* which would serve as a means to distribute computing resources to geographically dispersed customers (O'Neil, 1995: 50). The first time-sharing operating system was developed at MIT in 1961, partly in response to an internal study of the campus' computing needs and partly based on the experience of MIT researchers with earlier experiments with online computer resources carried out with the Department of Defense (DoD). By 1963, MIT's Project MAC (Multi Access Computing) had been created to further develop time-sharing technology into a stable technology and serve as an influential prototype, directing the development of computer technology towards the computer utility model. The project was funded by the Department of Defense's Advanced Research Projects Agency (ARPA). The goal of Project MAC's Multics project (Multiplexed Information and Computing Service), was to develop:

a computing system...capable of meeting almost all of the present and near-future requirements of a large *computer utility*. Such systems must run continuously and reliably 7 days a week, 24 hours a day in a way *similar to telephone or power systems, and must be capable of meeting wide service demands...*(Corbato, 1965, emphasis added)

Such a service, it was realized, would also place unique demands on the network used to

distribute computing resources, demands that were incompatible with the existing public circuit-switched network:

Existing telephone switching plant is engineered to handle the traffic of talkers. A crucial parameter of talker traffic statistics is the product of the average circuit holding time and the average calling rate during the “busy” hour; this quantity is typically in the range of 3-6 call minutes. Thus an adequate number of talking paths through the switching system may be from 5-10 percent of the number of subscribers. A study made of the holding times of Project MAC users revealed an average holding time of about 1 hour...It may therefore be difficult to add any sizable number of remote typewriters to an existing switching system without impairing telephone service... (Ossanna, 1970)

In 1966 ARPA initiated a second research project also intended to improve computer resource sharing: the ARPANET was intended to replace the proliferating number of specialized networks being implemented at the DoD. ARPANET was intended to foster data and resource sharing by overcoming the computer industry’s inability and unwillingness to develop sufficient common standards (Hirsch, 1970). ARPANET’s organizers would not encounter packet switching as a possible technical approach to developing their time-sharing network until 1967, when they crossed paths with representatives from the National Physics Laboratory at a computing conference. This meeting completed a cross-pollination of ideas that had begun in 1965 (Hafner, 1998).

Donald Davies at the National Physics Laboratory in England would have the opportunity to study MIT’s time-sharing system on several occasions over the course of 1965. Sharing CPU capacity by slicing multiple jobs into millions of discrete ‘quanta’ and then processing each in turn for a fraction of a second inspired the concept of applying a similar technique to *bandwidth*; rather than holding open a single channel between two users for a fixed amount of time (as is done in circuit-switched networks), computers could split messages into ‘packets’ and direct them individually to their final

destinations, thus allowing a line's total capacity to be shared between multiple users (Ibid: 67). Davies' packet-switching concept was adopted for the proposed ARPANET in 1968 (Ibid: 13, 41).

The tightly-knit lineage of time-sharing and packet switching resulted in a high degree of functional complementarity and shared assumptions regarding the needs of end-users, despite the lack of formal coordination of their development. Davies' formulation of packet switching was developed as the communications counterpart to time-sharing. Both were designed as a counterpoint to the computer resource bottlenecks inherent in the existing technical status-quo: hardware-oriented, integrated systems using proprietary standards and linear batch-processing techniques. At that time, very little demand existed in the private sector for anything different, as business applications had all been tailored for the batch-processing environment (O'Neil, 1995). But within the computer-science community there was significant frustration with batch-oriented processing and the slow process of software development, which required inscribing lines of code into punch cards, having the job run by computer technicians, having the processed cards returned as a print-out, and finding the typos that inevitably crept into the procedure. Debugging would be made infinitely easier by an *interactive* system that allowed for immediate cause-and-effect discoveries. So called real-time systems were also of great interest in the military environment, where tracking and surveillance were a priority for a number of endeavors. Packet switching and real-time remote computing were both designed to maximize the utility of their respective underlying resources (bandwidth and processing power) when used to handle the kind of activity generated in human-machine interactions, e.g. a person typing on a keyboard. Packet switching was

seen as a means of fostering computer-human interaction, not necessarily person-to-person interaction. Establishing a dedicated circuit for the short bursts of data typical of these interactions is impractical (Corbato, 1965).

Academic and military research environments tended to require data sharing between geographically distant colleagues. These institutions were also more likely to have multi-vendor computing environments because of their need for specialized hardware to tackle particular research problems. Business users, alternatively, had embraced the general-purpose families of compatible computers, such as the System/360. Given the resources at hand, computer-scientists took a software-oriented approach to solving these problems, although hardware modifications were also necessary. But software replaced hardware as the primary consideration. Further, the solution was intended to be hardware-portable. The entire thrust of the computer utility was to effectively and conceptually disconnect software and processing power from the machines they had become identified with, in the same way that electricity is largely identified with its applications, not the generator itself.

By solving a number of ‘problems’ with batch processing and data communications, the computer utility threatened to disrupt a number of practices on which IBM and AT&T depended. AT&T had been officially opposed to participating in packet-switching schemes since 1960 when it had been first exposed to the idea by Paul Baran at the RAND corporation. Baran had invented the packet-switching concept as a means of creating a survivable communications system able to dynamically route data around damaged lines and switches (Hafner, 1998).¹² However, AT&T refused to build a

¹² It was only *after* his own work in this area that Davies, and ARPA, would learn of Baran’s ideas. (Hafner, 1998; Abbate, 1999)

network according to Baran's designs, despite the military's insistence (Ibid: 64). And although Bell Laboratories (at the time, one of the most advanced computer research laboratories in the world) was involved in the Multics project, AT&T officially dropped out of the operating system initiative in 1969 once teleprocessing became a serious commercial concern. IBM was similarly resistant. Project MAC chose to pursue Multics in cooperation with General Electric's computer division, despite having a close working relationship with IBM, which had donated to MIT its top of the line computer systems for years:

The [Project MAC] staff believed that IBM did not really support time-sharing, or at least not MIT's approach to time-sharing. They interpreted IBM's interest as limited to wanting to sell its machines, not as a commitment to Project MAC's vision of the future of computing...IBM would not allow significant changes to its hardware design...it treated Project MAC as only a customer for its machines, not as a design partner (O'Neil, 1995: 51).

With regard to the ARPANET project, IBM refused to even bid on supplying the computers that would be used to route packets through the proposed network, saying:

The network could never be built...because there existed no computers small enough to make it cost effective...IBM had thought about proposing a 360 Model 50 computer...But...the Model 50 was too expensive to consider buying in large quantities (Hafner, 1996: 80).

The reluctance of both of these companies, the leaders in each of their respective fields, suggests the extent to which technical and economic considerations intertwined. IBM's technical model was focused on maximizing finite resources, like CPU, by centralizing them and eliminating as much idle time as possible through linear, batch processing. IBM's computer networks reflected the philosophy of their computers: single-function machines utilizing integrated, tailor-made technology. IBM's high-profile

SABRE airline reservation system, debuted only a year before the ARPANET, was a prototypical example.¹³ Their technology was designed around an assumption of *scarcity*, associated with costs of producing material goods, reflecting the economic tenets of their time. The value of the machines they built *depended* on a certain degree of scarcity. Public time-sharing services could at once drastically change the scarcity of computer resources and shift the bulk of revenue generation away from the sale of hard goods to the sale of software and services surrounding those hard goods.

Similarly, AT&T's engineering philosophies were also based on using the minimum resources possible to deliver services. As few links as possible were used to connect two parties by designing the network as a system of hierarchical nodes, concentrating the maximum number of lines served by each switch in the network. This was not only to minimize the number of expensive switches built into the network but also to minimize the decay of the analog signal over long distances. For example, AT&T's approach to increasing network integrity had been to increase the durability of each system component. Baran and Davies' technology was not designed to eliminate errors and conserve resources, but to *anticipate* and overcome them by making each system component redundant (Abbate, 1999: 16-17).¹⁴ Switching and computer resources were thus distributed far more evenly throughout a packet-switched network rather than concentrated into a few sites. In this sense, the architectural philosophy behind packet networks is fundamentally reversed from that of circuit-switched networks.

Like IBM, AT&T also equated efficiency with specialization. The network was better

¹³ <http://www.cnn.com/TECH/computing/9906/29/1960.idg/>

¹⁴ Paul Baran: "But even though we will use unreliable equipment, we expect to achieve better reliability...Systems such as this can be built only if one appreciates that unit reliability and systems reliability are two different things" (RAND 1965: 27).

able to use its resources efficiently because it was designed to deliver a single application – voice service. Non-technical information, such as the typical phone patterns of a city, had been translated into technical tenets, such as the minimum number of circuits and bandwidth required to serve a certain size of population. Packet-switched networks, in particular Baran’s conception of the technology, was designed as a general purpose network – suitable for a wide range of applications and uses requiring an equally broad range of bandwidths (Ibid: 19).

Investor speculation fueled a dramatic rise in the number of businesses looking to profit from the predicted boom in time-sharing, teleprocessing and the rise of the ‘computer utility’. A 1968 study by the Auerbach Corporation estimated that the industry had grown by a rate of 100% per year since the mid-1960s and would have revenues exceeding \$1 billion by 1973 (Mathison, 1968: x). Servan-Schreiber, in his influential 1968 text *The American Challenge* predicted that “The Computer utility industry can be viewed as the most basic tool of the last third of the twentieth century” (Ibid: vi).

Computer service bureaus were the first to add remote time-sharing services to their list of services. Computer manufacturers and regulated carriers soon joined them, raising concerns about anti-competitive behaviour on all sides. Regulators were called upon to intervene. The consensus was that the computer utility signaled profound and important change, the question remained – who would take the lead in defining that change?

Chapter 3: SNA's Accommodation and Containment

Fordist economic principles valued the static efficiencies realized from long-term investments in capital equipment. This complemented an economic logic that valued the large-scale, standardized production that characterized both the telecommunications and computing techno-economic status quo. However, this regime was under serious threat by the early 1970s as economic, technical and political spheres all began to shift towards an appreciation for *dynamic* efficiencies realized in the rapid turnover of capital investment and the value realized from implementing innovative technology. US economic and industrial policies began to reflect this new priority, as did competition in the private sphere. IBM especially found itself under pressure to respond to challenges in the electronic data processing marketplace that it had dominated for so long. Its Systems Network Architecture (SNA) product line represented an important shift in corporate and technological strategies, from a closed and proprietary set of compatibility standards (epitomized by the System/360) to an ARPA/NCP model of open standards, and a more distributed and 'communications oriented' approach to computing. SNA balanced the accommodation of environmental change with the retention of market control through its ability to dictate *de facto* compatibility standards.

The computer society and theories of economic growth

Teleprocessing received a great deal of economic and political attention because it was seen as a means of bypassing a bottleneck to the distribution of computer resources throughout society. Playing a very direct role in the newfound attention paid to computing at the economic policy level was Robert M. Solow's contributions to theories on economic growth.

Solow's work on economic growth, which he began to publish in 1956, positions technological progress as key to achieving stable economic growth accompanied by rising standards of living. The dominant models of growth emerging out of the depression era focused on the inherent instability of economic growth, depending on three unrelated factors being in balance with each other – i.e. the savings rate, the rate of growth of the labour force and the capital output ratio. The capital output ratio – the level of output from a given level of input – was considered a given technological fact, heir to sporadic and autonomous change. Solow married this Keynesian outlook with the neoclassical principle of equilibrium, formulating a mathematical equation that brought these three growth factors into a self-regulating balance. Significantly, the Solowian growth model adds to the picture of economic growth a degree of “technological flexibility” to the capital output ratio, that is, that economic pressures can direct the kind and level of productive output from technical development by qualitatively affecting capital investment. Solow wrote in his 1987 Nobel lecture:

I know that it occurred to me very early, as a natural born macroeconomist, that even if technology itself is not so very flexible for each single good at a given time, aggregate factor intensity must be more variable because the economy can choose to focus on capital-intensive or labor-intensive or land-intensive goods (Solow, 1988: 308).

Solow's pioneering work in “growth accounting” led him to conclude that, of the observed increase in output per capita between 1909-1949, only 12.5% was due to increases in observable labour and capital inputs and 87.5% was due to “technical progress in the broadest sense” (Ibid: 313). Solow refined his theory to demonstrate that this technical advancement was necessarily embodied in *new* capital equipment replacing older capital investments and improving productivity. A new emphasis was placed on

stimulating the rate of capital turnover, creating a concrete policy role for governments looking to increase their overall level of economic advancement. The computer's ability to automate and speed the informational processes of business and bureaucracy made it a natural target for policies encouraging rapid turnover and increased investment in technological equipment.¹⁵

Stemming from Solow's work, a growing anxiety regarding the "technology gap" between the US and other western nations was apparent by the early 1960s. As historian Richard Coopey writes:

A series of reports by the OECD and an influential book by Servan-Schreiber, in reinforcing these fears, placed *the computer industry* at the centre of discussion. By the mid-1960s this industry had come to *symbolise national modernity and technological competence* (Coopey 1998: 1, emphasis added).

In England, the Wilson labour government of 1964 aggressively pursued the commercialization of government research and the promotion of its domestic computer industry. Wilson would later recall, "When on the evening we took office, I asked Frank Cousins to become the first Minister of Technology, I told him that he had, in my view, about a month to save the British computer industry and that this must be his first priority" (cited in Abbate, 1999: 25).

That same year, the battle to build a viable Canadian independent computer-hardware industry was effectively lost. Incidentally, one of the final nails in the coffin stemmed from the British government promoted consolidation of two of its own domestic

¹⁵ Solow's theory focused on the investment in and production of *capital goods* as the driving force of economic growth; this investment strategy was simply nuanced to promote technical improvement, not simply "capital intensity". Also, it treated technological advancement as a steady, smooth process and an external factor to economic growth. The measurement of the benefit of technological change was a "residual effect" in the sense that the benefit was identified as the growth in output that could not be explained by measurable increases in capital and labour intensity alone. For all of these reasons, Solow's work remained firmly in traditional Neoclassical and Keynesian conceptions of economic activity. However, the emphasized role of innovation in economic growth demonstrates an increasing importance being placed on non-material goods and activities, such as learning and information.

computer firms, a strategy designed to bolster its domestic industry. ICT purchased Ferranti UK's non-military computer operation in 1963, simultaneously acquiring Ferranti Canada's independently produced FP-6000 model. The technology would be used as the basis for an ICT computer system intended to compete with IBM's System/360 (Vardalas, 1994). Although Canadian industrial policies would also become swept up in the 'computer revolution,' its marginal position in the global industry would give the issue of teleprocessing a double-edged significance, especially in light of regulatory decisions made in the U.S.

US Reactions to Teleprocessing

As the pressure to find a means to distribute 'computer resources' more broadly throughout the economy and society mounted, the computer and telecommunications industries increasingly appeared to act as dysfunctional bottlenecks. The computer industry's rapid cycles of innovation had produced an industry structured by 'smokestacks' of compatible equipment divided by corporate brand, and an increasingly lopsided monopoly of IBM equipment. The telecommunications regulatory structure, defined by *end-to-end control* of the communications grid by monopoly carriers, also discouraged the rapid implementation of novel technologies in the manner lauded by Solowian growth theory.

State intervention focused on eliminating the controls dominant players exercised over 'internal monopolies' that allowed them to define their services and hardware as a monolithic whole. The FCC and Justice Department both attempted to introduce competition within the sheltered preserves of AT&T's and IBM's own technical infrastructure, by defining and separating functional components into what they hoped

would become sustainable sub-markets of the communications and computing industries. The standards that would have to be developed in order to allow these components to inter-operate were largely left to the market, and existing non-governmental SDOs, to produce. Standards continued to be thought of as a *result* of an industrial structure, which in turn was a result of the inherent characteristics of the commodity being distributed.

The Rostow Reports and FCC Computer Inquiry I

From a regulatory standpoint, the existing sectoral boundaries delimiting telecommunications were growing more difficult to maintain. The model had always depended on grouping a complex set of interdependent technologies and services and defining them as a single, inviolable category: ‘phone service’. This monolithic picture of the service helped to naturalize the argument that the inherent qualities of the technical commodity – phone service – created a natural monopoly due to the economies of scale and the initial costs of delivering it.

The FCC Computer Inquiry (initiated in 1966) and the Presidential Task Force on Communications Policy (the Rostow Reports, initiated in 1967) redefined ‘phone service’ into core and peripheral elements as a means of integrating the incompatible approaches of the computer and telecommunications industries towards developing and implementing new technology. Already serious disputes had arisen between the two sectors.¹⁶ The challenge was to create a firewall between the two activities, while still allowing for their functional blending. As the Rostow report wrote:

¹⁶ Two high-profile examples at the time: The Bunker-Ramo Corporation offered remote access to a database of current stock-price information via lines leased from AT&T. When in 1965 it attempted to add a feature allowing brokerage firms to send “buy” and “sell” messages to offices over the same network both AT&T and Western Union refused to lease the necessary communication lines, claiming that BRC would in effect be acting as a communications common carrier. (Mathison, 1969: 21). Conversely, Western Union announced plans to develop a “national information utility” in 1966, proceeded to develop several specialized data services (e.g. SICOM, INFO-COM, PICS, etc.) and attempted to purchase Computer Sciences Corp., a large supplier of software and computer services. These activities provoked a great deal of concern over the limits of WU’s legitimate activities under its monopoly status.

These...are the twin principles which underlie the recommendations...: Maintaining the integrity and viability of the basic network as an integrated system on one hand; and on the other, releasing and encouraging the potentialities for improvement which might otherwise be restrained by tradition, business habits, or regulatory practices...(United States, 1969: 8)

The FCC, in its preliminary decision released in 1970, developed a regulatory structure based on the distinction between ‘processing’ services that were to be left unregulated (despite the fact they utilized leased lines from the carriers), and ‘communication’ services which were to be left under FCC regulation (despite utilizing similar computer technology as the teleprocessing services). *Processing* services supplied or transformed data to and from a customer, while *communication* services transported data between customers. Carriers were only authorized to provide remote processing services through an independent subsidiary. The FCC also created a third category of *hybrid services* that allowed for the unregulated development of computer-switched transport *and* data processing services, such as Bunker-Ramo’s proposed stock information service. The FCC and the Rostow Reports both characterised these services as processing oriented with incidental carriage functions. Nevertheless, the FCC reserved the right to judge such services on a case-by-case basis (Esbin, 1998: 26).

Both the FCC and the Rostow reports justify their regulatory demarcations based on the presence or absence of economies of scale associated with the technical/functional components identified by the framework. These economic conditions were in turn tied to the level of ‘diversity’ demanded from each service category. The existence of different service niches in an industry would defeat the potential economic efficiencies to be gained from a monopoly provider. Thus, both authorities determined that teleprocessing would *not* evolve into a handful of centralized computer utilities serving the entire

country as:

...teleprocessors are far from overcoming the high-costs of managing a time-sharing system, especially one that serves users with diverse processing requirements (United States, 1969: 29-30).

And for the same reasons, computer-switched hybrid services would be unable to achieve excessive economies of scale, because:

A single store-and-forward carrier would have to accommodate, on a single set of facilities, terminals with diverse line-speed, response-time and storage requirements. Such diversity would add to the costs of the system, offsetting the economies of scale of a single supplier....we cannot conclude that store-and-forward switching should now be provided by the telephone companies, or that the numerous firms which provide it need now be regulated as common carriers (Ibid: 33).

Tying *processing* to a notion of *diversity* (i.e. meeting diverse private needs as opposed to a single universal need) and *competition*, and contrasting it with a definition of *communications* associated with *homogeneity* and *economies of scale* essentially restricted the carriers' monopoly to the public network of *circuit-switched* equipment. The Computer Inquiry's findings were consistent with the FCC's policy since the mid-1950s to allow the interconnection of novel technologies to the public phone network if they provided private benefits to users without harming the technical integrity or economic viability of the public network. But how did it practically distinguish the physical and service limits of AT&T's "natural monopoly"? The 1968 Carterfone decision essentially stripped AT&T of control over "terminal equipment" (Walker, 1969: 61). The 1960 "Above 890" decision stripped AT&T of control over the sale of bandwidth, particularly as supplied by new microwave technologies. The FCC specialized common carrier decision in 1970 extended that decision to include point-to-point services that interconnected with local Bell Systems and bypassed its long-lines

division (TPC, 2002: 20). These decisions put an increasing emphasis on public, *switched* services as the only technical and service component of the Bell System that possessed the sufficient economies of scale to warrant natural monopoly status. The FCC would fight to maintain this distinction even in the face of court decisions stripping AT&T of this final protection, at least in its long-distance market (Ibid).

However, the FCC had already opened a back door for competition in the switched communications market by treating *data* services as qualitatively different from *voice*: it had reasoned that computer-switched services would, like computer processing services, not be used in the foreseeable future to serve a broad, public audience. Computers, except AT&T's specialized switching computers, were thought to only be able to provide specialized services to small, private niches. But this reasoning would be turned on its ear in less than two years after it was used to establish the US's first regulatory framework for data services, with the arrival of public packet-switched services. I take a closer analytical look at these events in the next chapter, as they occurred in the midst of Canada's attempt to define its own regulatory response to the computer utility and data networking.

Justice vs. IBM

In 1969 the U.S. Justice Department took parallel actions against IBM's own internal monopoly: the absolute control it exercised over the internal integrity of its computer systems. Justice's case had been initially prompted by IBM's apparently unfair competition against other integrated "computer system" manufacturers such as Xerox and Control Data, and existing or emerging computer sub-markets like service bureaus and software developers. The latter aspects of the case appear to have been particularly aimed

at preventing IBM's control over the emerging computer utility industry. For example, the suit had been partly provoked by IBM's decision to not develop time sharing services through its separate subsidiary that handled other service-related products. This decision had been made despite the strong possibility that it violated a 1956 consent decree banning IBM from entering the service-bureau industry. But developing its own public time-sharing offering was "considered vital to the ultimate growth of the company (Pantages, 1969a: 85). IBM had also been under pressure from Justice to 'unbundle' its tight integration of software, hardware and computer services that made it difficult for existing IBM customers to use independently provided computer utility services and software (Ibid). But a series of court decisions, out-of-court settlements and IBM's capitulation to begin *selling* its computer software (as opposed to giving it away to its hardware customers) essentially took a great deal of the wind out of Justice's sails (Datamation, 1969: 78).

By the early 1970s IBM itself had changed strategies away from dominating the computer utility market towards dominating the data communications market in response to larger shifts in the competitive computer marketplace. While IBM had increased its share of the 'computer systems' market since 1969, the company was losing ground against new forms of competition. IBM's proprietary systems, especially the modularized 360 product line, were being invaded by a new form of competitor known as plug-compatible manufacturers (PCMs). Rather than opposing IBM's closed set of compatibility standards with their own, PCMs simply treated IBM's technical dominance as a platform for their own hardware, designed to be compatible with IBM mainframes. The broad penetration of IBM equipment coupled with the rise of remote computing

created market niches for specialized plug-compatible terminals. As time-sharing placed increasing demands on machine memory, a plug-compatible memory sub-market also developed. The Justice Department's flagging case received a boost in 1973, when Telex, one of those plug-compatible manufacturers (PCMs), won its private suit against IBM, charging that the company had arbitrarily altered its interface standards in such a way as to make 'plug-compatible' equipment incompatible. IBM took a proprietary tone in its defense, its lead attorney saying, "*IBM must monopolize every product which it manufactures*, which might be replaced by a product manufactured by someone else" (Gardner 1973: 65, emphasis added). It also counter-sued Telex itself for "unlawfully obtaining IBM trade secrets and copyrights of IBM technical publications" (Ibid: 66). The court's decision recognized computer peripherals as a legitimate market in its own right, and IBM's protectionist behaviour as anti-competitive.

The Justice Department moved to expand its list of triable issues to include IBM's monopoly of the compatible peripheral market. Justice increasingly focused on the divestiture of IBM into independent corporate entities corresponding to independent technical parts, transforming the computer 'systems' market into a collection of markets of interdependent component manufacturers: a market structure that would generate the *economic incentives* to create public standards. The logic, explained by economist and witness for the prosecution Gerald Brock, is to create a market structure with weaker economies of scale. Monopolistic economies of scale were seen as only achievable through the construction of complete systems. Currently:

... "our difficulty is that IBM really does not see it within their own interest...to have perfectly accepted standards"... With functional separation, it would be in the interest of all the companies to have standards to increase the market of their different products (Pantages,

1974: 97).

Standards, once again, are seen as operating as the intermediate product of a market structure appropriate to the technical characteristics of the commodity being distributed.

Direct involvement by the state in the standards process itself:

...amounts to regulation and “we get lots more chances to foul things up if we go into the regulatory business than if we go into the structural reorganization business” (Ibid: 99).

This hands-off approach to standards opened up an opportunity for IBM. The development of the Systems Network Architecture was an attempt, like the development of the 360 line before it, to use standards as a means to define a new industrial status quo, while placing IBM at its centre.

An Internal Standards Regime: Systems Network Architecture

Teleprocessing drove demand for more, and more kinds of, terminals and peripherals to support remote-computing applications. From the mid-1960s to 1970 IBM saw its profit levels on terminal equipment fall dramatically, nor was the company capturing as large a share of this expanding and strategically important area. Despite the success of the System/360 as a standardized technical platform, IBM had a weak standards policy with regard to new products. As Jean-Jacques Duby, former Science & Technology Director of IBM Europe, describes:

The machine developers were not restricted by having to use any standard parts, and could manufacture their own. This strategy was suitable for a while: as soon as there was upgrading to be carried out, there were no standardisation obstacles in the way (Duby, 1995: 5).

As the uncoordinated part-numbers stacked up, IBM was soon getting tangled up in its own technical standards, to the point that “its own salesmen occasionally preferred to accommodate competitive terminal equipment rather than grapple with the problems of

internal offerings...” (Cooke, 1974: 57). To halt the slide, IBM committed in 1970 to develop a common set of components to be used throughout its product sets. These internal standards would serve to reinforce the barriers against plug-compatible invaders:

There will be heavy integration of terminal software/hardware architecture into host operating system and applications software packages. Emphasis will be on the exclusivity of IBM’s combined hardware/software approach (Ibid).

The strategy was to appropriate the market for diverse terminal equipment developed by the PCMs into IBM’s system of closed and proprietary standards. This standardization effort, which would be unveiled as the System Network Architecture in 1974, would evolve from 1970 in response to a number of developments.

In 1972 BBN, the firm contracted to design and operate the ARPANET, created a subsidiary to design and build a similar public packet-switched network. The Telenet network’s technical characteristics disrupted many of the assumptions behind the FCC’s findings in its first computer inquiry, made only a year earlier:

- Whereas the FCC split service providers into ‘processing’ service and ‘messaging’ services, packet switching provided ‘message processing’ services. Telenet’s distributed network of computers and packet transport erased the necessary distinction between ‘channel providing’ and ‘data manipulation’ more clearly defined in typical hub-and-spoke networks.
- ‘Hybrid networks’, like Bunker-Ramo’s, were not meant to serve a broadly defined public like Telenet’s general-purpose, non-proprietary computer network.

These characteristics also challenged IBM’s ability to use its power in the mainframe market to dominate the emerging teleprocessing market. Aside from the explicit challenge to the IBM’s proprietary, centralized model of computing (and networking), it also threatened attempts to move into the telecommunications portion of the equation, embodied in the Carnation private branch exchange initiative (PBX), developed in 1968

and released in Europe in 1971 (Ibid: 60). Packet switching threatened to steal a portion of total teleprocessing revenues but, more seriously still, disrupt IBM's control over its total system which allowed it to introduce new services and control the technical migration path of its customers.

Worse still, packet switching reinforced two other technical trends threatening centralised computing: minicomputers and distributed processing. Increasingly efficient integration of integrated circuitry initiated the now well-known downward spiral of price and size and corresponding upward spiral of processing power that remains a defining characteristic of the computer industry. The shrinking cost of computer power was challenging the existing computing models based on Grosch's law. The computer industry was moving from an assumption of resource scarcity to one of increasing abundance:

Those devices that must function around the clock do so because of the huge investment necessary to establish any usage at all...The minicomputers currently sell for around \$10,000, counting everything that is needed to make them useful...We must begin to think in terms of the cost...to the user, rather than the cost of raw CPU time. Above all, we must begin to get used to the idea that an idle computer is not necessarily a bad thing, and may be quite a good thing (Gruenberger, 1973: 59).

'Minis' opened computers to markets where their cost and size had formerly made them prohibitive, like the office. They were also taking the emphasis off of networks as a means to create remote processing services, to creating *distributed* processing networks – facilitating the constructive interaction of CPUs to produce faster and more flexible means of processing and distributing data. In 1970 Tymnet developed a network of distributed mini-computers using a proprietary method of packet switching to deliver remote-terminal time-sharing services and, in 1973, to provide packet switching services

to third-parties to connect their own computers over Tymnet's 'teleprocessing' network (Combs 1973: 40). Even more troubling to IBM was the fact that these networks had been explicitly designed to easily connect various brands of computer systems, overcoming the 'vendor lock-in' IBM had relied on for many years as a way to tie their terminals, software and network services together (Hirsch, 1970: 153). The vision of widely accessible computing resources appeared to be coming to light, but not through the computer utility model. The 'fireside terminal' was being replaced by the *programmable* terminal, or stand-alone mini! And while this critical shift in market and technical structure was ongoing, IBM was under pressure *not* to exercise its monopoly power to either shore up its hold on the mainframe market, or retard the arrival of other forms of computing. Systems Network Architecture represented a shift in using standards to create a market of closed, proprietary systems to a market based on control over the means by which peripheral components interconnect and communicate with each other. SNA was an internal standards effort built around a packet-based communication protocol that would wed the functional advantages of mixed installations, packet switching and distributed processing with IBM's existing control over *de facto* technical standards.

A standard platform for controlling innovation and change

System Network Architecture was a standard designed for future technical innovation: it encompassed the creation of a coherent, ongoing standardization policy internal to IBM while the technology itself stressed modularity and flexibility. SNA was, as the name itself suggests, a broadly defined framework for technical development, similar in intent to the 360 initiative but even more all encompassing. SNA's

development was, in fact, overseen by Bob Evans, who had previously been responsible for the launch of the System/360. His division, Systems Communications, was charged with “‘enforcing’ the system network architecture...on other IBM products”, globally within IBM (Karp, 1975: 22). The immediate competitive advantage of public, packet-switched networks was their ability to eliminate the need for multiple networks, one for each terminal and application. One of the guiding principles for packet-switched architectures was the ‘layering’ of functions into discrete bundles of ‘tasks’:

...to insulate functions from each other, and to establish standard interfaces between functions. Hence, a function at one level (say, an application program) need not worry about the peculiarities of another layer (such as the transmission layer). A second advantage of layering is that changes can be made in one layer without concern for their effect on another...Layering is the key to orderly, evolutionary system growth (Berglund 1978: 81).

Layering allowed for innovation and change within a standardized framework, but also ensured separation between network and application functions. Bolt, Beranek and Newman (BBN) had borrowed the concept of layering their network protocols from concepts that had developed within computer science and had been applied to software development. The NCP protocols were structured using a two-layer architecture in order to ensure the separation of network and host operations, to allow a single network interface with numerous applications. IBM borrowed back this computing concept for the creation of its more elaborately layered Systems Network Architecture.

SNA provided a *migration path* for internal IBM development, but also for customers, for third-party developers who would design compatible products, and for the direction of commercial computing in general. Locating the network’s intelligence in a central mainframe host (the System/370, introduced as the 360’s sequel in 1972)

provided a clear migration path for existing users that “had a large psychological, political and financial interest in the continuation of a centralized computing philosophy.” (Sherwood, 1978: 97) At the same time, it attempted to address the needs of “small-to-medium sized installation users who [were] not yet locked in to IBM and may be able to find an alternative to IBM’s line within a micro- or minicomputer-based framework” (Ibid: 96).

SNA preserved the basic tenets on which IBM’s legacy technology (and customer base) depended: centralization and hierarchy. SNA was debuted in September 1974 with great fanfare but limited functionality. Like NCP, it served as a means to create a unified network for terminals to contact applications residing on a mainframe host. However, unlike NCP, which was structured to provide peer-to-peer connections (for two computers to ‘talk’ to each other) SNA only allowed for terminals to communicate with their local host computers. While the structure was that of a traditional, centralized teleprocessing network, the novel advantage was that a *single* link protocol and access control could be shared by *different* kinds of terminals and applications. This was possible because network functions had been carefully isolated into three layers, or protocols, that provided networking ‘services’ to end-users.¹⁷

The end-points in any SNA-mediated communication are identified as ‘logical units’ (LUs), and can only establish contact with each other through the mainframe host. In a typical interaction, for example, when a terminal establishes contact with an application residing on the host, the ‘logical units’ are the terminal and the application. The request sent from the terminal uses the services provided by the three network protocols to create

¹⁷ Previously, application logic had been intermingled throughout network and terminal functions, requiring separate lines for each application.

a packet containing the ‘request unit’ (the substantive content), origin and destination addresses (Transmission control), path information (Path control), and error-correction and scheduling information (Data Link control). These three services are provided to the LU indirectly by the *host*, which acts as the System Services Control Point (SSCP), and “contains the centralized data about the current state of the network” (Gray, 1975: 55). The SSCP monitors and manages *all* of the network’s resources and establishes and deactivates links between logical units.

Network sessions (LU-LU connections) are hierarchical, with hosted applications serving as the Primary LU and terminals as the Secondary LU. The primary LU is ‘in charge’ of the session – giving ‘permission’ to the secondary LU to connect, and sending the termination notice once the session is complete. The three protocols that provide the basic networking functions (they form the ‘transmission subsystem’) are referred to collectively as Synchronous Data Link Control (SDLC).

Host-to-host communications were added in late 1976, but in such a way as to preserve centralized, hierarchical control. Remote terminals must first make a request to its *local* host to connect with an application residing on a *remote* host. Once the link is established, the second host takes over control of the session, as if it were the terminal’s local host (Berglund, 1978: 83).

When centralized computing was the only vehicle for commercial computing, and IBM held the choicest property, it manned its defenses, but with minicomputers and packet-networks threatening the entire approach to computing, IBM lowered its drawbridge:

For the first time in this decade IBM is actively helping users and computer vendors to attach non-IBM hardware to an IBM mainframe. In

one swift move the giant has defused much of the rancor surrounding the use of competitors' devices and had done it in a way that will be profitable to IBM (Ibid: 98).

IBM released sufficient technical details about the SNA architecture for six manufacturers to have developed SNA-compatible equipment before the first systems were being sold. Part of the intent of SNA was to take the ad hoc market niches the plug-compatible manufacturers had managed to invade, and create “a more coherent SNA-marketplace” for them to install their equipment at any network node (Karp, 1975: 21).

IBM had made a strategic choice to let its share of the peripheral equipment market erode and in return grow the overall value of its platform by increasing the number and diversity of applications designed to operate over it. Building an ‘open’ platform was concomitant with defining its system in terms of *standardized interfaces and architecture* rather than concrete pieces of technology. And while the standard was open, it remained proprietary and, IBM hoped, a *de facto* standard set internally by the company and enforced by its hold on the market. In this sense, it hoped to preserve the status quo within the data processing industry. Deriving value from an open system strategy depended on expanding the overall market size and generating new sources of income based on the value of its platform. To this end, IBM tied SNA's, and its own, fortunes to the telecommunications marketplace. What IBM intended, in short, was to reproduce the status quo of the computer industry, hinging as it did on a particular pattern of technical standards-making, within the telecommunications industry.

IBM positioned SNA, an end-to-end data architecture, as the vehicle to enter the data communications industry. A year following SNA's release, IBM formed Satellite Business Systems in partnership with COMSAT. Despite some concerns regarding the

potential vertical integration between IBM and SBS the service was licensed by the FCC in 1976.¹⁸ IBM announced that it would be the sole supplier of the proposed carrier's control equipment just prior to the expiration of their agreement with Control Data to stay out of the teleprocessing service business until 1979 (McLellan, 1979: 90). The move surprised some industry watchers because it contradicted IBM's traditional avoidance of regulated activities for fear of 'tainting' the computer industry with regulatory intervention. For a number of interlocking reasons IBM had positioned SNA as an explicit conflation of computer and telecommunication systems.

SNA technically redrew the lines of the EDP marketplace. On the one hand:

...the problem with IBM's CPU and memory market is that technology has been forcing down the costs and the prices – not that a formidable competitor is on the horizon...In the past this mainframe and traditional memory market comprised some 70% of IBM's business. [In 1978] it will comprise more like 30%, by 1985 it may account for no more than 10% (Anderson, 1977: 91).

On the other, data processing was increasingly dominated by information management services, becoming incorporated into front offices, and merged with communication facilities:

Between "The Office Market"...and "Transmission" is something we call 'No Man's Land,' and it is here that this battle of strategies will be fought, for this area represents some 70% to 75% of the entire data communications marketplace (Ibid).

Anderson argues that whether IBM's SBS venture was financially successful in the long run or not, its primary importance to IBM was in exercising control over initial developments in data communications in terms of technical standards and regulation.

SNA and SBS help IBM to:

¹⁸On the condition that a third party, Aetna Casualty and Surety, was included in the partnership. (McLellan, 1979)

... establish the standards by dint of its market share and its speed; to not have to reveal its strategy and specifications in advance; to not have to change its equipment half-way through development because of industry association's standards; and, most important, to have knowledge of how its communications architecture matches its future network (Ibid: 95).

In 1976, with the introduction of multi-host networking to SNA, IBM also introduced network management tools:

Users had previously turned to independent suppliers to provide network diagnostics...*it definitely was meant to eliminate application host dependency from the network* (Frank 1980: 138, emphasis added).

Network management was centred in the host, along with the rest of the network intelligence. The transmission facility itself is treated as an interchangeable component (as one of its engineers put it: "...telephone lines, a satellite channel, *or whatever...*" (Gray 1975: 53, emphasis added)). As one corporate data communication planner commented: "the traditional division of monthly operating cost is 65% for the common carrier and 35% for IBM. Under SNA, though, it looks like the expenditure will be 65% for IBM, 35% for the carrier" (Karp, 1975: 21).

Finally, the SNA technical strategy played a two-pronged role in the regulatory/legal arena. First, it drove a wedge into the critical 'no man's land' market described above, hopefully staving off AT&T's attempt to tariff these services, thus incorporating them into the domain of its regulated monopoly (Anderson, 1977: 95). Second, it bolstered their defence against the Justice Department in several ways: First, as already described, it diffused much of Justice's allegations regarding IBM's use of technical standards (and other means) to keep PCM equipment out of its systems. Second, against the charge of lack of competition in the EDP industry, IBM raised the spectre of AT&T's possible entry into the business via teleprocessing services of its own. IBM's lead counsel in the

case pursued this line of questioning the same year SNA was debuted:

Were you aware...that there exists a company larger than the IBM company, which was ready, willing and able to enter the [EDP] industry, but which is precluded from doing so by a wholly artificial [barrier, and of] the possibility that that portion of the consent decree might be withdrawn and that AT&T and Western Electric would then be free to engage more fully in the industry (Pantages, 1974: 95)?

Third, SNA reinforced IBM's argument that Justice had defined its case on an obsolete notion of what the computer business was. It argued for the technical impossibility for breaking up IBM. Barr asks Justice's expert witness:

Do you not understand...that without designing the total system, it is, in effect, impossible to design, in any serious way, any major part of that system?...Do you think people can just proceed along parallel lines and then, at some point, they'll just merge whatever they are doing (Ibid)?

In a related tactic, customer witnesses were called later in the proceedings to testify that "there is no longer a readily definable general purpose computer market. The lines of demarcation have blurred, and today's DP environment is far more complexly structured than it was in 1969 when the government initiated its case" (McCartney, 1979: 107). Based on the redefined marketplace IBM suggested that far from having 70% market control in 1972, it held a mere 32% (Ibid). Justice responded to these arguments by pointing out a seeming contradiction, that IBM was claiming that the market was at once more 'systems' oriented, thus requiring a single company to design large end-to-end systems; and at the same time claiming the industry was fragmented and modular, thus watering down its apparent dominant market share. SNA's open (but proprietary) system design was what allowed these contradictory arguments to be made. IBM was now seeking market 'control' rather than direct market 'share'.

SNA as the basis for a renewed hegemony

It may appear that the SNA initiative, as an internal IBM standard and the product of its own R&D department, was purely the product of IBM corporate strategy; An example of a dominant firm forcing a particular technical model onto the market it monopolizes. But the SNA initiative was in fact an excellent demonstration of an attempt at a hegemonic ‘compromise’ that sought to incorporate oppositional trends and change while preserving the larger hierarchical structure of practices that defined the computer hardware business.

By 1970 it was clear that IBM was facing a serious competitive threat in the form of increasingly efficient, inexpensive minicomputers developed by companies such as Digital Equipment. In 1968 Arthur D. Little estimated that the annual growth rate of minicomputer revenues would surpass those of mainframe sales by 1973, and that the population of installed minis would surpass other models by 1975 (Sharp, 1970: 32). A Canadian computer consultant wrote in 1970 that, “Minicomputers are really with us and show signs of over-running the computer market place before the end of the 1970s” (Ibid). While IBM was effectively preserving its stable of existing mainframe business customers, it appeared that the company was defending a hill fewer and fewer competitors wanted to take. Minis also seemed to have taken the lead in terms of technical innovation, having become favorites of computer science and other research organizations. The success of high-profile experiments like the Honeywell minicomputer-based ARPA network, and General Electric-based Multics time-sharing operating systems had reduced some of IBM’s reputation as the leader of computing’s future.

Simultaneously, IBM also faced competition from the plug-compatible manufacturers

(PCMs). Companies like Telex and Amdahl, unlike the mini manufacturers, were specifically eroding IBM's legacy mainframe market by copying IBM technology and undercutting them on prices. But this form of competition was actually beneficial for IBM in the long run as it:

- Enhanced the overall value of using an IBM mainframe due to the increase in compatible specialized and inexpensive equipment
- Took pressure off of the legal challenges of IBM's dominance of the computer systems market
- Reinforced IBM's position of leading technical change, as PCM strategy focused on copycatting IBM innovations

As one Datamation editor commented on the PCM situation at the time, "Like the classic film scene: the big bully swings his arm, his opponent [i.e. the PCM] ducks, and the guy behind [i.e. the computer system manufacturer] gets slapped" (Emmett, 1978: 78)!

SNA specifically embraced the PCM market by providing an open, stable platform for them to design and connect their equipment to. But it competed with the minis in the sense that it reproduced many of their technical advantages. IBM began to distribute processing power throughout its integrated systems while maintaining a centralized and hierarchical model of computing. It was in fact a sophisticated attempt to renew 'the unity of opposing structures' and maintain IBM's priority position within it. Or, to use Datamation's analogy, to redistribute the honey, while keeping everyone feeding from the same jar.

SNA also intentionally conflated the regulatory divisions between processing and communications that had emerged out of the FCC's first computer inquiry. SNA treated networks as essentially an extension of the computer itself, under centralized host control. It also extended that control into the realm of public networking by designing inter-host

communications to operate in the same manner as local network communications – control over local terminals was simply temporarily transferred to a remote host. The network carrying the data between host and terminal was reduced to operating as little more than a bare-bones ‘pipe.’ In an SNA network, the host essentially *was* the network, and the host was an IBM-compatible mainframe. In this sense, SNA also embraced many of the principles behind the NCP protocol (application neutrality, layered architecture, and packetized data) but tied them to a proprietary standard associated with IBM hardware.

Chapter 4: Canada and the carriers respond

A handful of international carriers led the development of the X.25 packet-switching standard in the first half of the 1970s, coordinating their work through the International Telecommunications Union (ITU). The initiative was carried out in parallel with, and in response to, IBM's System Network Architecture (SNA). Because of domestic market and regulatory conditions, Canada, and in particular Bell Canada, played a central role in the international process of developing and implementing X.25. The existing Canadian scene was characterized by power-sharing arrangements divided largely along provincial lines, and technical standardization served as an important vehicle for the federal government and the carriers themselves to define and pursue their agendas. Whereas US regulatory reform was characterized by the structural division of industries along imagined technological lines in order to develop competitive sub-markets, Canadian reforms took the form of a 'negotiated settlement' aimed at defining an interface between two independent yet complementary industry sectors: a competitive 'content industry' of computer services and a regulated 'carriage industry' of data transport services controlled by the existing carriers.

The move from economic to political regulatory rationale in communications

The federal governments of Canada and the United States initially treated the regulation of the telephone industry as a necessary evil: as a form of isolated market failure for which corrective action was limited to price controls exercised by arms-length organizations over privately operated monopolies. Emphasis was placed on creating a depoliticized, economistic solution to what was essentially an economic malfunction. In Canada, however, the economic notion of a *natural monopoly* was conjoined with a

concern for maintaining national sovereignty, implicitly injecting a more overtly political agenda for regulatory intervention. US regulators focused on the allocational efficiency of allowing telecommunications to be provided by a single entity due to the overwhelming economies of scale involved in what was purportedly a natural monopoly. In Canada, identical logic would have dictated that the country join a single North American network in order to further exploit those economies of scale. The vast majority of Canada's population would be more economically served by simply extending AT&T's domestic network and service area a relatively small distance. Instead, federal intervention acted to explicitly *resist* economic lines of least resistance that would have led to the creation of north-south extensions from neighboring US cities into Canadian territory. Communications policy has maintained this defining characterization: one that balances economic efficiencies and political goals. It is a largely accepted fact that, as Hudson Janisch argues, Canada's communication system is largely a product of its geography and demographics. These conditions have created "a very attenuated country five thousand kilometres long and three hundred wide," leading it to perennially confront "an immense challenge to maintain east-west traffic flows in the face of powerful north-south attractions" (Janisch, 1987: 1-2). In Canada telecommunications have come to be symbolically and practically linked with channels of political influence – both in terms of potential foreign and existing domestic control.

Babe argues that political efforts to preserve 'sovereignty' through telecommunications have primarily provided ideological camouflage for achieving economic goals that largely result in the opposite. Policy has tended to ensure that communications technology is employed to increasingly bind the Canadian establishment

to powerful economic and cultural flows originating from the US. Babe points out that while:

[o]n occasion communication media have indeed been purposefully and successfully deployed in aid of nation building...Far more common, however, has been the tendency [to deploy them] in manners supportive of continental integration; indeed, it may be fairly said that Canada as a nation persists despite, not because of communication media (Babe, 1990: 6).

In 1969, Department of Communications (DOC) Deputy Minister A. E. Gotlieb expressed this same antagonistic quality of communications media and the policy challenge it presents. Speaking specifically to the issue of satellite technology, Gotlieb spoke of the nationally cohesive properties of the technology:

I hate to use clichés, but I think there is an analogy with the railway here. When it was opened up, I imagine very, very few people lived at the end of the line, but the very fact this facility went in, I think, transformed the character of the country (Ibid: 5).

Only months later, Gotlieb warned that satellites presented a significant danger to Canadian sovereignty as it offered an express route for Canadian capital to flow *directly* to the US (Canadian Datasystems, 1970a: 73). To move beyond the domestic/foreign, horizontal/vertical, political/economic dichotomy framing both these observations, it is critical to observe the manner in which communication media have consistently been employed in Canada to create and control a politically unified *interface* between processes of capital accumulation located in the US and in Canada. In this sense, the project of 'sovereignty' can be understood as a process of consolidating regionally distributed centres of political-economic activity under federal leadership, substantially for the purpose of controlling the exchange of foreign capital.

It isn't surprising, then, that jurisdiction over Canadian telecommunications, being so

closely aligned with political authority itself, mirrors larger structures of political authority in Canada. From the beginning of the twentieth century, Canada's telecommunication regime very quickly fragmented along provincial lines (Winseck, 1995). This division of powers entered a period of crisis during the 1970s as telecommunications technology achieved increased strategic importance to economic development, and its current regulatory framework came under pressure for change. A 1980 C.D. Howe Institute report commented that communications policy during the 1970s took its shape, "at the delicate interface between technology and politics, and, in characteristic Canadian fashion, has come to be expressed primarily in terms of federal-provincial relations" (Woodrow, 1980: 1). Computer communications served as a key flash point around which many existing political-economic tensions were played out. In the rather jurisdictionally fragmented arena of Canadian communications, the Federal government found compatibility standards to be a critical means to pursue policy goals.

Federal/provincial tensions over new communications technology

In 1970, communication undertakings in Canada were embedded in a complex jurisdictional terrain balancing federal and provincial authority, divided by geographical and technological categories. Telecommunications was the most fragmented: 18 common carriers accounted for almost all telephone service revenues, sunk plant, and wages. Of this group, five fell under federal jurisdiction, only two of which (Bell Canada and BC Telephone) offered telephone services to business and residential customers. Publicly-owned CNCP was restricted to telegraphy and more modern message-switched services, while the Canadian Overseas Telecommunications Corporation (later Teleglobe) and Telesat Canada (both also crown owned), essentially served as "carrier's carriers"

(CCCTF b, 1972: 7). The remaining 13 provincially-incorporated companies were regulated by nine provincial utility boards, which (save Ontario) were not specialized communication agencies but had dominion over all regional public utilities including rail and electricity services (Ibid: 9). Although the federal government claimed legal authority to govern telecommunications in Canada, it accepted on historical precedent that the carriage industry was an “area of divided jurisdiction” (Woodrow, 1980: 15) that effectively meant carriers were regulated on an almost ad-hoc, company-by-company basis (CCCTF b, 1972: 6). However, there existed distinct areas of strong federal control and influence that cut across regional jurisdiction. Through the 1970s, the federal government would attempt to consolidate its control over the sphere of communications (Woodrow, 1980: 16), and in doing so, it naturally attempted to steer the industry along lines in which it had an established ability to influence. These powers stemmed from both practical and constitutional circumstances and included: the interconnection of facilities between provinces and internationally, the joint-use of facilities, telegraphy (the specific mention of telegraphy in S.92 10(a) of the BNA act was interpreted to include new *non-circuit switched* CNCP services like Telex and data services), and other international aspects of communication policy and practice (Canada, 1971a). However, these areas of federal influence, that tended to touch on interconnection and compatibility issues, were intrinsically linked to the standards-making processes of the telecommunications sphere. These powers were quite separate from the rest of Canada’s standards-making institutions. Telecommunication standards were worked out in practice by the Trans-Canada Telephone System (TCTS) – an unincorporated consortium of Canada’s largest carriers operating the national telephone network. The consortium also worked with

provincial telecom-standards organizations. The Department of Communication had ultimate authority over the approval of standards, and members of the department served as Canada's official representatives at the International Telecommunications Union. As an inter-governmental organization, state representatives sat as the only 'full members' of the ITU while substantive technical work was carried out by participants from the telecommunications industry – in Canada's case, the Canadian Telecommunications Carrier Association (Sirbu, 1985: 40). Just as with the Canadian Standards Association in other technical fields, authority ultimately terminated at the state, but it was conjoined with the self-regulating, participatory efforts of private industry and standards institutions.

At the end of the 1960s, and into the 1970s, regulatory and standards bodies were both dealing with the 'claiming' of new communication technologies by existing industrial and regulatory structures. Establishing a domestic satellite service had been a federal priority since 1965, launching the world's first service of this type in 1972. The government moved unusually quickly to demonstrate its authority over this new technology, which was already biased to be treated as a national concern, having emerged as an *international* concern due to its connection to space exploration, national security, and the ITU's existing responsibility for the international coordination of broadcast frequencies. Cable networks, on the other hand, offered a mixed picture in their application and character, leaving jurisdictional claims much more open to dispute. Cable service emerged primarily as a means of retransmitting *broadcast* programming (primarily a federal concern), but operated in *local* settings, and technically resembled a *telecommunications* undertaking (most of which remained under provincial control). The

debate helps to demonstrate how technologies are not categorized by technical characteristics alone (or even primarily), as they become intermeshed with political agendas and legal precedent. The Western provinces and Quebec made the strongest attempts to establish jurisdictional control over cable. The former argued that cable was clearly a *telecommunications* undertaking, and could potentially be used to challenge Alberta and Saskatchewan's established jurisdictional authority over their publicly owned carriers. Quebec argued in the opposite direction, that cable was a *broadcast* undertaking over which it had regulatory control as an extension of its right to "control broadcasting developments to meet the cultural objectives" of its Francophone majority (Lorimer, 1991: 160). The courts sided with the federal government, which had successfully argued that a) cable television is an important component of the existing broadcast system, and that b) broadcasting is a technically indissoluble national undertaking, as already established by judicial committee in *Re Regulation and Control of Radio Communication in Canada* (1932):

Broadcasting as a system cannot exist without both a transmitter and a receiver. The receiver is indeed useless without a transmitter and is reduced to a nonentity if the transmitter closes. The system cannot be divided into two parts, each independent of the other (Bird, 1989: 109).

In 1971 the CRTC issued a policy statement on cable television titled "Canadian broadcasting 'a single system'", in which it "attempted to show how this technology, seemingly heaven-sent for Canadians seeking US stations, could instead be used to strengthen the Canadian broadcasting system" (Ibid: 423). The extension of the 'single system' principle, and federal authority, to new carriage undertakings like cable networks was supported by judicial decisions made by lower courts in the mid-1960s and finally confirmed by the Supreme Court of Canada in 1977 (Woodrow, 1980: 11-12). Treating

broadcasting as a single, integrated system allows for its interpretation as an inter-provincial entity even if a particular instance of it occurs within a single province's borders. Canada strengthened the principle of interconnectedness as a fundamental characteristic of all communication undertakings – applicable to both broadcasting and telecommunications. It amplified the 'cultural sovereignty' aspect of telecommunication policy over the purely economic 'natural monopoly' argument established at the century's start, further differentiating it from the US regulatory framework. These principles were captured in the 1968 Broadcasting Act, the creation of the Canadian Radio Television Commission (also in 1968) and the Department of Communications (in 1969) – all of which reinforced the treatment of communications as an *integrated system*, under increasingly rationalized control at the national level.

The challenge of the computer utility

Like the Wilson government in the UK, Canada responded to these challenges with the creation of a ministry intended to lead policy initiatives surrounding new technologies. In Canada, the Department of Communications was created in 1969, and its Minister, Eric Kierans, made computer/communications a priority. The computer utility represented a second chance for Canada to establish a native presence in the global computer industry, which was viewed as key to future economic development, even continued economic sovereignty.¹⁹ By the late 1960s however, it was also common wisdom that Canada had essentially missed its opportunity to develop a domestic computer industry based on the independent design and production of integrated computer systems (Gardner, 1972: 95). In 1970, Kierans stated that "only the most

¹⁹ Minister Kierans: "...I am convinced that if we in Canada lost control of this essential information industry, any effort to maintain a distinct Canadian political entity would be futile" (Canadian Datasystem, 1970: 75)

‘unremitting optimist’ could ever expect Canada to become a manufacturer of large computer mainframes” (Canadian Datasystems, 1970: 71). The computer utility held the promise of shifting the computer industry *away* from the sale of mainframes *towards* a model dominated by the provision of computer services, software, networks and specialized remote terminals. These industries served a diversified and relatively immature market not yet dominated by large foreign firms, and this was where Canada’s “real opportunities” lay (Ibid).

But if the American dominance of Canada’s *computer* industry simply reasserted itself within the *computer utility* industry, Canada faced the possibility of losing even the secondary benefits of the current branch-plant status quo. The worst-case scenario would see mainframe production wither only to be replaced by the remote delivery of computer services to Canadian businesses from inside the United States. DOC officials pointed to both a lack of anti-dumping laws to discourage such a development, and new communication links providing “a very large built-in gate for information to exit the Canadian scene” (Canadian Datasystems, 1970: 73). The key to building a strong Canadian computer software industry came to be seen as resting on the successful development of a Canadian-owned and controlled computer-communications *infrastructure*.

The goal of the federal government was to foster the development of a unified and suitable national computer utility that allowed for the development of an operationally and economically independent software and peripheral industry (Canadian Datasystems March 1970: 74). The fear was that the introduction of any segment of the computer industry into the communications field would lead to an even more fragmented, foreign-

owned communications status quo (Ibid; Katz, 1970: 62). In the US, the FCC and Justice Department were actively clearing space for an independent computer-communications industry to emerge outside the stifling dominance of AT&T *and* IBM by using a combination of regulatory decisions and legal attacks to break up their respective monopolies. Between 1968 and 1971 the FCC completed its first round of key policy decisions touching on the interconnection of computer and communication services, all encouraging or enforcing the segmentation of the telecommunications industry into a range of sub-markets, each subject to various levels of competition and regulation, depending largely on their perceived technical characteristics. Remote processing services escaped regulatory oversight altogether. In the immediate wake of these decisions, Canada would forge the basis of its own computer-communications policy, initiating a slower process of regulatory change. Instead of courtroom and regulatory decisions, the main vehicle for change would largely rest on commissioned research, reports, green and white papers and a great deal of hosted negotiations between 'stakeholders'. Instead of segmenting its market, Canada was looking for a way to incorporate computer communication into an expansive 'single system' that stressed the integration of its component parts.

These dueling visions of the computer-utility serve as political Rorschach blots, with the purportedly same technological revolution taking on almost opposing, yet purportedly inherent, characteristics complicit with the political end-goals of each nation.

The Computer Revolution vs. The Information Society

US regulators, in contrast, considered teleprocessing to essentially be a tool of business and a business opportunity for prospective providers of new services. The

foreseen benefits to both groups were economic in nature. Concern for the ‘public interest’ extended only as far as ensuring that the public-switched telephone system was not eroded by these new undertakings. Canadian regulators emphasized the *social* impacts of a national computer utility. The introduction to the Telecommission report on computer utilities states that:

Out of this widespread availability of computer, or more correctly “information” power, there could flow social changes and opportunities for human development that promise to make the next few decades *among the most critical that mankind has ever faced* (Canada, 1971b: 1, emphasis added).

This somewhat hyperbolic passage is representative of the kind of emphasis the report places on the computer utility as a vehicle of dramatic *social* change. In discussing the “Promise VS Danger” of the information utility, the report sketches out the ‘utopian/dystopian’ choice faced by the nation:

Taken together, these improvements add up to an infinitely freer life than any to which human beings have ever before dared aspire - literally a life of limitless horizons in which human intelligence will be free to develop to its ultimate limits...by aggressively and imaginatively exploiting the promise of the computer utility, Canada could leap-frog decades of normal development and *become among the world’s first post-industrial societies*.

...Unfortunately, there is also a darker side to the information utility...In the absence of adequate controls, [it] could create a dangerous menace to the right of privacy and, if carried far enough, to a society in which conformity would become the price of survival...Potentially, the information utility could provide the rulers of a conformist state with the ultimate instrument for control of the minds and ideas of the people (Ibid: 24-25, emphasis added).

Discussion of the *information* society and economy makes a subtle contrast with similar talk in the 1960s of a *computer* society and economy. Work on time-sharing and remote computers, both technical and economic, seemed much more concerned with distributing the computer’s raw speed and calculating abilities more efficiently and usefully. And

while the informational nature of its services is implicit in these discussions, the language in which it is described focuses on these networks' ability to create a man-machine symbiosis, to put people in conversation with the computer rather than with each other, even indirectly ("conversational computing" was another term used to describe the real-time interactions time-sharing computers made possible). For instance, in 1966 Douglas Parkhill (future Deputy Minister of the DOC in charge of the Computer/Communications Task Force) published *The Challenge of the Computer Utility*, in which he described its potential to create "a man-machine interactive operating mode," in which "*the machine* becomes a sort of intellectual partner, responding immediately to the queries of the man, questioning his errors, and amplifying a millionfold his effective mental powers" (Parkhill, 1966: 3, emphasis added).

The notion of an "information" rather than "computer" utility became more prominent in Canada at the decade's start. The Science Council of Canada, for example, worked closely with the DOC to develop policy priorities on the issue of computer communications. In 1965 the council had published a report urging the Canadian government to facilitate and support the development of a domestic mainframe industry. But by 1970 the Council's focus had moved away from hardware, towards bridging Canada's "information gap" by developing a system to coordinate Canada's existing information outlets by developing techniques "for gathering, storing and retrieving" information. The Council discussed the networking of these resources, but largely in the figurative sense of creating standards to create a more transparent system of sharing geographically distributed resources (Canadian Datasystems, January 1970: 75-77). The emphasis was off remotely *processing* data ('teleprocessing'), and on sharing and

distributing information.

The notion of an 'information utility' placed computer communications more firmly in the camp of other carriage technologies such as cable and satellite. This in turn provided a regulatory context more compatible with the emerging unified communications regime under the authority of the DOC and CRTC. A focus on (as yet non-existent) network applications such as online news distribution, electronic commerce and even voting placed the computer utility into the realm of policy considerations dealing with areas of established federal jurisdiction, such as "the intellectual and commercial content" of electronic media (Canada, 1971b: 39), privacy (Ibid: 41), and the federal government's constitutional obligation to maintain "peace, order and good government" (Ibid: 38).

Canada's aim was to develop the basis for a vital domestic computer industry based on the competitive development of computer software and services (network 'content'), not large-scale, integrated facilities ('carriage'). This goal benefited from a common-carrier model of network development, similar to the framework into which cable carriers were being fitted. That is, a gateway through which foreign content could be funneled and controlled, and a platform to distribute and promote Canadian content. US policy, by contrast, sought to stimulate diversity and competition in its 'teleprocessing' industry, with much less concern for the distinction between 'content' and 'carriage' industries. The FCC's first computer inquiry found that 'teleprocessing' could be undertaken in an unregulated fashion, if it consisted of a communication line terminating at a computer providing "data processing services", defined as any service provided by a computer other than circuit or message-switching (Esbin, 1998). The regulatory distinction made

was still biased towards distinguishing between ‘computers and processing’ on one side of the ledger, and ‘switches and communicating’ on the other. This hardware-oriented set of categories was understandable from the perspective of US regulators in 1969, given that 1) these categories corresponded with existing practice, as most teleprocessing services functioned as a means to share centralized stores of data or processing power via existing networks, 2) neither computers nor networks were thought of as generic ‘platforms’ for a distinct industry of ‘content producers’, and 3) the US was looking to stimulate competition *against* corporations like AT&T and IBM, that is companies looking to build their own innovative facilities from the ground up.

The question of distinct data networks

A difficult question for Canadian regulators was the issue of new digital networks and specialized carriers. The US contrasted ‘teleprocessing’ services with telephone services in terms of audience and services: the former was identified as computer technology and thus a business tool for providing highly specialized services to market niches, and the latter was a communication technology used to provide a single service universally. Computers provided a multiplicity of services on a competitive basis, and US regulation was biased towards preserving this basic economic and technical characteristic as teleprocessors began to distribute access to computers over communication lines. For example, teleprocessing services could perform a certain amount of message switching (categorized as a communications service) and remain an unregulated ‘data processing’ undertaking if the FCC deemed that communication did not constitute their primary business activity. To a large degree, the data communications business was being ‘computerized’ in the sense that the character of the computer, and the computer industry

(if not particular firms, like IBM), was intended to remain dominant as the computer went 'online'. In 1971, the FCC also formally allowed for the creation of what it called 'specialized common carriers' like MCI and Datran. These carriers were also identified with the use of new technologies – for the most part, microwave towers – to compete with the incumbent carriers in 'specialized' markets. In retrospect it is less clear that MCI's ability to successfully compete with AT&T stemmed from technical advantages (as it claimed), or simply from its regulated ability to target niche business customers and exclusively serve heavily trafficked routes (TCP, 2002: 20). In either case, the US was actively encouraging the development of communication services based on new technologies that enabled service providers to offer targeted, specialized services.

Canadian carriers and their regulators were coming under increasing pressure from lobby groups such as the Canadian Chapters of the Data Processing Manufacturers Association and the Canadian Information Processing Society, to also create services, and service providers, tailored to the needs of computer utilities and data users. Oft cited complaints with the existing analog, circuit-switched services included:

- high error rates
- high minimum connection times
- inappropriate set bandwidths (either too large or too small)
- busy signals during peak periods
- expense and difficulty of attaching modems to phone lines

By 1970, frustration with the carrier's lack of response to customer demands was peaking, along with suspicions that the carriers' lack of responsiveness stemmed from a conflict of interest. A group of 11 of Canada's largest computer service companies

submitted a report to the Telecommission in which it noted the “Failure of the common carriers...to develop a new digital data network which would complement existing communications hardware is a further indication of a retrograde attitude by...carriers to develop and exploit their existing monopoly” (Roberts, 1970: 44). The TCTS “broke with tradition” in 1971 by pre-announcing “that it was thinking of building a nationwide digital data network” (Hutchison, 1973: 20). The TCTS debuted the Dataroute service in 1973, the world's first national public digital network (Sproule, 1986: 48). The service was “functionally separate from the telephone network although it share[d] some of the same physical transmission facilities” (Law, 1973: 48), in fact the service in a sense simply extended to end-users the digital facilities the TCTS had implemented internally to make its long-haul voice lines more efficient (Sproule, 1986: 48).

The Dataroute's network architecture was designed to meet “the need to remotely access large, expensive and hence centralized host mainframes...typified either as remote batch...or time-sharing terminals...” (Ibid) For example, Dataroute was a leased-line service, meaning that customers could only establish a static network using the telephone companies' digital facilities. Thus Dataroute provided vastly improved service for customers currently using modems and the Public Service Telephone Network (PSTN) to reach a particular remote facility, but was too inflexible to provide flexible access to a widely distributed set of online resources as described by the Science Council and Telecommission reports. In fact, soon after Dataroute was first announced, the Science Council published a report in which it described its vision for a Trans-Canada Computer Network, the communications infrastructure for its previously described distributed network of information resources. When asked directly about the announced Dataroute

service, Leon Katz, Chairman of the Science Council's Committee on Computer Applications and Technology, dismissed the network as an inappropriate infrastructure to achieve the sort of resource described in his report (Canadian Datasystems, 1971: 57).

Between the period marked by the publication of the Telecommission's report on the computer utility in 1971 and the CCCTF's publication of its own in-depth report, *Branching Out*, in May 1972 a schism in Canada's data-communications policy formation became apparent. The schism resided in the oxymoronic analogy of an "information utility."

"Computer utility" had emerged as the dominant term for multi-user time-shared services in Canada and the US around the mid-1960s, coinciding with an extended-period of speculation and investment in the new services (Glinski, 1969: 66-67). Time-sharing drew comparisons with more traditional public utilities, like power and water distribution. It was identified with a method of sharing the generation and distribution costs of an expensive, raw material that served a broad range of uses. Parkhill provides a typical example of this sort of thinking in his early work on the subject. Although he plays down the importance of the term "computer utility" (Parkhill, 1966: v) and later asserts that it "merely denotes a service that is shared among many users" (Ibid: 3), he eventually argues that:

It must be emphasized that whenever one associates the words "public" and "utility" with any sort of enterprise, one is immediately involved with something whose operation is governed by a complex body of legislation and custom. Consequently, if and when computer public utilities become common, they are bound to be strongly influenced by many of the same legal factors that have concerned other public utilities (Ibid: 145).

The legal factors he cites include possible public ownership, price regulation, common carrier and natural monopoly status, and an obligation to serve the public interest (Ibid).

Retaining the utility analogy, Canadian policy moved from the importance of *computer* power to the importance of ‘information power’, and how it could be distributed and accessed. The difficulty emerged around the fact that information is far too specialized, too complex and simply too expansive a resource to conform to a model based on centralization. While Grosch's Law provided some rationale for the centralization of processing power into as few actual machines as possible in order to exploit the potential economies of scale, the many disadvantages of centralizing the nation's data and software into a handful of machines quickly became obvious, including the fact that it seemed obvious that the breadth of services being described in the Telecommission report would lead to far greater *diseconomies* of scale through “increased managerial, coordination, terminal equipment, and software costs which may offset the scale economies in computational power” (Noll, 1976: 256). Countering this argument however, the notion of the potential economies of *scope* arose as the new economic force that would inevitably lead to monopoly conditions in the online *services* sector. Especially as the telephone companies were already switching over to new computer switches (the electronic switching system, or ESS), the argument that these computers could also be used for data processing, seemed to gain some credence. The Telecommission's computer utilities report included as an appendix the results of a report on the potential economies of integration available to telephone companies in this very manner: there appeared to be none (Canada, 1971a: C51).

A second problem with the utility analogy arose around the independence of the competitive ‘content’ industry Ottawa hoped would develop around a national computer utility. The FCC had drawn a regulatory line between computer and networks in order to

free potential entrants into the teleprocessing field from the direct control of, or competition with, the incumbent carriers. However, in Canada, there was equal concern regarding the potential control exerted by foreign-owned computer firms, which dominated the design and sale of large integrated computer facilities, over the nascent market for online services. If Canadian companies had to develop their software and data services in conjunction with the purchase or design of their own computer hardware, the level of required investment would squeeze out most independent operators and lead to dominance by larger American firms who could afford the capital investment. Thus Canadian policy had focused on separating *content* from a broadly defined *infrastructure*, rather than computers and networks. The latter could conceivably include the provision of “raw computing power” as well as network components in a regulated and non-competitive manner. As Minister Kierans described to the Montreal chapter of the DPMA in March 1970:

...the [computer utility] industry would be divided into two sectors, one supplying computer and communications facilities, the other providing application services...One possible advantage is that there might be no need of regulating application services since presumably, market forces would assure good services at competitive prices (cited in Canadian Datasystems, 1970: 75).

The problem was that this regulatory framework did not fit easily with any existing technical model, or any obvious interface between 'content' and 'facility' as it did in the US. And Canada's existing domestic computer industry simply wasn't confident that any independence could be achieved if a single regulated entity controlled so much of the underlying facilities (Miller, 1972).

Packets to the rescue?

Computer-switched networks like the ARPANET were treated by the FCC's first Computer Inquiry and the Rostow Reports as a form of 'hybrid service'. Both made reference to the inherent diversity costs of computer services and their inherent lack of economies of scale. From the Rostow reports:

A single store-and-forward carrier would have to accommodate, on a single set of facilities, terminals with diverse line-speed, response-time and storage requirements. Such diversity would add to the costs of the system, offsetting the economies of scale of a single supplier (United States, 1969: 32).

And parallel reasoning from a large study on the FCC's computer inquiry:

Whereas the consolidation of circuit-switched service requirements into a single large system has produced economies of scale, consolidation of disparate message-switched systems into a single multi-service message-switching system might result in *diseconomies* of scale... Very clearly, certain communication services which are most naturally provided via a message-switched system, could *not* be easily or economically accommodated by an all-purpose message switching net (Mathison, 1969: 68-69).

In short, networks like the ARPANET were not expected to extend beyond providing narrowly targeted services to closely aligned organizations, by virtue of the nature of computer technology.

Canadian regulators, with the benefit of writing two years after the FCC decision, were less dismissive of the possibility of a single 'transaction oriented' (i.e. packet-switched) network providing transmission services for all of Canada's data communication needs. The questions surrounding such a network surrounded how physically, institutionally and economically separate such a network should be from the existing telecommunications and computer industries (Canada, 1971a: 57-62). Also interesting to note is that the Telecommission document is less interested in the *lack* of

economies of scale in computer networks, than in the potential 'economies of integration' they offered. These economies would theoretically stem from the provision of both *transmission* and *processing* services by a single infrastructure (Ibid: 43-45). As mentioned above, the Telecommission report contains a research paper largely dismissing the potential for economies of integration to be realized. However, included in the report is a commentary by John DeMercado criticizing the paper for paying:

...too much attention...to the question of whether or not [ESS] computer-controlled...switching system could perform as computer processors. The well known conclusion, is of course that they cannot...it would have been appropriate if the authors had gone on to a detailed discussion of the economies of integration in store and forward distributed computer-communication networks, that were separate (or integrated with) the existing networks. For example, they could have examined what sort of economies of integration were involved if the Carriers were to adopt the IMP (of ARPA fame) to realize a distributed network (Canada, 1971a: D3).

The FCC largely abandoned the regulatory framework emerging from its first computer inquiry in 1976 with the initiation of a second inquiry to "once again grapple with the knotty problem of defining the boundary between communications and data processing..." (Data Communications, 1976: 12). The telephone companies had integrated computer technologies in such a manner as to have them perform the same switching functions as their mechanical and analog predecessors, only more efficiently. Thus services like AT&T's ESS posed no threat to the regulatory distinction between processing and communications. On the other hand, distributed packet-switched networks transformed the network itself into a 'processing' platform for a host of value-added communication services. The Network Control Protocols operated by the ARPANET had been designed to operate as a set of discrete 'layers' performing interdependent functions that collectively routed data between end-points. This mimicked how computer operating

systems were modeled to provide 'layers' of functions, each of which drew on the services of the layer beneath it in order to provide a platform for a wide-range of software (Abbate, 1999: 51). For example, application software such as a word processor, draws on more 'primitive' services beneath it that in turn draw on and make available the computer's more basic processing power. Packet-switching networks like the ARPANET and Tymnet were providing services that seemed to fall between regulatory categories such as 'hybrid', which was purportedly a processing service with some communication characteristics, and 'specialized common carriers', which were a form of regulated but competitive communications service that utilized new technologies to provide tailored service. The services of packet-switched networks came to be referred to as 'communication processing' - a complete conflation of the regulatory division between 'communication' and 'processing' services.

The FCC's problem was not with packet switching per se, which was the sort of technically innovative service it was looking for. The Commission had so far licensed two commercial spin-offs from the ARPA project, PCI and Telenet by 1973.²⁰ (Telenet was already commercially operational when it did so.) The real problem stemmed from the fact that the majority of new computer communication services were falling into the 'hybrid' category and the FCC was forced to make a 'primary business' ruling on each case. This resulted in a slow process for new businesses looking to bring new technologies and services into the market. It also resulted in old businesses attempting to enter the very markets the FCC and Congress had hoped to avoid becoming dominated by

²⁰ Telenet was a subsidiary of Bolt Beranek and Newman Inc. (BBN), the contractor that had designed the ARPANET. PCI was unaffiliated with BBN, although founded by a group of former BBN engineers that had worked on the ARPANET project.

the regulated and private monopolies from the computer and telecommunication markets. AT&T moved quickly to announce that it would soon develop its own “communications processing” services, and that it could legally do so within the letter of the limitations placed upon it by the 1956 consent decree with the Department of Justice (Hirsch, 1976: 100). IBM, using its newly developed SNA protocols and the infrastructure provided by its partnership with COMSAT, was prepared to launch its own data communication service. If the FCC's 1969 computer inquiry decision had intended to clear space to create a new and competitive teleprocessing industry, that space was beginning to seem crowded by the usual suspects. IBM and AT&T were both actively looking to extend their respective monopolies into the “no man's land” of the emerging electronic office marketplace (Anderson, 1977: 91).

In the meantime of course, Canada still had only the rudiments of its own regulatory framework for computer communications. On the face of it, packet switching seemed to offer at least a technological vehicle for realizing many of the goals Canada had sought for its national ‘computer utility’:

- It provided a data-optimized network addressing most of the technical drawbacks of using circuit-switched networks for data communication.
- The notion of 'layered' protocols meant that:
 - The network was 'application neutral' in terms of the computer services it was best able to deliver.
 - It was relatively easy to technically divide operational aspects of the network from the end-user service it made available.
- Its distributed architecture allowed computers and content to be located anywhere on the network (on any 'node').
- By providing a single interface and carriage technology, packet nets allowed service providers to capture 'economies of scale' in the delivery of data carriage, without

unduly limiting its 'economies of scope', i.e. the number of different services available over the shared network.

But while the theoretical benefits of the technology were apparent, the typical danger remained: the potential threat to Canadian sovereignty. The line of least resistance for importing the technology into Canada was, as usual, for Canadian organizations to lease lines across the border to the nearest node on the network. The University of Quebec, for example, had attempted (unsuccessfully) in 1971 to join the ARPANET and establish an inter-campus NCP network as a solution for its resource-sharing needs (Cheesman, 1999).

The X.25 Initiative

The ARPANET no longer held a monopoly on packet-switched networking by 1973. A number of similar research networks were also operational: NPL in the UK (based on John Davies' pioneering work) and Cyclades in France were two high-profile examples. Several commercial public networks had also arisen in the US: Tymnet's packet-switched time-sharing network, and Telenet, a BBN subsidiary. Packets had also invaded the sphere of private networking. For example, the airline carriers' had developed SITA, a packet-based international airline reservation network. The banks were in the midst of designing an international electronic funds transfer system (EFTS) to carry a global flow of monetary transactions. Looming over this effort in particular was IBM's SNA initiative, as the computer giant already dominated the world banking industry's processing needs, as it did most others.

The world's national carriers were left in the position of playing catch-up in an arena they were not only used to leading, but dominating entirely. Nevertheless, by 1973 a handful of carrier initiatives were underway: Spain's RETD had been in operation since

1970, the British Post Office awarded a contract to Ferranti Ltd. to develop the EPSS in 1973, Japan's NTT was working on two networks involving packets begun in 1973 (DDX-1) and 1974 (DDX-2), and a collection of European carriers contracted the construction of EURONET in 1975.

The Trans-Canada Telephone System had moved rapidly through a variety of digital services, building incrementally on existing facilities. Its 1972 *Multicom* services used modems and special analog lines to offer dial-up digital services, the *Dataroute* digital private-line service debuted in 1973, the same year it began to design a packet-switched service it announced the following year as *Datapac* (Sproule, 1986).

Until 1974, packet switching had been a low priority at the CCITT. Although the matter of data transmissions had been actively pursued since the 1950s, it was only in 1972, as part of Study Group VII (New Networks for Data Transmission), that the question of packets was even raised – as question 'C' of a list of 23 other questions to be studied by the group. The question itself suggests a distinct lack of enthusiasm for the technology:

Should the packet-mode of operation be provided on public networks, and if so, how should it be implemented (Sirbu, 1985: 38)?

But by 1974 it was quite clear that carriers *were* implementing such networks, and a standard would be required to allow them to interconnect across national borders. A Special Rapporteur for question C was appointed in July of that year. The X.25 standard would be formally accepted as a CCITT recommendation in September 1976, a little under two years later – an unprecedented level of haste. One incentive for rapid action on the part of carriers was the direct threat of competition from alternative packet-switched service providers. But these specific threats could be countered by an incumbent

carrier's own national packet offering. More significantly, the carriers faced competition with regards to setting a packet-switching *standard*, and in a larger sense, competition with regards to remaining the world's preeminent communications standards development organization.

The X.25 standard defines the technical conventions used by data terminal equipment (DTE) to communicate with data communication equipment (DCE), “the terminal's point of contact with the network” (Sanders, 1976: 54). X.25 defines the interface “between equipment provided by the carrier and equipment provided by the user, or computer manufacturer” (Sirbu, 1985: 38). But because this line of demarcation divides more than technical components (it divides industries and their respective industrial regimes) it was not certain from where a standard would emerge. The dominant interface would eventually determine how third-party manufacturers (still a rather novel concept for the carriers) designed their equipment, providing a significant competitive advantage to the standard bearer, so to speak. By 1974, the situation was looking critical from the carrier perspective as:

- IBM had unveiled its SNA protocols, presenting the possibility that the computer giant would extend its de facto computer standards into the networking field (Abbate, 1999: 153)
- ISO had begun work on the protocol layer responsible for controlling the data flow between the DTE and DCE (Sanders, 1976: 53)

Adding to the time pressures was the fact that the CCITT published its official ‘recommendations’ every four years at its plenary conference, with the next plenary scheduled for 1976. If the carriers failed to establish a standard in the next two years, the next opportunity to publish an official standard would not arrive until 1980. Given the numerous carrier packet networks under development in 1974, in another six years

achieving technical consensus would be infinitely more difficult (Abbate, 1999; Sirbu 1985).

According to the detailed account of the development of X.25 by Martin Sirbu and Lawrence Zwimpfer, Dave Horton, as Assistant Vice-President for Planning of the Computer Communications Group of the TCTS, was the first to seriously initiate “an international lobbying effort to press for the adoption of an interface standard” in time for the 1976 plenary (Sirbu, 1983: 39). Sirbu and Zwimpfer describe the Canadians as being particularly “anxious to see a defined standard” (Ibid). This is especially true relative to their counterparts in US regulatory and carrier circles, who were among the most resistant to the X.25 process. Below I draw on a number of the broader regulatory and competitive issues in both countries discussed earlier to demonstrate how they combined with and affected each country’s role in the international standards process.

First: Canada’s carriers were simply more motivated and capable of producing inter-carrier standards. They routinely worked together to negotiate standards for *domestic* communications under the aegis of the TCTS, which since 1931 had allowed a “highly variegated collection of carriers to operate as an integrated national communications system...[by providing] for the exchange of traffic nation-wide and establish[ing] standards, planning and coordination” (Janisch, 1987: 4). Although Bell Canada and British Columbia Telephone dominated the carriage industry in terms of total operating revenues, the national telephone network required technical and operational coordination between all the provincial telcos. This balance-of-powers was reflected in the decision making process of the TCTS: “Each member has one vote, and, as decisions have to be unanimous, the smaller companies wield greater influence than their market share might

otherwise indicate” (Ibid). Although the network itself was called the TCTS, “it is...important to understand that [the TCTS] is really a collaborative agreement to exchange traffic and is not itself a carrier. It owns no separate plant and facilities, and its staff is on loan from its member companies” (Ibid). Although the TCTS was the dominant voice in establishing technical telco standards in Canada, it was not a formal national standards-development organization like the CSA. It operated as a private organization (although unincorporated) on behalf of Canada’s largest telecommunications carriers, albeit with an operational culture and process more comparable with SDOs than a corporate entity.

In the United States, the situation was quite different as AT&T possessed a far more dominant control over the operation of the domestic communications system, in terms of geographic reach and total traffic. Prior to the divestiture of the Bell system in 1984, “...the Bell System developed internal standards which it shared with the Independent Telephone companies and manufacturers in various Bell-United States Telephone Association (USTA) forums” (Lifchus, 1985: 34). Irwin Dorros, speaking as Executive Vice-President of Bell Communications Research in 1987, commented that the standards situation in 1967 “might as well have been a hundred years ago...when it came to the creation of standards it was a Bell System show...it was not a public issue” (Dorros, 1987: 77). The Bell System created internal standards within a “hierarchical structural management that could resolve [controversy] a lot more easily than in the public arena” (Ibid). Thus AT&T was accustomed to planning its network standards as an internal process, compatible with its own timetable and corporate strategy.

Second: aside from a general orientation towards developing ‘public’ standards,

Canadian carriers were also much more motivated to actually develop a *packet-switching* standard. Their markets were much more difficult to defend against the private networks to the south that could easily, from an economic and geographic standpoint, expand north into Canadian territory, or from IBM that, as an international behemoth, had far greater economic and technological resources than even the large carriers.

By contrast, AT&T's market was less vulnerable to data competitors because of its more contiguous geographic reach and because it was on a par with even IBM in terms of capital and technical resources. At the same time, AT&T was motivated to *delay* the development of an international packet-switching standard for two reasons, stemming from the more aggressive deregulatory action taken by the FCC with regards to data communications:

1) *Interconnection requirements.* AT&T faced direct competition from specialized common carriers such as MCI and Telenet. MCI's main distinguishing technological characteristic was its use of microwave towers to provide its bandwidth. It had argued for and received regulatory permission to interconnect with AT&T's switched network in 1970 (TCP, 2002), thus greatly enhancing the value of its service (CNCP would not receive the same permission until 1976 (Janisch, 1987: 16)). However, because of the unique switching techniques used by packet-nets like Telenet and Tymnet, interconnection with AT&T simply wasn't an option. The existence of an international standard however would allow the networks to interconnect with each other as well as internationally. Further, they would benefit from the global acceptance of such a standard in terms of the affect it would have on standardized terminal equipment. AT&T, with no packet service as yet, had nothing to gain from any standard save their own proprietary

one (which they had yet to develop).

2) *Regulated rates of depreciation.* AT&T's hardware development cycle was tied to a 40-year depreciation time frame, while its direct competitors in packet-switch technology used an accelerated five-year depreciation. Howard Anderson explains that if the company that *invented* the transistor, AT&T:

...exploited even 50% of its technical advances, it would bankrupt the company...Working from a standard system of accounts that is approaching 60 years old, it assumes a very long depreciation period (20 to 40 years)...ATT can earn only some 8% return on capital, even though it earns from 27% to 30% pretax on its revenues....If AT&T were allowed to accelerate its depreciation, it would have increased operating expenses (depreciation) and this would allow it to go before the regulators and seek unpopular rate increases. So AT&T must update its plant in measured steps. But technology does not move forward in measured steps; it leaps (Anderson, 1977: 93).

AT&T had much to gain in terms of creating a few years of breathing space in the deployment of new hardware. Even after the X.25 protocol was established, AT&T did not offer packet services of its own until 1983 (Sirbu, 1985: 40).

It should be noted however that Canada's carriers were not themselves of one mind on the issue of packet switching. In fact, despite the principal role TCTS would play in the development of X.25, Canada's official representative organization at the CCITT, the Canadian Telecommunications Carriers Association (CTCA) would not ultimately endorse the recommendation. That endorsement was blocked by CNCP, which had developed its own proprietary packet service (Ibid). However, because of the TCTS' *de facto* position as Canada's national carrier, it was able to directly collaborate with other CCITT members to create the technical standard and support for it. In the US, by comparison, participation in the work of the CCITT was channeled through an organization referred to as the US CCITT. This organization was dominated by Bell

System representatives. Telenet, which was enthusiastic about the development of a standard, could not affect the US official position. Nor could it attend CCITT meetings to speak directly until mid-1974 when it received public carrier status from the FCC. Telenet did in fact contribute to the standard, working at informal meetings organized by the TCTS (Ibid: 39).

Third: Government policies and practices regarding standards and standardization in Canada and the US also had a significant impact on each country's role in the development of X.25. The US felt that technical standards were developed in response to market demand and thus market forces would effectively discipline agents to standardize their products to an optimal level. Message-switched, store-and-forward networks were thought of as possessing similar market qualities as the computer: specialized technology serving limited audiences, and thus inherently competitive. Diversity and innovation would be more valued than compatibility and interconnection and enforced compatibility would reduce the market's allocational efficiency (Mathison, 1969: 68-69; Rostow, 1969: 31-33). Thus the government moved to affect standards directly only through its internal consumption of computer and networking technologies. But because the civilian and military standards policies were at odds with each other, the US was ineffective at influencing the emergence of a domestic packet-switching standard (Cerf, 1983: 293).

The Canadian government, on the other hand, directly intervened domestically to establish a non-proprietary data-communications standard. In 1973, the Canadian government published a "green paper" stemming from the *Telecommission* and *Branching Out* reports, entitled *Computer/Communications Policy, a Position Statement by the Government of Canada*. That paper established a working group on the topic of

electronic payment systems. In 1975 the working group published a statement of government policy regarding the development of a national electronic funds transfer system (EFTS):

...the government supports a “common user communications network” for the payment system. This network is defined as a shared service which would be openly accessible to all qualified users on a fee-for-use basis...With respect to [communications policy, the recommendation] supports the objective of the Computer/Communications Green Paper of fostering the development of efficient and reliable nationwide systems of publicly-accessible data communications facilities. It will also encourage continued Canadian control over the evolution of the telecommunications facilities (Canada, 1975: 7).

The banks themselves rankled at the government’s intrusion into what they perceived to be their private commercial activity (Koekebakker, 1975). Stopping short of mandating specifics regarding the technical and operational character of the network, the government instead mandated the use of public non-proprietary standards as a way to fend off foreign control and technical fragmentation: an “essential prerequisite for a common user communications network is the development of suitable standards that will allow deposit-taking institutions, common-carriers and computer manufacturers to coordinate their efforts” (Canada, 1975: 7). The government was specifically looking to create the foundations of a ‘common-carrier’ approach to an electronic payments system. In short, its EFTS system was a clear extension of its larger data-communications policy. Commentators interpreted the government’s insistence on “clearly-defined, publicly-available” interfaces, “as a direct attack on IBM’s policy of keeping its protocols secret and incompatible with rival products” (Abbate, 1999: 153). Further, the policy was clearly a competitive gift to the regulated carriers, coming only month’s after the TCTS unveiled details regarding its forthcoming Datapac service and its SNAP protocols (the

Canadian forerunner to X.25), which were incompatible with IBM's SDLC/SNA technology (Datamation, 1975: 122). The TCTS had publicly stated that the banking industry would be one of its primary target markets for the Datapac service (Canadian Datasystems, February 1974: 45).

This episode demonstrates not only the Canadian government's treatment of data communications as a carriage issue rather than a matter of computer processing, but also how it used areas of jurisdictional influence – interconnection, standards and, in this case, the banking sector – to achieve policy goals without directly using legislation or court actions. In fact, the federal government attempted and failed to pass new communications legislation several times throughout the 1970s, facing increasingly focused provincial opposition to doing so. Nevertheless, the mandated EFTS standards were an effective means to encourage the model of data communications they desired.

Negotiating a standard

I focus my analysis of the technical features of X.25 around two major points of contention that arose during the negotiation of the standard itself. The first was the debate over the inclusion of a “connectionless” packet-mode along with the “connection-oriented” approach favored by a majority of the telco participants. The second was the related issue of interconnecting networks via ‘gateways’.

Datagrams and virtual circuits

Any computer or terminal attached to a packet network uses a similar bundle of basic services to function, including a means of packaging information into a discrete and discernable ‘block’ of data (‘framing’), a means for the block to reach point A from point B (‘routing’), and a means of ensuring that the data traverses the network successfully

(‘error/flow control’). Where packet networks primarily differ is how these functions are distributed between the ‘layers’ of software that control its operation, how they are distributed between the physical components of the network, and who owns and controls those components. This boils down to a question of which services are provided by the *network*, and which are provided by the *customer-premise equipment* attached to it.

The issue of connection-oriented and connectionless networks is a question of whether or not the terminal or the network should ensure the safe travel of data across the network. Abbate summarizes the technical parameters of the debate:

Data travels through a packet switching network as isolated packets that may be lost, damaged, or disordered before reaching their destination. Somehow the network must convert these individual datagrams into a continuous, orderly, error-free stream of data (known as a virtual-circuit because it mimics a dedicated circuit between two host computers). Network designers debated whether virtual circuits should be provided by the subnet or by the host protocols (also known as “end-to-end” protocols, since the host computers are the endpoints of the connection). A network that creates virtual circuits within the subnet of packet switches is said to be “connection-oriented,” one that simply transmits datagrams to be “connectionless” (Abbate, 1999: 156).

The ARPANET can be said to have operated as a connection-oriented network as the subnet of minicomputers was responsible for providing reliable, error-free transmission, and not the host computers attached to it. Vinton Cerf points out that “even though the ARPANET was considered kind of a datagram-like service – because you put a label on the front [of each individual packet] and say ‘here, deliver this’ – underneath, inside the [subnet computers]...things were delivered in sequence. And if they weren’t in sequence there was something wrong” (Ibid: 128). Because the ARPANET broke with *circuit-switching* as the first large-scale implementation of *packet switching*, many commentators have implicitly treated *packets* as inherently linked with *datagrams* and

connectionless networks, and connection-oriented networks as some sort of corruption of the packet ‘vision’ of networking. But the ARPANET itself did not forge this link between packets and connectionless datagrams. Larry Roberts, heralded as the ‘father of the ARPANET,’ instead sees the defining characteristic of packet switching as “the dynamic allocation of transmission bandwidth” (Roberts 1978: 1307). A circuit-switched network establishes and tears-down connections in response to specialized signals, not the actual traffic traversing the network. Logical connections within a packet-switched network are established and dissolved directly in response to the traffic it carries. This is true whether one is discussing a connection-oriented (where the logical circuit is established by network components) or connectionless (where the circuit is established by the host computer) packet network (Ibid).

In the wake of ARPA’s success, new packet nets pursued both the connection-oriented and connectionless techniques, depending on the network’s intended end-user, and relationship with the network operator. For example, two French networks set important technical precedents for both approaches to packet-switched networking: the Cyclades network was the first to implement a large scale network using the connectionless datagram approach, while the *Réseau a Commutation par Paquets* (RCP) pioneered the concept of virtual connections. Cyclades was a government-funded experimental network connecting computer centres in France. The RCP was organized by the French PTT as a pilot project for what would become TRANSPAC, France’s first public packet-switched network. Unlike the ARPANET, Cyclades did not consist of an independent subnet taking care of transporting data, and terminals taking care of processing and displaying data. In a very real sense, the terminals were an essential

element *of* the network as they were responsible for “packet assembly and disassembly, sequence numbering, flow control, and virtual connection processing.” Roberts points out (rather dismissively) that this sort of network requires a cooperative and coordinated relationship between the host operators in order to function. On the other hand, the RCP’s virtual circuit approach made it “more directly marketable [to a broad audience], not requiring substantial modifications to customers’ host computers” (Ibid).

When the TCTS put the X.25 process into high gear by widely distributing its own SNAP protocols to other carriers it called for a standard based on a *datagram* mode of operation. TCTS likely favoured the datagram given that it was being designed largely with the banks and its prospective use as a “common user” electronic payments system: “Datagram proponents argued that the overhead involved in setting up a virtual circuit was wasted for simple point-of-sale, or automatic teller transactions, where one packet in each direction might be all that is required” (Sirbu, 1985: 39).

One of the main opponents to a datagram standard was Roberts himself, who by 1975 was President of Telenet, a subsidiary of BBN. Placing more network intelligence and responsibility in the network than in the attached hosts had a clear business appeal – you can’t charge customers for what you’re not doing for them: “Simply routing packets represent only 10 percent of the value added of a packet network; providing virtual circuit service and other interface facilities would be the major contribution” (Ibid). This blunt economic fact compelled anyone venturing into the carriage industry – even ones with a background in computers, not telephones – to prefer a network design that favoured the network (and network provider) in terms of control and revenue. Faced with opposition from both Telenet and the French PTT, TCTS aligned Datapac with the X.25 initiative by

providing the virtual circuit function, however it “retained the datagram mode as the underlying transport mechanism” (Ibid).

Inter-networking

Closely related to the issue of connection-oriented and connectionless packet networks is the issue of passing data between networks, or ‘internetting.’ Cyclades developed its connectionless approach with internetting at the forefront of its concerns. The logic hinged on the assumption that the more complex (the services provided by) a network was, the more difficult it would be to share traffic between different sorts of networks. Packet switching had already been successfully applied to landlines, satellites and broadcast networks. However, the physical nature of each medium had required a different approach to be taken in terms of how packets were transmitted by each network. For example, ALOHANET, a broadcast network, worked on a principle of hosts acknowledging the receipt of data, with a lack of acknowledgement triggering the first host to rebroadcast the data (Hafner, 1996: 222-223). A strong host protocol increased the number of different kinds of networks that could interconnect because the protocols assumed less about the sort of network transporting its data.

Of course, the X.25 also had network interconnection as a major end-goal of the standards process. However, the goal was not to develop a protocol that would enable a diverse array of networks to interconnect, but rather to develop a common set of protocols that all networks would use – thus allowing interconnection. Interconnection would be an incentive promoting X.25 as a universal standard, and widespread adoption would result in a number of positive externalities, such as access to a growing pool of computer resources and people over an expanding X.25 network, and reduced cost and

increased availability of X.25 compatible equipment and software. It would also secure the CCITT's position as the standards organization of record in the nascent sphere of data communications – thus keeping the PTT-dominated organization in control of the technical direction of packet switching.

X.25 inter-networking further reinforced the existing telecommunications status quo by favoring the interconnection of public over private networks. Two X.25 networks communicating through an X.25 'gateway' needed to support two virtual circuits, the one connecting the first host to the gateway, the second connecting the gateway to the second host. The CCITT would later develop the X.75 protocol designed to eliminate the need for a second virtual circuit, creating a more efficient internet connection, with less likelihood for errors. However, X.75 was only allowed to be implemented between two *public* networks – that is, they could not be used to connect a private network, such as a wide-area corporate network to a public X.25 network even if the private network was itself using X.25: "the CCITT's restrictions on the use of X.75 reinforced the message that private networks were not full and equal members of its internet system" (Abbate, 1999: 165).

Abbate's claim that X.25 projected a PTT vision of packet networking in which:

...each country would have a single public data network, and that the various public networks would interconnect at national borders. [And that] [c]omputer owners would attach their machines directly to the public data networks, rather than to private networks linked to the public system... (Abbate, 1999: 166)

is reinforced by its addressing system. The CCITT had estimated that most countries would require 10 network addresses – the unique identifier used to route packets to a specific host. Two hundred addresses were reserved for the US, far too few if the CCITT

had also considered the thousands of smaller local networks that theoretically could have opted to join the X.25 net (Ibid).

A Telco Hegemony, Not a Telephone Paradigm

The X.25 protocol suite and the bottom-three layers of SNA shared similar data networking visions, although technically incompatible. The main functional difference stemmed from X.25's reliance on an ISO-version of IBM's link-level protocol (SDLC) called HDLC. The version of HDLC used by the CCITT allowed for peer-to-peer communications (a technical option IBM had vigorously fought against). Originally, in an SNA network, when two end-points communicated (e.g. a terminal and a host computer) one of them had to be designated as the *primary* node, which controlled the interaction. But in an X.25 network, two nodes in the sub-network shared responsibility in terms of flow and error control. Thus X.25, like NCP, was designed with the assumption that it would primarily connect computers to each other rather than terminals to centralized hosts. In other words, X.25 and NCP were both designed to operate primarily as a distributed network, while SNA retained an architectural focus on accessing centralized computing power.

Egyedi and others have suggested that the connection-oriented approach to packet switching is the product of a paradigmatic approach to networking based on the telco's experience with telephone services. However, as I illustrated above, a preference for connection-oriented networking is less associated with a specific technological model than it is with economic and service models. The computer firm BBN, hired to design *and operate* ARPA's network, designed its protocols in a manner that centralized its control and operation within the sub-network itself, rather than with the host computers it

attached. Initially there was a degree of resistance from the departments and research institutions for whom the ARPANET was being built. Many were dubious of the notion that it would open their personal stores of computing power and applications to other network participants (Abbate, 1999; Hafner, 1996). Both ARPA and BBN initially focused on designing a network that would require as little cooperation from the participating hosts as possible. The X.25 protocols, if anything, *continued* this initial trend by using the virtual-circuit concept to strengthen its control over the packet network. In this sense, first generation ‘net-heads’ and ‘bell-heads’ were entirely in agreement. This similarity receives little attention in the analyses provided by Egyedi and Abbate.

Instead, X.25 is typically contrasted with the TCP/IP protocols. But the transition from NCP to TCP/IP was less of an *evolution* of the ARPANET’s protocols and more of a *revolution*. BBN had developed NCP. TCP/IP was the end result of a shift in control over the network’s development from a private firm to a coalition of end-users (the Network Working Group (NWG), a collection of computer scientists including Vinton Cerf and Bob Kahn) who designed the network from their perspective and using their priorities. The hand-over of technical direction did not occur without a fight. BBN at first refused to hand over the source code for NCP to ARPA. ARPA eventually took legal action in order to prevent BBN from treating NCP as proprietary software (Hafner, 1996: 233). Once in the hands of this international group of researchers, the protocol evolved towards placing control and responsibility over network communications in the host computers itself, until it was no longer possible to speak of a ‘sub-network’ on which hosts depended to communicate with each other. Rather, the host computers played a far

more complicated role than the actual 'network' computers whose job was reduced to simply routing packets to the closest node.

Complicating attempts to draw paradigmatic lines between approaches to networking even further, Bell Canada opted to design its SNAP protocols using a connectionless datagram approach, while Telenet, a subsidiary of computer firm BBN, enthusiastically pushed for a virtual-circuit connection-oriented approach. IBM's SNA also opted for a far more circuit-like control over network routing. And while SNA centralized network control within host computers, like TCP/IP, the network was also designed to centre processing power within the mainframe as well, leaving end-users to access the network via relatively unintelligent terminal devices. In this sense, the IBM architecture resembles far more the CCITT's X.25 model.

While technical trajectories were certainly at play in the development of X.25, it's clear that such trajectories articulate at the most fundamental levels with the political and economic priorities of their developers. These priorities are not primarily determined by legacy technology, but by the structural position of the designers as service providers or end-users, as vendors or consumers of technology. The original ARPANET protocols are an interesting hybrid case. Although it was designed as a means to collectivize private computing resources, and thus the 'host' protocols were designed and implemented by the network's end-user community, its communication substructure was designed to be operated by a single, private firm (BBN) to provide a set of services to consumers. TCP/IP represents a radical extension of the first aspect of the ARPANET. X.25 represents an extension of the second aspect.

Conclusion

Undue attention has been paid to the Internet's impact as a finished technology rather than to the process by which it was formed and integrated into the existing social and economic framework. As a communications technology, standardization sits at the heart of this process. The preceding analysis demonstrates not only the role standards play in the adoption of new technologies, but in establishing their taken-for-granted character.

Focusing on the history of standards allows for a rigorously non-deterministic analysis of a technology, while still allowing technology to have real material qualities that, to some extent, determine the manner in which it is used. The history of a standard demonstrates the degree to which the 'inherent qualities' of a technology are assigned in the process of developing a negotiated implementation of it. Major standards fora, and the standards they produce, reflect the political, economic and technological nature of the domain to which they belong – whether that domain is highly-regulated, competitive or academic.

Early efforts to standardize packet-switched networks uniquely reveal how standards can be used to incorporate a technology into a particular industrial sphere of practice. The technology arose largely outside of an established commercial sphere while implicating two industries separated by regulatory and corporate legacies but joined in recent technical applications.

ARPANET and NCP

Packet switching was developed in the late 1960s in an atmosphere of revolt against the rigid status quo of the commercial electronic data processing industry. The computer had essentially remained a large, linear calculator since the 1950s, with end-users rarely

enjoying direct access. Increased use and rapid turnover of hardware made data interchange a priority for business and government. MIT's Project MAC and their Multics initiative developed time-sharing systems in an explicit attempt to push computing towards a 'utility' model, networked and accessible rather than isolated and closed.

Large-scale public time-sharing systems would be unusable with the existing circuit-switched networks (Ossanna, 1970). Packet switching was a response to the inadequacy of circuit-switched networks as a distribution grid for computer resources. A second motivation behind the ARPANET itself was to eliminate the many incompatible, proprietary terminal networks already in use (Hafner, 1998: 13, 66). Both ARPA and Multics were philosophically and materially 'opposed' to the computer and telecommunications status quo; they utilized incompatible techniques with the intent of displacing the legacy services and technology of the two industries.

SNA

By 1974 the concept of time-sharing networks accessing large centralized stores of 'computer power' was itself under pressure from minicomputers and distributed processing. Although the ARPANET had originally been intended to foster resource sharing between large centralized computer sites, the network itself had been built as a distributed network of minicomputers. Its architecture lent itself to the sort of peer-to-peer distributed computing that the less expensive minis were making possible.

IBM, still at the centre of commercial EDP, was fighting battles on several fronts simultaneously: competition from plug-compatible manufacturers (PCMs), public time-sharing services, an antitrust suit from the Justice Department, and the encroachment of

the minicomputer. Rather than fighting them all, IBM designed the SNA standard to unite some of its opposition against the rest.

SNA was a standardized, ‘open’ software and hardware architecture that allowed third-party manufacturers to design and sell their IBM compatible products into a stable ‘SNA marketplace.’ Strengthening what had already become a *de facto* market for PCMs (i.e., IBM standardized equipment), allowed the company to harness the value created by an independent network of suppliers and developers, giving a competitive advantage to IBM over minicomputers. It also diffused a large aspect of Justice’s case against the computer Goliath. SNA provided many of the technical advantages provided by the NCP protocols (e.g. inter-host communication over a consolidated network and flexible routing), while maintaining the hierarchical, centralized architecture that preserved the mainframe-oriented computing on which IBM’s technology and business depended.

X.25

Like the NCP protocols, X.25 used a peer-to-peer approach, rather than the master-slave hierarchy maintained by IBM’s initial form of SNA. It did however utilize IBM’s more elaborate architecture, and the link-control protocol it had developed for framing data and providing flow and error control. Despite their functional similarity, X.25 and SNA remained incompatible, reflecting the competitive circumstances in which the standard was created. X.25 strengthened NCP’s method of controlling network traffic by establishing virtual-circuits for each connection. The *inter*-networking protocol it developed was designed to allow only *public* networks to interconnect using a single virtual circuit, whereas inter-networking between public and private X.25 networks required two. This, in combination with a small address space suggests that the CCITT

standard projected a particular market structure onto its X.25 standard: one in which a low number of public networks interconnected using identical protocols.

Standards index control

All three of these network protocols centre network control and intelligence in the component of the network controlled by the standards maker. For NCP and X.25, that component is a sub-network of minicomputers to which host computers attach. Host computers were left in charge of displaying content, the network computers handled communications. For SNA, the central component is the host mainframe. The network itself provided bandwidth, divorced of any responsibility for routing and error-recovery.

These standards essentially tied the networking *service* to the network *hardware* owned and controlled by either the carriers (including new packet carriers like Telenet) or IBM. *TCP/IP* on the other hand divorced network control and operations from any proprietary hardware component. *TCP/IP* was a strong *host* protocol – meaning that it was the hosts, not the sub-net that provided end-to-end control over transmission. *TCP/IP* was also non-proprietary, meaning that it didn't favour or belong to any particular brand of computer hardware. And as opposed to X.25, the network vision it projected was one composed of heterogeneous networks, both public and private, with little discrimination in regards to underlying media or protocol (Abbate, 1999).

The technical differences between NCP and *TCP/IP* index a shift in control over the network's development and operations. Although the first universities involved in the ARPANET project were consulted during the network's development, they were largely divorced from its initial design and implementation. There was both an initial resistance to the idea of a resource-sharing network from the participating universities, and a

corresponding concern on behalf of ARPA officials that computer science departments would ‘mess around’ with the network (Hafner, 1998). Thus, the network was designed by BBN to provide networking services to a set of ‘consumers.’ The NCP protocol was designed so that the sub-network provided communication services to attached computers.

However, a small group of interested participants – mostly academics and graduate students at the connected institutions – formed what came to be called the Network Working Group in order to develop software for the attached hosts, i.e. network applications. The NWG developed into a standards ‘organization’ for host protocols used on the ARPANET. The drafting process was characterized by its openness, informality and a loosely defined consensus building process. Debate was publicly mediated using the ARPANET itself and Request-for-Comments (RFCs) authored according to few conventions (save that they focused on host protocols) in which the author could make a case for or against a particular specification, or simply express tentative ideas. NWG consensus typically led to ARPANET policy (Abbate, 1999: 73-74).

Control over network protocols shifted from the BBN to the NWG during the ARPANET’s transition from research to private network. BBN fought to retain control over the NCP protocols as a proprietary technology, but were successfully pressured by ARPA to release the NCP source code into the public domain. The NWG, and its international counterpart, the INWG, retained a focus on host-centred software. Their work on *inter*-networking contributed to the development of TCP/IP – which eventually replaced NCP as the ARPANET’s native protocol (Hafner, 1996: 233-237) A host-oriented, non-proprietary standard corresponded to increasing end-user controlled

standards process.

Why a theory of standards?

For the purposes of my research, a central advantage of framing the above analysis as a comparison of ‘standards’ rather than a comparison of ‘technologies’ is the manner in which the subject of technical change is depicted. Focusing on the standardization of technology shows how technical creation and innovation is a negotiated process: a negotiation between interest and perspective groups. Standards development organizations actively work to incorporate the various perspectives on a certain technology into a reified category that typically represents an established industrial configuration, practice and discourse.

‘Technology’ on the other hand suggests an isolated sphere of specialized knowledge and activity. It also makes invisible the process by which any particular technical object comes to be identified with a certain category of devices, in turn tied to particular spheres of practice, users and applications. The result is often an exaggerated unity within technical categories, and the erasure of internal ruptures over time within those categories. A similar criticism is often made of Kuhn’s notion of “paradigms” (Giddens, 1976: 143-4). The concept of homogenous, stable cognitive spheres of scientific and technological thought also lends itself to discussing change as an all-or-nothing, oppositional transition as it is by Kuhn and by economists such as Schumpeter. Especially popularized accounts of Schumpeterian change apply his concept of ‘waves’ of ‘creative destruction’, as well as his championing the role of independent entrepreneurs, to suggest that competition and technical innovation ‘wash away’ established techno-economic regimes (Webster, 1995: 8). These sorts of analyses of

technical change can erase any acknowledgement of important large-scale continuities that run through what appear to be dramatic technical changes, especially in terms of governance and ownership.

Problematic paradigms

The preceding analysis demonstrates the advantages of joining a focus on the process of standardization with the analytical concept of hegemony. Instead of attempting to preserve homogeneity with technical paradigms, a hegemonic model stresses how variety and dispute are allayed in the process of consensus building. Within the ‘computer paradigm’, for example, approaches to networking varied fundamentally between IBM, ARPA’s Network Working Group, and the BBN corporation. Using technology as a means to identify paradigmatic borders cannot explain how the above parties failed to successfully unite their vision of packet switching (SNA vs. TCP/IP vs. X.25). On the other hand, while Bell Canada embraced the ‘computer oriented’ datagram approach to packet switching, Telenet (a spin-off of computer firm BBN) insisted on the ‘telephone oriented’ virtual-circuit approach.

Anti-evolutionism

Secondly, a Schumpeterian analysis of North America’s transition from an industrial to information economy might stress the manner in which innovative entrepreneurs developed new technologies and services to challenge the power of the existing status quo, a status quo focusing its time and energy on maintaining its own supremacy. Emphasized would be the Darwinian evolution of technologies, the role of competitive forces, and the divisions between old and new regimes (‘creative *destruction*’).

The first problem with such an analysis is that it fails to explain the *source* of

oppositional innovation in the case of packet switching. Competition from minicomputers, teleprocessing firms and the carriers themselves clearly played a role in IBM's development of SNA, and competitive pressures introduced into the telecommunications industry prompted the carriers to develop X.25 at an unprecedented pace. *But* while these two standards represented mutually *competitive* forms of technical innovation, both were in response to a more fundamentally *oppositional* technical innovation, i.e. packet switching which was developed outside of the competitive marketplace itself, in research labs in the US, the UK and implemented by the Pentagon as a private network for its own community of users.

TCP/IP provides an even stronger example of technical innovation that represents more than a competitive approach to packet switching, but rather a radically oppositional one. The technology is not simply designed to replace one service provider with another, but rather to reduce the importance of *any* service provider altogether, by drawing into the host computers many of the responsibilities and powers currently centred in the 'network.' TCP/IP reflected the needs of a community of users building and operating their infrastructure in a *communal* fashion, sharing costs and responsibilities *collectively*. In fact, many years later, commercial Internet access providers remain caught in an industry with notoriously low profit margins as basic access is a relatively undifferentiated commodity and provides few opportunities for 'value added' services and features. All of the application-level services and features are provided by the many hosts connected to the network. It was this very fact that led even new and innovative competitors such as Telenet and Tymnet to embrace the X.25 protocol along with most of the incumbent monopoly carriers, because it tied a number of higher-level services to the

network itself.

A Schumpeterian analysis of the shift from an industrial to an information economy relies on the competitively driven ‘wave of creative destruction’ of dominant technologies in the face of newer technology. But I described above how the Canadian establishment recognized and embraced the concept of the ‘information economy’ earlier than in the US – at least in its communication policies. At the time, this was precipitated not by a need or desire for competition in the telecommunications industry, but by a desire on the part of federal regulators to preserve the *monopoly* position of carriers in the face of the expanding number of services and content being distributed over networks themselves. And this desire was in turn prompted by the *political* project of strengthening federal jurisdiction over the communications industry. The project of political sovereignty, a central rationale of Canada’s communications regulatory framework, in a strong sense defined itself in opposition to free market competition, which it identified with direct encroachment by economic powers in the US. Thus, regulatory lines were drawn between physical infrastructures (carriage), which should remain uncompetitive, and information (content), which should become an increasingly autonomous and competitive sphere. The valorization of the role of the country’s information industries prefigured a massive refocusing from the production of hardware to the production of software that would arrive in US economic policy by the late 1970s (Jessop, 2000).

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