University of Calgary

Emerging Broadband Platforms In North American Telecommunications

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES IN

PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF ARTS

GRADUATE PROGRAM IN COMMUNICATIONS STUDIES

CALGARY, ALBERTA
JUNE 2001

0-612-65019-7

Abstract

This thesis looks into factors responsible for the current overhaul in North American telecommunications and analyzes this overhaul by taking into account regulatory, technological, and business dimensions. It looks at how innovative ideas in technology have been transformed into new business models through the influence of risk-prone capital. It also analyses the impact of the emergent new business models on traditionally dominant players in the industry. This thesis aims at contributing to the existing literature on technological change and its implications for the evolution of a "networked economy".

Acknowledgements

I shall first and foremost extend my sincerest gratitude to my supervisor and mentor Dr. David Mitchell. Dr. Mitchell's invaluable supervision and mentorship not only made this thesis project possible but in the process showed me the importance of being focused in pursuing my goals. His academic guidance enriched my writing skills as well as my sense of intellectualism.

I also extend my gratitude to Dr. David Taras, whose tremendous support made my trips to Chicago possible for two consecutive years to participate in series of training on telecommunications. He also endowed me with his unrelenting encouragement to pursue my aspirations in the world of telecoms.

I take the opportunity to thank Dr. Edna Einsiedel for her genuine support during my job application to Nortel Networks in the United States. In addition to the above individuals, Mark Wolfe, one of my best friends, provided me with guidance on how to keep my academic standards high. I will be grateful to all the above individuals for what they taught me about the process of scholarship.

I am indebted to Sylvia Mills and Marion Hillier for their continuous assistance throughout my studies. Their delightful presence made visiting the office of Communication Studies always a pleasure. I am similarly indebted to all of my former colleagues at TELUS Communications for their genuine support during my stay at TELUS, which enabled me to better focus on my graduate studies.

And I owe the most to my family—my parents Mehri and Abdollah, and my lovely brother and sister, David and Mitra—for their unhesitating support and encouragement to pursue my goals in life.

In Gratitude

Without the generous co-operation from the following individuals, this thesis project would have proved an insurmountable task. I am grateful to each one of them for their insightful comments, analyses, and ideas, which helped me put together this research project. Together, they helped me to appreciate first hand the current profound transformations in North American telecommunications.

Ian Angus, President, *Angus Telemanagement Group*, Ajax, Ontario

Scott Berry, Director of Product Marketing, *Metromedia Fiber Networks*, White Plains, New York

James Crowe, Chief Executive Officer at *Level(3) Communications*, Broomfield, Colorado

Dr. Robert Feuerstein, Senior Network Architect, Long-haul Optics at *Level(3) Communications*, Broomfield, Colorado

Eamon Hoey, Chairman and Chief Executive Officer, *Fox-Hoey Consulting Inc.*, Toronto, Ontario

Darren Kelly, Senior Director of Transport Group at *Level(3) Communications*, Broomfield, Colorado

Richard Kuehn, President of *RAK Associates* and Co-founder of the *Society of Telecommunications Consultants* in the United States, Cleveland, Ohio

Bill MacDonald, Assistant Vice President, Integrated Network Solutions at *TELUS Communications*, Calgary, Alberta

Richard Nespola, President and Chief Executive Officer, *The Management Network Group Inc.*, Overland Park, Kansas

Bill St. Arnaud, Senior Director of Advanced Networks at *CANARIE*, Ottawa, Ontario

Michael Strickland, Senior Director of Long-haul Optics Transport at *Level(3) Communications*, Broomfield, Colorado

Paul Vabakos, partner at *Comventures*, a Silicon Valley-based venture capital firm, Palo Alto, California

Dedicated to my lovely parents

He knows a hundred thousand superfluous matters connected with the (various) sciences, (but) that unjust man does not know his own soul.

Rumi, 13th Century Persian mystic/poet

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Chapter One:

Introduction

1.1 Historical Overview

The extent of transformations in communication industries in North America has been the center of many recent debates in both academic and industry sectors. Undoubtedly, the telecommunications sector has come to epitomize not just change but also innovation in the field of communication industries at large.

Current transformations in communications spurred by the telecom industry are being felt across all facets of socio-economic activity, promising more opportunities for generating wealth, a more democratic system of information exchange, and more independent outlets of information.

In the past fifteen years, both American and Canadian telecom sectors have undergone dramatic regulatory reforms. These reforms, aimed at encouraging competition, have removed entry barriers to such sub-sectors of the field as long-distance, local exchange, and wireless telephony. In the 1980's, the industry experienced two crucial transformations: a technical shift, and a significant shift in policy. The crucial technical shift was digitization, which led to the birth of intelligent networks and consequently the development of a robust signaling and network management system. And the significant shift in policy involved deregulation of telecom markets. Via deregulation, competition was embraced as a superior means of organizing telecommunication supply as compared with the public and private monopolies of the past (Mansell, 1993; 3).

A monumental step in this direction was taken in 1984 when 'Ma Bell' (AT&T) was broken up into seven regional Bell operating companies (RBOCs). The latter were mandated to operate local exchange services, while the remaining AT&T was confined to providing long-distance services. This move, known as the Divestiture of AT&T, opened door to an array of new players in long-distance sector, resulting in dramatic cuts in long-distance rates. Local exchange services in U.S., however, remained closed to competition until the landmark *Telecommunication Act* of 1996.

After an eight-year delay, similar steps were taken in Canada when the Canadian Radio-Television and Telecommunication Commission (CRTC) deregulated the nation's long-distance industry in a landmark decision known as Unitel-92. Even though the Canadian telecom sector witnessed emergence of new long-distance carriers, the cartel-like Stentor Alliance[1] continued to keep Canadian regional carriers within their provincial borders, barring them from providing any type of communication services outside their operating provinces. On the local exchange front, deregulation was first debated in 1994, but it took Canadian regulators three years until it became law in May 1997[2].

With the emergence of the Internet as a viable means of communication, the industry was confronted with an unexpected and exponential demand for more efficient data communication networks. Existing telecom networks were originally designed for transporting voice signals, which to date have proved highly efficient. But carrying massive amounts of voice, data, and video signals from one point to another at high

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[1] When Bell Canada Enterprises (BCE) began to set the agenda for provincial carriers on how to conduct business. Stentor's origin dates back to 1931, when Canada's largest common carriers joined together to form a cooperative, unincorporated consortium to develop and maintain an all-Canadian, coast-to-coast long-distance network. The consortium was known as the Trans Canada Telephone System (TCTS). In 1975 TCTS changed its name to Telecom Canada. And in 1992, as the result of reorganization, it became known as the Stentor Alliance. Stentor was later dissolved in 1998 (Wilson, 1997: 36-37).
[2] Telecom Decision CRTC 97-8, *Local Competition—Local Unbundling and Interconnection*, May 1, 1997.

speeds required more efficient and complex networks. Thus the buzzword "broadband" was born and added to the telecommunications jargon.

Specifically, "broadband" refers to the transport of multiple communication signals—voice, video, data—over one single network and at very high speeds. One of the first and, indeed, overarching implications of the Internet for telephone companies as well as Internet service providers (ISPs) has been a seemingly insatiable demand for more bandwidth[3]. The exponential demand for high-bandwidth applications, coupled with scores of technical requirements, have placed a heavy burden on the networks of traditionally dominant phone carriers, compelling them to spend huge sums of capital to upgrade their networks. With the deregulation of markets across the sub-sectors of telecom industry and the consequent emergence of new entrants, all the players in the industry gradually became cognizant of the importance of having efficient, modern and high-speed networks.

Crucial to this realization was the then untapped potential of fiber optic technology. In fiber optics technology, communication signals are transmitted in the form of light traveling within strands of glass, instead of electrons traveling through copper, a method still dominant in many networks. Transporting optical signals over glass has enabled many communication carriers to dramatically lower their network transport costs and at the same time increase network capacity substantially. Optical technology has already driven down the price of moving a bit of information over long distances to 0.006% of what it was in 1996 (*Business Week*, Oct. 9, 2000:147). Because the transport of signals in the form of light over glass is far more efficient than all the existing methods, optical

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[3] The transmission capacity of an electronic line, expressed in bits per second, bytes per second, and Hertz per second.

technology is poised to provide solutions to many unresolved communication bottlenecks[5] in both corporate and residential markets.

The above changes in regulatory regimes and communication technologies, coupled with Internet's exponential growth, led to a more competitive telecom environment. On the other hand, the impact of rapid developments in fiber optic technologies proved strong enough to lead to the emergence of new business models and thus an increasingly competitive telecommunications industry.

1.2 Research Question

This study will try to answer the following research question:

What are the key drivers of innovation in the emergence of new broadband communication platforms in an increasingly competitive North American telecommunications industry?

In the above question, I regard the implications of optical-based technologies on the industry as a vehicle that has given birth to new business models in the field of telecommunications.

In this research question, the term *broadband communication platform* refers to a new form of business model pertaining to the field of telecommunications. A major example of such platforms is *leased wavelength* services. In this model, multiple wavelengths of light are inserted onto a strand of fiber optic cable, amplifying the

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[5] The term bottleneck in today's telecommunications represents a technical difficulty to provide high-speed applications from a phone company's central office or a cable carrier's head end to the customer premise. The distance between central office/head end and the customer premise is known as the last mile. The last mile has traditionally used copper wire or coaxial cable, which have much less transmission capacity than optical fiber.

existing capacity of the fiber by several fold. These platforms are the result of new technologies, whose entry into market has been supported by risk-prone private capital that has turned them into new business models. Some of these new business models are poised to challenge traditionally long-time dominant players in the industry.

The term *drivers of innovation* refers to financial, technical, and regulatory forces and agents that have influenced the emergence of broadband business platforms. One of the main drivers of today's dynamic high-tech industry that has gone largely unheeded by many in academic circles in Canada is the intimate relationship between innovators of technology and a cash-rich financial industry. This relationship has given rise to the emergence of a new class of entrepreneurs who have begun to undermine the positions of many well-established players in the telecom sector. Since 1990, more than USD$100 billion in venture capital (VC) funds have been funneled into start-ups, most of which have been in the areas of telecom equipment manufacturing and communication service provisioning (*Business Week*, ibid).

The above research question aims to bring fresh perspectives to the debate surrounding recent developments in an *increasingly competitive telecoms industry* in North America. The *North American telecoms* industry here will refer to developments within the US and Canada. This thesis focuses on the financial and business aspects of the "new networked economy". It does not deny the socio-political factors related to technological change and innovation. But this research project is not a social inquiry into the potential implications of new communication technologies.

1.3 Scope and Relevancy

The full set of issues affecting today's complex telecommunications industry is so wide-ranging that addressing all of them would require several volumes. They include such things as the interconnection of competing networks (encompassing a whole range of both regulatory and technical issues); difficulties surrounding the deployment of high-speed broadband networks; and open access to broadband pipes by smaller ISPs, to name a few.

The scope of the issues that I will discuss in this thesis is restricted to the birth of new broadband communication platforms—that is business models respective to broadband networks. They can be summarized as follows:

- the impact of wide scale deregulation as it was initiated by the 1984 divestiture of AT&T;
- the emergence of intelligent networks and their implications for the industry;
- how the rise of the Internet in the early 1990's spurred an insatiable need for more bandwidth and more efficient communication networks;
- the passing of *Telecom Act of* 1996 into law;
- the resurgence of optical technologies in North America as the savior of bandwidth crunch;
- deregulatory trends in Canadian telecommunications and the state of the deployment of broadband communication technologies in this country.

I should emphasize that my thesis does not try to provide a comparative picture of broadband communications in Canada and the United States. However, certain parts of my discussion refer to the state of broadband technologies with a comparative look between Canada and its neighbouring country to the south. Some of the topics of discussion that will include comparative looks are: The emergence of dark fiber as a new business model (Chapter Four); and the extent of access to venture capital by entrepreneurs (Chapter Three).

Today, the overarching technological shift in North American telecommunications is characterized by the emergence of non-switched, packet-based, and off-network technologies. The combination of these technologies enables high-speed connections and greater throughput for data traffic. This technological shift, powered by deregulatory decisions, has resulted in a complete overhaul of the existing economics of telecoms and the birth of new business models.

The significance of the research question posed in this thesis is its ability to foreground some of the crucially important relationships in the birth of new business models that have acted as the cornerstone of technological innovation and change. These relationships are socio-economic and at times political. The research question, therefore, opens up some of the dimensions of today's networked economy that have been continuously neglected in Canadian academic circles. This research project is also significant for the chcices it offers to policy makers who are interested in the deployment of broadband communication technologies and their potential implications for the economy, education system, and community.

1.4 Design of Inquiry

The next four chapters address optical-based broadband communication technologies and the resultant business models. Each chapter is designed to analyze and evaluate certain aspects of broadband communication technologies and the characteristics unique to their deployment.

Chapter Two provides a background on the deregulation of telecommunications in North America and its outcome for creating competitive markets particularly in long-distance sector. It presents diverging views on the need to deregulate telecom markets. It also highlights the significance of the *Telecommunication Act* of 1996 in U.S and Decision 97-8 by the CRTC in Canada. Later it opens a discussion on natural monopoly theory and analyses motives behind the development of such a system in Canada and the US.

Chapter Two also demonstrates how changes in technology presented the first threats to natural monopoly system, particularly to AT&T (i.e. the emergence of Microwave technology). It then describes how these changes coupled with antitrust concerns led to the company's eventual divestiture. I later explain how the emergence of digitization brought new and important changes to network management.

In this chapter I borrow theoretically mainly from: Robin Mansell's models of alternative telecommunication development; William Melody's views on the changing face of telecoms in the age of deregulation; and Johannes M. Bauer's views on notions of market ***equilibrium*** and ***disequilibrium***. In her models— that she calls "idealist" and "strategic"— Mansell (ibid: 5-10) talks about market characteristics and their impact on competition and technological change and the determinants of change. Melody, in turn, analyzes issues surrounding telecom deregulation and related technologies. Chapter Two also discusses how the rise of the Internet resulted in the current exponential demand for high-bandwidth applications and an urgent need for the development and deployment of high-speed, data intensive networks.

Other issues discussed and analyzed in Chapter Two are dynamics of competition in Canada, both in the enterprise and residential markets; prospects of competition in deregulated markets. The chapter ends with a discussion on whether there is a need for government intervention in Canada in the design and deployment of broadband communication networks.

The information gleaned from the above literature review helped orient a further qualitative stage of my research. This latter stage involved interviews and a case study. Interviews were conducted with some of the leading authorities in North American telecommunications industry. Their expertise includes: broadband communication technologies; the relationships between incumbent carriers and their emerging competitors; and the roles of venture capital firms that have been involved in incubating numerous start-ups.

Another important part of my research strategy involved gathering information from professional consulting and market research firms. Such firms included: Pioneer Consulting, an international market research and analysis firm based in Cambridge, Massachusetts that specializes in global high-speed telecommunication networks and technologies; the Yankee Group, based in Boston, Massachusetts which focuses on telecommunication markets; and RHK a research firm based in San Franciscothat specializes in the fiber optic sector. Data from these companies, which highlight the most recent trends in the industry, enabled me to map out a realistic picture of today's telecommunications. I call the data from these companies 'live data', inasmuch as it reflects the latest developments and trends in the industry and also because it highlights their strategic direction.

In Chapter Three, "Innovation in Today's Telecoms", I discuss how ideas behind new communication technologies are turned into business models and new companies. My emphasis here is on the role of VCs as economic agents behind the flourishing of new technologies designed by entrepreneurs. I provide an analysis of Canadian capital markets respective to funding of new business ideas and initiatives in the field of telecoms and explore its strengths and weaknesses. To deepen my analysis, I turn attention to discussions from scholars in this field such as Davis and Smith[4], and Lera.

Chapter Three also looks at how innovative technologies affect established players and their dominance in the market. In this discussion I use Christensen's theory of *sustaining* and *disruptive* innovative technologies and apply it to new Internet technologies that have created new markets for startup companies and disrupted the dominance of established players.

Another important theme in this chapter is segmentation of the industry. It discusses how deregulatory policies and private capital have contributed to the emergence of subsectors both in the carrier and telecom equipment vending sectors. This section also analyzes why established players in telecoms regard VC-funded startups as additional sources of revenue that can help established players further consolidate their position in

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[6] I am referring to Charles H. Davis and Richard Smith's article entitled "Management of Technology and Technological Change in Canada: Learning and Teaching Innovation and Competitiveness" in *Developing Technology Managers in the Pacific Rim*, by Karen Minden and Wong Poh-Kam (eds.), M.E. Sharpe, 1995

the market. Chapter Three ends with a discussion on the role of academia versus market forces in the development of innovative technologies and the need for incumbent forces in the industry to accommodate themselves to changes in technology.

Chapter Four can be considered the cornerstone of this research project. It describes the new business models in today's telecommunications, and looks into the economic and strategic values of each model. The models discussed in this chapter include *dark fiber*, *leased lambda (wavelength)*, and *co-location* of telecommunication equipment. Chapter Four looks at Internet traffic growth and issues surrounding measuring its growth. It then provides a brief description of fiber optic technologies and explains their significance in the overhaul of current telecommunication networks.

Starting with the dark fiber model, Chapter Four turns its attention to the description and analysis of specific new business models in North American telecommunications. It then sheds light on the CRTC's and FCC's policies on dark fiber and explains the differences between the Canadian and the American regulatory agencies concerning this model. In this section I also provide an analysis of how dark fiber model has enabled emerging communication carriers to launch services and compete with incumbent carriers. This section also provides diverging views from industry observers and executives on the benefits and implications of dark fiber for the telecom industry.

Optical wavelength services is another major new business model affecting the economics of telecommunications. This section foregrounds the importance of dense wavelength division multiplexing (DWDM) technology in the development of wavelength services and offers two platforms from which they can be provisioned.

Taking into account advances in DWDM technology, I provide an analysis of demand elasticity and its relation to bandwidth growth.

An important part of Chapter Four is devoted to the analysis of deployment of these new business models in Canada and the debates surrounding them. Here I create a forum by bringing different viewpoints from different sectors of the industry including government-supported organizations like CANARIE involved in the deployment of broadband communications technologies.

Co-location is the last major business model discussed and analyzed in this section. This model involves provisioning of central office space to a variety of communication carriers in need of additional space to locate their communication equipment. This is due to diversification of communication services markets fueled by deregulatory policies of recent years. In this section I discuss two main existing models in co-location business and highlight the important elements in successful functioning of the model. I later discuss what factors have led to sophistication of co-lo business over the past year. Chapter Four later turns its attention to the current state of broadband technologies and advances made in their deployment. For example, it focuses on different access technologies and their evolution since the emergence of the Internet as a viable means of communication. It then introduces more advanced broadband technologies and presents the prospects for their deployment by reflecting viewpoints from industry experts.

Other important issues taken up in Chapter Four include bandwidth glut and the emergence of metropolitan area networks (MANs). The former debate refers to recent concerns in the industry about the massive deployment of optical infrastructure in recent years, prompting some industry observers to suggest that supply in bandwidth has far outstripped demand and could turn bandwidth into a cheap commodity. And the latter issue is about the importance of building broadband networks in densely populated metropolitan areas and the need to equip them with latest optical-based broadband communication technologies due to concentration of Internet traffic in these areas.

Chapter Five provides a case study of a next generation carrier involved in new business models discussed in Chapter Four. This carrier is Level(3) Communications based in Broomfield, Colorado. The study highlights the interrelation of forces of technological innovation and technological change. These relationships are closely associated with deregulation of telecom markets and the presence of grounds conducive to technology adoption in the market place. Issues discussed in this case study include the company's network architecture, description of its products and services, and network management. I will then analyze the company's business practices in the context of innovative technologies in a deregulated telecom environment.

Chapter Five also involves a discussion on the role of government-supported, central planning bodies and market forces in the development of standards in new technologies. In the course of the case study, interviews with the company's senior executives proved instrumental in conducting the case study. Chapter Five closes with a look at the potential ramifications that next generation carriers' business model holds for traditionally incumbent carriers.

As the global economy — with all its associated socio-economic benefits and unpredictability— continues to take shape, governments the world over are increasingly turning their attention to their communications infrastructure. The importance of deregulating national monopolies and upgrading telecommunication networks by governments stems from the role of communication networks in successfully managing modern economies. Undoubtedly, Canada and the United States, with their world-class telecom infrastructure, have proved to be the torchbearers in this field.

Today, advanced communication networks are not only needed to provide voice and data services, but also to conduct a range of businesses, and the exponential growth in e-commerce activities only attests to the role of the emerging 'networked economy'. With this thesis project, therefore, I hope to contribute to developing a better understanding of the importance of networked economy, and in the process, fill a neglected academic gap in the field of communication studies in Canada.

Chapter Two:

Deregulation and Competition

2.1 Regulating Telecoms

The transformation of telecom industries from public utilities to commercial entities is the most significant aspect of change in today's telecommunications environment. This particular aspect has been the target of heated debates. Some consider this transformation natural given today's forces of globalization and the urge by governments to keep their economies competitive both on regional and global levels (Geller, 1993: 21).

But there are critical scholars who think that opening telecom networks to wide-scale competition heralds the free flow of capital, which could result in growing divisions between the world's rich and poor (Babe, 1995: 207). Mosco echoes a similar view. He (1988: 117) calls deregulation a reconcentration of power and argues the end result of this process may be excessively fragmented markets that fail to provide necessary coordination, guidance, or planning for the new arena. Further, Mosco argues that this may lead to a reconcentration of power in the hands of industry leaders.

To others, on the other hand, telecommunication is an important sector in most economies, which is in need of significant investment by the private sector if development goals are to be met (Melody, 1997: 14). And there are scholars who argue that the efflorescence of new communication services as a result of technological convergence will erode the traditional notion of "universal service" as we know it today (Mueller, 1997: 174).

However, the overarching question in today's aggressively deregulated telecoms remains to be answered: How to devise a flexible regulatory structure for the new telecoms? In this regard Mansell (1996:187) rightly argues that the degree policy makers are able to maneuver within the boundaries of technical and structural constraints vary substantially through time. That is to say, we cannot create the perfect and the most desired policy and regulatory structure for the new telecommunications, and leave it untouched for, say, another twenty or thirty years, especially with today's constantly evolving market forces. It is fair to say that in devising a new telecom regulatory model, what remains certain is the continuity of dynamism in telecoms fueled by the emergence of new technologies as well as new business models.

2.2 Natural Monopoly Theory

Historically, most governments have viewed the new telecom service possibilities primarily as government owned or regulated public services, not services to be supplied by private businesses in normal markets (Melody, ibid: 13). This view has been adhered to most seriously in Nordic countries of Europe, and in Canada, where not just telephony, but also all other forms of communication technology have been viewed as important tools in nation building.

In his detailed work on the history of the development of telephone system in the United States, Milton Mueller Jr. (1997) outlines how the natural monopoly concept was developed and implemented by the U.S. governments and regulators. As a theory, natural monopoly was the product of a new school of political economy. This view held that competition in certain industries was destructive and inefficient and ought to be superseded by government regulation (Mueller, ibid: 12). The ultimate justification for this theory was not scale economies but the necessity of a unified service.

The development of a natural monopoly system in the US involved the regulation of private monopolies as a means of avoiding the substantial amount of investment capital by the government needed to supply the service, and thus limit the growth of government bureaucracy. The natural monopoly model was further consolidated in the US, when in 1893, AT&T Chairman Theodore Vail convinced state governments that a regulated monopoly with a universal service obligation was a better model to adopt. In this way, AT&T was able to attract all the capital it needed for growth and modernization, and was the primary source of new technologies in the field through the Bell Labs[1] (Melody, ibid).

It should be noted that Vail's policy of "universal service" was not based on a grand social vision with the aim of making basic communication services available to all Americans. Rather, it was a politically economic response to the then emerging dual service model mainly as the result of the entry of non-Bell/independent companies into telephony services. As Mueller explains, the term 'universal service' had never appeared explicitly before that time; neither had anyone inside or outside of the Bell System publicly defined such a comprehensive vision of the telephone industry and the respective roles of Bell, the independents, and the government. The term entailed the elimination of fragmentation and the unification of telephone service under regulated local exchange monopolies (Mueller, ibid: 92).

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[1] Bell Labs remained the R&D and equipment arm of AT&T until 1996, when it was spun off and became independent of AT&T and began to be publicly traded in financial markets. That arm today is known as Lucent Technologies (*Bell Labs Innovations*).

In Canada, Babe (1990: 137-49) explains how in the telephony sector 'natural monopoly' revolved around three underpinnings: first, reputedly vast and inexhaustible economies of scale; second, the claim that 'service universality' can best be achieved through system wide cost averaging and cross-subsidization; and third, the doctrine of 'system integrity' (maintenance of high service standards through end-to-end control).

For decades, private and publicly owned phone companies in Canada claimed that -- through cost-averaging and cross-subsidization -- their services were able to cover sparsely settled geographic regions and reached demographically lower-income groups. Cost-averaging meant that the entire operating territory was treated as one unit. And cross-subsidization referred to subsidization of a region, service, or subscriber group by another. As to their claim on service universality, phone companies argued that competition undermines service universality because entry by competitors centers on the most lucrative markets, which will invariably drive prices towards cost and will leave the phone company insufficient funds with which to cross-subsidize high-cost regions and disadvantaged subscriber groupings (Babe, Ibid: 139).

On the contrary, as Babe demonstrates, Bell Canada's pricing scheme for northern communities was primarily based on distance. Given the small size of most isolated northern communities, residents there found the long-distance network to be at least as important as local exchanges were to southerners (Babe, Ibid: 141). Moreover, because the distances separating the communities are vast, Bell's distance-based pricing scheme made telephone communications in the north very expensive. In 1984, for example, for its full territory Bell Canada received only CDN$291 in long-distance charges per main station, while in the eastern Arctic it received CDN$917.16 per main station (Babe, Ibid).

As to the 'universality of service', a policy of parsimony by Bell Canada was responsible for a slow and unabated deterioration in rural service through the period 1940-70. In the 1950s, for example, Bell's operations were mainly focused in the vibrant, urban markets where 92 per cent of its telephones were located. In contrast, only 42 per cent of independent companies' telephones were located in urban and 50 per cent of them in rural markets (Babe, Ibid).

Therefore, as Babe clearly demonstrates, the three historic pillars supporting the doctrine of 'natural monopoly' in Canadian telecommunications grew frail to a point that today they hardly make sense. With the deregulation of long-distance sector and the opening up of local exchange markets to competition, the main challenge for Bell as well as other incumbent phone companies has been how to reinvent themselves for the age of competition and deregulation.

2.3 Regulated Monopolies: Walking on Thin Ice

Despite the immunity granted by the law and lawmakers, the AT&T monopoly later proved susceptible to challenges posed by advances in technology. The first cracks in the edifice of the incumbent monopolist AT&T, came with the developments in microwave technology[2] in 1946. Microwave technology is a transport medium in the form of electromagnetic wave. It vibrates at 1Giga Hertz and above and travels only in straight lines. It also needs to be strengthened after traveling certain distances. Its applications

[2] Microwave technologies were used to provide analog, rather than digital, communication services at this time (Mansell, Ibid).

include communication satellites, PCS cellular systems, and wireless local area networks (LANs).

At the time of its introduction, microwave technology enabled AT&T's competitors to bypass the incumbent's physical infrastructure and provide private line, including long-distance services. Cognizant of the technology's lucrative potential, microwave equipment manufacturers and potential private system operators argued that adequate frequencies were available and that there was no reason for the FCC to protect the economic interests of the existing incumbents. In July 1959, the FCC concluded that adequate microwave frequencies existed and made microwave frequencies generally available to private users upon application (McNamara, 1991: 28). For AT&T, this simply translated into loss of revenue.

AT&T responded by attempting to integrate microwave capability into its network and offered a new service to its customers that deprived them of incentives to build their own private microwave systems. The new service called Telpak[3] provided large discounts to users of groups of private lines. High volume users gladly accepted the Telpak rates and abandoned plans to build private systems, later becoming AT&T supporters in future regulatory hearings (McNamara, Ibid: 29). But the technology was later adopted and put into use by its future competitors, most particularly by the Microwave Communications Integrated (MCI). MCI later played an instrumental role in challenging the AT&T in long-distance markets and eventually in bringing about the divestiture of the incumbent. In 1969 AT&T began to face direct competition from MCI when the latter was permitted to operate the first competitive long-distance service. This was a blow to AT&T since

[3] Telpak A offered a discount of 51 per cent for the use of at least 12 lines; Telpak B offered a discount of 64% to users of at least 24 lines; Telpak C offered a discount of 77% to users of at least 60 lines; and Telpak D offered a discount of 85% to users of at least 240 lines.

MCI did not have to carry the same burden of providing local service. In effect, MCI could take the most profitable long-distance customers without having to cross-subsidize these profits to cover the costs of local service. At the time, for a long-distance call made in the Bell System, "60 to 70 per cent of the charges were returned to the local telephone company as a form of subsidy to keep local rates low and to make telephone service affordable" (Noll, 1997: 81). This gave MCI a competitive advantage over AT&T.

In 1972 MCI began operating a commercial private line service between St. Louis and Chicago. The private line service continued until MCI launched Execunet in 1975. Execunet was an intercity and the first dial-up switched service introduced by a long-distance phone company in competition with AT&T (Newton, 1994: 411). The FCC, acting upon a Bell complaint, found that MCI's Execunet service exceeded the company's operating authority. However, the FCC later declared AT&T's complaint unlawful and adopted a registration system that enabled non-Bell equipment to be attached if it presented no potential harm to the network. It was this decision that fully opened the customer premises equipment (CPE) market to competition[4].

AT&T's anti-competitive responses to companies such as MCI and its attempts to suppress their newly adopted technologies greatly concerned the government (Head et al, 1994: 107). At the center of this concern was AT&T's transfer of revenues from its monopoly local telephone service to help pay for development of unregulated services. This practice meant that home telephone users were subsidizing AT&T ventures into new services for big business users (Head, Ibid). In November 1974 the Department of Justice brought suit to break up the Bell System on antitrust grounds. AT&T responded to the

[4] Because of court challenges by AT&T, however, the decision did not go into effect until 1978 (Blumenfeld and Cohen, www.technologylaw.com/telephony.html).

federal suit with its traditional argument that it was immune from antitrust suits because it was pervasively regulated at the state and federal levels, and requested that the suit be dismissed (McNamara, Ibid: 41). Throughout years of legal wrangling with the Department of Justice and a year-long court battle, AT&T never admitted to wrongdoing. To have done so would have opened the company to countless suits from competitors claiming illegal business practices and financial harm. In the face of heavy pressure, and the likelihood that litigation would drag on for years, AT&T agreed to be broken up. Finally, a *consent decree* settled the case in 1982 (Head, Ibid). The consent degree is also known as *modified final judgment.*

The consent decree divested AT&T of its regional Bell operating companies (RBOCs) and limited AT&T's operations to long-distance services. AT&T was allowed to continue ownership of its world-renowned Bell Labs. Today, as the result of wide spread deregulation adopted in *Telecommunication Act* of 1996, RBOCs have dwindled in number to three. Table 2.1 shows the original RBOCs at the time of divestiture and their present status.

Table 2.1 The RBOC Transformation

Original RBOC	Merged with or Acquired by	Merger Volume (USD)	Resulting Company
Bell South	Remains to be seen	N/A	N/A
Pacific Telesis	Acquired by Southwestern Bell Company –1997	$16.6 billion	SBC Communications
Southwestern Bell	Acquired Pacific Telesis-1997	$16.6 billion	SBC Communications
Ameritech	Merged with SBC-1998	$62 billion	Ameritech-SBC
Nynex	Acquired by Bell Atlantic-1997	$25.6 billion	Bell Atlantic
Bell Atlantic	Acquired Nynex 1997	$25.6 billion	Bell Atlantic
Bell Atlantic	Merged with GTE-1998	$53 billion	Verizon
US West	Acquired by Qwest-1999	$64 billion	Qwest Communications

AT&T's divestiture heralded a new era in the lucrative long distance sector. The market witnessed the emergence of an array of new carriers providing customers with discount prices. MCI, Sprint (a spin-off of United Telecom that was jointly owned and operated by GTE), and Long Distance Discount Services (LDDS), which gradually evolved into today's WorldCom, were examples of some of the most successful long-distance carriers.

Despite the significance of the AT&T breakup, deregulation did not offer any new services to consumers based on any new technology. As I indicated in the previous chapter, the local exchange markets were kept closed to competition, leaving end users, both residential and corporate, to only one locally dominant carrier. Also, technical innovations in digital networks were limited to improvements in signaling systems and network management. These also did not induce any competition either in long distance or local exchange.

The substantive changes to communication laws came with the landmark *Telecommunication Act* of 1996. This legislation involved complete overhaul of the earlier Communication Act of 1934[5] and removed all the remaining barriers to competition. Aufderheide (1999: 62) puts it astutely in context: "the 1996 Act first addresses telecommunication issues, then mass media issues—first in broadcasting, then in cable. It then proceeds to address implementation issues and introduces new regulatory features regarding obscenity, indecency, and violence on both telecommunications and media services."

Throughout the Act, most attention was given to wired telephony and the development of broadband networks and services. The FCC was mandated by Congress to evaluate and examine the state of the deployment of broadband networks and provisioning of related services to Americans (Section 706 of the Act). The FCC also became the responsible body for presiding over implementation of laws governing interconnection of competing networks. Many of those laws have since become obsolete as the result of developments in fiber optic technology, or have been part of legal wrangling among competing parties. Some of the main themes of the Act are as follows:

- Opening of local exchange markets to competition;
- Unbundling of network elements (UNEs) by the incumbent common carriers;
- Open access to high-speed networks by smaller and nonfacility-based ISPs;
- Universal service laws and the definition of basic telecommunication services;

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[5] The Communication Act of 1934 had led to the creation of the Federal Communication Commission (FCC).

- Laws governing entry of RBOCs into long-distance services (Section 271).

The passage of the Act into law was immediately followed by a torrent of mergers and acquisitions, which continue to consolidate the industry (see Table 2.1 for example). Also, both communication service provider and equipment vendor sectors have evolved into new specialized segments. The communication service provider sector has given birth to such sub-sectors as broadband access providers, application service providers, network service providers, and content aggregators, to name a few.

In turn, the telecom equipment-vending sector has also witnessed the emergence of vendors specializing in specifically selected markets. Their target market includes densely populated metropolitan areas and/or multi-dwelling units (MDUs) in both residential and business markets. There are also equipment vendors today in the fiber optic space that target *edge networks*, that is, their focus is on the portion of the optical network that sits between the core backbone and access part of the network.

2.4 Something Important Happened

Between the 1920s and 1970s the telecom equipment sector in much of the world was dominated by a handful of manufacturers protected from competition by the exclusive purchasing practices of the PTOs. Cawson (in Mansell, 1993: 16) calls them a club or cartel. During this period, the equipment cartels brought about improvements in the quality and capacity of the public telecommunication networks that had little effect in destabilizing the traditional carriers' position in the market. In the late 1970s and early 1980s, the industry went through a radical technical shift with the arrival of digital technologies. The arrival of these technologies provided a much-needed boost to network performance and enhanced signaling systems[6]. The PTOs welcomed the technology and began to diffuse it throughout their national networks.

Digital services are based on the conversion of information, voice, data, image and text into binary codes, which can be recognized by computers. Three main components of the telecommunication network have been affected by the digitization of the telecommunication network: switching, transmission, and terminal equipment (Mansell, Ibid). The digital paradigm enabled high-speed processing and transmission. Its introduction, as Mansell puts it, was a radical, and perhaps even revolutionary innovation. This development exposed the AT&T, as the dominant service provider, to competition and thus the loss of market share. The loss of market share occurred as large corporations, taking advantage of digital technologies and the resultant intelligent networks, built their own private networks (Mansell, Ibid).

Conceptually, the intelligent network was born in the United States in 1985 and pioneered by Bellcore (Bell Communications Research) at the request of Ameritech, one of the RBOCs. Bellcore was jointly owned by the RBOCs until 1997[7]. The term 'intelligent network' (IN) refers to a network that allows functionality to be distributed flexibly at a variety of nodes on and off the network and allows the architecture to be modified to control the services (Newton, Ibid: 542-3). An IN has the following characteristics: (a) distributed call-processing capabilities across multiple network

[6] Today's dominant signaling system, SS7, which enables voice mail, caller ID, and other advanced features, became possible with digital technology. For a detailed discussion on SS7, see Harry Newton's *Newton's Telecom Dictionary* by Flatiron Publishing Inc.

[7] Eighty percent of the U.S. telecommunications network depends on software invented, developed, implemented, or maintained by Bellcore. In 1997, Bellcore was acquired by Science Applications International Corporation (SAIC), one of the world's largest providers of systems integration and program management. Later the combined organization was renamed Telcordia Technologies (www.telcordia.com).

modules, (b) real-time authorization code verification, (c) one-number services, and (d) flexible private network services (Newton, Ibid).

The goals behind the development of intelligent network were:

- to help establish equipment and interface standards to give the RBOCs the widest possible choice of products;
- to create opportunities for non-RBOC providers to offer services that would stimulate network usage;
- to increase the rapidity of new service introduction;
- to encourage the development of competitive equipment and products;
- to open the public network to greater use by non-RBOCs.

In the process, the term 'intelligent network' gained currency in the technical and trade literature (Mansell, Ibid: 19-20).

Mansell raised the question whether the implementation of the intelligent network will create opportunities for the restructuring of the telecommunications market. The answer arrived in the events after the *Telecommunication Act* of 1996. After a decisive overhaul of communication laws the market witnessed the emergence of new service providers and new telecom equipment makers. As already indicated, despite its great contributions to network operations and development of an advanced signaling system, digitization and the resultant intelligent networks did not bring about competition in the market. And the emergence of new service providers was limited to the long-distance domain, which became possible through the breakup of the AT&T monopoly in the court of law, not through digitization.

The only new class of service providers to emerge as a result of the technological advances of the 1980s was competitive access providers (CAPs). CAPs operations were limited to providing alternative point-to-point digital access channels through their own metropolitan fiber builds. CAPs were not allowed to provide switched services, as it was only the RBOC territory. The leading CAPs in the late 1980s and early 1990s were Metropolitan Fiber Systems (MFS), which was acquired by WorldCom in 1996 and Teleport Communication Group (TCG) acquired by the AT&T in 1998.

2.5 Canadian Deregulation: Feeling the US Effects

Due to its immense size and large population, the US has consistently exerted considerable influence on the Canadian economy. And telecommunications has not been exempt from the scope of this influence. In fact, the late former Canadian Prime Minister, Pierre Trudeau, once remarked that for Canada living next to the US was comparable to a mouse sleeping alongside an elephant, and that the mouse had to be very attentive to the elephant's movements lest it turn over in the night (Wilson, 1997:173).

In a harbinger of more dramatic deregulatory decisions to come, the CRTC in 1978 permitted Canadian National and Canadian Pacific (CNCP) to interconnect with then federally regulated telecommunications companies (Bell Canada, BC Tel, etc.) to provide private leased services. However, CNCP was not allowed to enter the long distance business (Crandall and Waverman, 1999:38). As we saw in Chapter One, the first tangible move by Canadian regulators toward deregulation was made in 1992, when Unitel, as the first competitor, was permitted to enter the long-distance sector. The legislation is known as Unitel Decision (*Competition in the Provision of Public Long Distance Voice Telephone Services and Related Resale and Sharing Issues*, CRTC 92-12). A year following the Unitel Decision, a new *Telecommunication Act* was passed, which enshrined federal jurisdictional sovereignty over all telecommunications (Crandall and Waverman, 1999: 39).

Five years after the Unitel Decision, and a year after the US *Telecommunication Act* of 1996, Canadian regulators opened the local exchange market, the most monopolized sector of the Canadian telecom industry. This opening became possible in a significant legislative overhaul of communication laws known as Decision CRTC 97-8, *Local Competition—Local Unbundling and Interconnection*. Similar to the 1996 Act in the United States, Decision 97-8 deals extensively with the opening of local markets into competition. In order to promote competition in local exchange markets and broadband services, the Decision mandates both CATVs and incumbent phone companies to open their high-speed lines to not just CLECs but also to small ISPs[8]. Unlike the 1996 Act, which leaves provisioning of optical dark fiber among carriers detariffed, Canadian legislation imposes strict regulations on it (Decision 98-11). Another major difference between the two legislations (1996 Act and Decision 97-8) lies in the laws governing long-distance services. The 1996 Act imposes a 14-point checklist on the RBOCs (Section 271) to gain entry into long-distance markets both in their regions and outside. Whereas the incumbent provincial carriers in Canada had always been active in the provisioning of long-distance services in their operating province(s). And there are no guidelines imposed on Canadian incumbent carriers in order to expand their long-distance services beyond their incumbency. It is very important to note that was a fundamental difference in the process of deregulating telecom markets in Canada and US.

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[8] CRTC Order 2000-983 and Decision 99-11 mandate phone companies and cable carriers respectively to open their network facilities to small ISPs. Order 2000-983 gives providers of digital subscriber line (DSL) services the same interconnection benefits as CLECs. Also, Decision 99-11 mandates all incumbent cable carriers to provide resale of their high-speed Internet services at retail prices to small ISPs.

The process of deregulation in the US was the result of legal pressure and lawsuits launched against dominant players, namely the AT&T. Whereas in Canada the opening of telecoms into competition was not just influenced by developments in the US but also it was the realization by businesses and regulators alike of benefits of open markets.

Since Decision 97-8, Canadian telecommunications has witnessed a great deal of dynamism. Today, the Canadian telecommunication industry is a CDN$36.701 billion market and is projected to grow into a CDN$49.749 billion dollar by 2003 (see Table 2.2). These figures include segments of the industry such as wireless, consumer ISP, basic data, enhanced data, satellite, long-distance, and local exchange.

But the current dynamism in Canadian telecoms has failed to bring about significant transformations in the industry landscape. The local exchange market, for example, has remained virtually untouched, especially in the residential markets. The only significant attempt at bringing competition to residential local exchange markets was made by Sprint Canada, a subsidiary of Call Net Enterprises. In 1999, Sprint Canada started offering competitive local telephony to residential customers in Toronto, Montreal, and Calgary. Having experienced significant expenditures and a low return on margins, the company curtailed significantly its operations in residential local markets. This move plunged Sprint Canada into its worst financial crisis, resulting in the overhaul of its management team at highest levels[9]. Sprint Canada has once again turned its focus to business data markets (Angus Telemanagement, Nov. 13, 2000). Other examples of efforts in bringing competitive local exchange services to residential consumers include the cable carrier Videotron in Quebec, which is conducting trials in competitive local service over cable.

[9] Philip Bates, Sprint Canada's then president and Chief Operating Officer (COO), left the company to launch Riptide Networks, a metro carrier's carrier in Toronto. In late October 2000, due to serious lack of access to capital, Riptide Networks declared bankruptcy.

Also, in Nova Scotia cable companies are providing voice communications over their cable plant (Ian Angus).

Unlike the local exchange sector, deregulation has had starkly different results for the Canadian long-distance sector. Canadians have continuously enjoyed the benefits of significant reductions in long distance rates both by the incumbent provincial carriers and interexchange carriers (IXCs[10]). Fierce competition in Canadian long distance has resulted in reduction in the sector's market size from CDN$8.3 billion in 1998 to CDN$7 billion in 2000. This continuous reduction will make the sector a CDN$5.4 billion[11] market in 2003 (Paul DeLottinville & Associates, 2000: 61). With the Internet positioning itself as a global medium for communications and commerce, Canadian individuals and businesses find themselves increasingly dependent on Internet-enabled, data-intensive applications to facilitate interactive transactions and disseminate information. This trend, in consequence, has made Canada the country with the highest percentage of Internet users in the world.

According to a study by PricewaterhouseCoopers (November 2000), regular Internet users in Canada comprise 48.2 per cent of the population. This includes business, educational and home Internet users. The same study reports that 22% of Canadian households using the Internet have high-speed access. The 22% represents access to xDSL and cable modem technologies, the two main dominant broadband access platforms in residential markets. The US households with Internet access comprise 43% of the population. Moreover, as Canadian providers of broadband services increase in

[10] A widely used term in the industry that refers to a long-distance carrier.
[11] These figures represent total residential and business long-distance markets.

number[12], demand for network infrastructure connectivity and capacity will continue to accelerate. This translates into a big urge to make broadband services available more broadly.

[12] Some CRTC regulations enable non-facility based providers of communication services to get into broadband service provisioning by relying on the incumbents' infrastructure.

Table 2.2

Canadian Telecommunications Services Revenues (CDN) $ millions

Service	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*CAGR[13] %*
Local Service Market Revenues (Total)	**10,000**	**11,000**	**12,300**	**13,600**	**15,000**	**16,700**	10.80
Local Service Market Revenues (Residential)	5,700	6,200	6,700	7,200	7,800	8,400	8.06
Local Service Market Revenues (Business)	4,300	4,900	5,600	6,400	7,300	8,300	14.06
Local Service Market Revenues (Basic)	8,400	9,000	9,800	10,600	11,500	12,500	8.27
Local Service Market Revenues (Enhanced)	1,600	2,000	2,500	3,000	3,500	4,200	21.29
Centrex Services	390	421	455	491	530	570	7.89
Long Distance Service Market Revenues (Total)	**8,300**	**7,600**	**7,000**	**6,400**	**5,900**	**5,400**	-8.24
Long Distance Service Market Revenues (Residential)	4,700	4,300	4,000	3,700	3,400	3,200	-7.40
Long Distance Service Market Revenues (Business)	3,600	3,300	3,000	2,700	2,500	2,200	-9.38
Dedicated Digital Service Market Revenues	**670**	**750**	**840**	**940**	**1052**	**1178**	11.95
Dedicated Analog Service Market Revenues	**430**	**426**	**422**	**418**	**413**	**410**	-0.95
Switched Service Market Revenues	**210**	**212**	**214**	**216**	**218**	**220**	0.93
ISDN Service Market Revenues	85	95	106	118	132	148	11.73
VPN Service Market Revenues	165	198	238	286	343	412	20.08
International Service Market: Total	**3940**	**3900**	**3960**	**4120**	**4400**	**4850**	4.24
International Service Market Revenues: Voice	**3200**	**2940**	**2710**	**2495**	**2290**	**2110**	-7.99
International Service Market Revenues: Data	**740**	**960**	**1250**	**1625**	**2110**	**2747**	29.99
Audio conferencing Service Market Revenues	**74**	**96**	**125**	**163**	**212**	**276**	30.12
Videoconferencing Service Market Revenues	**62**	**84**	**113**	**153**	**207**	**280**	35.19
Frame Relay Service Market Revenues	**185**	**213**	**245**	**282**	**324**	**372**	14.99
ATM Service Market Revenues	**65**	**78**	**94**	**113**	**136**	**163**	20.19
Internet Service Market Revenues	**920**	**1390**	**2100**	**3200**	**4830**	**7300**	51.32
LAN/WAN Internetworking Service Market Revenues	**130**	**163**	**204**	**255**	**320**	**400**	25.21
Network Management Service Market Revenues	**110**	**132**	**158**	**190**	**228**	**274**	20.02
Fixed Satellite Market Revenues	**42**	**47**	**53**	**60**	**67**	**75**	12.30
Mobile Satellite Service Market Revenues	**64**	**70**	**77**	**85**	**94**	**103**	9.98
Mobile Packet Data Service Market Revenues	**16**	**18**	**20**	**23**	**25**	**28**	11.84
2-Way Mobile Radio Service Market Revenues	**215**	**268**	**335**	**418**	**523**	**653**	24.88
Cellular/PCS Mobile Radio Service Market Revenues	**3,600**	**3,900**	**4,200**	**4,500**	**4,900**	**5,300**	8.04
Paging Service Market Revenues	**242**	**244**	**246**	**249**	**252**	**255**	1.05
Fixed Wireless Service Market Revenues	**0**	**0**	**35**	**105**	**262**	**655**	165.50
Total Services	**33,215**	**34,491**	**36,701**	**39,610**	**43,763**	**49,749**	**8.42**

Source: Paul DeLottinville & Associates Inc. April 2000

[13] Compound Annual Growth Rate (CAGR)

2.6 A Glance at Today's Canadian Telecoms

The current status of Canadian telecommunications suggests that it is poised for a steady growth in various areas of the new economy. Even though businesses will enjoy more competitive service offerings, residential markets will also have choices, though the same could not be said for local exchange markets. The biggest growth area in Canadian telecoms will be in the wireless sector, particularly in wireless applications. More Canadian consumers use their wireless phones and other wireless devices to receive and transmit information and engage in other activities such as shopping[14]. High-speed wireless is another emerging area with residential and small businesses as its main target areas. High-speed wireless could be looked upon as a viable and competitive broadband access platform against cable carriers, phone companies, and other DSL-based ISPs[15].

On the regulatory front, the CRTC will continue to deregulate the market place as specific sectors of Canadian telecoms demonstrate signs of maturity for more competition. However, provincial governments' intervention in devising strategy for broadband communications remains a problem that runs counter to the goals and the spirit of deregulation. For example, the recent CDN$300 million Alberta SuperNet contract awarded to Bell Intrigna Consortium by the government of Alberta is perhaps

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[14] Perhaps the best example in this area is the recent announcement of a trial run of location-based wireless services between ClearNet Communications (now part of TELUS) and Lucent Technologies Canada. Based on this trial, wireless devices will find a nearby banking machine, report on local traffic conditions, or search the Sympatico-Lycos Yellow Pages directory for businesses (Angus Telemanagement, Nov. 13, 2000).

[15] The Toronto-based MaxLink Communications (www.maxlink.com) was one of the leading names in this area. Due to lack of access to sufficient funding, the company later went bankrupt.

the best recent example of such intervention by a provincial government. Bell Intrigna is the Western telecom arm of Bell Canada Enterprises (BCE). The consortium includes such other major technology players as Axia Netmedia, Cisco Systems, and Microsoft. Upon completion, the initiative is expected to connect 422 communities in rural Alberta to the information superhighway.

Strange about such government intervention is that the number of years it has taken, and the amount of money spent on devising a deregulatory policy for the country's telecommunications industry should has not made it clear to many that the goal of deregulation was not to encourage government intervention in devising strategy for broadband communications.

Seen from another angle, as Eamon Hoey (Chairman and President, Fox-Hoey Consulting[16]) suggests, awarding of SuperNet project to Bell Canada was a meticulously designed business strategy by Bell Canada Enterprises (BCE) to expand its operations into western Canada. Hoey adds that, since deregulation of local exchange markets, setting a foothold in the west was a longtime BCE goal and SuperNet was the best potential opportunity for the company to consolidate its presence in this part of the country. Hoey suggests that BCE achieved its goal under the pretext of "connecting communities" in Alberta.

There are two other significant developments in Canadian telecoms that deserve attention, for they seem bound to have major impact on how broadband services are provided to businesses and residential customers. These two developments are:

- the entry of provincial incumbent carriers into markets hitherto closed to them;

[16] Eamon Hoey is among Canada's top telecommunication consultants and is highly regarded in the United States. His views are widely sought by such leading media outlets as the Wall Street Journal, the National Post, the Globe and Mail, CTV, ROBTV and CBC Newsworld.

- targeting multi-tenant units (MTUs) and multi-dwelling units (MDUs) with optical-based high-speed services.

Today, the incumbent local exchange carriers (ILECs) like TELUS Communications and Bell Canada are aggressively deploying optical fiber cables in provinces where they had no operations prior to Decision-97-8. These optical networks are primarily deployed in major metropolitan areas and target large business customers. For example, TELUS Communications, with network engineering assistance from Metromedia Fiber Networks (MFN), is to construct a 225-kilometer, 144-strand fiber optic network in the Greater Toronto Area (GTA). The network, among the biggest metropolitan optical networks in North America, will reach 3000 businesses and is expected to cost TELUS CDN$100 million (*Voice*: 3). Calgary is another Canadian metropolitan area where 360 Networks is deploying a substantial fiber optic network. The Vancouver, BC-based carrier's carrier is planting a 22-conduit pipe, which presently does not contain any fiber, pending anchor tenant agreements from potential customers[17].

The second development involves creating cyber buildings by connecting metropolitan building to the Internet via fiber optic technology. Companies that operate in this area are known as building local exchange carriers (BLECs). In the US, the forms of relationships that are forged between BLECs and property management companies have ignited heated debates with the FCC at the center of it. In Canada, a whole range of activities is taking place in this area mainly in the form of partnerships between communication carriers and property management companies. Table 2.3 illustrates some

[17] "Carrier's Carrier" a class of communication carrier, and "anchor tenant" a dark fiber related term are both discussed at length in Chapter 4

of the partnerships forged between major property management firms and communication carriers.

Table 2.3

Recent Partnerships/Alliances between Telecom and Property Management industries in Canada

Property Management Company	Partnering Communication Carrier
Trizec Hahn	Allied Riser, Broadband Office Inc, Cypress Communications, Net Stone, OnSite Access
Boardwalk Properties	Own Internal Development
Bental Corporation	Group Telecom, Norigen Communications, Bell Intrigna, AT&T with Allied Riser
Oxford Properties	AT&T, Norigen Group Telecom
Brookfield Properties	Group Telecom
Cadillac Fairview	Group Telecom
Standard Life Assurance	Group Telecom
O & Y Properties	AT&T with Allied Riser Communications

Source: TELUS Advanced Communications (TAC), November 2000

2.7 Creating Competitive Markets in Telecommunications

"The supposed tidal wave of competition that the law was expected to unleash is barely a ripple for most local phone consumers."[18]

Divergent views on what makes telecom markets competitive and the rapid pace of change in the industry have left the policy discourse in North America in disarray. New developments in network architecture (e.g. metropolitan area networks or *MANs* that

[18] Seth Schiesel, senior telecommunication reporter, *New York Times*, November 21, 2000

enable new carriers bypass telco central offices, thereby rendering some of the interconnection laws obsolete) and shifting alliances in the market (e.g. the emergence of metropolitan carrier's carriers and their partnerships with BLECs have rendered some of the CLEC[19] status laws obsolete) have already rendered some parts of *Telecommunication Act* of 1996 as well as Decision 97 out of synch with technological developments. For one, legislation pertaining to the interconnection of competing networks in particular had a built-in tension and has proved shortsighted. It was designed to facilitate co-existence between CLECs and the incumbent local exchange carriers (ILECs).

For another, the business model adopted by CLECs has proved to be flawed. This is because this model relied entirely on the networks of the very carriers they had targeted in the marketplace with the hope that interconnection laws would guarantee them both revenue and gain in market share. Not surprisingly, CLECs have consistently faced numerous obstacles in providing service to their customers.

Local exchange markets in both Canada and US remain competitive only on paper. And the cost of entering into local exchange markets and providing an alternative to the last-mile bottleneck remains prohibitive. This has clearly played to the advantage of ILECs in both Canada and the US, who, instead of preparing themselves for competition and open markets, have demonstrated an unquenchable need for more consolidation. But the emergence of carrier's carriers (Chapter Four) as a new class of service providers pinpoints to a more competitive landscape.

[19] The *Telecommunication Act of* 1996 sanctioned CLECs, as a new form of service provider to compete against ILECs that traditionally dominated local exchange markets in both voice and data.

In the next section, I explore and analyze competition in North America's deregulated telecom industry based on theories from Johannes M. Bauer, William Melody, and Robin Mansell. The section articulates on the relevancy of the theories to current developments in the industry and draws conclusion about the state and direction of competition in North American telecoms.

2.8 Equilibrium and Disequilibrium Notions of Competition[20]

In any market, the development of a desired competitive environment depends on behavioral criteria (e.g. utilizing information for developing strategy) as well as structural features of an industry (e.g. the number of competitors, market entry conditions, etc.) Moreover, a presumption is made that effective competition is desirable (Bauer, 1999: 3).

In neoclassical economics, a great deal of emphasis is put on equilibrium and the structure of marketplace to the extent that it undermines competition as a process. Neoclassical Economics looks at competition as a structure with large number of price takers (Bauer, Ibid). It also provided incentive to those seeking the creation of perfect competition in the market. But as Schumpeter pointed out (in Bauer, Ibid: 4), the notion of perfect competition is based on a highly simplified assumption, which should be seen as a theoretical construct and not an attempt to describe real world markets. It is equally true of today's telecommunication markets. As many hoped, deregulation and the emergence of new technologies and services have not addressed all the issues surrounding the new telecoms like universal service, local competition etc. Even if the

[20] This section greatly benefits from the work of Dr. Johannes M. Bauer's paper entitled "Competition As a Turbulent Process: Lessons for telecommunications regulatory reform" presented at the 27th Telecom Policy Research Conference in Alexandria, Virginia, September 25-27, 1999. Dr. Bauer teaches at the Department of Telecommunication at Michigan State University.

legislation had not been flawed in its design, it would have not guaranteed the desired competitive markets. Despite deregulation, today's Canadian telecom industry, for example, is an oligopoly in which actions of two main players (Bell and TELUS) set the market agenda. Therefore, attempts by regulators to create competitive markets do not necessarily guarantee the emergence of such markets. Competition is an ongoing process that involves success and failure.

Another important element in the emergence of competitive markets is the role of knowledge and the ability of firms to use it effectively. This element has become particularly significant in our emerging "knowledge-based" economy, whereby effective attainment and use of knowledge have enabled many firms to outsmart their competitors in both marketing strategies and development of new products. Effective use of knowledge is an integral part of competition as a process, which awards larger market shares to more efficient firms and penalizes less efficient ones with shrinking market shares or even elimination from the market.

Bauer (Ibid: 9) further formulates how a workable competition can arise in a given industry. Such a workable competition, according to Bauer, generally depends upon the following four conditions:

- the existence of at least five firms to supply the market;
- none of the firms must hold more than 40% of the market share and the remaining competitors are fairly equal in size;
- market entry and exit barriers must be low;
- customers must have the ability to switch suppliers without significant transaction costs.

However, Bauer misses one factor that plays an important role in market equilibrium: access to capital. As I briefly noted in Chapter One, risk-prone venture capital firms have played an instrumental role in turning knowledge and new ideas into effective and successful businesses. Effective use of knowledge by entrepreneurs has not only influenced the process of decision making in turning ideas into business plans, but also has challenged the established ways of doing business. Effective use of knowledge with the support of capital introduces new products, methods of production, and establishes new monopolies or eliminates the existing ones. Therefore, the ability to use knowledge wisely and in a timely manner could not be the only guarantor in creating competitive markets.

Equally important in equilibrium and disequilibrium notions of competition is the role of regulator in the design of competitive markets. The regulator should remain independent from undue influence and ensure that anti-competitive behavior is prevented. Sustaining independence by policy makers becomes particularly crucial in a deregulated environment, where there are diverse players and influential parties interested in influencing the regulatory process. Melody (1997: 195-196) emphasizes the dynamic nature of telecom technology and new service opportunities and asserts that it is very important that the barriers to entry be minimized and the door to competition be opened as widely as possible. Melody further argues that while regulation can prepare the ground for competition, it can only foster the growth of competition if regulation is both strong and independent. This will enable the regulator to implement the government's policies more effectively and resolve industry problems in a progressive rather than an *ad hoc* manner (Melody, Ibid: 198).

In today's fast-changing telecommunication environment the process of regulation should take into account developments in technology, which have already rendered parts of deregulatory laws obsolete. It is regulators' responsibility to be attentive to new developments in communication technologies and to develop strategies based on changes in technologies. Therefore, in order to achieve equilibrium in a competitive market place, regulation as a process should be prospective rather than retrospective. This process could certainly benefit from past experiences retrospectively to devise more sound policies.

2.9 Alternative Models of Competition in Telecommunication

In a comprehensive and thought-provoking discussion on the political economy of network evolution in North America, Robin Mansell (1993) proposes two alternative models for telecommunication development: the *Idealist* and the *Strategic*. Each model finds its roots in a particular theory of competition.

The first model, the Idealist, envisages the emergence of a mature and fully articulated competitive model. In this model, according to Mansell, the following characteristics of the market are present: a large number of sellers are active in the market for goods and services such that the impact of one seller on the market is negligible; buyers perceive that sellers produce a homogeneous product; and buyers have access to perfect knowledge, or at least sufficient knowledge to make informed, rational decisions (Ibid: 6).

This type of competition is characterized by the absence of barriers to market entry and exit. This model also falls within the genre of idealistic analyses which are based upon 'a mystified and mystifying notion of technology as a cure for the world's very real problems (Smythe and Dinh in Mansell, Ibid). Moreover, the Idealist model assumes that the combined forces of technical innovation and competition will erode monopolistic control of the telecommunication infrastructure and services it supports.

The second model is referred to as the Strategic model. It is rooted in the theories of imperfect competition, monopolistic competition, and oligopolistic rivalry (competition among small numbers of suppliers). The Strategic model seeks to provide a reality-based analysis of institutional processes (Smith and Dinh in Mansell, Ibid). It also assumes that institutions are characterized by 'indeterminate, unstable oligopoly wherein the transnational corporations deliberately employ short-run pricing strategy to achieve long-run entrenchment and monopoly power in national market, foreign and domestic' (Melody in Mansell, Ibid). Mansell further indicates that in the Strategic model there is continuous rivalry among a relatively small number of dominant firms. The next section analyses current trends in North American telecommunications by taking into account the above two models.

2.10 Prospects of Competition in North American Telecoms

With deregulation of the telecommunications industry in full steam, North American markets have witnessed a bewildering number of players both in the communications services and equipment sectors. While new service providers have struggled to gain market share away from the incumbents, selling equipment to large service providers has been the main challenge facing emerging equipment vendors. A look at market conditions under deregulation suggests that they retain characteristics from both Idealist and Strategic models.

Despite the presence of a large and diverse set of players in North America (Idealist model), the market continues to remain dependent on fluctuations and strategic moves by big players. This trend runs contrary to the Idealist model's notion that regards the impact of one seller in the market negligible. On the other hand, the current low level of barriers to market entry is in line with the Idealist model.

Another important development has been the continuous innovation in the emergence of new technologies and services by equipment vendors and service providers alike. Even though they have not brought about any perfect or near perfect competition in the markets, they constitute one of the main characteristics of the Idealist model: the combined forces of technical innovation and competition erode monopolistic control of the telecommunication infrastructure[21].

There are also market characteristics that adhere to the assumptions in the Strategic model. For example, short-run pricing strategy to achieve long-run entrenchment and monopoly power in markets is no longer conducive to the characteristics of today's markets. Short-run pricing can guarantee temporary gains in market share, but eventually it will hurt a company's bottom line. Also, short-run pricing does not have any positive impact on the prospect of profits. This approach may result in increasing a company's outstanding debt, further discrediting its financial health.

Another trend relevant to the Strategic model is the continuous rivalry among a small number of dominant firms in telecommunications. Despite the large number of players, a

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[21] This is particularly true of the developments in the design and deployment of dark fiber networks both in Canada and the US. Chapter Four discusses dark fiber model at length.

small number of well-established and large-sized companies assert considerable influence on the direction of markets. An example of this can be seen in the telecom equipment sector, which is mainly dominated by Cisco Systems of San Jose, CA, Lucent Technologies of Murray Hill, NJ, and Nortel Networks of Brampton, ON. The three companies hold dominant positions in the areas of switching (both tandem and optical), IP telephony, optical cable, and DSL products.

Exponential growth in Internet traffic and the rapid pace of deployment of optical fiber by a smorgasbord of carriers support the rosy predictions for the prospect of competition in North American telecoms. With North American backbone Internet traffic growth at 350,000 Terabytes[22] per month (RHK, 1999: 4), it is not surprising to see the emergence of new specialized players in local access, metro transit, and long-haul markets. This new breed of carriers could also unleash another wave of competition in the still underserved and optics-poor residential markets. Broadband access providers including building local exchange carriers (BLECs) and optical local exchange carriers (OLECs) are among this new breed of players in the broadband game. As we will see in coming chapters, a lot still needs to be done to bring competition to all segments of the market.

[22] Each Terabyte represents one trillion bits of information.

2.11 Summary

Regulators should focus on providing economic grounds that would make deployment of costly broadband infrastructure less cumbersome for private businesses. As we will see in the proceeding, the Canadian government should encourage the private industry to be motivated in bringing innovative broadband technologies to the market place. Some industry observers have argued that government-sponsored organizations like CANARIE have turned into *de facto* regulatory bodies, trying to set the agenda in Canadian telecommunications and devise industrial policy for provincial governments. Such government-supported interventions in the realm of high-tech industry could result in the further loss of talented and educated individuals to the south of the border, a trend with which Canada is all too familiar.

On the business front, Canadian businesses hoping to compete against established players are in need of innovation. According to Ian Angus (President of Telemanagement Group), the success of any Canadian competitive carrier (CLEC or otherwise) will depend not just on the way their business is structured, but also on two other factors: financing, which should be provided over several years that any new carrier will be losing money until it starts to become profitable. The second is execution, which requires a management team that is capable of delivering services that customers want in a cost-effective way.

Also, Canadian CLECs should stop following the same ill-fated strategies followed by their predecessors both in Canada and US. In the words of Angus, "it sounds as though they have copied their business plan over the same book. There must be a book called *Local Telecom Strategy for Dummies* floating around in the industry".

The new business models that are primarily derived from developments in optical technologies still have to make their impact felt in North America. Moreover, the industry's desire for more consolidation does not seem to have diminished yet, as more consolidation in the optics as well as metropolitan carrier markets will influence the direction of competition in coming years. The current reshaping of telecom industry and further deregulation of markets should not come to the benefit of business customers alone. It is regulators' responsibility to ensure that the benefits of overhaul in telecoms would also benefit residential consumers.

Chapter Three:

Innovation in Today's Telecoms

3.1 Introduction

This chapter explores the process of innovation in today's North American telecommunications and analyzes the main forces responsible for their emergence. The core argument is that private and risk-prone funding from *venture capital* (VC) firms have acted as the main engine behind the efflorescence of new technologies.

The majority of today's technology powerhouses (e.g. Cisco, Ciena, Juniper, Netscape) were incubated by VCs. These companies have been an indispensable part of the cycle of technology innovation. This cycle has not been confined to developments in the optical space. It has also encompassed other areas such as e-commerce, wireless technologies, and IP/HTML applications.

As noted in Chapter One, since 1990 in the US alone more than USD$100 billion in venture capital funds have been funneled into technology start-ups. The bulk of this immense capital spending has gone to telecom equipment manufacturing and communication service provisioning sectors (*Business Week*, October 9, 2000: 147).

A consequence of the liberalization in service provision markets has been creation of immense opportunities for the makers of communication equipment to diversify their product offering to service providers, hence diversifying their product portfolio. On the other hand, the extent of activities by VCs has contributed to fragmentation in both the service provision and the equipment manufacturing sectors. In the following sections I will discuss how these developments have created fertile ground for the emergence and success of innovative ideas and technologies.

3.2 A Canadian Outlook

In Canada communication technologies have always played a crucial role in the development of its socio-political identity. Communication technologies, from railroad to satellites, have been used successfully in the development of a culture that defines Canada. Canadians have been equally open to the adoption of the Internet as a viable means of communication, and have demonstrated impressive adoption rates. Today Canada is one of the world's most connected countries and Canadians, together with their southern neighbor, generate 58% of the world's Internet traffic (*America's Network*, April 1999).

But in the development of advanced technologies and the funding of new ideas in technology, the landscape is somewhat different. In Canada, according to Eamon Hoey (CEO and President of Hoey-Fox Associates) most technology start-ups have received funding from American VCs to sustain the early stages of their business operation. Financing technological innovation in Canada, as wealthy as the country is, has consistently suffered from unfavorable capital markets and government policies that have had little regard for R&D in the area of technology. For example, during the 9-year reign of Progressive Conservatives in federal government (1984-1993), the notion of pursuing aggressive industrial and technological policies were frowned upon (Davis and Smith, 1995:16). At the federal level, science policy was a minor dossier looked after by a junior minister of state. In provincial governments, science policy traditionally has been located within ministries of higher education (Davis and Smith, Ibid). However, recently provincial governments have taken serious initiatives in wide scale deployment of broadband communication technologies. The government of Alberta is one of the best examples in pursuing large-scale deployment of broadband networks in the province. Its SuperNet initiative—contracted to Bell Canada, an Ontario-based incumbent carrier—was a bold attempt to diversify Alberta's telecommunications market[1].

Another noteworthy example is Innovative Systems Research Network (ISRN), which is comprised of five regional networks (Maritime, Quebec, Ottawa, Toronto, Vancouver). ISRN describes its objective as follows:

- a vehicle for joint research proposals and funding partnerships;
- a forum for discussion and dissemination of results;
- a venue for funding agencies to elaborate their collective interests in research on innovation systems;
- a channel to acquire and distribute data and other material for collective use by the members of the network;
- within the subnetworks to develop better understanding of the regional innovation systems in their respective parts of the country;
- to systematically compare research findings across the subnetworks and thus contribute to a more comprehensive understanding of the national innovation system in Canada (from ISRN website: www.utoronto.ca/isrn).

However, Davis and Smith, (Ibid: 23) argue that another problem with Canadian policy in the area of advanced technology is that it rarely defines explicit objectives such as market share or R&D spending targets. This continues to be the case despite the results from studies that have recommended that the country take a more serious stance in the support of the development of new and advanced technologies. A case in point was a

[1] In Chapter Two, I support a laissez-faire policy in the deployment of broadband communications. However, Alberta government's move was bold and surprising in the sense that it disregarded TELUS's long-standing technological dominance and its economic weight in the province.

recommendation by National Advisory Board on Science and Technology in 1991, which informed the prime minister of the time that:

Canadians will not succeed in meeting international competition, and will therefore face a declining relative standard of living, unless we become much more adept in applying science-based technology to create a continuous flow of innovation and productivity growth. There is no more serious challenge facing Canada today (NABST 1991, in Davis and Smith, Ibid:16).

However, the lack of sufficient investment in R&D by the federal government remains a persistent problem. This problem threatens to create an acute lack of university professors across the country, which will translate into an equally serious lack of professionals in Canada's high-tech sector. According to *eMPOWR Canada*—a national initiative between Canadian technology firms and universities[2]—a majority of Canadian university professors are approaching retirement so much so that of the 33,000 university professors in Canada today, only 1,000 will still be teaching after 2010 (*Ottawa Citizen*, April 13, 2001).

According to eMPOWR Canada officials, the university bottleneck restricts Canada's ability to generate people for the new economy. Private company members of eMPOWR Canada have announced that they are willing to invest $CDN500 million of their capital to increase funding for research and development in universities. The group believes that Canada must focus on attracting more professors to teach future technology professionals (*Ottawa Citizen*, Ibid).

In recent years, CANARIE—Canada's advanced Internet development organization—has made significant moves in bringing new and advanced technologies to

[2] eMPOWR stands for Microelectronics, Photonics, Optoelectronics and Wireless and Radio engineering. Fifteen companies, twenty universities and six organizations are involved in the initiative (www.empowr.ca).

Canadian organizations. But unfortunately CANARIE's attempts have shown little success in breaking the access bottleneck and introduce advanced broadband technologies to Canadians[3]. This is largely due to serious differences it has with the private industry in how broadband communication technologies should be deployed.

Hoey suggests that anybody trying to start a new business in Canada faces a systemic barrier, which is an unfavorable capital market. In a particularly capital intensive business like telecommunications, this problem worsens. The reason there is little available risk capital, Hoey suggests, is because most of the available capital in Canada is being funneled to pay the national debt. Hoey also suggests aptly that the country's conservative business culture is another underlying characteristic of its capital markets.

This is witnessed perhaps best in the Canadian competitive landscape, where numerous emerging competitive service providers have gone bankrupt due to lack of access to sufficient capital. However, it should be noted that a combination of regulatory structure and faulty business plans has been instrumental in the plunge of Canadian competitive service providers.

As noted in previous chapter, Canadian CLECs followed consistently the same business plan that was very similar to each other and void of innovative approaches to provisioning of advanced data services; also, instead of building their own networks, they relied heavily on communication infrastructure from incumbents. This put almost their entire operation at the mercy of co-operation from incumbents and the availability of sufficient network infrastructure.

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[3] Chapter Four discusses in more detail CANARIE's proposed business models that aim to break the access bottleneck.

3.3 Market Segmentation

The removal of regulatory barriers in the telecommunications sector can be viewed as a blessing for VCs and other financial institutions that have maneuvered their way into many untapped lucrative markets. Hitherto, these markets have been under the tight control of monopoly players. Lera (2000: 414) aptly argues that the ongoing transformation in the services provision sector forced adaptation of the manufacturing sector for growth in the resultant market place.

This resultant market place is highly segmented and represents unique characteristics. This is a very different picture from the monopoly days of telecoms. Under the monopoly system, relations between equipment manufacturers and service providers were typically based on vertical integration, with direct or indirect capital participation by the service providers in the manufacturer's business. In addition, telecom operators were often domestic businesses, and as monopolies, there were few manufacturing companies sharing the industrial market (Lera, Ibid.).

But today's segmented service provision sector has created an equally segmented equipment manufacturing sector. For example, businesses in metropolitan areas have developed unique demands for their broadband communication needs, thus requiring optical systems from manufacturers that are specifically designed to meet their needs. This segmentation can be categorized as follows:

- equipment makers target specific service providers;
- software developers target specific service providers and telecom equipment makers;
- makers of wireless equipment target wireless voice and data carriers;

The role of VCs needs to be emphasized here if one is to appreciate why telecommunications has become such a diversified and segmented industry. A unique aspect of this segmented market place is the fact that specialized suppliers of telecom equipment (e.g. Corvis Corp and ONI Systems) do not have historical relationships with incumbent carriers. This creates opportunity to create new relationships in the telecom industry. What we are experiencing today, as Lera (Ibid: 417) argues, is in fact a reconfiguration of the service provision market structure, which affects the strategies and policies of telecom operators as well as those of the manufacturing sector.

3.4 The Speed of Innovation

One of the main implications of innovative technologies is that established companies in the same area fail to adopt or conform to the technological change. This change mainly affects the established firms' dominance in the products they offer. Moreover, the short product life-cycles in telecommunications due to innovation and deregulation exert further pressure on established firms, particularly those in the carrier sector.

Thus the emergence of innovative technologies, which are disruptive in nature, requires established firms to respond to the technical change in order to maintain their products' dominance in the market. In this regard, Henderson and Clark (in Christensen, 1997:30) argue that most product development organizations work very well as long as a product's fundamental architecture does not require change.

In designing a framework of failure in the adoption of innovative technologies, Clayton M. Christensen of Harvard School of Business offers a strategic distinction between what he calls *sustaining* innovative technologies and those which are *disruptive* (Ibid: xiv). According to Christensen, sustaining and disruptive technologies have the following characteristics:

Sustaining:

- they improve the performance of established products;
- can be discontinuous or radical in character, along the dimensions of performance are historically valued by mainstream customers in major markets;
- they can precipitate the established firms' failure.

Disruptive:

- they bring a very different value than had been available previously;
- they under perform established products in mainstream markets but maybe fully performance-competitive in the future;
- they offer cheaper, simpler, smaller, and, frequently, more convenient products to use;
- they are first commercialized in emerging or insignificant markets.

Innovation in today's telecommunications industry has revolved primarily around Internet-based technologies. This focus on the Internet is due to the medium's enormous potential in facilitating communications for both consumers and businesses alike. Using Christensen's distinction, in the carrier side of telecommunications, dominant firms have been reconfiguring themselves (sometimes with difficulty) to catch up with disruptive technologies. These disruptive technologies are primarily the result of innovations in the Internet protocol (IP) and optical sectors. In the IP sector, for example, incumbent carriers are developing voice over IP[4] (VOIP) products with the aim of keeping their dominance in voice communications. This is due to growing competition from new, competitive carriers that have built their infrastructure based on IP technology.

Incumbent carriers have also had to transform their existing products to improve their performance and sustain their customer base (sustaining technologies). These transformations are a response to a growing competition from VC-funded start-ups, some of whom have been able to grab market share from the incumbents. Also, deregulatory trends have put an inevitable pressure on dominant carriers to meet the challenges of competitive markets. Similar type of activities can be seen in the manufacturing sector.

An important implication of these sustaining/disruptive technologies has been a torrent of mergers and acquisitions (MAs) throughout the industry. The rationale behind MAs for the service provision and equipment sectors can be summarized as follows:

- to augment market share by increasing the size of the company;
- to contain the disruptive effects of innovative technologies by acquiring innovative start-ups.

3.5 The Role of VCs

Over the past ten years, a consistent interdependence has been witnessed between the extent of deregulation and the pace of activity by VCs in funneling risk-prone capital to innovative business ideas. Many of these ideas have eventually been transformed into business plans and products. Some of these products are sustaining technologies that have

[4]Also known as Internet telephony, the technology offers much cheaper voice applications using the Internet technology. It enables customers to bypass public telephone networks controlled by the incumbent phone carriers.

helped with the improvement of existing products. Others have been disruptive which have not yet been widely accepted in the market.

Elsewhere in his study, Christensen (Ibid: 30) maintains that established firms tend to be good at improving what they have long been good at, while new entrants seem better suited for exploiting radically new technologies.

The above argument by Christensen is particularly pertinent in the equipment manufacturing sector. In this sector, most of the new technologies have come from VC-funded startups. Among these startups, those with either a breakthrough technology or a financially successful base have become targets of acquisition by the established players. For example, *Optera*, Nortel Networks' hugely successful fiber optic flagship product, comes from the company's acquisition of Cambrian Systems Corporation, then a Kanata, Ontario-based startup (Nortel news release, December 1998).

For another, AOL-TimeWarner Inc. over the past few years has bought up several small companies because of their inventions. AOL took over Netscape Communications Corp., creator of a web browser; Tegic Communications, which makes software for putting text into a cell phone faster; and Nullsoft, which created the popular free online music player Winamp and whose founder also programmed Gnutella, a service that lets users share files directly with each other without having to go through a central gatekeeper (*Washington Post*, April 29, 2001).

With respect to the influence and the role of VCs in the flow of innovative technologies, George Gilder[5] (*Forbes ASAP*: February 19, 2001: 120) argues that the

[5] George Gilder is a contributing editor at *Forbes ASAP* and editor of the monthly *Gilder Technology Report*. He covers trends in new technologies.

effects of VCs play out not simply in months but over decades. The data coming from the industry is supportive of Gilder's argument. In year 2000 alone, VCs poured cashed into 5,380 new companies (*Forbes*, February 19, 2001: 86)—this is despite the plunge in technology stocks since April 2000. What Gilder's argument suggests is that we can expect many more breakthrough technologies in the long run. Moreover, according to Venture Economics and National Venture Capital Association[6], despite the seriousness of economic downturn in the high-tech industry, in the first quarter of 2001 1,072 startups in North America received a total of $USD11.7 billion in funding from American VCs (in *Lightreading.com*, May 10, 2001). Of these startups, 57 per cent were optical and Internet related companies.

Vinod Khosla, a partner at Kleiner Perkins Caufield & Byers[7], concurs with Gilder and maintains that VCs will continue to be the engine behind innovation in high-tech industry. Khosla argues that the current downturn in technology markets does not change the underlying cycle of technology innovation (Forbes, Ibid). He continues that the only roadblock that could hamper the cycle of innovation is talent scarcity.

But Bill St. Arnaud (Senior Director of Advanced Networks at CANARIE) offers a different argument and maintains that many of the fundamental and innovative developments have come from academic community, not VCs. He cites Napster, the Web, and hypertext transport protocol (HTTP) as major innovations that have come from academic community. These fundamental innovations, according to St. Arnaud, later lead

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[6] Venture Economics: www.ventureeconomics.com; National Venture Capital Association: www.nvca.org
[7] Kleiner Perkins Caufield & Byers (www.kpcb.com) is a leading VC based in Menlo Park, California. It has provided funding to companies that are known today as technology powerhouses. Some of these companies include Amazon.com, America Online, Inc., Compaq, Lotus, Netscape Communications, Sun Microsystems, Corvis Corp., and 360 Networks.

to other innovations that are incremental and funded by VCs. St. Arnaud goes on to say that major Internet-based companies like Amazon.com and E-bay are in fact benefiting from innovations that originated in academic institutions.

James Crowe (Chief Executive Officer at Level(3) Communications) sees a very different role for VCs from St. Arnaud. Crowe maintains that VCs approve of innovative ideas and finance their process in the market until they reach a financially stable stage. He continues that even though large companies like Lucent, Alcatel, and Nortel are known for developing standards and new technologies, they are often pushed along and in many cases outpaced by VC-funded startups. Crowe uses Ciena as a company whose technology is considered largely responsible for the current overhaul in the upgrade and reconfiguration of telecommunication networks worldwide[8].

3.6 Summary

It is likely that innovation in the high-tech industry and telecommunications in particular will continue to be at the infrastructure level (e.g. e-commerce and optics). More innovative—and most likely disruptive—technologies will be introduced by VC-funded startups; technologies that established companies will not initially consider worth investing in. Therefore, it is fair to argue that the more decline in VC spending on new ideas, the greater the likelihood that there will be a slowdown in the development of innovative technologies.

[8] Crowe is referring to dense wave division multiplexing (DWDM). Chapter Four discusses this technology in detail.

New markets will come into being under the pressure of innovative technologies, which will require very different management capabilities from established markets (Christensen, Ibid: 209). As a result of the emergence of new markets, established players will find themselves compelled to change not just their marketing and product strategy practices, but also their corporate culture; the latter being a hard-to-overcome challenge for many of them.

Chapter Four:

Broadband Platforms: Optics to the Edge

Fiber optic technology is doing to telecommunications what microprocessors did to computers.

Ian Angus[1]

4.1 Introduction:

In the previous chapter, I tried to identify the main economic agents in today's telecoms and explored and examined their significance in the transformation of innovative ideas into new technologies and business models. This chapter demonstrates the present dynamics of telecommunications, this time by exploring the impact of fiber optic technologies on the traditional models of telecoms. It describes characteristics of Internet traffic, highlights the main debates surrounding fiber optic technologies, and how the industry is coping with these technologies.

Later, I will look in detail at emerging broadband platforms and analyze them as business models. This chapter will also look into how these models are being played out in Canadian telecommunications and how different debates are influencing their deployment. Another topic discussed in detail is the deployment of new optical-based technologies in metropolitan areas. Here, I will clarify the reasons behind the need for a robust broadband infrastructure in North America's metropolitan areas and highlight the main themes in the development of such an infrastructure. The concluding section summarizes the developments in the industry.

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[1] Personal interview with Ian Angus, President, Angus TeleManagement Group (www.angustel.com).

4.2 Internet Traffic Growth and Characteristics Of Telecommunication Demand

The Internet is characterized today by an unprecedented expansion, a seemingly unquenchable need for more bandwidth, and customized content delivery. On the other hand, transport services and technologies are driving the emergence of what is known as *next generation* service providers. Internet traffic growth is one of the most intriguing and least understood factors in today's telecommunications. Continuous penetration of personal computers (PCs) into households and corporations alike; exponential growth in e-commerce; and the increasing popularity of streaming video programming on the Internet can be cited as the main engines of growth in Internet traffic. Thus continuity in growth has made mapping out a clear picture of future network traffic an extremely difficult task.

Perhaps, this continuity is best witnessed in the e-commerce sector, where establishing online presence by corporations has become almost a religious norm. In its infancy stage in 1999, worldwide business-to-business (B2B) e-commerce was a USD$154 billion industry (Gartner Group[2], 2000). This sector is projected to become a USD$7.9 trillion market by 2005, comprising 7 per cent of worldwide B2B commerce (Gartner Group, Ibid).

The ability of fiber optic technology to process and transport massive amounts of data has enabled communication carriers of all sorts to better handle the exponential

[2] Gartner Group is a professional consulting firm based in Stamford, Connecticut specializing in business technology (www.gartner.com).

growth in traffic on their networks and utilize broadband services more efficiently. This has also enabled communication carriers to increase revenue from broadband services. Revenues from broadband communications in the residential sector are projected to witness a fourfold increase from USD$9.95 billion in 1998 to USD$45.72 billion in 2005 (Frost & Sullivan, 2000).

Massive growth in data traffic has contributed to an astonishing growth in American telecommunications. At present, the overall size of American telecommunications stands at USD$525.4 billion (Telecommunications Industry Association—TIA, 2000). The latter figure comprises the following sectors, each with its own annual growth rate:

- Equipment sector at $135.4 billion with 11.5% growth;
- Transport services at $252 billion with 8.5% growth;
- Support services at $138 billion with 17.3% growth.

And yet, despite huge opportunities offered by deregulation and high growth rate in Internet traffic, incumbent carriers (e.g. TELUS and Verizon) still control the bulk of revenues in telecom services. Unlike enterprise sector, this control is much stronger in the residential sector, which remains largely untouched despite deregulation.

Worldwide telecom revenues today stand at USD$1 trillion[3] with $650 billion in voice services, USD$250 billion in video broadcasting, and USD$100-150 billion in data services. These figures translate into 4-5% of the world's gross national product (GNP). But in the USD$150 billion data space, CLECs and new IP-centric companies like Verio and Net2Phone have generated no more than USD$20 billion. The combined market capitalization of these competitive carriers as publicly held companies does not exceed

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[3] These data were obtained during a phone interview with Paul Vabakos, a partner with Comventures. Comventures is a venture capital firm based in Silicon Valley. Also, please note that the figures represent revenues generated from telecom services on a global basis and do not reflect the overall financial size of the industry.

50% of market cap in the data space. These figures clearly suggest that global telecom industry is still in dire need of further deregulation and increased competition. It is, therefore, requisite upon governments in various parts of the world to seize upon the momentum to create open markets in their communication sectors. This means upgrading their crucial information infrastructure for the emerging network economy.

Understanding Internet traffic patterns is crucial to both established and competitive carriers alike, not just for competitive reasons but also for future expenditures in network infrastructure. It also helps carriers in such areas as product development and product management to better develop and organize potential new products. According to a report by RHK (December, 1999), a professional market research and analysis firm specializing in fiber optic markets, Internet traffic growth in North America stood at 350,000 Terabytes per month (Tbpm) at the end of 1999, already surpassing voice traffic, which had a 50,000 Tbpm growth at the same time. The same report by RHK indicates that deregulation in the telecom sector has diminished the FCC's ability to collect data on either voice or Internet traffic patterns. This is at a time when data is leading voice in capacity.

It is important to stress that the growth projections by most service providers are not reliable. On one hand, there is little incentive to provide anything other than hyperbole, and on the other, there are no standards or even common metrics (RHK, Ibid: 1-1). In response, Lanning, O'Donnell, and Neuman[4] (1999: 1) offer an alternative method for forecasting and measuring demand in communication services particularly in the data

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[4] Steve Lanning of Lucent Technologies, Shawn O'Donnell of Massachusetts Institute of Technology (MIT), and Russell Neuman of Annenberg School of Communications, University of Pennsylvania, "A Taxonomy of Communications Demand", *Telecommunication Policy Research Conference*, September 1999.

space. They argue that traffic estimates are becoming increasingly unreliable because accelerating rates of use and new communications applications invalidate conventional forecasting assumptions. Since conventional forecasting assumptions are premised on existing or foreseeable services, Lanning et al instead offer building *aggregate estimates* for demand based on the *elasticity* of demand for bandwidth.

Based on Lanning et al's argument, price elasticity (see the section "4.6 Demand Elasticity" on p.83) models are necessary to grasp the interaction between the Moore Law-type[5] technological progress and non-linear demand functions. These have implications for network planning, universal service policies, and commoditization of communications carriage (Ibid). The rate of progress is even faster in the optical space, where bandwidth capacity doubles nearly every 12 months.

Relating Moore's law to optical switching capacity, Paul Vabakos of Comventures names five things that can be retooled to improve throughput in the optical fiber:

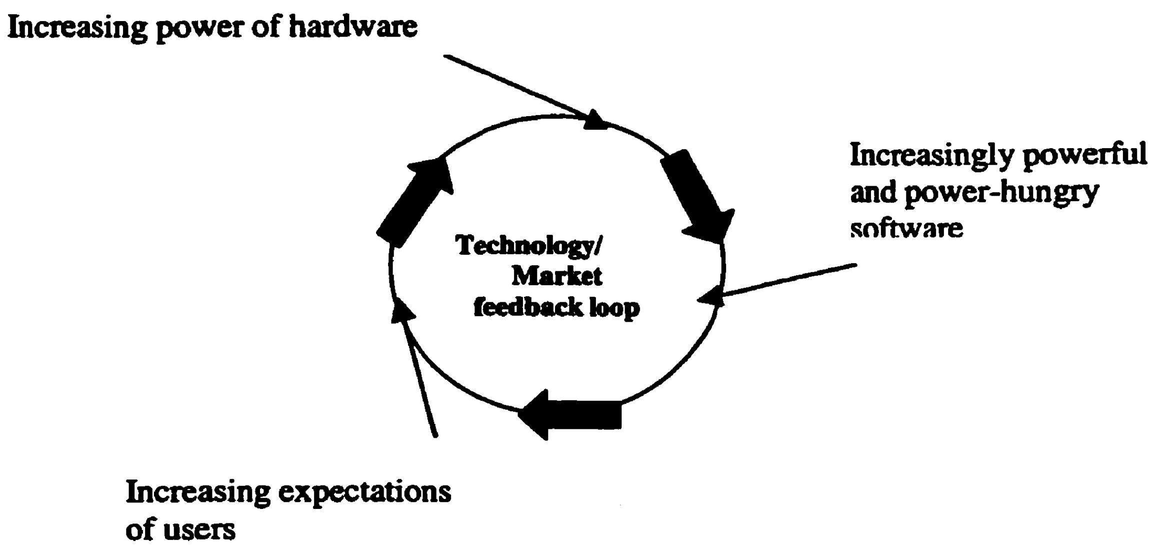
- bit rate per channel
- number of channels
- modulation scheme
- the bands
- the number of fiber strands

In the period from 1997 to 2001, the per second bit rate has increased from 1Gbps to 40Gbps, the number of channels from 1 to 200, modulation from 1 to 16, bands from 1 to 4, and the number of fiber strands from 4 to 864. Over the past five years we have seen

[5] According to Moore's Law, microprocessors double computing capacity every 18-24 months. In the course of preparing a speech on microprocessors in 1965, Moore realized that each new chip contained roughly twice as much capacity as its predecessor, and each chip was released within 18-24 months of the previous chip. If this trend continued, he reasoned, computing power would rise exponentially over relatively brief periods of time. Moore's observation described a trend that has continued and is still remarkably accurate. It is the basis for many planners' performance forecasts. In 26 years the number of transistors on a chip has increased more than 3,200 times, from 2,300 on the 4004 in 1971 to 7.5 million on the Pentium II processor (from Intel's website: http://www.intel.com/intel/museum/25anniv/hof/moore.htm).

that lower prices in Internet services have caused fundamental changes in the mix of applications and thus the nature of communication demand. This is due to further penetration of optical technologies into the network architecture, which has facilitated service provisioning and enhanced speed and quality of service.

For a better understanding of the implications of their methodology, Lanning et al have developed what they call *technology/market feedback loop*. The feedback loop (see the figure below) is based on interactions among three main parties in the industry: hardware makers, software makers, and end users.



End users demand smarter, faster applications; software publishers write new applications with the expectation that hardware manufacturers will provide the additional processing power necessary to run them; and hardware manufacturers offer systems with greater power, increasing the expectations of users and completing the loop (Ibid: 4).

The Lanning et al model can be used in other segments of the industry such as communication equipment and e-business applications. The application of this model could have far reaching implications for the service provider market and raise the question as to how aggressive carriers should be in making investment in next generation network technologies. Regulators should also take seriously the existing patterns of change in price elasticity. This, as Lanning et al (Ibid: 28) argue, helps policy makers decide whether their intervention in the market expedites or impedes the availability of low-cost services to all end users.

4.3 Fiber Optic Technologies at a Glance

As discussed briefly in Chapter One, fiber optics refers to transmission systems that use laser light beams to transport information (data, voice, video) from one point to another. Fiber optic transmission became widely used in the 1980's when the long-distance carriers created nationwide systems to carry voice conversations digitally over optical fibers. Benefits of fiber optics technology include low transport costs, low power consumption, ability to carry vast amounts of data at very high speeds, and insensitivity to over-the-air electromagnetic interference. Without going too much into technical detail, I will briefly outline the most important factors in the transport of signals based on fiber optic technology.

Fiber optic transmission systems have been traditionally deployed in the form of Synchronous Optical Network (SONET) rings. SONET is the most widely deployed optical architecture in the world; and its European counterpart is known as Synchronous Digital Hierarchy (SDH). SONET is a physical interface that allows interworking of transmission products from multiple vendors. SONET uses time division multiplexing (TDM) to send multiple data streams simultaneously. SONET's smallest increment of provisioning is STS-1[6], which represents one time slot (frame) of capacity or 51.84 Mbps.

All SONET systems are defined by optical line rates known as Optical Carrier (OC) signals. OC signals interface with STS blocks of signals, which act as an electrical equivalent of an OC. For example, an STS-3 represents electrical equivalent of an OC3 (155Mbps) signal. One of the benefits of SONET systems is their *self-healing* capacity. When a line goes down SONET systems use their ring architectures to reroute traffic.

In the mid 1980s in the US, Bellcore (today's Telcordia Technologies) initiated SONET technology on behalf of all RBOCs to attain multi-vendor networking and to create an infrastructure to support new broadband services. It was later adopted by the American National Standards Institute (ANSI) (Newton, Ibid: 953). The following table demonstrates the existing SONET rates. In the following sections and chapters, I will be using line rates from this table.

Table 4.1 SONET transmission rates

OC/SONET Level	Line Rates	Transmission Capacity
OC-3	155 Mbps	84 T1s
OC-12	622 Mbps	336 T1s
OC-48	2.5 Gbps	1344 T1s
OC-192	10 Gbps	81284 T1s
OC-768	40 Gbps	325136 T1s

[6] Synchronous Transport Signal-1: The basic SONET building block signal.

4.3(a) Strengthening Optical Signals

In all existing optical networks, light signals have to be converted into electrical signals at the customer premises so that end users can transmit and receive information. Optical signals always need to have their integrity and strength maintained when traveling over long distances. This is achieved by converting optical signals into electrical form and back into light using a variety of specialized equipment. This process in optical networking is known as optical-electrical-optical (OEO) conversion process.

OEOs are instrumental in the transport of optical signals. Most carriers have separate networks for their data traffic and integrate them on SONET rings using Asynchronous Transfer Mode (ATM) switching system. On the other hand, IP traffic is transported over routers that are linked to ATM virtual circuits. A virtual circuit is a temporary communication path created between devices in a switched communications system. Other users may share the actual lines at the same time, but the virtual circuit appears exclusive to the users that are communicating with each other (Newton, Ibid: 1115). Telecom equipment makers have optimized their ATM switches for SONET systems.

With growing diversification in demand for data traffic particularly in metropolitan markets, there has been a rise in expectations from SONET systems to operate more efficiently and economically. The major drawback of SONET systems today is their inability to meet the demands of optical networking in high-traffic metropolitan areas. This is because their chipset limitations have restricted ATM virtual circuits to OC-12 capacity (Clavenna, 2000: 55). This is a particularly pressing technical issue in the deployment of optical networks in metropolitan areas. Levine (*America's Network*, 2000:

2) describes other shortfalls of SONET systems as bandwidth inefficiency and the long process of circuit provisioning. Since 50% of network capacity in a SONET is tied up for protection purposes it leaves a large amount of bandwidth unused. Another drawback to SONET systems concerns the amount of time and effort required for installation of circuits.

In order to install SONET circuits, technicians must be sent to multiple locations to manually set up the equipment, a process that could take between one to six months. Nevertheless, the growth in SONET systems does not appear to be showing any signs of slowing down. According to Pioneer Consulting (August 2000—In *BCR*, November 2000: 52), over a five-year period from 2000 to 2005, the SONET market is forecast to reach USD$19.87 billion in North America. This figure includes both traditional and next generation SONET systems. This growth is fueled by the activities of such optical-based, greenfield carriers as Level(3) Communications and Williams Communications on the national scene as well as such carriers as Looking Glass Networks and American Fiber Systems on a metropolitan level.

4.3(b) Fattening Optical Pipes

Another major optical networking technology is dense wavelength division multiplexing (DWDM). DWDM is widely considered the most significant innovation in telecommunications since the invention of fiber optic technology. First developed in 1996 by the Linthicum, Maryland-based Ciena Corporation, DWDM technology is poised to turn the economics of telecommunications upside down. In DWDM, several lasers or wavelengths of light—also known as *lambdas*—are merged onto a single strand of optical fiber. DWDM enables the existing optical infrastructure of telephone companies and other carriers to be dramatically amplified, while allowing them to maintain the same degree of performance and robustness.

DWDM gear available today from makers of telecommunication equipment support up to 160 lambdas on a single strand of fiber, each capable of carrying optical signals at up to OC-192 level. Among the world's leading makers of DWDM equipment are: Nortel Networks, Ciena Corp., Lucent Technologies, Cisco Systems, Alcatel, Corvis, Fujitsu, and ONI Systems[7].

It is worth noting that while DWDM does significantly increase network capacity, it also contributes to an increase in a carrier's network transport costs. According to Heywood (*BCR*, May 2000: 56), regeneration stations now account for more than half the cost of building and running some network backbones. That is because light coming into a regeneration station has to be de-multiplexed into its individual wavelengths. In addition, each wavelength needs to go through its own OEO conversion process to restore the strength and shape of the light pulses. So, for example, 40 wavelengths need 40 lasers, and lasers are expensive to buy and maintain. Moreover, when a carrier deploys a higher level of SONET transmission equipment (e.g. OC-768) it will need to install it at every regeneration station. This represents a highly expensive and time-consuming proposition (Heywood, Ibid.).

[7] The following data from Pioneer Consulting (Cambridge, MA) shows the global DWDM long-haul market share:

- Nortel Networks with 45% market share
- Lucent Technologies with 26% market share
- Ciena Corporation with 11% market share
- Alcatel with 9% market share
- Others[7] with 7% market share
- Cisco with 1% market share
- Fujitsu with 1% market share

Sometimes deployment of new networks by some carriers involves installation SONET at high levels of its hierarchy like OC-192. This practice is in anticipation of future network growth, but it does not involve lighting up of all available fiber strands. If traffic growth is fast and continuous, the carrier can light up more available strands, add new strands of fiber in its existing conduits, or simply trench the ground and deploy new conduits.

Fiber optic cables are deployed primarily in three modes:

- aerial on existing poles
- buried in existing conduit; and
- new trenching and laying of conduit (St. Arnaud, Feb, 2001)

Installation charges in the above three modes are almost entirely made up of labour costs, which have made deployment of fiber such a costly task. Aerial installation on existing poles is by far the cheapest installation methodology. It also enables the carrier to enter new markets faster. This method is also known as optical ground wire or OPGW.

The latter two methods are very costly due to high costs of trenching, particularly in metropolitan areas. In North America, the average trenching and installation cost of optical fiber within a metropolitan area is USD$124,000 per km (Nortel Networks, Spring 2000). Trenching and conduit installation do not always involve insertion of fiber strands into the conduits. Before fiber can be placed in the conduits, the carrier could negotiate anchor tenant agreements with customers to determine the number of required strands.

In the last part of this section, I would like to briefly touch on the existing types of fiber and the amplification technology. Today there are primarily two types of optical fiber in the market: multi mode and single mode fiber. Multimode fiber has a core diameter of between 50-100 microns. It is the most commonly used fiber type for short distances. Multi-mode fiber allows several beams of light to pass through it, but they cannot travel long distances.

In contrast to multi-mode fiber, single-mode fiber is best suited for long haul networks as well as for deployment of DWDM systems. The core diameter of a single-mode fiber is no more than 10 microns. Since single-mode fiber is extensively used in DWDM systems in long haul networks, carriers often face a problem specific to this type of fiber known as *fiber dispersion*. Fiber dispersion is the broadening of an optical signal that results from the many discrete wavelength components traveling at different rates. Once the optical signal is converted into digital mode, dispersion limits information carrying capacity of a single-mode fiber link. Makers of optical cable have especially designed single-mode fiber products that resist dispersion. They are known as non-zero dispersion shifted fiber (NZDSF). Major manufacturers of optical fiber in North America are Corning, Lucent Technologies, Alcatel, and Sumitomo.

In 1995, Corning, the world's largest maker of optical fiber, introduced a breakthrough amplifying technology known as Erbium-Doped Fiber Amplifier (EDFA). EDFA boosts light signals without OEO conversion process by doping strands of fiber with erbium, a rare earth element. EDFA gave a tremendous boost to fiber-optic transmission systems. Instead of requiring a regenerator every 20-25 miles, an optical amplifier is placed 75 miles apart, and a regenerator is required only once in several hundred miles (400-600 miles). In addition, an optical amplifier can amplify all of the channels in a DWDM signal, whereas regenerators are required for each channel (Techweb Encyclopedia[8]).

4.4 Dark Fiber: A New Paradigm in Telecommunications

This section describes one of the most successful new business models in telecommunications: the dark fiber model. The dark fiber model has fueled heated discussions in the industry, while at the same time leading to significant shifts in the economics of telecommunications. Present debates revolve around the model's impact on incumbent carriers and the future of broadband communications. Changes brought about by this model include considerable drop in the price of bandwidth and the emergence of new players that thrive on it.

Dark fiber refers to an optical fiber that does not contain any optronics elements in it: a dark fiber is void of any signal. Dark fiber is leased to customers that are in need of communication infrastructure. In this model, it is the customer's responsibility to add optoelectronics at both ends of the network. Adding transmission to the dark optical fiber involves placing of SONET or DWDM equipment at both ends of the network. Customers of dark fiber are primarily competitive carriers in need of communication infrastructure to enter new markets and data intensive organizations that consume large amounts of bandwidth like most financial institutions.

Proponents of dark fiber make their argument primarily based on the customer's ability to increase bandwidth vis-à-vis growth in network traffic. Unlike traditional metered services, as the argument runs, this capability brings the customer unlimited

[8] www.techweb.com/encyclopedia

bandwidth at a fixed cost combined with unparalleled security due to exclusive use of fiber. Both in Canada and the US, unique to this business model has been the absence of incumbent carriers.

In Canada, two of the biggest incumbent carriers, Bell Canada and TELUS Communications, are obligated by the CRTC tariff structure (*Decision 98-11*[9]) to provide optical dark fiber. However, CRTC allows de-tariffing of high-speed services as competition becomes available on specific routes. For example, between Montreal and Toronto there's no tariff governing fiber prices, because multiple carriers run fiber on this particular route (Angus). But in the U.S incumbent local exchange carriers (ILECs) are under no obligation to provide dark fiber to any customer. There is no tariff structure in place by the FCC for dark fiber services.

In North America, the most active—though not the only—players in the dark fiber model are carrier's carriers. A carrier's carrier is a wholesale provider of network transport services either on a national basis or within a metropolitan area (The Yankee Group, June 2000: 6). A carrier's carrier operating in a metropolitan area is referred to as a *metro carrier's carrier*.

Customers of dark fiber lease optical fiber on an *indefeasible right of use* (IRU) basis. This means that once the owner leases the optical fiber to the customer, the customer reserves every right to conduct any type of communication business with the optical dark fiber. IRU agreements are usually signed for 10- to 20-year periods. 20-year IRU agreements are mostly made for long-haul transport purposes.

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[9] Prior to Decision 98-11, the CRTC had indicated in Decision 97-11 that rates for the lease of optical fiber be based on distance. And today both TELUS and Bell are required to charge their customers based on facility distance and per meter per strand of fiber.

The price of dark fiber depends whether it is needed in a metropolitan area or for long-haul transport purposes. Dark fiber economics for metropolitan areas tends to be short term with usually no upfront costs, whereas for long-haul there is an upfront cost involved. An important cost factor in leasing dark fiber is the number of strands of fiber being leased. Table 4.2 shows the main factors involved in leasing dark fiber:

Table 4.2

Metro	Long-Haul
No upfront cost involved	Upfront cost of IRU as well as recurring cost of co-location rental
On short term basis; usually 5 to 10 year	Almost always based on 20-year IRUs
Cost: between USD$50 to $300 per fiber per month per mile/km	Cost: USD$1200 to $3000 per mile per fiber on a 20-year IRU basis

***Source*: Nortel Networks, Fiber Services**

Owners of optical infrastructure, mainly carrier's carriers, place strands of fiber within their conduits based on anchor tenant agreements they make with property management companies that own large business buildings or residential high-rises in metropolitan areas. In an anchor tenant agreement, the carrier secures a specific amount of optical fiber to run to particular building(s), which guarantees revenue flow from that particular number of strands. Depending on agreements made between the customer and carrier, optical wavelengths could also be provisioned over the IRU fiber.

4.4 (a) Enabling New Service Providers

In the same way that deregulation in telecommunications has facilitated entry into the markets by new service providers, the dark fiber model has provided a platform from which competitive carriers can launch new communication services. This model is particularly significant for new service providers because it provides significant cost reductions in communication infrastructure and helps them focus on their core business. It is also profitable for the enterprise sector. Scott Berry, Director of product marketing at Metromedia Fiber Networks (MFN), indicates that many enterprise and government customers have uncertain and unpredictable growth rates in their data and video communications. So they prefer to run their data/video over an infrastructure that is capable of handling continuous growth, viz. fiber. Moreover, bandwidth scalability offered by DWDM technology enables further service provisioning to meet the diverse bandwidth needs of customers. Clearly, this model will have serious ramifications for the ILECs in North America.

The threat that the dark fiber model poses to incumbent service providers has two dimensions to it: one is dramatic reduction in the price of bandwidth, and the other is a dramatic increase in the amount of bandwidth offered to the customer. Berry suggests that CLECs may still need some copper loop from ILECs but they can bypass the ILEC central office for the most part via fiber. Therefore, the presence of an alternative physical infrastructure is a negative factor for ILECs. As we will see in the section on metropolitan carriers, small carriers relying on dark fiber infrastructure have managed to grab some of the most lucrative customers away from incumbent carriers.

Reflecting on the implications of dark fiber model on the ILECs, Ian Angus (President, Angus Telemanagement Group) believes that it fundamentally undermines the traditional economics of telecommunications as we know them today. The 'traditional model of telecoms' mainly refers to generating revenue via metered services, that is, provisioning of transport services based on the amount of bandwidth consumed by the customer.

Angus further argues that the Canadian ILECs will be compelled to devise new strategies to face the threat posed by the dark fiber model. Paul Vabakos (partner in Comventures) presents an even more pessimist view. He believes that most ILECs will be facing *fiber exhaust* as one of their main problems, and that this problem will be more acute in the metro. He goes on to say that the ILECs will not be able to respond to the aggressive strategies of new companies like Level(3) Communications and MFN.

In stark contrast, some observers argue that the dark fiber model could offer significant benefits to the incumbent carriers. Richard Kuehn (President, RAK Associates) states that one positive implication would be provisioning of dark fiber connections by carrier's carriers to the ILECs that are expanding their networks outside their operating regions. This would provide the ILECs an opportunity to reduce the underlying costs associated with network construction[10].

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[10] For example, in 1999, Verizon Communications, one of the biggest RBOCs in US, made a USD$550 million dark fiber purchase from MFN and acquired 9.9% ownership of the company (Yankee Group, Ibid: 9). Verizon plans to use the dark fiber from MFN for expansion beyond the states where it operates as an incumbent. Also in 1999, Bell South, the Atlanta-based Baby Bell, announced a USD$3.5 billion investment in Qwest Communications to buy 10% stake in the Denver-based giant optical carrier (*New*

4.4(b) Network Management in Dark Fiber Networks

Customers that run their communication operations on IRU dark fiber need expertise to manage their networks. Due to the complexities of an optical network, most customers do not have the in-house expertise needed to manage their network. Customers have the option of outsourcing the management of their network to a third party that specializes in the repair and maintenance of fiber optic networks. In many cases these are the same companies that offer maintenance and repair services to major carriers. They offer the same terms and conditions to dark fiber customers as they do for the major carriers. In many cases the companies that install the fiber are also the ones that maintain it (St. Arnaud, Ibid).

Companies with significant ownership of optical infrastructure like MFN, Level(3) Communications, and 360 Networks, have their own set of policies for managing their customer's network. Some undertake management of all network elements, including optoelectronics, while others limit their management efforts to only certain aspects such as monitoring conduits that contain customer fiber. The following is a brief examination of how MFN offers network management services[11].

York Times, April 19, 1999). Bell South will be using Qwest's optical infrastructure and expertise in data and Internet to provide a broader range of services to customers outside its operating states.

[11] All the information about MFN's network management services was obtained during a phone interview with Scott Berry, Director of Product Marketing at MFN.

MFN creates private networks for its customers, and the customer is free to install whatever telecom gear they wish. So in a sense MFN does not manage or monitor the customer network. MFN does not monitor customer's network traffic, nor does it offer such services upon request. Rather MFN's management is primarily at the transport layer; it does not involve itself in the application layer. What MFN does is maintain the fiber network by monitoring the status of fiber strands in the conduits.

In the leased lambda space, MFN manages the optronics equipment that a customer leases from it. It is requisite upon the customer to create lambdas on the IRU fiber leased from MFN. The customer has the choice of either purchasing optronics equipment from a vendor like Ciena Corp., or leasing it from MFN and asking the latter to provide management for it. So MFN provides management for the equipment not the customer's traffic patterns. Unlike MFN, Level(3) Communications offers a more diverse management service. The main difference between the two competitors is that the latter offers traffic monitoring upon customer request. (Chapter Five explores in detail Level(3)'s operations both in dark fiber and leased wavelength services).

4.5 Leasing Wavelengths: Light as a Source of Revenue

As an offshoot of dark fiber services, leasing optical wavelengths has emerged as an equally successful business model. The roots of this model come from a landmark technological innovation in 1996 by Ciena Corporation[12]. This innovation is widely seen

[12] In 1996, Ciena developed the first wave division multiplexing system that amplified the existing capacity of fiber optic networks.

responsible for the current overhaul in telecommunication infrastructure on a global scale.

Wavelength services are offered based on DWDM technology. Using DWDM equipment, carriers offer high-bandwidth connections to ISPs, large corporate customers, and wholesale carriers. According to Bill St. Arnaud (Senior Director of Advanced Networks at CANARIE), these services are also called *dim-wavelength* and *dim fiber*, meaning a wavelength on a network that is sold to a customer like dark fiber. For example, a customer could buy a dim wavelength between Ottawa and Toronto rather than leasing fiber on an IRU basis. The chief benefit of leasing wavelength/lambda is that it helps the customer bypass the costs of leasing dark fiber in the form of 10- to 20-year-old commitments.

One important element in this model is that optical wavelengths are almost always offered in two rate increments: OC-48 and OC-192. Carriers have not yet adopted OC-768. The reason for the availability of the above two line rate increments is the high costs of opto-electronics and laser maintenance. And usually, but not always, the amount of bandwidth leased in the form of wavelength starts at 50 Gbps. Customers in need of more than 150Gbps-200Gbps of bandwidth are recommended to lease dark fiber.

4.5(a) Two Models in Wavelength Services

Offering wavelength services can be conceived in terms of the following two models[13]:

A: On IRU fiber leased by the customer

B: On the Carrier-owned lit fiber

The **A** model involves creation of wavelengths for the customer on the same IRU fiber leased by the customer. Implementation of this model depends on whether or not the carrier would be open to leasing IRU fiber. The customer that leases IRU fiber could ask either for the installation of opto-electronics or for the creation of wavelengths. The pricing scheme for this model involves an installation fee and a fixed monthly fee for bandwidth usage. In this model, where the customer is already paying for the IRU fiber, the service provider only charges a fixed monthly rate for the bandwidth used.

For example, MFN creates wavelength on the IRU fiber it has leased to a customer and charges a fixed fee irrespective of the actual amount of bandwidth used on the wavelength. In contrast, Level(3) Communications charges only in terms of the actual bandwidth used in a given month. A customer must decide whether it has the in-house expertise to manage this function, or whether it should outsource it to a third party.

In the **B** model, wavelength services are offered on the service provider's fiber. Wavelengths can be created upon customer demand and fiber availability. Either the service provider or the customer can undertake provisioning of opto-electronic equipment. However, it is recommended that the service provider lease the

[13] The two models discussed here are a picture drawn from conversations with executives at Level(3) Communications and Metromedia Fiber Networks. Other carriers in North America involved in this business follow the same guidelines discussed in these two models with only minor differences.

optoelectronics equipment to the customer and thus increase revenue from a single product offering.

The benefit of this model is that it enables competitive service providers and ISPs alike to evaluate strategically their bandwidth needs in a particular market before incurring large amounts of capital outlay. In other words, it supplements launching major network expansion in areas where the capacity may not justify leasing dark fiber. Multi-dwelling unit (MTU) real estate properties in metropolitan areas are poised to be the biggest market segment to be targeted by broadband access providers using wavelength services. The following categorizes factors that are taken into account by both service providers and customers in the provisioning and purchasing of dark fiber and leased lambda services:

1. <u>Factors in provisioning fiber to data-intensive businesses in metropolitan areas (service provider criteria):</u>

-What infrastructure currently exists now?
-Difficulty of getting right-of-way (ROW) permits/licenses to dig up streets to install fiber.
-How much fiber will be needed?
-Is there a demand for private networks (using fiber) vs. leasing T1/T3 from the ILECs?

2. <u>Dark Fiber vs. Leased Lambda (customer criteria)</u>:

-What applications are going to be used?
-Costs associated with leasing dark fiber vs. leasing lambdas (monthly/yearly).
-Length of IRU dark fiber vs. leased lambda.
-Cost of purchasing equipment + leasing dark fiber compared to just leasing lambdas.
-Time to implement.

3. <u>Consideration to extend fiber to a building or create a lambda on an existing fiber</u>:

-How far is building from fiber backbone?
-The issue of obtaining permits to dig up streets to install fiber (ROW).
-Are building tenants high bandwidth users (return on investment)?
-Does the carrier have the right equipment to offer lambda services?

4. <u>Type of equipment placed at a location with either dark fiber or leased lambdas</u>:

-Optical/DWDM
-Digital cross connect/switch
-Lambda router

4.6 Optical Growth and Demand Elasticity

Elasticity of demand is the degree to which a percentage change in price leads to a corresponding percentage change in market demand. For example, if market price declines 3 percent and market volume increases 3 percent, demand elasticity is .03/.03= -1. In theory, the price of bandwidth should fall vis-à-vis a growth in demand. This depends on the presence of optical infrastructure, mainly dark fiber, in a given area. In the past few years, due to lack of sufficient bandwidth and optical infrastructure, companies offering Internet services made efforts to extend computing cycles and computer hardware to minimize their bandwidth usage. This led to the emergence of companies whose specialization was in data compression, caching, and distributed computing. Akamai is one such company.

However, with optical infrastructure becoming increasingly available, technologies like caching and distributed computing may not be around for a long time. Moreover, new service providers with access to optical infrastructure—either their own or leased from others—will offer their services at cheaper rates to differentiate themselves from their competitors. David Passmore (*BCR*, December 2000: 18) has discussed the implications of the drop in the price of bandwidth on ILECs. He argues that "incumbents will be forced to upgrade to the latest technology and bring on more bandwidth. And with a lower price per unit of optical bandwidth, incumbents will have to sell a lot more just to maintain current revenues". However, Passmore (Ibid.) adds that in areas and regions where dark fiber is not widely available, incumbents will be insulated from the need to cut their prices.

The increase in the number of wavelength channels on a single strand of fiber is another force in driving down the price of bandwidth. In the next three years, the industry expects to see eight times as many DWDM channels on a single strand of fiber (Passmore, Ibid: 16). The more the number of DWDM channels, the more bandwidth scalibility and thus the lower costs for high bandwidth services to the customer. However, if the percentage of the increase in market demand for more bandwidth does not match the percentage of the reduction in the price of bandwidth, most carriers could find themselves in a financial quagmire. In light of such a development, the industry will have to deal with commoditization of bandwidth that can seriously undermine revenue models of all communication carriers. This development is also known as bandwidth glut (see the section on bandwidth glut on p.101).

But the current increase in the number of people getting online in North America and the number of businesses that establish online presence make demand elasticity in telecoms a compelling business case. By the end of 2000, 3.4 million American homes and businesses had broadband Internet access through cable modems, compared with 1.2 million DSL subscribers. By 2005, it is estimated that there will be about 13.8 million cable-modem subscribers and 11.2 million DSL subscribers (*New York Times*, Dec.28, 2000). Over the long term, though, this could not prove a sustainable growth pattern.

4.7 Dark Fiber/Leased Wavelength in Canada: An Analysis

In the current transformation in North American telecommunications, upgrading strategies by established carriers mainly involves expanding their scale and size, while for new competitive carriers it entails differentiating themselves from incumbent players. In Canada, deregulation and transformation in telecoms has drawn resistance by the incumbents against the introduction of new optical technologies at the network level. The Canadian incumbents have presented a number of reasons for resisting new developments in telecommunications at the network layer. On one hand, they argue that Canada is a small market—one tenth of the US—which does not have a massive enterprise customer base spread across numerous metropolitan areas. Given the unlimited bandwidth and drastically cheaper prices associated with the dark fiber/leased lambda models, its introduction by the incumbents would seriously undermine their bottom line. The immediate consequence of this model, in incumbents' view, would be loss of jobs for Canadian professionals on a massive scale.

Despite the industry's position, the dark fiber model is being aggressively pursued and promoted in Canada. In particular, CANARIE, Canada's advanced Internet development organization, has been the torchbearer of dark fiber/leased lamda models. CANARIE is a government-funded organization (Industry Canada), whose goal it is to accelerate Canada's advanced Internet development and its use by facilitating the widespread adoption of faster and more efficient networks[14]. In recent years, CANARIE has been promoting what it calls "customer-owned dark fiber" in a concerted effort to

[14] CANARIE website (www.canarie.ca)

break the control of Canadian incumbent carriers over the last mile bottleneck. But, as we will see in the next section, CANARIE's efforts have raised criticism from diverse viewpoints in the industry.

4.7(a) CANARIE & the Industry: Battling it Out

CANARIE has advanced the view that essentially every business, school board, municipality, and government institution in Canada would benefit greatly from the conveniences associated with dark fiber/leased lambda networks. Under this regime, they would no longer be dependent upon traditional incumbent phone carriers to provide them with service, and could save telecommunication costs in excess of 1000% (St. Arnaud, February 2001: Ibid).

Two important questions can be raised here that need to be answered by CANARIE officials:

1. How can an organization (e.g. school) with no expertise in telecommunications be able to run and manage complex fiber optic networks?
2. How will CANARIE be able to pursue its goals when its entire operations are run over leased optical fiber from Bell Canada, the nation's biggest ILEC?

According to Ian Angus, the dark fiber model will certainly affect the incumbents in North America. He maintains that there is good reason to be concerned about the ability of municipalities, as operators of telecom networks, to make wise technology decisions. He points to the lack of expertise in understanding emerging technologies on the part of municipalities. However, Angus gives credit to CANARIE for its efforts to bring optical broadband networks to rural Canada.

Eamon Hoey (Chairman and Chief Executive Officer of Hoey-Fox associates) shares Angus's thoughts on the implications of dark fiber/leased wavelength models for Canadian telecoms. But he is critical of dark fiber model and the carriers that have based their business model on it. Hoey believes that the dark fiber model does not break the ILEC control over the last mile and argues that the hard part of it is extending the fiber to business buildings and residential areas, a task he believes is not yet tackled in Canada.

Regarding CANARIE, though, Hoey takes a somewhat hard-line approach and simply calls for the organization's closure. According to Hoey, CANARIE's activities are part of a bigger problem, which he calls the problem of bureaucrats. He argues that CANARIE comes from a thinking based on the ability of bureaucrats in Ottawa to develop an industrial policy for the country by spending government money. Hoey further argues that the theory behind CANARIE's existence is a leftover from 1960's, 1970's, and the 1980's when bureaucrats thought they could positively adjust the market[15].

Canadian telcos have reserved their own disagreements with CANARIE's activities. According to Bill MacDonald (Assistant Vice President at TELUS's business communications unit), CANARIE has been acting unilaterally in what it has been promoting. MacDonald argues that CANARIE has not taken a broad industry approach and has been making its own one-sided perspective on what is good for the Canadian economy. He asserts that the business model being promoted today comes mainly from

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[15] Calling CANARIE's activities in telecommunications true idiocy and absolutely ludicrous, Hoey points out how the same individuals at CANARIE supported the ill-fated C2Plus wireless project in the late 1980's, which later failed miserably and put Canada five years behind in the development of PCS technologies. Elaborating on C2Plus, Hoey explains that the same people at today's CANARIE thought they could export the wireless technology to the rest of the world because Nortel Networks pushed them to deploy it and standardize it with the promise of creating thousands of jobs for Canadians. Yet today Canada has less penetration of wireless PCS than most Europe and particularly Nordic countries.

Bill St. Arnaud (Senior Director of Advanced Networks at CANARIE), not from any other segments of telecommunications. MacDonald maintains that St. Arnaud is pushing a social agenda surrounding the Industry Canada's *Connecting Canadians*[16] initiative, and uses this to spin other things such as customer-owned private dark fiber networks.

However, MacDonald admits that some of the underlying concepts of what St. Arnaud is promoting are valid, but questions other aspects such as the expertise of those who are expected to operate these complex networks. MacDonald believes that taxpayers should not pay for municipalities and education institutions activities in telecommunications and emphasizes that this expertise already exists in organizations that retain them. For example, MacDonald argues that it does not make sense for a kindergarten to run a fiber optic network.

As the senior director of Advanced Research and Development Network Operations Center (ARDNOC) at CANARIE, Bill St. Arnaud responds to the criticisms leveled against his organization by arguing first that CANARIE is not in any way advocating an industrial policy or industrial technology approach. In response to concerns surrounding municipally owned dark fiber networks, St. Arnaud says that it has never been CANARIE's policy to advocate municipalities run telecommunication networks. Instead, he clarifies that what CANARIE is trying to do is to ensure that the optical network infrastructure remains open to all competitors in any community. According to St. Arnaud, municipalities can ensure that their right-of-way access is provided to companies that keep their strands of fiber fully open to all competitors[17].

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[16] It is the name of a project used first by John Manley, then minister of Industry.

[17] On the failure of C2Plus, St. Arnaud concurs with Hoey that it was a dismal failure but adds that Nortel was not the only supporter of the project. It was also supported by the Industry Canada.

On CANARIE's relationship with Canadian ILECs, St. Arnaud asserts that CANARIE's main problems and differences are with TELUS Communications. According to St. Arnaud, TELUS's management is concerned about the implications of the customer-owned dark fiber model and its competitive potential since the model can undermine the company's main revenue stream, which is based on the traditional bandwidth metered system. In contrast, St. Arnaud asserts that CANARIE has not faced any resistance from Bell Canada in this regard and that it enjoys a healthy relationship with Bell. However, St. Arnaud emphasizes that the bulk of Canadian ILECs' revenue is still generated at the last mile, which is primarily voice communications.

4.7(b) What is Next?

CANARIE's attempts over the past four years to connect Canada's R&D institutions have been significant and remain under-appreciated. Many Canadians are still not aware of CANARIE's valuable contributions in the adoption of new technologies in education and research institutions. However, CANARIE is increasingly becoming an institution embarked on setting the agenda for Canadian telecommunications, a development that some observers claim is stepping outside the framework of its responsibilities.

At this time it is too early to say whether or not CANARIE has emerged victorious in its promotion of customer-owned dark fiber networks in Canada. Being the most connected country in the world, one wonders whether CANARIE's plans should be adopted, ultimately to the detriment of the industry and the risk of thousands of professional jobs migrating to south of the border.

CANARIE's contract with Industry Canada will expire in late July of 2002. According to St. Arnaud, for the first time in 3 years CANARIE will not receive new program funding in the 2001 fiscal year. CANARIE plans to launch CAnet4, which according to St. Arnaud, would require minimal funding compared to CAnet3. If CANARIE does not receive funding for the launch of CAnet4, it plans to link its existing infrastructure to an American carrier and ask for high-speed connectivity to Internet2[18]. But CANARIE is not the only Canadian organization promoting communication services based on dark fiber and leased wavelength models. Other major Canadian organizations from both private and public sectors involved in these models include:

- 360 Networks
- Big Pipe from Shaw Cable Systems[19]
- municipality and utility companies

360 Networks is the biggest Canadian organization in the private industry conducting business in dark fiber and leased lambda areas. The Vancouver, BC-based carrier's carrier has already extensive operations in the US and is involved in deploying optical infrastructure in major metropolitan areas across North America, Europe, and Asia. The company is planning to target large businesses with its leased lambda services, which could offset a major telecom war in Canadian markets. 360 Networks has a strategic alliance with Alcatel, the giant French maker of telecommunication equipment, to build a

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[18] Internet2 is the equivalent of CAnet3 in the US with a strict focus on connecting American universities and colleges. It is led by over 180 universities working in partnership with private industry and the US government (www.internet2.edu).

[19] Big Pipe Inc. a subsidiary of Shaw Ventures, is a national fiber optic network with US points of presence (POPs) in Washington, DC; Palo Alto, California; Chicago, Illinois; Seattle, Washington; and New York, among others. With dark fiber leased from 360networks, Big Pipe is creating a 12-strand fiber optic backbone covering 3,939 miles (*Broadband Week*, February 5, 2001).

USD$1.6 billion undersea transoceanic fiber optic network linking North America and Japan (*Globe and Mail*, Nov.1, 2000).

Other emerging players in Canada in this space include municipalities and utility companies. While they lack experience in telecommunications, they do control right-of-way access and therefore have the option of deploying optical infrastructure in metropolitan areas in the hope of selling dark fiber to business customers. Hydro One Telecom, a subsidiary of Hydro One in Ontario and South Dundas municipality in Ottawa are two such organizations (*Angus Telemanagement*, Nov.6, 2000).

However, for 360 Networks, municipalities, or utilities to become successful with their business plans, they must take into account the bandwidth needs of businesses. If businesses do not require massive bandwidth offered via these models and do not want to invest in the associated opto-electronic equipment, it will take a long time for these models to reach maturity stage. Nevertheless, the exponential growth in network traffic is signaling a promising prospect for them.

4.8 *Co-location:* More Space for More Carriers

Tremendous expansion in competitive bandwidth provisioning fueled by deregulation has spurred an unprecedented thirst on the part of carriers for more space in which to house their communication equipment. This trend has led to the emergence of a new model in telecommunications known as *co-location*.

In the past, co-location involved a situation where a CLEC or an ISP housed its equipment with a dominant provider like MCIWorldcom or an RBOC. But today both ILECs and major Internet backbone providers like UUNet (an MCIWorldcom company) are fast running out of 'co-lo' space. This has led to the emergence of companies whose main expertise is in providing space to emerging niche service providers. These niche service providers include applications service providers (ASPs), content providers, video streaming companies, metropolitan broadband access providers, and building local exchange carriers (BLECs). Some of the players in this space include: Co-lo.com; CoreLocation; Equinix; Eureka; Switch & Data Facilities; AboveNet (an MFN subsidiary); and Co-space.com. Some of the above players have experience in the real estate business.

The important thing to note about this sector is the seemingly endless demand by niche service providers for more co-location space. In 1999, the hosting market was a USD$1.8 billion and is expected to be more than a USD$17.6 billion industry by 2003 (*Telecommagazine*, Nov.2000). It is estimated that there are 42 national co-lo providers, with more than 25 million square feet coming on-line in 2002, a 50% increase over current availability (*Telecommagazine*, Ibid).

4.8(a) Two-Flavors of Co-location and Service Characteristics

Co-location is a form of provisioning central office (CO) space. Providers of CO space are also known as *carrier hotels*. The term carrier hotel refers to the space and other value added services that these companies offer to their customers. The companies in this space are also referred to as Internet business exchanges. Co-lo providers fall into two categories: neutral and *non*-neutral.

A neutral co-lo provider gives niche service providers immediate access to owners of high bandwidth fiber backbone, like Level(3) Communications and MFN. Owners of fiber backbone could also be metro carrier's carriers like FiberNet Telecom and American Fiber Systems. Fiber connectivity is of crucial importance to any customer of co-lo companies because it is the main platform from which the customer can launch its services.

Unlike the traditional telecom CO model, where carriers lease physical space from a building owner, neutral co-lo providers offer air conditioning, backup DC power, dust control and high-level security in addition to real estate (*Telecommagazine*, Ibid). A neutral co-lo provider enables service providers to have access to major backbone networks. In this way, service providers do not have to go through costly capital outlays such as building their own network backbone.

A major appeal of a neutral co-location facility is carrier choice and the ability to interconnect with a wide range of suppliers (*America's Network*, October 2000). Moreover, a neutral co-lo facility can act as a matchmaker by joining its tenants (service providers) together in service partnerships based on common needs. In many cases ISPs and ASPs have linked services, as have competitive local service providers and web hosting companies, among other partnership configurations (*Teledotcom*, January 8, 2001). For each alliance, the co-lo provider charges involved parties a fee.

Non-neutral co-lo providers prefer customers they have been already conducting business with. Non-neutral companies are generally incumbent service providers that are mandated by regulatory requirements to provide racks of CO space to their competitors. Regulatory responsibilities and partnerships with customers/competitors have caused most incumbent service providers to run out of space for co-location in their COs. Nevertheless, unlike carrier-neutral co-lo providers, non-neutral carriers own their networks and guarantee network connectivity. Regardless of type, co-lo providers need to take into consideration and execute the following four elements in their overall service provisioning (*Telecommagazine*, Ibid):

- access to capital
- fiber connectivity
- power supply
- choice of location

Of the above four elements, fiber connectivity and power supply are most critical for any co-lo provider. A co-lo provider's value to its customers lies in its ability to connect them to backbone fiber optic networks. Therefore, ensuring access to the backbones of major optical carriers like Level(3), MFN, or WorldCom is essential before the launch of service. It is worth noting that for optical backbone carriers providing connectivity to co-lo providers could sometimes conflict with their business strategy. This is because most optical backbone carriers also have their own co-lo facilities. Without fiber connectivity, a co-lo provider is nothing more than a building.

Sufficient availability of power is equally critical for any co-lo provider. It has become a particularly pressing issue for many co-lo companies in major metropolitan areas like New York City and throughout the state of California, where companies are struggling with inadequate electric power. To alleviate power shortages, therefore, many carrier hotels have opted to locate their facilities on university campuses, where spare power capacity is usually available in sufficient amounts (St. Arnaud). To avoid power shortage crises, carrier hotels increasingly establish strategic presence in Tier2 and Tier3 metropolitan areas. The cheaper cost of real estate is another reason.

Because a neutral CO is fundamentally a real-estate issue, entry requires up-front capital. Most neutral and even non-neutral co-location facility owners buy the building, and build the facility based on presold commitments. (*Telecommagazine*, Ibid). For example, in year 2000, 360 Networks paid USD$118 million in cash and USD$26 million in stock to secure co-location space in Los Angeles, Atlanta, and Dallas (*America's Network*, Ibid).

4.8(b) Co-location: More Than Space Provisioning

Basic co-location services include space and bandwidth but no managed services. In its early stages, this was the most popular platform in co-location business, as customers outsourced servers to reduce traffic costs and improve their network performance. Increasing competition in the co-lo space has prompted companies to look for new ways to differentiate themselves from their competitors. This has made the co-lo market extremely price-competitive. Rob Lamb, Vice President of business development and founder of Colo.com, asserts that the co-lo business is no longer just about finding a use for an old building (*Teledotcom*, Ibid: 64). Co-lo companies have decided to offer value-added services as their chief differentiating product strategy. Citing increased competition in co-lo space, Ron McMurtry (*BCR*, January 2001: 37), Vice President of e-business at WorldCom characterizes the co-lo industry as "long-distance all over again", cunningly referring to sharp decreases in long-distance prices in recent years that have turned it into one of the least profitable sectors in telecoms.

Dick Anderson, chief technology officer at AT&T Solutions, disagrees with McMurtry arguing instead that by adding value added services (e.g. data storage capability and e-business infrastructure) to their portfolio of products, co-lo companies will be able to win large size customers. Anderson goes on to say that large size customers, such as banking institutions, gravitate to the more highly managed services because they will be able to expand more aggressively into e-business applications, which can be provided to them by co-lo companies (*BCR*, January 2001: Ibid). The opportunity to avoid capital outlay necessary to launch and maintain services offered by co-lo companies enables customers of all size to meet high and unpredictable growth in their business. The following table (4.3) illustrates customer priorities in selecting their ideal co-lo provider. As shown in the table, reliability (e.g. sufficient power) and sufficient bandwidth (e.g. fiber connectivity) stand out as the most critical factors.

Table 4.3

Reliability	**22%**
Bandwidth	**21%**
Security	**16%**
Other	**12%**
Price	**10%**
Access to equipment	**5%**
Technical support	**5%**
Location	**5%**
Managed Services	**2%**
State-of-the-art facility	**2%**

Source: The Phillips Group (in *Teledotcom*, Ibid)

4.9 The Broadband Scene: Optics to the Edge

Over the past three years, the industry has witnessed penetration of fiber optic communication systems from their original use in long-haul networks into local access networks. This section explores the state of emerging broadband technologies and service providers in North America and their prospects of success. It adds a fresh perspective to the current debate surrounding the bandwidth glut, and elaborates on the significance of metropolitan markets in the development of broadband services.

The exponential growth in Internet traffic is not just a North American phenomenon but is being witnessed on a global scale. However, the bulk of traffic is being generated in Canada and the US (58%, see Chart 4.1). According to International Data Corp. (IDC[20]), the number of computers and other devices worldwide accessing the Internet will grow from 78 million at the end of 1997 to more than 515 million by the end of 2002 (in *America's Network*, April, 1999). There will be multiple Internet devices per user, particularly as the number of non-PC access devices grows during this five-year period. Initially, the bulk of Internet users was at home and in mid or large size businesses. But over the next several years, smaller businesses will increase their presence on the Internet.

[20] IDC provides information services about technology, industry analysis, market data, and strategic guidance to builders, providers and users of information technology. The company is based in Framingham, Massachusetts (www.idc.com).

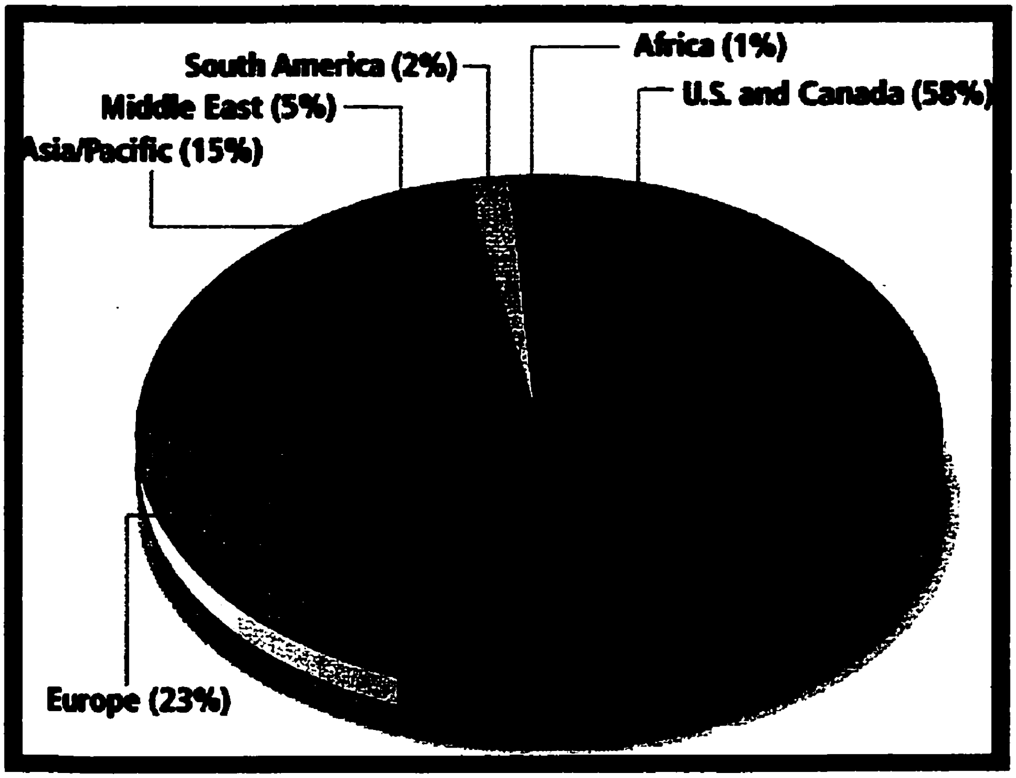

Chart 4.1 **Source:** ***America's Network*, April 1999**

Consistent growth in Internet traffic results in consistent growth in the diversification of access technologies followed by a decrease in prices. In the past ten years, access technologies (e.g. 56K modems and DSL modems) have gained market share in both residential and business environments. But the growth of market share has not been equal for all of them. In fact, some of the access technologies have seen their prominence rise in the early years of the Internet and then fall, as Internet users demanded more high-bandwidth access technologies. Table 4.4 illustrates the pace of demand for a variety of access technologies based on their revenue projections.

But as broadband communication technologies become more widely available and adopted by more users, low bandwidth technologies such as 56Kbps modems and ISDN will be replaced by higher-speed access technologies like DSL and cable modem. The latter options will continue to be the dominant modes of broadband access technologies for the foreseeable future. Phone companies and cable carriers will continue to battle it out in convincing more customers to choose their respective mode of broadband platform. Despite their lax performance in recent years in catching up with cable carriers, phone companies are gaining considerable ground in providing DSL to customers, both in residential and business sectors[21].

[21] For example, in 2000 both Verizon (New York) and Bell South (Atlanta), two of the largest RBOCs in the US, rolled out more than 755,000 DSL lines, meeting their expectations for the year (*Teledotcom*, January 2001: 11). And here in Canada, according to Strategis Group, a Washington-based professional research and consulting firm, by 2003 there will be 3.5 million DSL subscribers in Canada compared to only 1.8 million cable modem subscribers (in *BCR*, October 1999: 8).

Table 4.4 (All figures in millions of US dollars)

	1998	1999	2000	2001	2002	2003
Dial[1]	1,206	2,302	3,314	4,458	5,607	6,627
56 kbps	197	467	746	1,068	1,472	1,782
DSL	—	24	105	259	504	876
Cable	18	74	276	697	1,225	1,786
FT1/T1	896	1,687	3,019	5,619	7,921	9,268
DS3 (45Mbps)	255	568	1,345	3,696	7,610	12,657
OC-3 (155Mbps)	—	49	351	1,094	2,339	4,140
Total Broadband	1,169	2,402	5,096	11,365	19,599	33,569
Bundled[2]	270	575	1,151	2,348	3,615	4,842
Total	2,842	8,048	10,307	19,239	30,293	41,978

[1]includes integrated services digital network (ISDN)
[2]includes local loops and customer premises equipment (CPE)

Source: IDC 1999

The only contending technology that could potentially render DSL and cable modem technologies obsolete is fiber-to-the-x (FTTx). FTTx involves direct penetration of optical fiber to residential neighbourhoods, inside buildings, or to neighbourhood curbs. It will be the last major push of optical fiber to the network. The main feature of this technology is its ability to bypass the copper-based last mile, which currently generates the bulk of the revenue for cable and telephone companies. A main area of activity for carrier's carriers in metropolitan markets has been extending the reach of fiber to corporate buildings, and in some cases, to residential condominiums.

But of the existing scenarios in FTTx technology, fiber-to-the-home (FTTH) is the least likely in North America. This is due to high cost of trenching and deploying fiber to each and every house. In the U.S and Canada, many people live in detached homes. Therefore, for a long time to come, in North America most people will have to cling to their DSL and cable modems as their primary choice of broadband technologies.

According to Richard Kuehn (President, RAK Associates), even though FTTx is the desired mode of broadband for the future, it does not make sense to extend a strand of fiber to a neighborhood to provide a 64 Kbps voice channel and perhaps 1-2Mbps of data for Internet browsing. Commenting on why FTTx is not cost effective as a residential access technology, Paul Vabakos of Comventure cites the inability of carriers in this space to have access to capital to extend optical networks in residential neighbourhoods. The only factors that could make this technology cost effective are:

- continuous reduction in the price of opto-electronics;
- and the development of new trenching technologies that would drastically reduce the cost of labour.

4.10 The Bandwidth Glut: To Believe or Not to Believe

According to KMI Corp.[22], over the past 21 years, 85 million miles of fiber were installed in the United States alone. More than two-thirds of that was installed since 1996, with a full 33 million fiber miles coming in year 2000. The debate on bandwidth glut emerged when industry analysts and observers were alarmed by the massive deployment of optical infrastructure in North America. Immense activities in the deployment of fiber

[22] From *Teledotcom*, March 19, 2001, p.52. KMI Corp. is a company based in New Port, Rhode Island that conducts research and provides consulting on global fiber optic markets (www.kmicorp.com).

optic infrastructure by both new and incumbent carriers alike has prompted many industry observers to suggest that supply in bandwidth could soon surpass demand and turn it into a cheap commodity. Though it is too early at this time to announce the arrival of a bandwidth glut, its emergence could certainly have devastating effects for the telecom industry on a global basis.

John Puttre (*BCR*, August 1998: 12), principal at Puttre Inc.[23] and a staunch believer in bandwidth glut, likens the developments in the optical sector to long-distance industry's present woes. He argues that the emergence of hundreds of long-distance providers and resellers from late 1980's and mid 1990's drove down per minute cost of a long-distance call by more than 80%. Puttre argues that the need by major long-distance carriers at the time (Sprint, MCI, AT&T, WorldCom) to fill up their newly deployed optical pipes with voice traffic, was the main drive behind the emergence of hundreds of long-distance resellers. These resellers were invited to find customers to generate traffic and revenue on the networks of major long-distance carriers. Thus, finding a long-distance buyer became a reseller's chief responsibility.

Ambitious deployment of optical infrastructure in North America by such carriers as Level(3) Communications and Global Crossing has prompted them to take their model global. Since these companies have deployed massive optical infrastructure overseas, their critics have argued that these business models will be a major force in creating bandwidth glut on a global scale.

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[23] Puttre Inc. is a professional firm that specializes in strategic marketing, consulting, and intelligence gathering for telephony, computing, video and Internet companies.

For example, Grahame Lynch (Group Editorial Director at Advanstar Communications[24]), argues that in some areas big optical pipes do not match the small geographic areas and small populations that they serve (*America's Network*, February 2001). Lynch cites the 8 Terabit optical link between Singapore and India—the largest live optical link announced to date—and questions whether such a huge optical link is needed between two countries with limited communication infrastructure and very small number of Internet users[25].

Lynch goes on to point out that North American *data-CLECs* (those that concentrate on data-intensive customers in metropolitan markets) could have generated more bandwidth in metropolitan areas, which would have helped fill the enormous capacity that is being deployed today. Lynch supports industry criticisms leveled at such companies as UUNet and Level(3) that have claimed that Internet demand is doubling every three to four months. Using data from AT&T research labs and academic institutions, Lynch (Ibid.) argues that in fact the Internet growth is doubling every 12 months.

The current abundance in bandwidth could be best realized if high-bandwidth applications such as video and audio streaming became more widely available by service providers and were part of mainstream communication services. Despite the above arguments and counterarguments regarding bandwidth glut, carriers continue their crusade in building substantial optical infrastructure. Table 4.5 illustrates the range of

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[24] Advanstar Communications (www.advanstar.com) is a worldwide business information company serving specialized markets with information resources and integrated marketing solutions. The company is based in Boston, MA and has 103 business publications, and organizes more than 101 tradeshows and conferences. Among its publications include *America's Network*.

[25] It is worth mentioning that India's fixed line teledensity measures at just 3% and that Singapore, with a population of just 4 million, will never have a bigger Internet base than Los Angeles County (*America's Network* Ibid.).

activities in the deployment of optical infrastructure by global carriers. Carriers in italics are European based.

Table 4.5: Global Facility-Based Bandwidth Insurgents

Operator	Planned Intercity Fiber Miles	Network Reach
MetromediaFiber Networks	200,000	67 US and European cities
Global Crossing	100,000	200 cities worldwide
360 Networks	88,000	100 cities worldwide
Flag Telecom	40,000	20 cities worldwide
Williams Communications	31,000	125 US cities
Qwest Communications	26,000	150 US cities
Level(3) Communications	20,000	150 US, Asian, and European cities
Aerie Networks	20,000	200 US cities
Global TeleSystems	16,000	50 European cities
Enron	15,000	40 US and European cities
Colt Telecom	9,000	32 European cities
Viatel	6,000	64 European and US cities
KPNQwest[26]	4,100	50 European cities

Source: *Americas Network*, February 2001

Countering the tide of pessimism over bandwidth glut are those who see the whole issue as a myth. Bandwidth optimists present their argument based on cost analysis, taking into account the amount of capital needed to create bandwidth glut.

James Crowe (Chief Executive Officer at Level(3) Communications) is one of the optimists who does not believe in any potential emergence of a bandwidth glut. Quoting Bob Metcalf, the inventor of Ethernet, Crowe argues that to say there's a glut of

[26] In 1999, Qwest of Denver, CO and KPN Royal, the Dutch incumbent carrier, jointly founded KPNQwest (www.eu.net). The company targets European markets.

bandwidth because there's a lot of fiber is like saying there's a glut of microprocessor because there is abundant sand. Fiber to bandwidth, Crowe maintains, is like sand to microprocessor, meaning it is a necessary component but it takes enormous effort to turn the fiber into usable bandwidth. And yet this is what is often missed in discussions of bandwidth glut. For instance, the cost of fiber as a percentage of the total cost of a finished bit over the life of the fiber is only about 4%; the remaining 96% is the cost of operations and optoelectronics to light it up (personal interview with Crowe).

Crowe further points out that to light up even the current amount of fiber in the ground would take approximately USD$1 trillion dollars, a financial prospect simply out of question. The total amount of capital spent on optoelectronics in 2000 hardly exceeded USD$15 billion. So we have not seen any evidence of glut yet and there may not be one for a long time to come. According to Crowe, the time-consuming process of circuit provisioning is another indicator against bandwidth glut and today, if customers want a broadband connection at OC3 or OC12 rates, they will have to wait in line for at least 4 to 6 months.

Richard Nespola, (President and Chief Executive Officer at The Management Network Group (TMNG), one of America's leading telecom consulting firms) shares Crowe's views and supports his stance from a marketing perspective. In arguing against charges on bandwidth glut, Nespola raises the following two questions:

- How can the enormous raw bandwidth available underground be turned into marketable products and services?
- How can the industry provide the human expertise required to market such a massive infrastructure to potential customers in the form of communication services?

What is clear in discussions surrounding the bandwidth glut is that the price of bandwidth will continue to decline worldwide. For example, according to the International Telecommunication Union (ITU), the cost of international circuits has been decreasing at an astonishing rate of 72% annually (Lynch, Ibid). But since the majority of telecommunication networks around the globe are increasingly becoming data centric, the question of bandwidth glut becomes less relevant.

Moreover, on a global basis we may soon witness a shift in the direction of Internet traffic growth from North America to Europe and Asia Pacific. In North America this shift would entail a growing maturity in markets as end users move toward the use of multimedia applications on the Internet. However, in Europe and Asia it would imply continuous decline in the price of regular Internet services, which would enable more end users to get online and generate more bandwidth. But, this shift does not necessarily mean that Europe and Asia Pacific would surpass North America in Internet traffic growth. It would mainly imply drastic growth in traffic as a result of deregulatory policies adopted by the respective governments in those regions. Only in the absence of the above global developments could we experience a potential bandwidth glut.

To witness the growth necessary to fill the available optical-based broadband networks, it is important that they demonstrate deep penetration into metropolitan areas, where the bulk of bandwidth is generated. Since much of the activities in the buildout of optical infrastructure have taken place in long haul networks, the focus of the industry should increasingly shift toward equipping metropolitan areas with optical infrastructure. Fortunately, this shift has already taken place.

4.11 Metropolitan Area Networks: Bandwidth Attack in Metro

The term metropolitan area network (MAN) is originally derived from the networking term *local area network* (LAN). LAN is a communication network that serves users within a confined area such as a building or a campus. Therefore, MANs can be considered the next step in LANs that are extended in their reach to cover a geographic area such as a city or suburb. MANs are still evolving in topology, data rates, and above all access protocols. Their emergence has created the single most dynamic sector in North American telecommunications. The following critical factors have contributed to the emergence of MANs:

- concentration of Internet traffic in metropolitan areas;
- increasing sophistication in the bandwidth needs of corporate customers in metropolitan areas;
- absence of adequate fiber optic infrastructure to support the massive growth of Internet traffic in metropolitan areas.

The above factors have led not only traditional carriers but also a new breed of carriers to target data-intensive customers in metropolitan areas with advanced optical-based services. Leading the charge here are metropolitan carrier's carriers that are funded almost entirely by venture capital firms. These carriers have sprung in Tier1, Tier2, and Tier3 metropolitan areas, where supply of fiber-optic capacity is less developed than in long haul networks. Until recently, transport services have been carrier's carriers core products. These services have been mainly in the form of lit fiber, dark fiber, and wavelength services. But increasingly, services by metro carrier's carriers have evolved beyond transport solutions to include co-lo, fiber connectivity, and Gigabit Ethernet[27]. Joining the chorus of metro service providers are utility companies and municipalities, some of them aggressively expanding fiber-optic networks in major metropolitan areas.

Metro service providers fall into two main categories: those that are facility-based and have their own optical infrastructure (metro carrier's carriers—Table 4.6); and those that are nonfacility-based and rely on infrastructure from others. There is also a subcategory within metro service providers that are also nonfacility-based and market their services to tenants of apartment complexes and commercial buildings. This particular breed of metro carriers is known as ***building local exchange carriers***, or BLECs.

The following summarizes the main characteristics and some of the challenges of metro service providers:

- they are carrier neutral;
- they capitalize on the transport needs of large corporate customers;
- they offer bandwidth in the range of DS3 (45Mbps) to OC192 (10Gbps);
- securing right-of-way is one of their main obstacles;
- non-facility-based carriers rely on optical infrastructure from facility-based carriers;
- they are funded by venture capital firms;
- they tend to capitalize on their real estate expertise to target multi-tenant units in the metro;
- they provide a communication platform to niche service providers like media streaming companies to launch their services in metropolitan areas.

Metro carrier's carriers utilize the latest optical technologies to reduce transport costs associated with legacy transport technologies. They prefer optical transport

[27] An Ethernet technology that raises transmission speed to 1 Gbps. Primarily used in backbone networks, metro carriers are increasingly adopting it as a competitive advantage against ILECs. Some metro carriers offer this service to corporate customers as a high-speed and affordable solution.

platforms that support multiple protocols (e.g. IP, TDM, ATM). Taking advantage of DWDM technology, metro carriers offer multi-protocol services on a single wavelength, which gives them cost competitiveness and fast time-to-market capabilities.

For example, a 10Mbps Ethernet service consumes an entire DS3 circuit when deployed on a traditional SONET network. In contrast, multi-protocol support on a single wavelength permits arbitrary mixing of IP and other protocols. Here, a 10Mbps Ethernet service consumes no more than 10Mbps (Kennedy, *Telecommagazine*, February 2001). The multi-protocol capability of the metro optical systems give a service provider the opportunity to combine TDM and SONET circuits coming into the system onto a single circuit (Kennedy, Ibid.).

4.11(a) The Economics of MANs

The widespread availability of Ethernet in the enterprise sector, combined with its simplicity, reliability, robustness, and relatively inexpensive associated costs have made it a prime target for MAN-based carriers. According to Sweeney (*America's Network*, December 2000) Ethernet and IP already account for most of the total network traffic in the US, so the overall network should reflect this fact by harmonizing itself with the structure of the enterprise.

The price of a Gigabit Ethernet-based connection (1000Mbps) in a metropolitan area is projected to be equal to that of a T3 (45Mbps) or an OC-3 (155Mbps) connection.

According to David Passmore (*BCR*, July 2000: 18), if a customer does not have enough traffic to justify a full Gigabit Ethernet connection, lower cost 10/100-Ethernet services can be provided on the Gigabit carrier's MAN backbone at equally low prices. Moreover, the bulk of expenditure (80%) for facility-based MANs come from CO and the remaining 20% are channel related expenses (Weingarten, 1999: 15).

According to results from a research conducted by Dell'Oro Group that compares the average selling price of Fast Ethernet, Gigabit Ethernet, and 10 Gigabit Ethernet switches to those of OC3, OC12, OC48, and OC192, there are stark price differentiation between SONET and Ethernet gear. The prices—based on Layer 3, modular-based, fiber ports—are converted into dollars per Gigabit of bandwidth.

Ethernet Port

- 10 ports of Fast Ethernet (each port at USD$475 in 2000) *equals* 1 GigE of bandwidth ($4750);
- Average selling price for Gigabit Ethernet (that is one single port) is $1550;
- In 2004, the average selling price per Gigabit of Fast Ethernet will be $3,116; Gigabit Ethernet will cost $838; and 10Gigabit Ethernet port will be $485.

SONET Gear

Dell'Oro Group applies the same methodology to SONET equipment, using OC3 (155Mbps) ports:

- About 6.5 OC3 ports would be needed for one Gigabit of bandwidth, each port costing $6,229 apiece. So the total comes to $40,118;
- In 2004, one Gigabit of bandwidth with the same number of OC3 ports will be $263,676 (Clavenna in *Lightreading.com*, November 2000).

A comparative look at the above two families of technologies suggests that Ethernet bandwidth will continue to be 85% cheaper than SONET bandwidth for the foreseeable future. Put another way, service providers can spend either USD$150,000 in Ethernet equipment, or USD$1 million on SONET gear to get the equivalent bandwidth. As one can see, carriers in the MAN space are betting on the above cost reductions promised by Ethernet technology. They offer high-speed services at a fraction of the price of a T1 connection.

MAN carriers can also be described as part of the non-SONET block in the industry. Deployment of SONET gear is intertwined with ATM switching system and chipset limitations on ATM switches that have restricted it to OC-12 (622Mbps) capacity have made MAN carriers turn their focus to Ethernet technology. They argue that the above bandwidth limitations on ATM-SONET systems in the metro hinder carriers to provide business customers with high-bandwidth services in the range of Gigabits.

Cogent Communications (D.C.) is a well-publicized example of a MAN carrier that offers Gigabit Ethernet services at cheap prices. But despite the publicity the company has received, it has yet to demonstrate signs of profitability. Almost all of Cogent's funding comes from Cisco Systems, which also acts as the primary supplier of equipment to Cogent. Therefore, it is too early to talk about MAN carriers' financial success at this time.

Table 4.6: Metro Carrier's Carriers Offering Dark Fiber/Leased Lambda Services

1998 → 3	1999 → 9	2000/2001 → 20
-Looking Glass Networks -Fiberworks -Airfiber	-TXU Communications -NEON (North East Optic Networks) -Onfiber -FPLFibernet -C2C Fiber -Avista Fiber -Looking Glass Networks -Fiberworks -Airfiber	-Sigma Networks - Velocita (formerly Pf.net) -Pathnet -GiantLoop Networks -Fibernet Telecom Group -Global Metronetworks -American Fiber systems -Western Integrated Networks (WIN)* -Carolina Broadband* -Fiber Technologies -Onfiber -Intellispace -TXU Communications -NEON (North East Optic Networks) -FPLFibernet -C2C Fiber -Avista Fiber -Looking Glass Networks -Fiberworks -Airfiber * These companies are deploying fiber not only targeting business customers, but also aiming to compete with major CATVs in their operating regions.

4.12 Summary

In this chapter I have tried to shed light on the most crucial developments in North American telecommunications over the past ten years. I have focused on innovative technologies and their associated business models, which, together have contributed significantly to the profound transformations in the telecommunications sector. As we saw in the course of this chapter, these transformations have been at the infrastructure level and are enabled largely by advances in fiber optic technologies. The chapter also highlighted the role of new breeds of carriers that are poised to set a new agenda in the North American telecom landscape.

Since the full deregulation of telecom markets—we have witnessed two waves of competition at the local loop: the first was the emergence of CLECs with a business model heavily dependent on ILEC infrastructure; the second was the rise of metro service providers. As we saw in Chapter Two, the CLEC story has become primarily one of failure due to their flawed business model and the over-optimistic view by regulators, who felt that interconnection laws would result in the emergence of competition in the last mile.

As far as metro service providers go, their main challenge will be service delivery in a timely manner. The main problem facing metro-centric carriers is one of managing the connectivity needed by customers. This includes rapid and dynamic provisioning of bandwidth to wholesale and retail customers (Weingarten, Ibid: 4).

A certain development inwaiting for this nascent sector is a wave of consolidation. A good number of these carriers will become target of acquisition, either as a result of bankruptcy or in the form of strategic alliances. In such a scenario, the buying companies will mainly benefit from the physical assets put into place by the failed companies rather than winning a new customer base. Concerning the industry claims in the optical networking sector—the promise of virtually limitless bandwidth, ultra low costs, on-demand provisioning, and elimination of OEO conversion process— will take a long time to materialize.

Chapter Five:

Case Study: Level(3) Communications

5.1 Introduction

The following case study examines and analyzes the business practices of Level(3) Communications, a telecommunication concern that operates as a carrier's carrier. This case also demonstrates the effects of industry deregulation, the emergence of innovative ideas, and the resultant business models at work. In other words, this case study is part of a larger response to the initial research question posed in the first chapter[1]. The primary reasons for choosing Level(3) Communications as the topic of choice for this case study can be summarized as follows:

- the company's business practices encompass all of the models discussed in Chapter Four;
- the company was launched after the passage of the *Telecommunication Act* of 1996;
- both financially and operationally, the company's business plan has proved successful;
- the rationale behind the launch of the company has contributed to more competition in the market place;
- the company is well regarded among industry professionals and financial analysts.

The data collection for this case study primarily involved interviews with company executives. The executives interviewed for this study are: Dr. Robert Feuerstein, Senior Network Architect, Michael Strickland, Director of Long-haulHaul Optics, Darren Kelly, Senior Director of Transport Group, and James Crowe, the company's Chief Executive

[1] What are the key drivers of innovation in the emergence of new broadband communication platforms in an increasingly competitive North American telecommunications industry?

Officer. All interviews were conducted over the phone. Company executives were chosen for the interviews because the pertinent information needed for the case study was within their easy reach. They were also chosen because they could provide reliable information on the company's business operations. Information available on the company's website was another helpful source.

5.2 Company Background

Headquartered in Broomfield, Colorado near Denver, Level(3) Communications is a carrier's carrier with extensive fiber optic networks in the United States, Western Europe, and parts of Asia. The company is publicly traded on the NASDAQ stock exchange under the symbol LVLT and has about six thousand empoloyees Level(3) offers a wide selection of optical-based services including broadband transport, co-location services, submarine transmission services, and the industry's first softswitch-based services. The latter is part of the company's IP-based package of services. According to Darren Kelly, Senior Director at the company's Transport Group, Level(3) has captured 13 per cent of market share in softswitch services in the US, the largest in the industry.

Level(3) customers deliver services over the company's optical network. Level(3) is gaining market share in the carrier's carrier space at a relatively rapid pace, while at the same time building its global optical communications network. Revenues rose to USD$825 million in 2000 from USD$200 the year before . Revenues were expected to double again in 2001 to a projected USD$1.7 billion – a recent compound annual growth rate (CAGR)of about 110 per cent .

Upon completion, Level(3)'s network will consist of 24,000 miles of fiber route (38620km), connecting 50 cities across the US, and 21 cities in Europe and Asia (*ORMS Today*, June 2000). The company has also 15,000 (24135km) miles of rights-of-way secured along US railroad tracks.

Level(3) Communications was founded in 1997 by James Crowe, the company's present Chief Executive Officer. Kiewit Sons' Inc., a wholly-owned subsidiary of Peter Kiewit Sons' Inc[2].,was instrumental in the realization of Crowe's communication aspirations. In 1988, Kiewit helped Crowe found Metropolitan Fiber Systems (MFS), then a competitive access provider (CAP[3]). After taking MFS public in 1993 and raising USD$1.4 billion, Crowe acquired Uunet Technologies, the largest ISP in the world, for USD$2 billion. Later in a USD$14 billion deal in 1996, Crowe eventually sold the combined Uunet-MFS to WorldCom (*ORMS Today*, Ibid). For a period of time Crowe shared WorldCom's chairmanship with Bernie Ebbers, the Edmonton-born Canadian who still serves as the company's Chairman.

With USD$4 billion cash, James Crowe overhauled Kiewit Sons' communication services group and turned it into a new communication carrier and named it Level(3) Communications. According to James Crowe, the name of the company refers to the first three layers in the protocol stack of the Open System Interconnection (OSI) model. Level(3) is still considered the best-funded startup in the history of American telecommunications. But today Level(3) is no longer just a startup. The company has received funding in five pre-planned stages. According to both James Crowe and Michael Strickland (Senior Director of long-haul optics transport), today Level(3) has USD$14

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[2] Peter Kiewit Sons' Inc is a 115-year-old construction, mining, information services, and communications company headquartered in Omaha, Nebraska (www.kiewit.com).

[3] See Chapter Two for a brief discussion on CAPs

billion in cash, which it intends to spend on the construction of its global network. By spending the latter figure Level(3) expects to become a revenue focused company. The North American portion of its network buildout alone has been more than USD$3.5 billion.

Greg Maffei, former Microsoft Chief Financial Officer and the present CEO at 360Networks, another global carrier's carrier, credits Crowe with being the first to see how deeply the Internet would eventually change the economics of telecoms. Maffei asserts that "what Intel did was drop the cost of a compute cycle at a pace that no other company could match; Cisco did the same to the cost of a router port; and Level(3)'s ambition is to push down the cost of a unit of bandwidth on a long-haul communications network faster than anyone else in its industry" (*ORMS Today, Ibid*).

Dr. Robert Feuerstein, Senior Network Architect at Level(3), states that since its launch, the company has undercut the ILECs' pricing scheme considerably. Feuerstein further indicates that his company only sells high-bandwidth services on a wholesale basis to carriers, ISPs and large enterprise customers. Level(3)'s biggest competitors in the industry are Metromedia Fiber Networks (MFN) based in White Plains, New York, Williams Communications based in Omaha, Nebraska, Qwest Communications based in Denver, Colorado and Global Crossing based in Bermuda.

Level(3) uses single mode fiber from Corning, the world's largest maker of optical fiber, and remains among Corning's biggest customers. In October 2000, Level(3) expanded considerably its orders from Corning (US Warburg, October 2000), further indicating the company's aggressive network build out strategy.

5.3 Network Architecture

Level(3) Communications' long-haul network consists of eight SONET rings, passing through 50 cities across the U.S. A new SONET ring is expected to be added to the current architecture by the end of the first quarter of 2001. Level(3) uses DWDM technology extensively, particularly in its long- haul network. Its metropolitan network consists of series of rings. Metro rings pass through densely populated sections in metropolitan areas, where most businesses are concentrated.

In larger metropolitan areas like New York, Chicago, and Los Angeles, Level(3) has a number of what Strickland calls "collector rings." Collector rings have a subsidiary collector node, very similar to gateways in form and function though smaller in scale, which interconnect two or more rings.

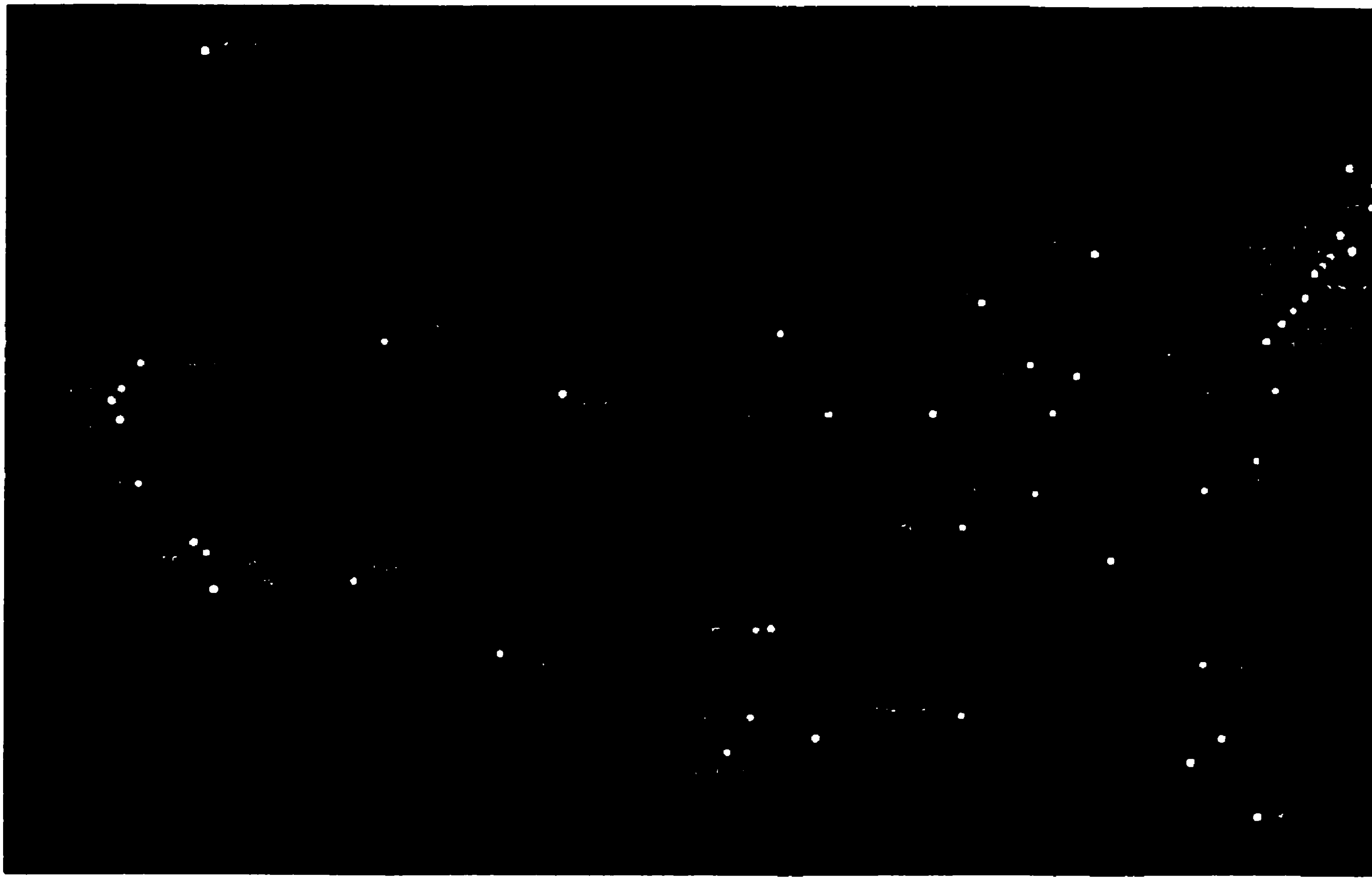

Figure 5.1: Level(3) US Network

What is significant about Level(3)'s network is that it is multi-conduit. A multi-conduit optical network contains more than one conduit, which enables the carrier to have a continually upgradeable network. It also prevents the carrier from experiencing fiber exhaust, which means running out of transmission capacity in a conduit. As part of its business plan, Level(3) places ducts for future growth and future fiber types. The company has exclusive agreement with Corning to provide it with its latest LEAF[4] products. For its metropolitan network buildout, for example, Level(3) uses Corning's *MetroCor* single mode fiber, a type of fiber specifically customized for the launch of DWDM-based services in metropolitan markets.

In the long-haul portion of its network, Level(3) has 12 conduits in place, while its metropolitan networks contain up to eight conduits. During the initial launch of its long-haul network, based on the cities that the company passed through, its fiber-count[5] was anywhere from 72 to 216 strands in a single conduit. And in the metro market, the fiber-count is expanded from 144 strands up to 864 (Strickland). Strickland states that the fiber-count in metropolitan markets depends on the number of buildings in that particular metropolitan area and the number of fibers needed for a particular building.

In addition, Level(3) has a significant undersea cable as part of its global optical network. *Project Yellow* is the name of Level(3)'s undersea cable operations. Tyco International was the company responsible for building the installations and laying the suboceanic portion of Level(3)'s optical cable. According to Strickland, the suboceanic

[4] LEAF is the name of Corning's flagship optical fiber product. Its latest version, E-LEAF, has been recently deployed by Level(3) Communications. Corning's LEAF competes directly with Lucent's *Truewave* optical fiber products.

[5] Fiber-count refers to the number of strands of optical fiber in a single conduit.

portion of the network stretches from New York to the west coast of the United Kingdom and has terrestrial parts into New York City in the US and London in the UK.

Level(3) also has network construction in Europe and Asia. There are two long-haul rings in Europe, with another one planned for construction in 2001. The two existing European rings connect most of northern Europe and the third will go to southern part of the continent passing Milan in Italy. As for Asia, there is one long-haul connection between Japan and Hong Kong, which will become a full ring sometime in 2001. The Asian ring will include Taipei and Seoul as well. There are also plans in the works for further expansion in Asia to include parts of Australia. Feuerstein did not provide any date for the completion of those portions of the Asian network.

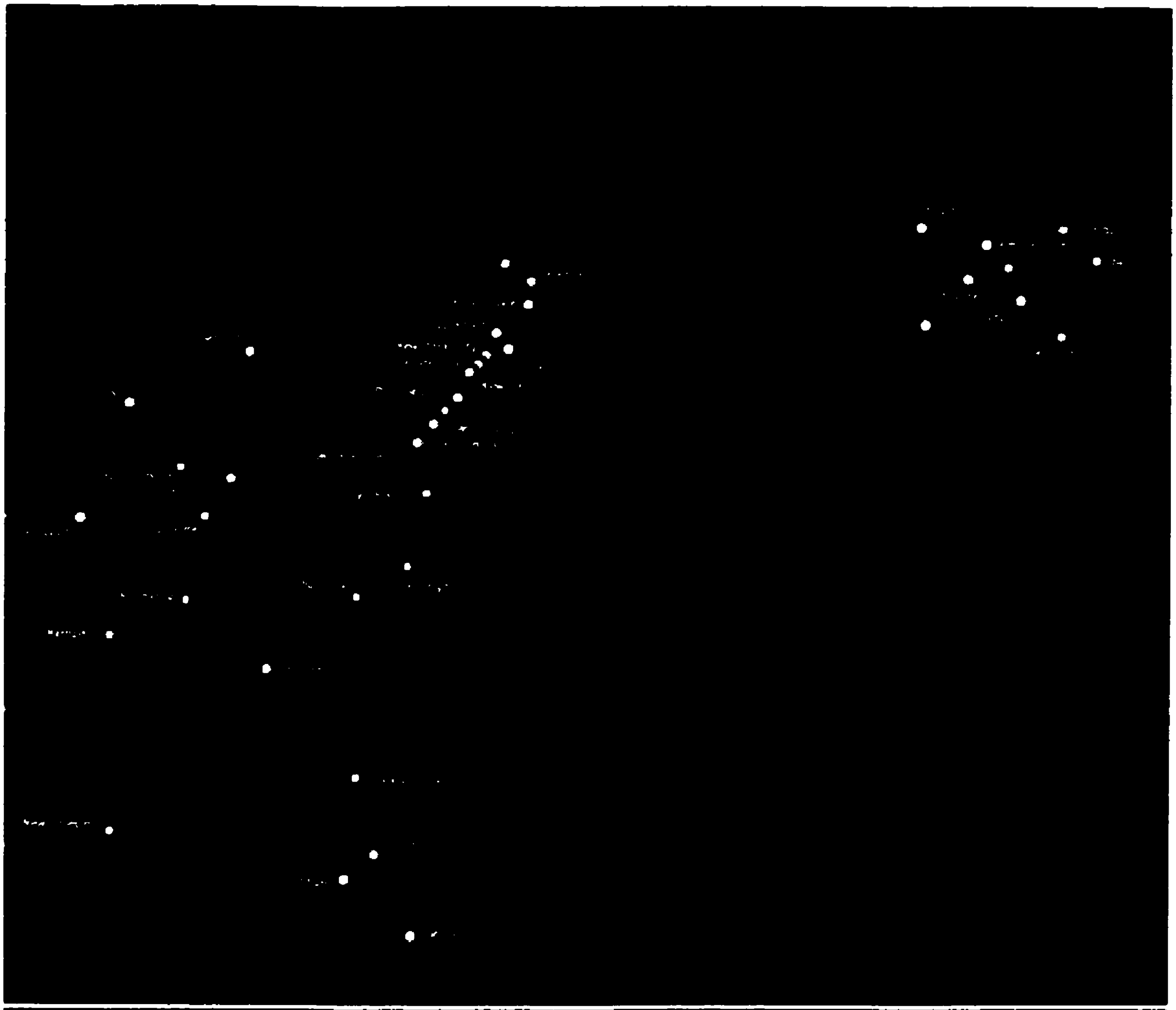

Figure 5.2: Level(3) European NetworkThe Project Yellow portion of Level(3)'s global architecture.

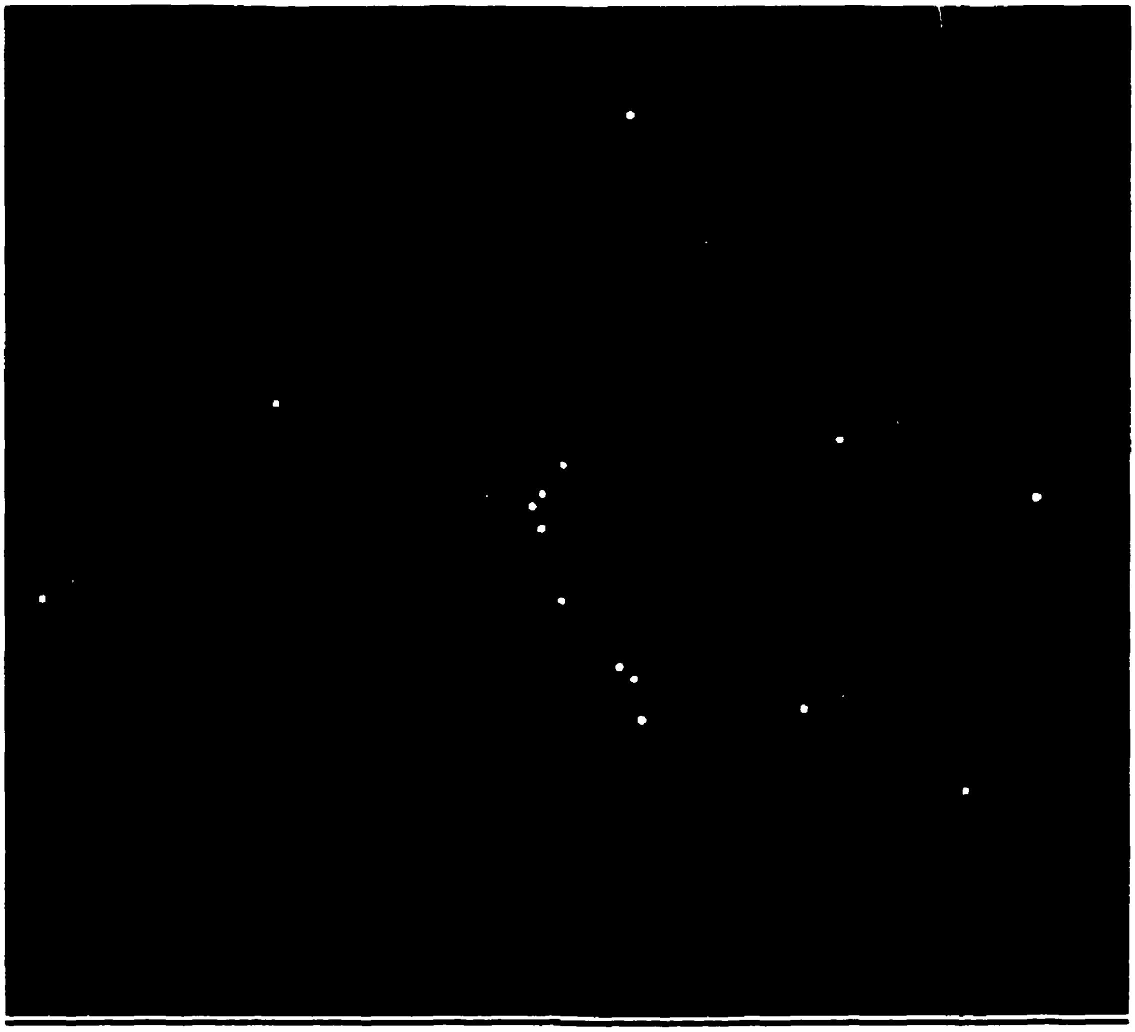

Figure 5.3: Level(3) Asian Network

5.4 Products and Services

As a company conducting business primarily in a carrier's carrier space, Level(3) provides communications infrastructure to data-intensive customers mainly in the form of leased IRU fiber. Strickland describes Level(3)'s core business model as "selling dark fiber to customer companies in order to enable their network to serve more customers. Our customers are primarily web-centric businesses, carriers, CLECs, and sometimes ILECs. Not all of Level3's customers have the same business plan; they go after different customers like businesses in metropolitan areas and residential customers". Level(3) does offer wavelength services. The following takes a closer look into Level(3)'s services. Level(3)'s communication services are broken down into two main categories:

- transport services;
- IP Colocation, which includes *Crossroads*.

5.4(a) Transport Services

Transport services make up the most critical part of Level(3)'s portfolio of communication services and generate the bulk of the company's revenue. Transport services are offered under the brand name (3)Link Global Transport Services, which include (3)Link Dark Fiber, (3)Link Private Line, and (3)Link Global Wavelength. Optical dark fiber is usually leased on a 10- or 20-year term. Once the customer buys the

IRU fiber, it is responsible for installing the optical equipment at its end/facility. Upon customer request, Level(3) installs the equipment at the CPE. It also provides consulting to its customers on issues regarding network and equipment needs.

Each customer must carefully decide whether it should lease dark fiber or lease lambda. This decision clearly depends on how much capacity they need. The following table illustrates how customers' bandwidth needs affect transport service types they receive from Level(3):

Table 5.1

IRU Dark Fiber	**Leased Wavelength/Lambda**
At least 150 Gigabits of bandwidth and more	Less than 50 Gigabits of bandwidth and up to 100 Gigabits

According to Dr. Feuerstein, within the company's portfolio of transport services, unprotected wavelength remains the most popular product because it is the most affordable. But in that case the customer needs to provide his/her own protection and management since Level(3) does not provide SONET overhead for this kind of service.

Wavelengths are sold as a separate product and offered at minimum speeds of OC-48 and OC-192 over Level(3)-owned optical fiber. Offering wavelengths at these speeds is almost universal among the carrier's carriers in the industry, because offering wavelength at lower than OC-48 rates is not economical given the high costs associated with buying and maintaining opto-electronics equipment.

There are two parts to offering leased lamdas:

- via an initial optical equipment turn-up fee, which helps cover the cost of installing equipment;
- via a monthly fee that depends on bandwidth consumption ranging from OC-48 (2.5Gbps) to OC-192 (10Gbps).

BLECs increasingly are becoming Level(3)'s carrier customers. In wiring up metropolitan markets with its optical infrastructure, Level(3) targets buildings in metropolitan areas that consume traffic at least at OC-48 or more levels of bandwidth. It then provides access to its infrastructure for those broadband access providers (or BLECs) that target these multi-tenant buildings.

Unlike its main competitor, MFN, Level(3) does not offer wavelength services over IRU dark fiber. Customers are responsible for the creation of lambdas on the fiber leased from Level(3). Level(3) does not add opto-electronics to create wavelength for the customer. However, if the wavelength already exists on the customer's fiber they can hire Level(3) to maintain it. The pricing is cost out on a per-mile basis with a minimum charge for 300 miles of distance. If a customer is connecting two cities that are less than 300 miles apart it still pays the minimum rate. Most customers prefer to buy multiple wavelengths. Like any other business, there are different discount levels depending on how much bandwidth a customer buys. Due to confidentiality, Dr. Feuerstein could not provide the pricing scheme for wavelength services but said that most of the time it is negotiated on an individual basis.

5.4(b) IP Colocation: Crossroads

IP Colocation incorporates a suite of services that includes Internet access, voice over IP (VOIP), and other IP-based broadband services catered to IP-intensive companies. These services are bundled together under the brand name *Crossroads*. The Internet access is provided over the company's Internet gateways and Level(3)-owned "co-lo" facilities. The important feature about Level(3)'s co-lo facilities is that they provide space to Level(3) customers and connect them to the Internet via Level(3)'s Internet gateways located at these co-lo facilities. These co-lo facilities, therefore, are different fromthird-party co-lo companies like Co-lo.com[6].

VOIP services are offered under the brand name *(3)Voice*. This service seamlessly integrates Level(3)'s enhanced all IP network with traditional circuit-switched networks to provide a high-quality, cost-efficient solution for routing voice traffic (company website). In (3)Voice, calls are delivered to a Level(3) gateway, where a protocol conversion device converts the PSTN circuit-switched calls into IP protocol. The calls are then delivered via the Level(3) network to a Level(3) media gateway nearest to the destination of the calls. Using softswitch technology at its media gateways, Level(3) converts the calls and their signaling from IP back to SS7, the traditional PSTN signaling

[6] Third party co-lo companies are also known as neutral co-lo companies. For more on co-location see Chapter Four under the section "Co-location: More Space for More Carriers".

format. The terminating point could be a local exchange carrier (LEC), an international carrier, a PTT, or a private termination facility.

5.5 Network Management

To a certain extent, Level(3) does manage customer networks. It offers WAN services as well as remote hand (outsourcing) where the company's operation force in the field provides the hands-on daily maintenance of networks for other companies. Upon customer request, it provides management of electronics and optronics for customers in addition to equipment maintenance. Strickland believes that this will be one of the areas in which Level(3) will be strong. Level(3) does not lease opto-electronic equipment to any customer. The customer buys the opto-electronic equipment from a vendor once they purchase dark fiber from Level(3). But they can hire Level(3) to be their operational and maintenance force.

5.6 Innovation and Level(3)

The dynamics behind the emergence of successful companies like Level(3) Communications can be attributed to three critical and interdependent factors:

- government-induced deregulation;
- appropriate business environment for the development of market-based standards;
- demand for new communication services.

In response to changes in the global economy and to the interdependence of economic poles, regulatory bodies in North America have opened up the critical sector of telecommunications to competition. A critical feature in this opening up to competition has been the removal (at least theoretically) of a stranglehold on the provisioning of an array of communication services to both businesses and consumers. However, it is important to note that this stranglehold still exists in many areas, particularly in the residential sector.

The development of new ideas, business models, and technologies has been spurred by the development of markets conducive to innovation. This became possible when governments took moves towards deregulation. But one should not conclude that governments have been the engines of innovation and growth in the last decade of economic expansion. The result of government-induced deregulation was the development of an environment conducive to the emerging of market-based standards and protocols in telecommunications.

Efforts in the private sector to develop market-based standards have always faced competition from government-sponsored, central planning bodies. Often the process of central planning has been defended as being predictable, elegant, and unifying. In contrast, market-based standards have usually been regarded as sloppy, messy, and risky (Crowe). Central planning bodies have operated by inviting competitors and participants from governments to meet at national or international standards bodies (e.g. International Telecommunication Union—ITU) to negotiate the direction of standards into the future. In fact, the OSI model is an example of this process.

But as Crowe points out, competition between government-sponsored bodies and market forces reached a critical point with the advent of World Wide Web in the early 1990s. Crowe emphasizes how over the past 15 years market-based forces always moved more quickly than the central planning standards. He further argues that competition was heightened with the emergence of the Internet and eventually market forces emerged victorious. This victory was assured with the birth of Ciena Corp.

Crowe aptly cites two developments that can be considered crucial moments in the history of communications in North America:

- the introduction of hypertext markup language (HTML);
- the introduction of what is known today as dense wavelength division multiplexing (DWDM)[7] in 1996 by the Linthicum, Maryland-based Ciena Corporation, at the time a startup.

These, according to Crowe, were the start of ITU's loss of control over the standards process. It was reinforced by the growing role of VCs (venture capital firms), which remain at the very heart of the market-based technology development process.

On the state of competition in the local loop market, Crowe believes the second wave of competition led by metro carrier's carriers and BLECs have a much better chance than their predecessors defined by CLECs. He attributes this rosy prospect to the ability of these companies to bypass RBOC central offices, and thereby much of the interconnection laws sanctioned by the FCC in 1996.

On the future of RBOCs in the US (also closely related to Canadian incumbents), Crowe argues that they will become increasingly consumer-oriented services companies. He further argues that they have not demonstrated any capability to innovate at the

[7] More information on DWDM technology is available in Chapter Four under "Fiber Optic Technologies at a Glance".

network level in a way that would make them competitive in a market-based environment. Crowe believes that, eventually, technology savvy startups will introduce a market-based technology in the local loop that would cause RBOCs and other ILECs enormous difficulty.

Even though Crowe's argument is a plausible one, it remains to be seen if the RBOCs will be allowed to provide data services to business customers outside their operating regions. This is already happening in Canada. But such a development in the US could result in the emergence of a new round of competition for corporate data services and put Level(3) and similar companies in a more defensive mode.

5.7 Summary

Level(3) Communications has based its business philosophy on the capability of the marketplace to bring about innovation at the network level, thereby enabling availability of more bandwidth at lower costs. It is the company executives' hopes to not only transform the economics of telecommunications in the service provider sector, but also to create value for their shareholders in the way Cisco, Microsoft, and Ciena have done -- though the latter goal could prove an uphill challenge in today's convoluted markets.

Level(3) has adopted an innovative business plan that has contributed to the reduction of bandwidth cost across the board in the industry. The company's business plan is based on price elasticity, stating that every time the price of bandwidth falls by one per cent the carrier will generate two per cent more customers for that bandwidth. So the cheaper the cost of bandwidth to end-users, the more end users are won as customers.

Therefore, the carrier maintains profitability as long as it has the capability to provide a greater amount of service to those customers.

The success of Level(3)'s business plan is indicative of the availability of an untapped, hidden demand for new and innovative services in telecommunications industry. The markets for leased lambda services, optical dark fiber and associated products demonstrate how seriously demand has grown for new approaches to the delivery of communication services.

Drawing a picture on the future state of wavelength services, Strickland asserts that the industry will witness situations where wavelengths would be used for entry into new markets. Carriers or large enterprise customers would go to a carrier's carrier like Level(3) to penetrate a region where they have no presence and network infrastructure. Such customers might want to offer the same services in new markets that they offer in their existing markets. What they could do is buy wavelength from the likes of Level(3) to launch service in that targeted market and gauge their chances to see if their business would be a success. This allows them to evaluate their strategic goals in that particular market and decide whether they should later embark on building a new network there. On the benefits of such a model, Strickland reiterates Bill St. Arnaud's statement that the customer does not bear the same commitments and responsibilities associated with IRU leased dark fiber.

As Level(3) Communications moves toward becoming a cash-flow positive company, at which point it would be considered mature, an important factor needs to be taken into account for its successful operation: differentiation from competitors. Given the rise in the number of carrier's carriers in the U.S,, a customer would desire its carrier to be able to handle its communication needs most effectively. At present, Level(3) enjoys that head start and market leadership in this field. Some of the new carrier's carriers that could emerge in the future as competitors to Level(3) include Velocita (D.C.), Aerie Networks (Denver, CO.), and PetroNet (Denver, CO).

On the same note, Crowe emphasizes the importance of early entry into marketplace for any technology company. He states that what scares him most is the emergence of Level(4) Communications, that is a company whose name is perhaps unknown but has a good group of people and technology that can provide them with financing. That is always what a competitor in the field of technology should worry about.

Chapter Six:

Conclusion

The design of information and communication networks including their technical and organizational characteristics is a crucial determinant of whether stocks of codified knowledge can be accessed and used in a variety of electronic forms.

(Mansell, 1997: 187)

6.1 Chapter Review

In the course of this thesis, I have tried to map out fresh perspectives on the profound transformations that have taken place in North American telecommunications. To explain the role of telecommunications in the design of the "new networked economy", my thesis has tried to answer the following research question as posed in the first chapter:

What are the key drivers of innovation in the emergence of new broadband communication platforms in an increasingly competitive North American telecommunications industry?

I have focused the above question mainly on the business and technological aspects responsible for the dynamism in today's telecommunications. Here I regard the implications of fiber optic technologies as a vehicle that has given birth to new business models in the industry. And in covering developments in North American telecom industry my focus has been on Canada and the US. The above aspects have been largely neglected by academic researchers whose attempts have primarily revolved around the socio-political as well as cultural aspects of change in information technologies.

Therefore, by uncovering a different set of issues surrounding telecommunication technologies, this research project hopes to have contributed to the available literature on the impact of information technology.

In examining the above research question across the course of the past five chapters this inquiry has been able to identify five key drivers of innovation – or change agents – that together have been influential in bringing into being the emergence of *broadband platforms* (i.e. new business models respective to broadband services). These are:

1. legislative → deregulation

2. judicial → divestiture rulings

3. business strategy → knowledge as a strategic resource

4. financial → role of venture capital firms

5. technical → digitization and optical networks

In Chapter One, "Introduction", I sketched out the major deregulatory and technical events in the industry over the past 20 years. For example, I mentioned the significance of the AT&T Divestiture Act and its ramifications for long-distance and local exchange sectors. Pointing to major issues and debates surrounding today's telecommunications industry, Chapter One explained the significance of the above research question and its relation to the development of a networked economy. I then highlighted the most relevant topics chosen for discussion and analysis in this thesis and mapped out the thesis content for the coming chapters.

Driver #1: legislative→ deregulation. In Chapter Two "Deregulation and Competition", I explored the process of how telecom entities evolved from public utilities to commercial organizations, a transformation that was fueled largely by the governments' deregulatory policies. These deregulatory policies later led to the emergence of a dynamic long-distance industry.

Driver #2: judicial → divestiture rulings. Chapter Two looked at the natural monopoly system and its development in Canada and the US. I described how governments and businesses alike justified this system over decades to create a single and unified system of communication infrastructure. In addition, I demonstrated how advances in communication technologies, notably microwave, threatened natural monopoly of AT&T and eventually, with the help of the court of law, gave an end to its decades-old stranglehold over telecommunication services.

This chapter also uncovered the role of digitization as a crucial technological shift in the way telecom networks operate. This technology led to the development of a robust signaling and network management system. However, these developments did not prove to be strong enough incentives in themselves to stimulate competition in the market place. In this chapter I briefly touched upon the main themes of the *Telecom Act of 1996* in US and suggested how advances in technology, notably in the fiber optic sector, have rendered parts of the Act's rulings obsolete (i.e. interconnection of competing networks; co-location of communication equipment).

Chapter Two describes how deregulation in Canada affected the operations of Canadian phone companies—hitherto confined to certain provinces—and unleashed a new wave of activities characterized by attacks into each other's turfs.

Driver #3: business strategy → knowledge as a strategic resource. Chapter Two also examined the dynamics of competition in telecoms by taking into account two alternative models of competition proposed by Robin Mansell: the "idealist" and the "strategic" models. Taking into account the above two models, Chapter Two concluded that the presence of a large number of players in the market does not necessarily guarantee a healthy and dynamic market place. Despite the presence of a large number of players, the current telecom markets continue to be sensitive to the actions of a small number of large companies. This pattern suggests that the strategic use of knowledge in today's telecommunications industry can place a telecom entity (large or small) far ahead of its competitors.

Driver #4: financial → role of venture capital firms. Chapter Three, "Innovation in Today's Telecoms", was an examination and analysis of the main drivers behind innovation. My research in this chapter uncovered that these drivers are mainly financial in nature led by venture capital firms (VCs). The chapter described how VCs interface with new technology companies and maintain a highly interdependent relationship. While this relationship is less dynamic in Canada than in the US, the chapter points to the role of provincial governments in Canada in the introduction and deployment of broadband technologies. Despite being the target of criticism by some industry observers, provincial governments in Canada have been increasingly active in the development and adoption of broadband communication technologies. However, this chapter indicated that many Canadian start-ups have been able to fund their business operations successfully by the financial support of American VCs.

Another important finding in Chapter Three concerned the segmentation of telecommunications industry both in service provision and equipment manufacturing sectors. In recent years, each of these sectors has become segmented into smaller subsectors funded by VCs, a development that has profoundly transformed how service providers and equipment vendors conduct business and relate to each other.

Expounding on the effects of what Christensen calls *sustaining* and *disruptive* innovative technologies, Chapter Three revealed important challenges and opportunities faced by both established and emerging competitive firms in conforming to technological change. Drawing on the views of industry experts and those involved in the VC markets, Chapter Three concluded that the influence of VC-funded innovations plays out over a long time and that VCs will continue to be one of the main engines of innovation in an emerging networked economy.

Driver #5: technical → digitization and optical networks. As the cornerstone of my thesis, Chapter Four, " Emerging Broadband Platforms: Optics to the Edge", analyzed some of the fundamental changes in North American telecommunications at the infrastructure level that have led to the birth of new business models for broadband—what I refer to as *broadband platforms*. The chapter focused on fiber optics technology as the overarching factor in bringing about infrastructural changes in the industry. The resultant new business models are primarily those of *dark fiber, leased wavelength, and co-location*—each of them acting as a platform for the launch of numerous broadband communication services.

Chapter Four sheds important light on the implications that these new models entail for North American incumbent carriers as well as enterprise customers. It presents a debate reflecting the views and criticisms of professionals in the industry about the impact of innovative technologies in telecommunications on traditional models of telecommunications as we know them today.

In order to better understand the current transformations in North American telecommunications, I carried out a number of interviews, most of which reflected in this chapter. These interviews were mostly conducted over the phone and opened a broad and rich scope of views on the dynamics of change in telecommunications. Moreover, the data gathered from professional research firms supported my arguments about the impact of broadband communications and the crucial role of optical technologies in their development.

An important finding in Chapter Four concerned the relation between demand elasticity and growth in bandwidth. To reiterate, demand elasticity is the degree to which a percentage change in price leads to a corresponding percentage change in market demand. What I discovered here was that the growth in the number of DWDM channels could undermine demand elasticity in the growth of bandwidth-rich services, putting communication service providers under immense financial pressure. I then suggested that this potential anomaly in bandwidth price reduction and demand for bandwidth-intensive applications could be staved off by greater availability of optical infrastructure in metropolitan and residential markets.

Chapter Four contextualized the differences between the way new business models have been introduced in Canada vis-à-vis the US. I argued here that in the US context, the widespread availability of risk capital has enabled the emergence of various new service providers that offer optical-based broadband services. In contrast, in Canada, where access to risk capital is very limited, the majority of support has come from government and government-supported agencies like CANARIE.

Chapter Four also presented diverging viewpoints on what is known as the *bandwidth glut* debate. Immense activities by a smorgasbord of communication service providers to lay optical infrastructure (particularly in long-haul) have prompted some industry observers to suggest that supply in bandwidth could soon surpass demand and turn it into a cheap commodity. But Chapter Four disagrees with the above argument and draws the conclusion that the prospect of bandwidth glut is highly unlikely. It is far more expensive to light the fiber with optical equipment and turn the raw capacity into usable bandwidth than it is to lay fiber in the first place.

In closing, Chapter Four offers an in-depth analysis of Metropolitan Area Networks (MANs). As geographical enlargement of local area networks (LANs), MANs cover portions of or a whole metropolitan area. They are characterized by their deployment and utilization of latest fiber optic technologies. Chapter Four looks at the economic factors influencing the development of MANs as well as their implications for the evolution of a truly broadband environment.

Chapter Five, "Case Study: Level(3) Communications", takes a look at a firm in which all three of the above broadband platforms (i.e. dark fiber, leased wavelength, co-location) are at work. It illustrates how an organization benefits from the effects of industry deregulation, the emergence of innovative ideas, and the use of advanced optical technologies. My conversations with some of the company's top executives provided further guidance into the company's operations and its plans to attain its long-term strategic goals in an increasingly competitive telecom market. These interviews also enabled me to better examine the company's business policies with regard to dark fiber and leased lambda transport models. They also helped me analyze how emerging next-generation telcos influence the delivery and pricing of bandwidth in the market place.

The case study exemplifies how market forces have prevailed over government-led central planning bodies in the development of protocols and standards. This finding further underlines the role of VCs in the development of new technologies and market-based standards. Therefore, any decrease in the role of VCs can be rightly regarded as fewer chances for new business ideas to flourish.

6.2 The Long Road Ahead

Despite significant changes in North American telecommunications, the development of broadband networks – which would provide the fundamental grounds for a networked economy – are still in their infancy stage. There are enormous technical as well as regulatory challenges that need to be overcome. Some of the main challenges include:

- imbalance in the optical infrastructure between long haul and metropolitan networks;
- migration from IPv4 to IPv6;
- conformity of the existing regulatory regime to changes in technology.

One of the main technical challenges today entails the elimination of a serious imbalance in the availability of raw bandwidth between long-haul and metropolitan networks. This imbalance has prompted many skeptics to declare the arrival of a bandwidth glut, disregarding the fact that the penetration of optics still remains relatively undeveloped in both metropolitan and residential markets.

Enterprise customers—despite growing sophistication in their communication needs—still rely on the traditional T1 family of transport services. These services are well established, well managed, but are offered at expensive prices (particularly in Canada). Also, they are barely sufficient for bandwidth-intensive applications that are suitable for mid- and large-sized customers.

Another equally crucial development in-waiting is the introduction of a new generation of Internet Protocol (IP) that will offer unlimited Internet addresses as Internet traffic continues to grow. The industry hopes that this new version of IP—so-called IPv6—will replace IPv4, the current generation of IP in use. According to Vint Cerf—who, with his colleague Robert Kahn, devised the Internet's original architecture in the 1970s—two challenges stand out in this area. "First, the growing shortage of addresses needs to be dealt with. Second, telecom networks need to be scaled up to cope with faster connections in an efficient manner. The reason these two problems are so important is that unless they are fixed properly, the "end-to-end" principle on which the Internet was founded could be under threat. And that could have serious repercussions" (*Economist*, March 22, 2001).

On the regulatory side of things, the industry is in dire need of upgrading the existing legislation to catch up with technical changes that have taken place since the *Telecom Act of 1996* was passed into law. For example, both the FCC and the CRTC need to clarify their stance on laws governing the deployment of broadband technologies to multi-dwelling buildings in metropolitan areas. Also in serious need of modification are the ways in which competing networks from ILECs and CLECs are regulated. This is particularly important in the light of the recent plunge of CLECs and immense activities in the deployment of optical infrastructure in metropolitan areas.

6.3 The Telecom Malaise

The chorus of hapless telecommunication companies that have seen their profits fall precipitously over the past year reflects an irony about long-standing prosperity: unlimited investment in unlimited opportunities could entrap a firm in a financial quagmire.

Accounting irregularities and mismanagement in giants like Lucent Technologies were not the only problems in the telecoms industry over the past year. Enormous capital investment by both established financial institutions and VCs in all sectors of telecommunications— fiber optic networks, wireless systems, and new local exchange carriers—resulted in the birth of many new players. These emergent players consumed enormous sums of private capital without delivering concrete results to the investment community. From 1996 to date, new local communications carriers—both CLECs and next generation—have invested more than $USD50 billion in new network infrastructure. In the same period, communication carriers over all have raised about $USD177 billion of capital (*New York Times*, April 22, 2001). On the other hand, merger and acquisition (M&A) spree by large carriers like AT&T has been significant in contributing to the current slowdown. In the latter development, large carriers spent tens of billions of dollars on acquiring smaller established carriers to prepare themselves for competition that was coming from emerging CLECs and next generation telcos. This left acquiring carriers with the huge task of network integration and system upgrade, which, as in the case of AT&T, put them under further financial pressure. The overall result was a slow pace in execution that eventually prompted Wall Street to pull the plug on such M&As. Under pressure from impatient investors and board members, in fall of 2000, AT&T announced that it intended to split the company into three companies with four separate stocks — one each for its wireless, cable, business and consumer operations (*New York Times*, April 22, 2001).

As Floyd Norris of *New York Times* puts it in context, "price competition became rampant in many areas of the industry, which was good news for customers but not for the providers or their creditors. Demand kept growing, but not rapidly enough to keep up with supply" (*New York Times*, February 16, 2001). A case in point has been the carrier's carrier sector, where a large number of VC-funded players have been active in installing fiber in metropolitan markets—sometimes a number of them in the same market.

Put another, two factors can be considered chiefly responsible for the current dramatic slowdown in telecommunication markets. These two factors encompass the developments described above:

- a severe imbalance in ratio of capital expenditure to revenue among all classes of carriers, both incumbent and next generation;
- a backlog of inventory excess by the makers of communication equipment.

For telecom markets to see their fortune turn around, the imbalance in ratios of spending to revenue needs to go back to the level where massive spending began. This should happen vis-à-vis a reduction in the inventories of communication equipment manufacturers. At least a nine-month to a one-year time frame is needed for telecom markets to gather momentum. But any positive change would not entail a return to rosy days of untrammeled growth in stock prices, or another round of massive billion-dollar investment in celebration of the arrival of the Internet age.

It is important to note that regulators (particularly American) partly bear the responsibility for the current downturn, if not meltdown[1], in the high-tech industry. Over the past five years, regulators in Washington blocked a series of mergers that could have led to a speedier consolidation of the industry and to a more competitive landscape. Such consolidation would have created a new block of incumbents with a much clearer strategy in mind to upgrade their infrastructure. For example, the FCC blocked:

- Bell Atlantic from merging with TCI (at the time the biggest cable TV carrier);
- AT&T with SBC;
- Bell South from acquiring Sprint (*Wall Street Journal*, September 27, 2000).

Opposition from regulators at both local and federal levels significantly impeded the pace of consolidation in the industry.

What is ironic about regulatory opposition to mergers is that the same regulators that adopted full deregulation of telecommunications failed to realize that full-deregulation entails consolidation of all sub-sectors of the industry. Realization of the above failed mergers between mainly RBOCs and IXCs (long-distance carriers) would have been essential in eliminating the existing duplicate network architecture—long-distance and local exchange. The negative impact of putting roadblocks against the process of consolidation has been the loss of months and years of precious time.

[1] Of the 1,262 companies that went public from 1998 through the end of 2000, the shares of 152, or 12 percent, can now be bought for less than a dollar (*New York Times*, April 15, 2001).

6.4 What is to Come?

The next three years will be crucial in determining the shape of new telecommunications in North America and the resulting broadband infrastructure. By then, the industry will undoubtedly have overcome its present malaise and will be poised for a new round of growth followed by a new round of M&As. Most M&As will be mainly in the communication equipment manufacturing sector, as high-tech bellwethers like Cisco and Nortel will have digested their restructuring plans and be prepared for new R&D spending.

In the service provision sector, it is likely that the industry will undergo massive consolidation. This wave of consolidation will likely involve largely metro-centric carriers, both facility-based and non-facility-based. The main benefit of consolidation in this sector will be to avoid bandwidth from becoming a cheap commodity. It might also help eliminate existing mismanagement at some incompetent carriers that have demonstrated little expertise in executing on their business plan. Consolidation in the carrier's carrier sector will help the industry realize who is against whom in the long run. This will also help the industry to re-evaluate some of the common strategies in offering broadband communication services. One such fondly held strategy has been service bundling.

Since the full deregulation of telecom markets, the bundling of a panoply of communication services gained currency as an important business theme among almost all telecom carriers. The rationale behind offering bundled services—local telephony, long-distance, and high-speed Internet—was that customers would benefit from the convenience of receiving all their communication needs on a single bill and from a single service provider. For the consumer market, this strategy is more plausible since consumers generally do not want the hassle of dealing with numerous bills from a variety of service providers.

But the same strategy for corporate customers could prove ill-fated. Increasingly, business customers prefer to receive communication services from a number of service providers rather than making themselves captivated to one single carrier. By diversifying their communication resources, business customers can reduce the risk of becoming digitally stranded should the service provider's network fail. Offering bundled services is a strategy on which companies like TELUS and Bell Canada have been concentrating their efforts. There is an important point about this strategy when it comes to targeting corporate customers: just as telecom carriers avoid relying on a single telecom equipment vendor in building out network and designing new operation support systems[2] (OSS), enterprise customers will be equally in a better position to diversify their communication resources. This also encourages competition in the service provider sector.

The next three years will be equally crucial whether competition will arrive in local exchange markets, residential sector in particular. To date, all the efforts by both regulators and entrepreneurs in the industry have failed to replicate the success of long-distance competition in local exchange markets. This will be one of the most important

[2] Systems that perform management, inventory, engineering, planning, and repair functions for telecom carriers.

and perhaps the last frontier in broadband communications that requires enormous effort and attention.

6.5 Future Directions for Research

Telecommunications is the most important infrastructure of the information age and fundamental to realization of an information society. A robust and advanced communication infrastructure enables countries to have a more competitive place in today's global economy where trade barriers are crumbling at an unprecedented pace. Melody (1997: 490) rightly argues that "the growth of electronic services as a distinct component of the information infrastructure has provided an avenue for the design of new services that are more responsive to the specific needs and demands of particular users". He then suggests that "soundly based public policy direction and effective telecom regulation can increase the possibilities for benefit, reduce the risks of loss and harm, and ensure that the implications for all sectors of society are considered, as steps towards an information society are taken" (Ibid).

As mentioned prior, expansion of broadband services (telephony, data, and video) into residential markets remains a challenge that needs adequate research by academia as well as private industry. Research in this area is directly related to issues surrounding the last mile[3] problem. The ILECs—as owners of the last mile and dominant providers of

[3] The last mile has traditionally used copper-based telephone wire or coaxial cable.

communication services—still generate the bulk of their revenue from voice communications coming mainly from residential customers.

The development of advanced broadband technologies in residential markets would bring about a true convergence of Internet and broadcasting industries. This, of course, requires the deeper penetration of optical technologies into residential neighborhoods, which at this time remains a very expensive business proposition. This thesis advises the ILECs to participate in research on the development of broadband technologies for residential markets. This R&D would secure them a role in the convergence of the above-mentioned sectors. Failing to participate in and contribute to research in this area could cost the ILECs loss of significant revenue and thus a place in the convergence game. There are already large carriers, ILECs and otherwise, that are active in the development of optical broadband communication services for residential markets.

The Full Service Access Network (FSAN) initiative is the definitive global model under development by carriers and telecom equipment vendors to provide a framework for close-in fiber optic installations. Established in 1995, FSAN studies the feasibility of extending optical fiber technology closer to residential neighborhoods. It is backed by some of the most powerful industry players, including such ILECs as SBC Communications, Deutsche Telekom, and Qwest Communications. The total number of telephony lines operated by FSAN carrier members is more than 310 million (CIR, Summer 2000: 18). There is no Canadian ILEC member of FSAN.

Canadian researchers should take the opportunity in launching major research projects to study the technical and policy issues concerning full penetration of optical technologies into Canadian residential markets. Participation of leading Canadian carriers (i.e. Bell and TELUS) in such research projects will certainly be a valuable advantage and can contribute greatly to finding and developing cost-effective solutions. Another important area of research that was not taken up in this thesis is broadband wireless. This particular area is still in its infancy stage and has the potential to emerge as a viable broadband platform.

Research in the above areas benefits consumers and the industry participants alike. It will also help avoid gaps in the development of broadband communication services between corporate and residential sectors. One of the problems with Canadian academic institutions is the lack of co-operation with private industry and resistance against funding of research projects by the private sector. This lack of co-operation is an obstacle that works against the flourishing of innovative ideas in Canadian academic institutions. Co-operative research between academia and private industry coupled with "soundly based public policy", to use Melody's words again, will open new vistas for the development of a truly networked economy.

REFERENCES

Aufderheide Patricia (1999) *Communications Policy and the Public Interest: The Telecommunications Act of 1996*, The Guilford Press, New York, London

Babe Robert E. (1990) *Telecommunications in Canada*, University of Toronto Press.

Babe Robert E. (1995) *Communication and the transformation of economics: Essays in information, public policy, and political economy*, Boulder CO: Westview Press

Bauer Johannes M. (1999) "Competition As a Turbulent Process: Lessons for telecommunications regulatory reform" presented at the 27th Telecom Policy Research Conference in Alexandria, Virginia, September 25-27, 1999

Christensen Clayton M. (1997), *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Harvard Business School Press, Boston Massachusetts

Crandall W. Robert and Waverman Leonard (1999) "Competition in Telecom: The US and Canadian Paths", *The Electronic Village: Policy Issues of The Information Economy*, Dale Orr and Thomas A. Wilson (eds), C.D. Howe Institute, pp.34-58

Davis Charles H. and Smith Richard (1995) "Management of Technology and Technological Change in Canada: Learning and Teaching Innovation and Competitiveness" in *Developing Technology Managers in the Pacific Rim*, by Karen Minden and Wong Poh-Kam (eds.), M.E. Sharpe

Freeman, C. and Perez C. (1988) "Structural Crises of Adjustment, Business Cycles and Investment Behavior" in *Technical Change and Economic Theory*, pp.38-66 by G. Dosi, C. Freeman, R. Nelson, G. Silverberg and L. Soete (eds). London: Pinter

Geller Henry (1993) "Changing Technologies and the Role of the FCC in the United States", *Global Telecommunications Policies: The Challenge of Change*, edited by Meheroo Jussawalla, Greenwood Press: Westport, Connecticut, London. pp.11-21

Head Sydney W. et al. (1994) *Broadcasting In America*, Sydney Head, Christopher H. Sterling, Lemuel B. Schofield (eds), seventh edition, Boston and Toronto: Houghton Mifflin Company

Lanning Steve, O'Donnell Shawn, and Neuman Russell (1999) "A Taxonomy of Communications Demand", *Telecommunication Policy Research Conference*, September 1999, pp.1-30

Lera Emilio (2000), "Changing relations between manufacturing and service provision in a more competitive telecom environment", *Telecommunications Policy*, 24, pp.413-437

Mansell, Robin (1993) *The New Telecommunications: A Political Economy of Network Evolution*, London: Sage Publications

Mansell Robin Silverstone Roger (1996) "Network Governance: Designing New Regimes", *Communication by design: The politics of information and communication technologies*, Robin Mansell and Roger Silverstone (eds), Oxford: Oxford University Press, pp.187-210

Melody William H. (1997) "Policy Objectives and Models of Regulation", *Telecom Reform: Principles, Policies and Regulatory Practices*, edited by William H. Melody pp.13-27

Melody William H. (1997) "Designing a Workable Telecom Regulatory Structure for 21st Century Information Societies", *Telecom Reform: Principles, Policies and Regulatory Practices*, edited by William H. Melody pp. 489-501

Melody William H. (1997) "On the Meaning and Importance of 'Independence' in Telecom Reform", *Telecommunication Policy*, Vol. 21, No. 3, pp.195-199

McNamara John R. (1991) *The Economics of Innovation in the Telecommunications Industry*, Quorum Books, New York

Mosco Vincent (1988) "Toward a Theory of the State and Telecommunications Policy", *Journal of Communications*, Winter 1988, pp.107-125

Mueller Jr., L. Milton (1997) *Universal Service: Competition, Interconnection, and Monopoly in the Making of the American Telephone System*, the MIT press and the AEI press

Newton Harry (1994) *Newton's Telecom Dictionary*, Flatiron Publishing

Noll A. Michael (1997) *Highway of Dreams: A Critical View Along the Information Superhighway*,

Shinal, John G. and Mullaney, Timothy J. "At the Speed of Light", *Business Week*, October 9, 2000, pp.145-66

Wilson G. Kevin (1997) *Deregulating Telecommunications: U.S. and Canadian Telecommunications, 1840-1997*, Rowman and Littlefield Publishers Inc.

<u>Journals:</u>

Lynch Grahame, "The Coming Bandwidth Bubble Burst", *America's Network*, February 2001, www.americasnetwork.com/issues/2001issues/20010201/20010201_coverstory.htm

America's Network, "Internet Backbone and Service Providers: A Market Overview", April 1999, http://www.americasnetwork.com/issues/99issues/990415/990415ispover.htm

Levine Shira, "The Blindside of Optical", *America's Network*, November 1, 2000, www.americasnetwork.com/issues/2000issues/20001101/20001101-optical.htm

Broadband Week, "Shaw's Big Pipe Seeks Big US Partners" February 5, 2001 http://www.broadbandweek.com/news/010205/print/010205_cable_shaw.htm

Puttre John, "The Oncoming Glut of Bandwidth", *Business Communications Review (BCR)*, August 1998, vol. 28, no. 8, pp.12-14

Business Communications Review, "DSL May Challenge Cable Modems Worldwide", October 1999, vol. 29, no. 10, p.8

Frost & Sullivan (www.frost.com) in *Business Communications Review*, January 2000, vol.30, No.1, p.8

Telecommunication Industry Association (TIA) and its subsidiary, the MultiMedia Telecommunications Association (MMTA), "2000 Multimedia Telecommunications Market Review and Forecast", in *Business Communications Review*, February 2000, vol.30, No.2, p.8

Business Communications Review, "B2B to Be Huge Report (Gartner Group) Says", March 2000, vol.30, no.3, p.8

Heywood Peter, "Optical Networking in Five Easy Pieces", *Business Communications Review*, May 2000, vol. 30, No. 5, pp.54-63

Passmore David, "Ethernet: Not Just for LANs Anymore" *Business Communications Review*, July 2000, vol. 30, no.7 pp.18-20

Passmore David, "Optical Optimism" *Business Communications Review*, December 2000, vol. 30, no. 12, pp.16-18

Clavenna Scott "More Generations of SONET to Come", *Business Communications Review*, November 2000, vol. 30, No. 11, pp.52-9

Business Communications Review, "Should You Outsource Your Internet Datacenter?", January 2001, vol.31, no.1

Gilder George and Swanson Bret, "Telecosm Explosion", *Forbes ASAP*, February 19, 2001 pp.120-122

Hawn Carleen, "The Man with the Golden Touch", *Forbes*, February 19, 2001 pp.86-90

"Upgrading The Internet", *The Economist*, March 22, 2001

Globe and Mail, November 1, 2000

Clavenna Scott, "Metro Optical Ethernet", November 2000, published by *Lightreading.com*

"VCs Turn Back the Clock on Funding", *Lightreading.com*, May 10, 2001

New York Times, "Bell South Buys Qwest Stake for $3.5 billion", 19 April, 1999

New York Times, December 28, 2000

Floyd Norris, "How Telecom Became a Black Hole?", *New York Times*, February 16, 2001

"Just Who Brought Those Duds to Market?" *New York Times*, April 15, 2001

"Sitting Pretty: How Baby Bells May Conquer Their World" *New York Times*, April 22, 2001

Horner Peter, "Something to Crowe About: Is Level(3) CEO Jim Crowe Building the Next Great Communications Company?" *ORMS Today*: A Publication of Institute for Operations Research and the Management Sciences, June 2000, (www.informs.org/executives)

"Business Leaders Want $1 Billion for Universities" *Ottawa Citizen*, April 13, 2001

Buckley Sean, "Carrier Hotels: Click and Mortar", *Telecommagazine*, November 2000 http://www.telecommagazine.com/issues/200011/tcs/carrier_hotels.html

Kennedy Michael, "The Business Case for Metro Optical Systems", *Telecommagazine*, February 2001, http://www.telecommagazine.com/issues/200102/tcs/the_business_case.html

Allen Lori M., "Shacking Up", *Teledotcom*, January 8, 2001, vol. 6, No.1, pp.62-66

"Entrenched Bells Pull Ahead in DSL Race", *Teledotcom*, January 22, 2001, vol. 6, no. 2, p.11

"Can They Dig It?", *Teledotcom*, March 19, 2001, p.51-59

Voice, a TELUS publication, vol.2, issue 17, p.3

"How a Telecom Meltdown Will Cause the Next Recession", *Wall Street Journal*, September 27, 2000

"Collapse of Dot-Coms Stifles Tech Innovators", *Washington Post*, April 29, 2001

Professional Reports:

Angus Telemanagement, "Hydro One and South Dundas Selling Fiber Capacity", Number 257, Nov.6, 2000

Angus Telemanagement, "Sprint Expands Data Services", Number 258: November 13, 2000

Angus Telemanagement, "Lucent and ClearNet in Wireless Trial", Number 258: November 13, 2000

Angus Telemanagement, Number 259: November 20, 2000
Blumenfeld and Cohen, www.technologylaw.com/telephony.html

CANARIE, "Customer-Owned Dark Fiber FAQ", by Bill St. Arnaud, February 2001, http://www.telekomnet.com/writer_allan/7-20-00_darkfiber_faq.asp

Communication Industry Researchers (CIR), *Fiber-to-the-x: The New Market for Fiber to the Desk, Cabinet and Home*, Summer 2000, Charlottesville, Virginia

Dell'Oro Group, "Nortel Networks Ranks #1 in Optical Internet Solutions", Nortel Networks, Optical Internet, Business Development Team, July 2000

Nortel Networks News Release: "Nortel Networks to Acquire Cambrian Systems for up to USD $300 Million"
http://www.nortelnetworks.com/corporate/news/newsreleases/1998c/12_9_9898680_Cambrian.html

Nortel Networks "Metro Case Study", by Alan McKie, Optical Network Planning,
Spring 2000

Paul DeLottinville & Associates Inc., *Canadian Telecommunications Industry/Market*, April 2000

RHK Telecommunications Industry Analysis, "Edge Switching and Routing: Internet Traffic Growth" December 1999.

Robertson Stephens Inc. "Guide to Building A Next Generation Network in 1999" by Tim Weingarten,
No.167, May 3, 1999.

US Warburg, "Optical Components: The Good, The Bad, and The Ugly" October 2000.

Yankee Group, "The Wholesale MAN: Carrier's Carriers in the Local Loop" by Beth Moore and Mary Regan, June 2000

Glossary

ATM (Asynchronous Transfer Mode): A network technology for both local and wide area networks (LANs and WANs) that supports real-time voice, video, and data.

BLEC (Building Local Exchange Carrier): A network service provider that partners with real estate owners and managers in order to provide broadband services within an apartment house or office building.

CAP (Competitive Access Provider): An organization that competes with the established telecommunications provider in an area.

CLEC (Competitive Local Exchange Carrier): An organization offering local telephony and data services, mainly competing with established telecom carriers.

CPE (Customer Premises Equipment): Communications equipment that resides on the customer's premises.

CRTC (Canadian Radio-Television and Telecommunication Commission): Canada's regulatory agency overseeing the country's communications industries including wired, wireless, cable, radio, TV, and satellite. It is based in Hull, Ottawa in the province of Ontario.

DSL (Digital Subscriber Line): A broadband technology that dramatically increases the digital capacity of ordinary telephone lines (the local loops) into the home or office. It is offered in a variety of flavors, each at a certain amount of bandwidth and speed.

DWDM (Dense Wavelength Division Multiplexing): An optical technology that dramatically increases the bandwidth capacity of optical networks by inserting optical wavelength onto a strand of optical fiber.

FCC (Federal Communication Commission): The U.S. government agency that regulates interstate and international communications including wired, wireless, cable, radio, TV, and satellite. It is based in Washington D.C.

FSAN (Full Service Access Network): An international initiative under development by carriers and telecom equipment vendors to provide a framework for close-in fiber optic installations.

EDFA (Erbium Doped Fiber Amplifier): An amplifying technology in optical networking that strengthens integrity of an optical signal over long distances without the need for electrical regenerating. It was the first successful optical amplifier developed by Corning Corp.

ILEC (Incumbent Local Exchange Carrier): A traditionally dominant local phone company such as Baby Bells in the U.S and provincial phone carriers in Canada.

IN (Intelligent Network): The public switched telephone network architecture of the 1990s, which was developed by Bellcore (now Telcordia Technologies) and the ITU. It was created to provide a variety of advanced telephony services such as 800 number translation, local number portability (LNP), call forwarding, call screening and wireless integration.

IRU (Indefeasible Right of Use): An agreement between a telecommunication carrier and a customer in need of communication infrastructure that leases infrastructure from the carrier to conduct business over the leased infrastructure for a certain period of time, usually for 10- to 20-year lease periods.

LAN (Local Area Network): A communications network that serves users within a confined geographical area. It is made up of servers, workstations, a network operating system and a communications link.

MAN (Metropolitan Area Network): A communications network that covers a geographic area such as a city or suburb. Today MANs are known for their advanced optical infrastructure.

MDU (Multi Dwelling Unit): A commercial or residential building with multiple offices or apartments.

MTU (Multi Tenant Unit): A building with multiple offices or apartments. MTUs are more economical to target for installing DSL and other broadband links than single-occupancy offices or houses.

OC (Optical Carrier): The transmission speeds defined in the SONET specification. OC defines transmission within the optical, not electrical domain.

OEO (Optical Electrical Optical): A term that refers to network devices that convert photonic transmission signals to electronic signals for switching purposes. It then reconverts the signal back to light for output.

OPGW (Optical Ground Wire): An optical infrastructure deployment methodology that involves installing fiber using electrical poles as opposed to installing it underground.

OSI (Open System Interconnection): A standard for worldwide communications that defines a framework for implementing protocols in seven layers.

OSS (Operation Support System): Systems that perform management, inventory, engineering, planning, and repair functions for telecom carriers.

RBOC (Regional Bell Operating Company): The regional Bell telephone companies that were spun off of AT&T by court order in 1984. Although some have since merged with others, the initial seven companies were Nynex, Bell Atlantic, BellSouth, Southwestern Bell, US West, Pacific Telesis and Ameritech.

SDH (Synchronous Digital Hierarchy): The European counterpart to SONET. See SONET.

SONET (Synchronous Optical Network): A fiber-optic transmission system for high-speed digital traffic. Employed by telephone companies and common carriers in the mid 1980s, SONET speeds range from 51 Mbps to multiple Gbps. SONET is an intelligent system that provides advanced network management and a standard optical interface. It uses a self-healing ring architecture that is able to reroute traffic if a line goes down.

TDM (Time Division Multiplexing): A technology that transmits multiple signals simultaneously over a single transmission path. Each lower-speed signal is time sliced into one high-speed transmission.

UNEs (Unbundled Network Elements): A term coined by US regulators during the design of the *Telecom Act of 1996* that refers to network elements that ILECs are required to open to their likely competitors. Opening of these elements was meant to speed up the process of competition in the local loop.