Nortel Technology Lens: Analysis and Observations

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"The company that gave Canada its most consequential shove into modern research and development has now attained the kind of critical mass that Nortel needs to provide its customers with an invaluable head start on the 21st Century."

Peter C. Newman, author & business historian

Nortel: Past Present Future*

***** From the 100th Anniversary report about the founders and builders of Nortel, 1995

Executive Summary

This report is about the role of technology and technology management at Nortel Networks Ltd. or Nortel for short, a former world class Canadian telecommunications company. It provides an assessment of these two technology perspectives in respect to the demise of the company and what lessons were learned in regard to the rise and dramatic fall of the company over the study period, 1996 - 2009. The report is referred to as the *Nortel Technology Lens Report*. This document is the fourth in a series of reports carried out over the past four years by an interdisciplinary research team from the University of Ottawa.

Details on the earlier reports, including a report on the methodologies used to conduct this research, as well as a comprehensive overview report and a report on governance at Nortel can be found online at http://sites.telfer.uottawa.ca/nortelstudy/. This report is also available on the same link.

The goal of this study has been to examine the demise of Nortel from several perspectives, namely strategic management, business practices, governance, technology, and technology management; each undertaken with a view to learning lessons from the demise of the company from these different perspectives. The team comprised members associated with the Telfer School of Management, the Faculty of Law, and the Faculty of Engineering.

To start, our findings tell us that Nortel did not fail because of its technologies, nor because of the manner by which the technical side of the business managed the technology processes within the company. However, various technologies and more broadly, business management practices, were imposed upon the engineering assets of the company by a fundamental shift in corporate strategy associated with the chaotic emergence of the commercial Internet and its profound impacts on traditional telecommunications equipment suppliers and service operators throughout the world in recent years. Nortel was caught in the fray of this transformation.

In order to appreciate the technical strengths and weaknesses of Nortel prior to the onset of the fusion between traditional telecommunications and the rapid emergence of computer networking in the mid-90s, this report looked back some 25 years prior. This was undertaken in order to appreciate how a relatively cloistered Canadian telecommunications supplier to its prime customer, Bell Canada, was transformed into a global behemoth with some 70 percent of the world's communications traffic flowing through Nortel supplied equipment and infrastructure by the turn of the 21st Century. By 2000, Nortel was one of the most valued companies in the world with a market capitalization of nearly $400 billion. Ten years later the company was gone. Why?

The answer to that question is at the core of these various coordinated and multifaceted research reports. In March 2014 the research team released its collective assessment of what befell Nortel and what lessons could be extracted from that demise. The high level technical findings were contained in that initial report. Over the past year the engineering research team has been mining further our rich aggregation of data and information gleaned from a number of lines of enquiry, including interviews, surveys,

published and internal documents from Nortel as well as multiple organizations comprising Nortel customers, competitors and industry analysts, among others, as well as various other information inputs.

Nortel depended on creating and gaining access to technologies essential to its various product offerings. Our research shows that, until the end, Nortel's technology, people and adaptability remained among the best in the industry. However, a major corporate attempt to gain technology through acquisitions was a general failure. Once the company began to return to its roots circa 2004 and to re-focus on developing technology in-house rather than on trying to acquire technology through acquisitions, it managed to revive its leading-edge capability of the past. At the time of filing for protection from creditors in 2009, Nortel held leading technology in a number of emergent areas, notably in 4G/LTE wireless, in long-haul optical and in other fiber-optic transmission technologies.

Fundamentally, Nortel did not fail because of its technology or because of allegedly wrong choices in terms of specific technologies. The basic technology issue was the erosion in the senior management's confidence and willingness to continually recognize and appreciate the strength of the in-house technology capability. Nortel's technology managers identified the key emergent trends in the market sufficiently early to create both speculative and potentially competitive products, such as Internet Protocol routers and wireless access systems. However, by the mid-90s Nortel no longer created products speculatively; instead the company chose to wait for a clear market demand. As a result Nortel lost valuable time to market and at the same time began to lose its market leadership role.

This situation arose as a result of executive management misreading the pace of convergence between traditional telecommunications networks and the commercialization of the Internet, at the time a means of data communication and sharing that resided on leased lines from telecommunications networks. As such the early Internet was developed independently of telcos and their traditional suppliers.

Many lessons were learned with respect to both technology decisions and technology management. For example, a fundamental lesson learned is to avoid losing sight of the fact that technology companies need forward-looking technology vision and technology-oriented decision-making at key points within the organization (e.g., one former Nortel executive stated that over a time during our study period that only one of the top dozen or so Nortel officers had any technology background). In addition, in the case of a company like Nortel with strong P&L divisions, an individual with a deep understanding of technology needs to be in a central role in each of the business lines and where possible, to act collaboratively across business units, especially when there was no central research lab.

The disbanding of Bell-Northern Research (BNR) created a gap in the company's central ability to see the future, as Nortel had done in the past when it launched initiatives such as the '*Digital World*', something that most of us now take for granted. It was an executive decision to dismantle BNR, one primarily designed to create more formal lines of executive accountability under the CEO. It had certain merits in a short-term sense; but it had significant unintended consequences for the longer term. From the time of the decision to close BNR to the actually wrap-up of the business unit took several years. This process had generally negative consequences on R&D staff morale and saw the gradual loss of key technical resources. These issues are explored in this report.

Nortel's modern business success, circa 1970s onward, was based on a model of deep technological expertise that allowed the company to create entirely new markets and associated product lines, such as it did in leading the transition from analog to digital telecommunications, so-called *Digital World*, a visionary perspective on a future that Nortel dominated for many years. At that time, Nortel was highly regarded by the telecommunications industry for its technology leadership skills, product reliability and customer support. Bell-Northern Research, the central laboratories for Nortel, enabled the company to gain and maintain a first-mover advantage in many markets for more than two decades.

Pre 1996 Nortel was a leader in wireline telephony across a range of switches, networks and access devices (e.g., handsets). From 1996 through 2001 conditions in the marketplace caused Nortel to experience explosive growth in terms of the scope and scale of the company and its revenue streams. This demand was being driven by the emergence of a worldwide deregulated telecommunications infrastructure, coupled with rising consumer awareness and expression of needs, along with businesses moving toward global connectivity. Exactly how that connectivity was to be realised was a matter of speculation and Nortel decided, along with a number of other telecommunication equipment companies that a technology known as Asynchronous Transfer Mode (ATM) was the best technical choice to address the needs of the changing environment.

Until the mid-1990s Nortel's business model was characterized as 'defining the future', where Nortel, together with its symbiotic relationship with Bell Canada was able to define the technology and the service provider needs. Consumers had little say at that time in the products and services available to them, so the voice of the requirement was to a large extent that of the service provider. This symbiotic relationship gave Nortel a significant advantage and was a barrier to new entrants in the equipment market. It worked when the marketplace for Nortel products was dominantly telecommunications service providers, so-called telcos (e.g., Bell Canada), and pre the rapid emergence of the commercial Internet and explosion in enterprise networking.

By 2001/2002 the telecommunications industry was at the peak of its transformation. It was the year that profoundly changed the relationships between customers and their suppliers, following the high-growth years of the late 1990s. This change in relationship marked a massive shift for companies like Nortel, which until then was telling customers what they needed in terms of technology and products to one in which customers were telling suppliers what they wanted and in the process transformed the procurement process across the telecom industry.

It is worth noting that the concept of 'customer' in the telecommunications industry changed around this time from the traditional service provider (i.e., telco), essentially telling the consumer or business customer what they could or, more significantly, could not have to one where consumers began having a voice and a choice. Due to deregulation and the emergence of alternative technologies, such as cable providing connectivity, the consumer suddenly could choose different suppliers. If the consumer could not get what they wanted from their traditional supplier they could go elsewhere. The customer's needs were no longer those of the service provider, instead they were shifting to those of the consumer. Nortel did not respond to this change in the way that other suppliers did, some of whom responded enthusiastically to consumer demand and so embraced wireless technologies and Internet Protocol. Internet protocol had emerged as a very user friendly means of non-voice communication. Subsequently Internet Protocol has established itself as the communications protocol of choice, even for voice and other

real-time services, for which, technically, it has some limitations. This led to the abandoning of ATM as an infrastructure of choice.

In the period from 2002 through 2005 both Nortel and its industry were hit by disruptive business and market changes rippling through the industry following the collapse of the so-called dot-com era, a period often referred to as 'irrational exuberance' after the introduction and initial growth phase of the first generation of commercial Internet companies through the last half of the 90s and into the beginning of the new century.

From 2006 to the end in 2009 Nortel struggled to regain its footing. In the end, it failed. Product development had focussed on enhancements of mature products with little investment in future products. By this time, the business relationships and the belief that Nortel had a good vision of the future had faded with many key customers. Nortel became a company competing with little differentiation from competitors, what is known as a 'me too' business. Nortel did not have the cost structure to compete on price and little else against emerging competition from the Far East.

Following the decision to file for protection from creditors in 2009, Nortel technology, in two distinct areas, 4G/LTE wireless and long-haul optical was still leading the world, technology which was acquired by other companies, to subsequent significant success, when Nortel's assets were sold off later in 2009.

Exhibit A
Changing Technology Environment over the Study Period

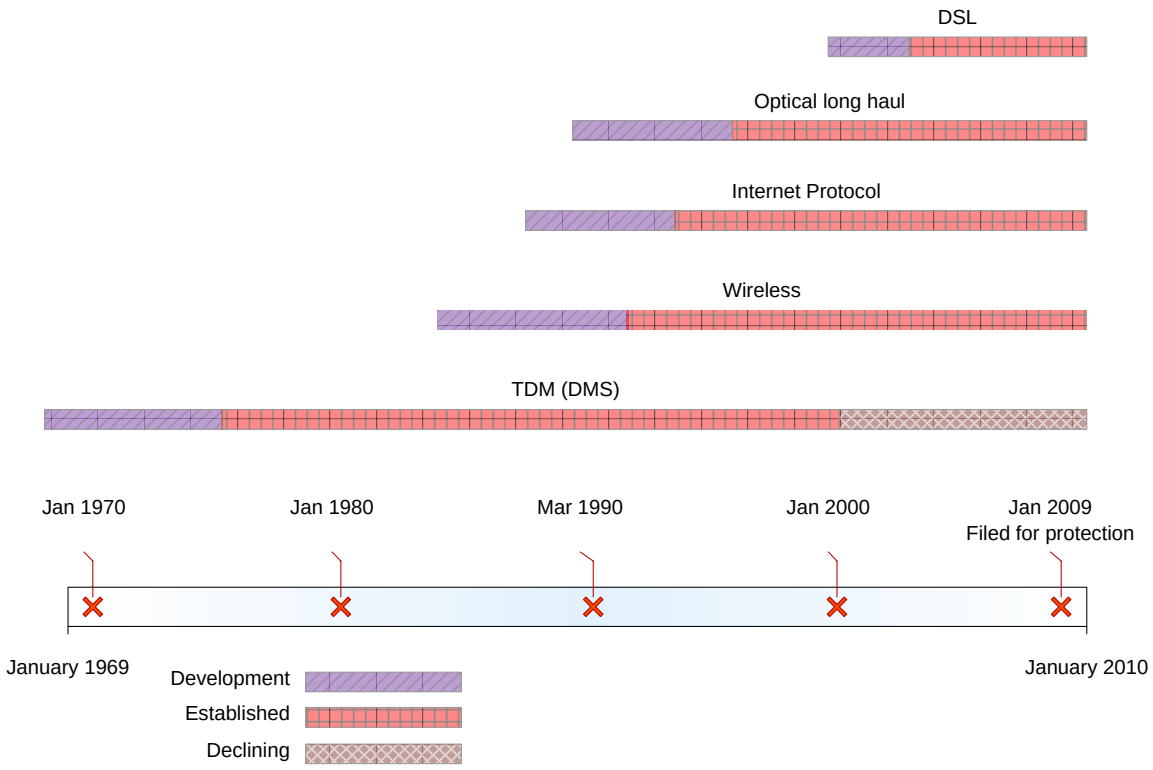
Product Area	<1996	1996-2001	2002-2005	2006-end
Wireline	Growth	Reaching Maturity	Mature & in Decline	Continuing Decline
Wireless in general	Emerging & growth (e.g., 1G in decline, 2G emerging)	Growth (e.g., 2G mature & 2.5G emerging, mature & decline with 3G emerging)	Growth (e.g., 3G)	Growth (e.g., 3G maturing, 4G emerging)
Wireless CDMA	Introduction	Introduction-Growth	Mature & in Decline	Decline
Enterprise	Initial product introduction	Acquisitions to assist growth	Growth	Growth – Maturity
Optical	Growth	Rapid Growth	Demand Collapse	Flat growth more competition

The changing state of the technology landscape over the study period is illustrated in ***Exhibit A***, which presents the general industry technology environment over this period. It shows technology-based product trends in response to market conditions over four time intervals from pre-1996 to the winding-up of Nortel in 2009. It specifically focuses on wireline (i.e., switching and transmission), wireless,

enterprise and optical offerings, all core products on offer from Nortel. This framework has been used as a context for organizing the findings reported here.

Chapter 2 addresses *Nortel Technology*. For example, ***Exhibit B*** sets out an historical to contemporary macro picture of Nortel's technology-based offerings spanning some 30 years. Each bar represents a major technology defined product set that has up to three states noted on each. The first of these states relates to the emergence of a new technology-based product offering according to the technology label on the bar in what is referred to as 'development', when both products and markets are emerging through the actions of early adopters. Typically, Nortel was either early into this first phase of new products or was in fact the market leader and definer of new products.

Exhibit B
Technology Offerings from Nortel



The 'established' phase corresponds to general market acceptance and is dominated by early through late majority adopters. This is followed, in the case of time division multiplexing (TDM), the longest bar, by a 'declining' state of growth that set in around 2000 following the dot-com crash; however, products remained mature and sustaining until the end of Nortel. Each of these and other technologies are considered further in this report.

Using the general market situation throughout the study period, it became possible to map Nortel's offerings into the pattern as shown in ***Exhibit C***, which illustrates the changing status of Nortel product offerings across the same four time periods from pre-1996 through 2009. The colour key represents the

various states in Nortel's ability to meet customer requirements as described by former large Nortel customers during the data gathering phase of the project and according to the following coding schema.

Exhibit C
Changing Customer Perception of Nortel Product Offerings over Time

Code	Code Meaning
Dark green	Vastly exceeds customer requirements (e.g., dominant in the days when Nortel told customers what they needed)
Light green	Exceeds customer requirements
Yellow	Meets customer requirements
Orange	Falling behind customer requirements and/or competitors' products
Red	Does not meet customer requirements

Technology Base	<1996	1996-2001	2002-2005	2005-2009
New technologies driving sales of new products				
Wireless – CDMA market and products				
Enterprise– product and market				
Wireline				
Optical				

In particular, ***Exhibit C*** illustrates how Nortel's success in the market place was being affected by changing perceptions of the strategic value of the company to many of its long-term customers. This is not a technology or product specific issue; but rather an aggregate reflection on customers' perception of overall company performance of Nortel as a consequence of the many factors considered in this investigation into the demise of the company. The clear trend here is that confidence in Nortel was shifting from strategic buying to basically sourcing for maintaining existing infrastructures. This also reflects the emergence of the so-called 'black cloud', discussed at length in our main report, whereby many long-term Nortel customers began to lose faith in their supplier of choice as Nortel tried to adapt to the rapidly changing technical, business and market conditions at the time.

Chapter 3 is concerned with *Acquisitions and Alliances* as they relate to technology. As part of Nortel's effort to address elements of these rapidly changing conditions, it chose to spend more than $30 billion in the acquisition of companies, most of which were transacted in Nortel stock. The principal reasons Nortel sought to acquire technology and products through acquisitions were threefold. Firstly, to narrow the gap in time-to-market while also trying to outmanoeuvre rivals that also may have wanted to acquire the same technologies, products and people that Nortel was targeting. For at that time infrastructure suppliers, both telecom and computer networking suppliers, were all engaged in transforming themselves through mergers and acquisitions (M&A) activities that were unparalleled in the history of the telecommunications industry.

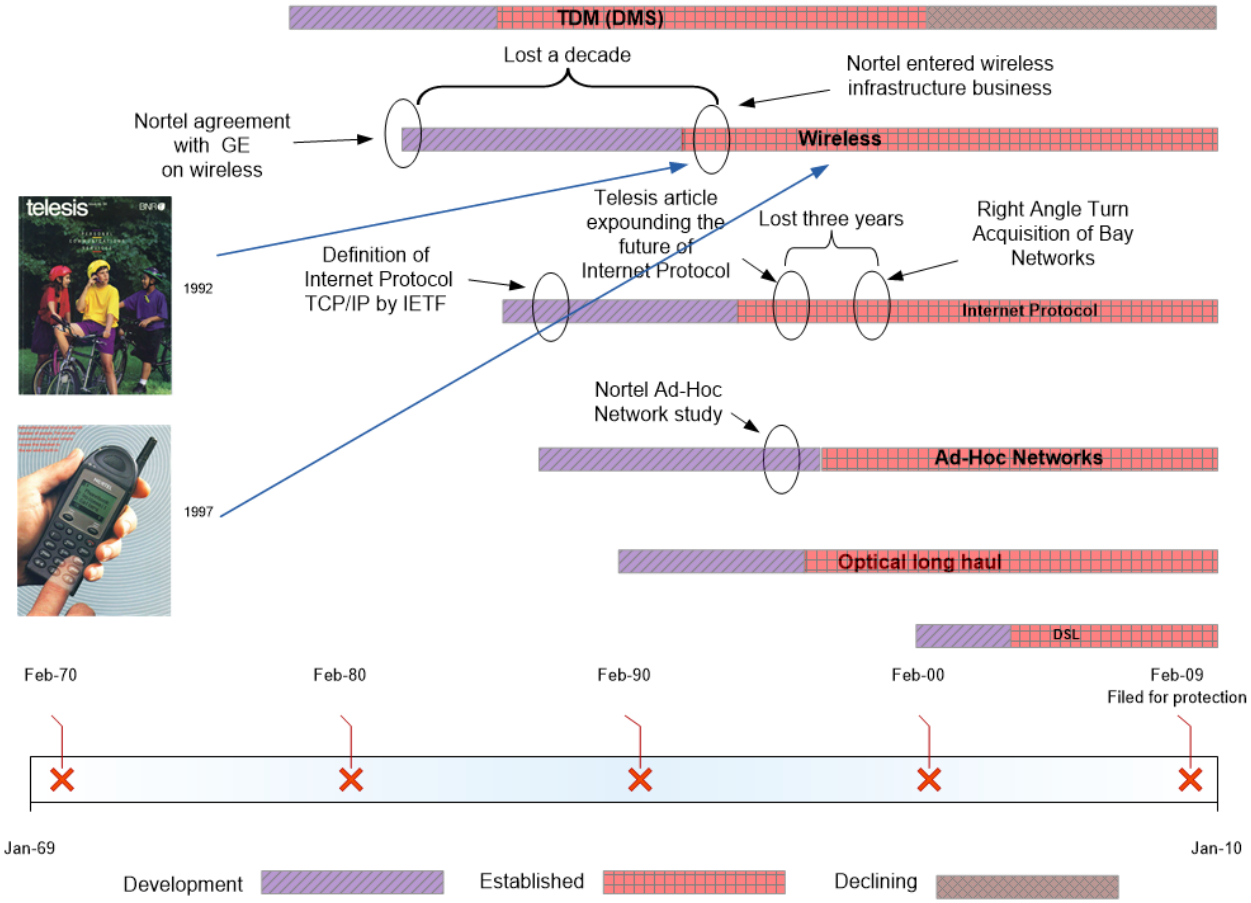
Secondly, Nortel wished to establish technical, product and market leadership as a result of unifying voice and data networks through a product set that let carriers, Internet service providers (ISPs) and corporate networks deliver data and voice traffic over the same Internet Protocol controlled infrastructure.

Thirdly, executive management wanted to change the culture of Nortel from that previously described to one that resembled an agile and dynamic organization that could both change speed and direction on a moment's notice. In order to inject this style into Nortel, particularly Nortel's R&D operations, it was deemed appropriate to acquire entrepreneurially driven companies, mostly from the US East and West coasts. This later point was a major reason for buying Bay Networks, the largest acquisition in the Nortel portfolio.

Chapter 4 deals with *Technology Management* in the company. This is considered from two perspectives, namely within the context of the R&D function as a business activity and as a consequence of overall corporate strategy as driven by executive management. In this regard ***Exhibit D*** identifies three example of where Nortel lost significant time to market, not because it did not understand the technical choices nor how to build products with appropriate technologies; but rather it lost time due to strategic business decisions to avoid certain 'markets' (e.g., access products) while betting on others that failed to materialize (e.g., ATM, WiMax) as well as executive decisions devised and imposed on the engineering enterprise (e.g., organisational change, acquisitions of companies with technology that failed to meet Nortel standards and even interoperability) and a poor record of successfully integrating acquisitions into the Nortel fold.

Nortel could not have been successful without significant amounts of research and development activities by a large cadre of talented scientists, engineers and technical managers. At the same time, R&D priority setting changed as a consequence of a shift in corporate culture from being a 'definer' of the future to a 'contractor' that designed to customer wishes and contracted out its manufacturing to 3rd party fabricators around the world. Internal funding for R&D was critical to the company's earlier successes.

Exhibit D
Nortel & Lost Time to Market

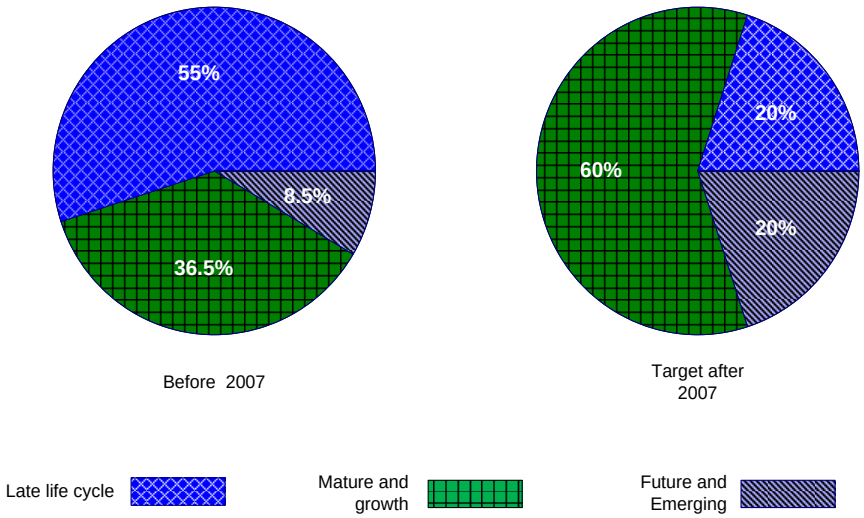


Nortel was by far the largest single corporate R&D performer in Canada for many years. For example, between 1999 and 2009, Nortel spent almost $32.2 billion cash on internal R&D and more than $30 billion in stock and cash on acquisitions, mostly for technologies, as noted in Chapter 3.

Over the study period Nortel spend between approximately 15 to 20 percent of revenues on internal R&D; however, over this same timeframe the profile of R&D investment shifted from a traditional 15 to 20 percent of the total being direct to new 'blue sky' futures to less than 9 percent at a time when technical changes and choices were rampant in regard to future considerations. Instead, Nortel put more R&D resources into enhancement of late life cycle products and into existing and maturing products. The 'future' and 'emerging' domains were contracted inside and expanded outside the company through acquisitions, most of which failed to yield technical advances or future revenues. The acquisition account was mostly a write-off.

Exhibit E illustrates the distribution of R&D funding in accordance with the three themes noted above.

Exhibit E
R&D Resource Allocations



We found a number of documents clearly indicating that the executive management recognized the changes taking place in the industry, with all the opportunities and challenges that they introduced. The documents also indicated that they knew what needed to be done in order to respond to the new environment, an environment of 'customer power'. The consumer and business customer had emerged as the voice defining the future, with a need to communicate, be it web pages, music, images, video, text, email, etc. The network was the means to do this. The opportunities were enormous, but so were the challenges. How can you fail when you are a well-positioned leader in a market with exploding demand? The answer: one blunder after another, primarily as a result of unintended consequences.

Why blunder? Our assessment was that management was acting with good intentions and the best interests of the company throughout the study period. What was missing was a serious effort by the mid-1990s to appreciate the full dimensions of radical departures from the solid and well founded traditions and corporate culture that took years to congeal within Nortel. The very companies that Nortel acquired with good intent were weak and underdeveloped in comparison with the traditions in play within Nortel at the time. Moreover, there was a range of unintended consequence that were at most only given cursory consideration as to potential negative impact, if at all. These issues are primarily discussed in this Chapter.

Chapter 5 addresses *Technology & Engineering Lessons Learned from the Collapse of Nortel*. Despite saying all of the right things both publicly and internally about the need and the will to respond to changing conditions and new opportunities, executive management indicated that they had lack of confidence in their own people to implement the necessary changes they identified. So instead of empowering them and giving them the tools: training, resources, support etc., they chose to acquire the technologies and skills of mostly start-up companies with limited experience at the engineering level of Nortel's own R&D resources. To do this involved more than $30 billion in investment to acquire companies at over inflated prices and then expecting its people to integrate these alien products into Nortel product lines while operating with two different corporate cultures, one of which executive management was trying to

change at breakneck speed. This was a contributor to what ultimately weakened the company. As a sign of the times, we identified two internally used damaging phrases to morale, particularly in R&D, that were attributed to executive management in reference to the internal culture as being a "dinosaur" and to BNR as being "a multi-billion dollar sink hole".

The *Right Angle Turn* was a defining moment for Nortel. The company had a respected reputation for bold and dramatic claims; such as its visionary role in both laying the foundations for and providing key parts to the world's digital communications and fiber infrastructures. The Right Angle Turn was generally seen in similar light – Nortel saw the way. Consequently, the 'Turn' was marketed as a change in technical direction, shifting from 'dial tone', meaning the traditional voice centric switched network, to 'web tone', meaning the Internet and moving from 'copper wire' to 'fiber optics', and from voice to multimedia communications.

Yet, it was much more than that. The 'Turn' was a message to both the market and to employees, especially R&D – change was coming and fast. The 'much more' relates to three other elements of the strategy to implement the Turn. All three were internally focused and promoted the need to be more *agile* in projects, more *dynamic* in organization, and more *responsive* to customers' needs, especially the emerging enterprise market, a potentially large market for Nortel and its competitors.

We also found strategic documents that were unfocused. Nortel's strategy seemed to go after every opportunity, many of them technologies and business opportunities that they had formerly abandoned, such as access products and multimedia products. There was no clear position on multimedia, wireless, IPTV and many others. In eventually recognizing this gap Nortel tried to fill it too quickly by buying companies that were active in such technology and market spaces. The ensuing problems were that the companies Nortel bought were not necessarily brand leaders or even successful in their market space. Some had good intentions but no products. We identified brand dilution, detracting Nortel's image from the solid base that it had developed prior to acquiring the companies, as discussed in Chapter 3.

The historical customer base did not want nor trust Nortel any more while the newcomers, new service providers in wireless, cable operators, and enterprises, etc. did not yet really know Nortel other than a 'brand' name. The result was that Nortel was left out in the cold, especially as the 2000s progressed to mid-decade.

In the end, a number of key lessons were learned in respect to how Nortel fell from global dominance to emerge as a transformed phoenix with its assets distributed as spoils among its competitors. Here is a list of the ten most significant lessons.

- Nortel did not fail because of technology nor because of its products. We found no systemic problem with Nortel's own technologies nor technology management processes;
- It is essential to avoid losing sight of the fact that technology companies need strong forward-looking technology vision and technology-oriented decision-making at key points within the organization;
- Nortel/BNR had world class engineers, scientists and product visionaries. The breakup of BNR created a gap in the company's ability to continue fostering a visionary and innovative R&D environment producing a capacity to 'see the future';

- Like partnerships, acquisitions require a degree of symbiosis between the companies involved. The more strategic the importance of an acquisition the more carefully the integration process needs to be effectively managed and nurtured. Nortel had a reasonable targeting plan to seek out acquisition target; but it had no apparent plan to effectively integrate acquisitions into the Nortel fold;

- Technology management as an engineering enterprise was well run and subject to the priorities of corporate strategy and budgets. The corporate strategy to change direction while remaining focused on 'bit hauling' with new technologies limited the value-add Nortel could offer its customers; especially as corporations and end-users and their intermediaries (ISPs and telcos) became more astute customers about access devices and telecommunications and networking infrastructure;

- Abandoning the development of access technologies and products, especially personal devices, was a serious technical and business oversight, which led to efforts to catch up without success before it was too late, particularly in wireless;

- Nortel's choice of CDMA wireless technologies and products 'ham-strung' the company to basically a North American market. At the same time, Nortel was late into GSM and never became a significant player;

- Nortel was a world leader in the development of LTE intellectual property for the next generation of mobile communications;

- Nortel remained to the end a world leader in optical technologies and related telecommunications products and had a treasure trove of technology patents worth billions of dollars; and,

- Technologies and products acquired through M&A initiatives were difficult to integrate and failed to gain market traction for a range of technical, cultural and management reasons.

The failure of Nortel is a complex and dramatic story in the annals of Canadian corporate history. We hope that this report, in complement with the other reports in the uOttawa series along with a number of academic papers arising from this research, will assist people; in particular business executives and their cadre, policy makers and students of business, in being better prepared for unintended consequence of rapidly changing markets, technology convergence, the marrying of different business cultures and responding to dynamic transformations in many directions concurrently.

Chapter 1

Introduction

1.1 Preamble

This report is about the role of technology and technology management at Nortel and provides an assessment of these factors in respect to the demise of Nortel. The report is referred to as the *Nortel Technology Lens Report*, one of a series of documents issued by the University of Ottawa as part of a multi-year investigation into learning lessons from the failure of Nortel.[1]

1.2 Problem Statement

The research team set about to examine Nortel's technologies and technology management practices, including organizational structures and practices that shaped the governance of the technology function. This was done with a view to learning whether the technology aspects of Nortel's business offered any systemic evidence of contributing to the corporation's failure.

1.3 Summary to Approach & Methodologies

As guiding principles, this project in its entirety, used the collapse of Nortel to learn more about corporate failure, about its causes and potentially about how analogous failures can be prevented. Consequently, the approach to this project was multifaceted. Moreover, it was not oriented toward assigning blame. Consequently, there is no attribution to any identifiable individual. Interview quotes are provided, but only in an annonomized manner. The only reference to person's names coincides with the various 'timelines' in the history of Nortel, as exemplified by the 'era' or 'term' of each of the CEOs during the study period from 1996 to 2009.

This is the fourth report in the uOttawa Nortel investigation, the others being a *Principal Findings Report*, an overall *Methodology Report*, and a *Governance Report* as viewed from a legal perspective. The reader is directed to the uOttawa website for background and details on the project methodology at: http://sites.telfer.uottawa.ca/nortelstudy/, in addition to finding access to the other reports just mentioned. The site also contains media reaction to the earlier reports.

What follows is a summary of the methodological approach developed by the technology lens team in the Faculty of Engineering and coordinated with other members of the research group in the Telfer School of Management and the Faculty of Law.

[1] The idea of a 'lens' report derives from the fact that the interdisciplinary research team shared large quantities of common data and information and in so doing applied their diverse views to this common pool in the metaphorical sense of viewing the pool through different disciplinary 'lenses', focusing on distinct functional areas of Nortel's operations and practices within its industry and within the changing market conditions of the time.

Multiple lines of enquiry were used in developing this report. They included annonomized interviews and online survey results, independent research via library and internet materials, internal reviews of Nortel and other company and industry data and information, relevant industry, academic and media reports, and materials supplied to the team by sources from within and external to Nortel. These resources were all used with a view to gleaning an understanding of the technology story at Nortel over the study period.

Interviews included former senior staff of Nortel including CEOs, competitors, customers, and government officials; as well as media representatives and thought leaders in telecommunications. In addition, information was collected from several hundred participants to an online survey that solicited views to specific questions along with unstructured comments to their answers. Members of the Board of Directors of Nortel were not interviewed owing to legal implications associated with the wind-up of the company.

This report does not examine commercialization strategies, product lines or individual products other than by example. However, in order to appreciate the technology choices and transformations made by Nortel post 1996, a critical time in respect to the technological choices made by Nortel, the framework for this analysis has looked back in broad terms over a period of two decades prior to the formal study period. Much of this 'looking back' is reflected in charts and associated descriptions in order to establish technology and technology management patterns and to watch those change over time.

Given the uncertainty at the onset of the study as to why the company failed, other than the perception that it ran out of operating funds, the entire research team adopted a 'grounded' theory approach, an accepted methodology for seeking patterns within available information without applying any *a priori* conditions.

The information collected was then examined by the investigative team in order to develop a failure analysis model as a framework to map out the lessons learned from the various lens views. As a final step, and an important one when a grounded approach is used, we assembled our findings and presented them to an external and representative group who participated in supplying information for the study and that the research team felt would be in the best position to tell us whether our interpretation of the interviews and the analysis of all the information at hand provided appropriate insight into the demise of the company and our reasons why.

With respect to setting the study timeframe, Nortel reached its peak in terms of market value and industry position in 2000-2001 under CEO John Roth. Consequently, the overall study start point was initially set in the mid-1990s at the beginning of the rapid rise of Nortel to global dominancy. However, as the technology team undertook more interviews and other related investigations, we came to realize that decisions made in earlier times, coupled with a culture forged in the early days were possible contributors to the failure of the company. Consequently, this report casts back some additional twenty years prior to the formal study period (1996 – 2009) to examine the origins and dynamism of Nortel's technology focus and changing fortunes from then until the end.

1.4 Data & Information Gathering

To address the problem statement above, we set out to first identify relevant information from the multiple sources previously identified. This was followed by an extensive period of data and information collecting and analysis. Moreover, during the multi-year information gathering phase, we were able to

identify gaps in information associated with the timeframe of the study and were subsequently able to fill and supplement our then current information holdings by further interviews and examination of additional information sources.

1.5 Principal Findings

Nortel depended on creating and gaining access to technologies essential for its various product offerings. Our research shows that, until the end, Nortel's technology, people and adaptability remained among the best in the industry. However, the attempt to gain technology through acquisitions was a general failure. Once the company began to return to its roots circa 2004 and to re-focus on developing technology in-house rather than on trying to acquire technology through acquisitions, it managed to revive its leading-edge capability of the past. At the time of filing for protection from creditors, Nortel held leading technology in a number of emergent areas, notably in 4G/LTE wireless, in long-haul optical and in other fiber-optic transmission technologies. What follows are the details that led the team to the findings noted above. The technology lessons learned are covered in Chapter 5.

Chapter 2

Nortel Technology

2.1 Overview

Nortel Networks Corporation, or Nortel for short, was a Canadian headquartered multinational telecommunications and data networking manufacturer that operated from 1895 to 2009. At its height, Nortel accounted for more than a third of the total valuation of all the companies listed on the Toronto Stock Exchange (TSX) and employed some 94,500 worldwide, of which some 12,600 were technical experts in such fields as engineering, physics, computer science and human factors as well as industrial design and ergonomics.

Fundamentally, Nortel did not fail because of its technology or because of allegedly wrong choices in terms of specific technologies. The basic technology issue was the erosion over time in the senior management's confidence and willingness to continually recognize and appreciate the strength of the in-house technology capability.

Nortel's technology managers identified the key emergent trends in the market sufficiently early to create both speculative and potentially competitive products, such as Internet Protocol routers and wireless access systems. However, by the mid-90s Nortel no longer created products speculatively; instead the company chose to wait for a clear market demand. As a result Nortel lost valuable time to market and at the same time lost its market leadership role.

This situation arose as a result of executive management misreading the pace of convergence between traditional telecommunications networks and the commercialization of the Internet, at the time a means of data communication and sharing that resided on leased lines from telecommunications networks. As such the early Internet was developed independently of telcos and their traditional suppliers, with much of the development work carried out in universities and government laboratories, primarily in the United States.

Nortel's primary R&D centres were located in Canada, the United States, United Kingdom, and China. In Canada, the main facility was the R&D centre in Ottawa, which was also corporate headquarters for research and development. There were additional R&D sites in Montreal, Belleville, and Calgary. In the United States, the company's major R&D sites were in Research Triangle Park near Durham, North Carolina; Richardson, Texas; Billerica, Massachusetts; and Santa Clara, California. The main UK R&D centres were in Harlow and Maidenhead. Facilities for R&D in China were primarily in Beijing with smaller labs in a number of locations in eastern China. Other labs were scattered around the world in such places as Tokyo, Japan and Wollongong, Australia, and in North America places such as Atlanta, Georgia, Ann Arbor, Michigan, and Edmonton, Alberta. As recently as 2006, Nortel established an R&D facility in Bangalore, India.

Many lessons were learned with respect to both technology decisions and technology management. For example, a fundamental lesson learned is to avoid losing sight of the fact that technology companies need forward-looking technology vision and technology-oriented decision-making at key points within the organization (e.g., one former Nortel executive stated that over a time during our study period that only one of the top dozen or so Nortel officers had any technology background). While this does not mean that the CEO needs to be a technology visionary; however, such an individual should be near the top of the corporate hierarchy and should have the ability to make and enforce decisions. In addition, in the case of a company like Nortel with strong P&L divisions, an individual with a deep understanding of technology needs to be in a central role in each of the business lines and where possible, to act collaboratively across business units, especially when there was no central R&D lab .

2.2 Technology Environment over the Study Period

What follows is an explanation of how Nortel and its technologies and products fitted into the changing pattern as illustrated in Exhibit 1, which presents the general industry technology environment during the study period. It shows technology-based product trends in response to market conditions over four time intervals from pre-1996 to the winding-up of Nortel in 2009. It specifically focuses on wireline (i.e., switching and transmission), wireless, enterprise and optical offerings, all core products on offer from Nortel.

Exhibit 1
Changing Technology Environment over the Study Period

Product Area	<1996	1996-2001	2002-2005	2006-end
Wireline	Growth	Reaching Maturity	Mature & in Decline	Continuing Decline
Wireless in general	Emerging & growth (e.g., 1G in decline, 2G emerging)	Growth (e.g., 2G mature & 2.5G emerging, mature & decline with 3G emerging)	Growth (e.g., 3G)	Growth (e.g., 3G maturing, 4G emerging)
Wireless CDMA	Introduction	Introduction-Growth	Mature & in Decline	Decline
Enterprise	Initial product introduction	Acquisitions to assist growth	Growth	Growth – Maturity
Optical	Growth	Rapid Growth	Demand Collapse	Flat growth with increasing competition

Pre 1996 Nortel was a leader in wireline telephony across a range of switches, networks and access devices (e.g., handsets). By the early 1980s wireless telephony was emerging as a new and novel mode of

communications. In 1982 Nortel (then Northern Telecom) and General Electric (GE) announce plans to develop, manufacture, and market cellular mobile telephone systems, with Northern Telecom providing switching between base stations based on the DMS-100 and GE supplying cellular radio communications equipment. This marks the entry of both companies into the cellular radio telephone market. Nortel chose not to enter into either the wireless infrastructure or handset business at this time even though they had the technical capability. It is worth noting that at this time cellular wireless systems were not considered part of the telecommunications infrastructure.

From 1996 through 2001 conditions in the marketplace and within Nortel were explosive in terms of growth in the scope and scale of the company and its revenue streams. This was being driven by the emergence of a worldwide deregulated telecommunications infrastructure, coupled with rising consumer awareness and expression of needs, along with businesses moving toward global connectivity. Exactly how that connectivity was to be realised was a matter of speculation and Nortel decided, along with a number of other companies that a technology known as Asynchronous Transfer Mode (ATM) was the best technical choice to address the needs of the changing environment.

By 2001/2002 the telecommunications industry changed. It was the year that profoundly changed the relationships between customers and their suppliers, following the high-growth years of the late 1990s. This change in relationship marked a massive shift for companies like Nortel, which until then was telling customers what they needed in terms of technology and products to one in which customers were telling suppliers what they wanted and in the process transformed the procurement process across the telecom industry.

It is worth noting that the concept of 'customer' in the telecommunications industry changed around this time from the traditional service provider (i.e., telco), essentially telling the consumer or business customer what they could or, more significantly, could not have to one where consumers began having a voice and a choice. Due to deregulation and the emergence of alternative technologies, such as cable, providing connectivity, the consumer suddenly could choose supplier. If the consumer could not get what they wanted from their traditional supplier they could go elsewhere. The customer's needs were no longer those of the service provider, instead they were those of the consumer. Nortel did not respond to this change in the way that other suppliers did, some of whom responded enthusiastically to consumer demand and so embraced wireless technologies and Internet Protocol. Internet protocol had emerged as a very user friendly means of non-voice communication. Subsequently Internet Protocol has established itself as the communications protocol of choice, even for voice and other real time services, for which, technically, it has some limitations.

In the period from 2002 through 2005 both Nortel and its industry were hit by disruptive business and market changes rippling through the industry following the collapse of the so-called dot-com era, a period often referred to as 'irrational exuberance' after the introduction and initial growth phase of the first generation of commercial Internet companies through the last half of the 90s and into the beginning of the new century.[2] During this period product development had shifted to enhancements of mature

[2] "Irrational exuberance" was a phrase used by the then-US Federal Reserve Board chairman, Alan Greenspan, in a speech given at the American Enterprise Institute [December 5, 1996] during the Dot-com bubble of the 1990s. The phrase was interpreted as a warning that the market might be somewhat overvalued. (Source: http://en.wikipedia.org/wiki/Irrational_exuberance)

products with little effort compared to the past put into development of new technologies and new products, with the notable exception of 4G/LTE an emergent wireless access technology.

Acquisitions and strategic alliances continued, explored in Chapter 3, were a common practice in the industry since the mid-1990s and Nortel continued this practice into the 2000s, albeit at a significantly reduced pace and cost compared to the heydays of the last half of the 1990s. Acquisitions were primarily for technology and know-how; whereas, strategic alliances were dominantly marketing and sales arrangements rather than deep technical alliances.

From 2006 to the end in 2009 Nortel struggled to regain its footing. In the end, it failed. Product development had focussed on enhancements of mature products with little investment in future products. By this time, the business relationships and the belief that Nortel had a good vision of the future had gone with many key customers. Nortel became a company competing with little differentiation from competitors, what is known as a 'me too 'business. Nortel did not have the culture to compete on price and little else against emerging competition from the Far East.

Following the decision to file for protection from creditors in 2009, Nortel technology, in two distinct areas, 4G/LTE wireless and long haul optical was still leading the world, technology which was acquired by other companies, to subsequent significant success, when Nortel's assets were sold off later in 2009.

2.3 Corporate Perspective on Technology

Nortel's modern business success, circa 1970s onward, was based on a model of deep technological expertise that allowed the company to create entirely new markets and associated product lines, such as it did in leading the transition from analog to digital telecommunications. At that time, Nortel was highly regarded by the telecommunications industry for its technology leadership skills, product reliability and customer support. Bell-Northern Research, which served as the central laboratories for Nortel, enabled the company to gain and maintain a first-mover advantage in many markets for more than two decades.

Until the mid-1990s Nortel's business model was characterized as 'defining the future', Nortel, together with its symbiotic relationship with Bell Canada was able to define the technology and the service provider needs. As has been noted elsewhere, consumers had little say at that time in the products and services available to them so the voice of the requirement was to a large extent that of the service provider. This symbiotic relationship gave Nortel a significant advantage and was a barrier to new entrants in the equipment market. It worked when the marketplace for Nortel products was dominantly telecommunications service providers, so-called telcos (e.g., Bell Canada), and pre the rapid emergence of the commercial Internet and explosion in enterprise networking.

The company featured a flexible organizational structure that enabled it to allocate resources to identified opportunities. It was a business model based on conceiving, creating, designing , building and supporting products, While this model led to well-designed, reliable solutions, it also ultimately led to a culture of justified confidence , sometimes perceived as arrogance, and even hubris. By the mid-1990s, the global telecommunications marketplace was heading into a rapid transition resulting from the demand for computer networking and changes in regulatory frameworks, particularly in the United States. Suddenly Nortel was faced with an entirely new set of established competitors from the computer networking

industry. In fact, Nortel's somewhat close links with its service provider customers caused it not to act swiftly or with commitment to the changes that swept the industry well into the early 2000s.

Nortel achieved rapid growth in the late 1990s, however, the associated increase in physical and human resources led to an increase in overhead and unnecessary duplication of effort across the company. Moreover, as the company reacted to the emergence of Internet technologies beginning in the late 1980s and to the opportunities presented by the late 1990s anticipated massive demand in capacity created by the exuberance of the dot-com boom, Nortel chose to embark on acquisitions to fulfil anticipated technology and product needs. This approach proved to be a failure because ill-chosen and poorly integrated acquisitions de-focused and over-complicated the organization.

2.4 Key Technical & Corporate Milestones

Exhibit 2 presents four profiles along with time that are characterized by a 'corporate' bar illustrating key events from a business perspective. This provides a context for the 'technical' bar, which identifies major technical advances over the same time period. This view spans the period from roughly 1970 to 2010, forty years of Nortel history.

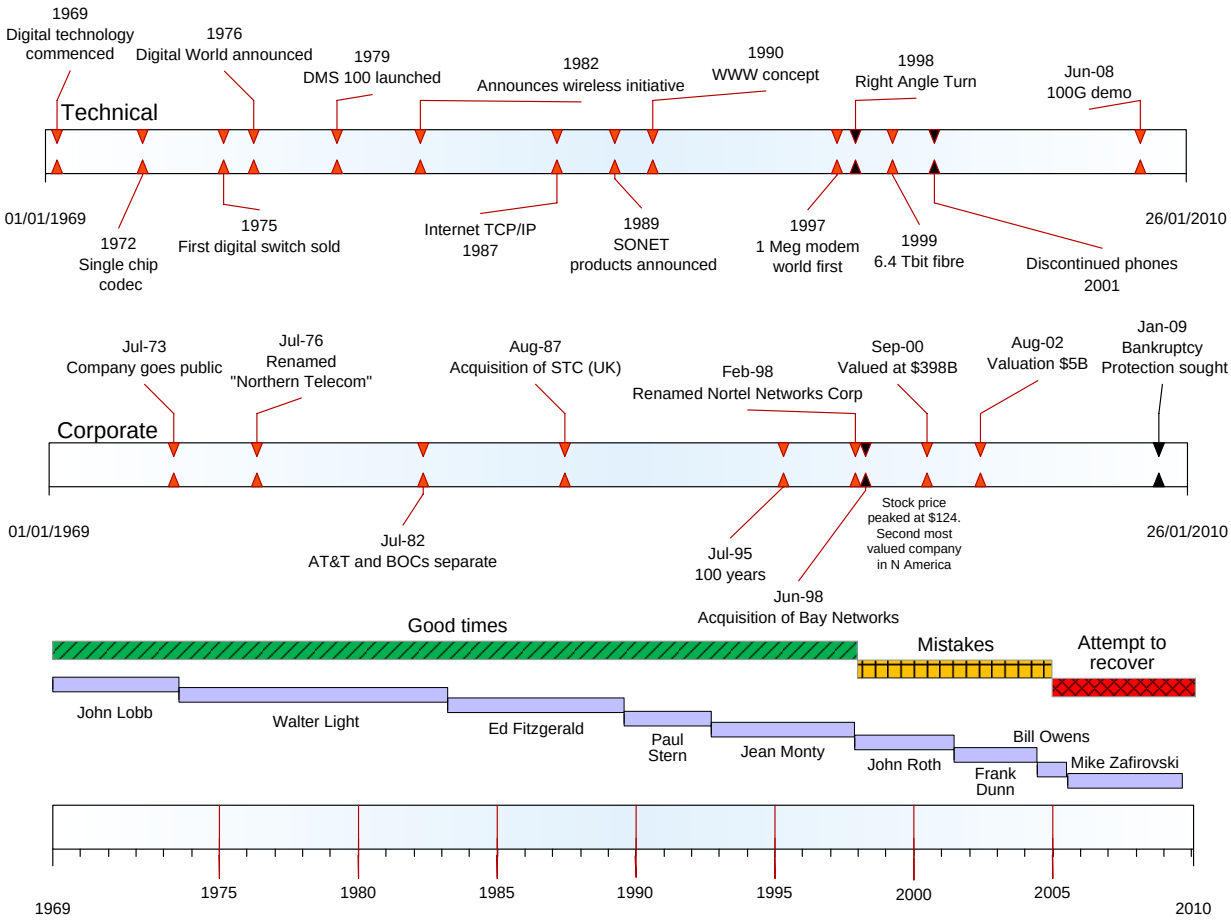
The third bar down reflects the general state of Nortel's business environment as characterized by three periods: green – exceeding customer requirements, thus leading to growth and 'good times'; yellow – meeting customer requirements but losing its competitive edge by no longer exceeding customer expectations as a result of various internal mistakes; and red – indicative of not meeting customer requirements and consequently losing market share and leadership positions culminating in 'bad' times coupled with a late attempt to recover lost ground. The transition from 'good times' to 'bad times' took less than five years, a massive shift for a large corporation.

The next bar down captures the era for each of Nortel's CEOs during the various events summarized in the exhibit. As can be seen, the CEO eras tend to become shorter over time, the implications of which are addressed in the general findings report associated with this series.

The corporate bar shows a number of key events, basically from first going public in 1973 to filing for protection from creditors in 2009, a period of some 36 years. The exhibit also shows changes in the corporate name, stock market valuations and some key external events like the breakup of AT&T in 1982 and the acquisition of Bay Networks in 1998.

The technical bar illustrates a number of major Nortel accomplishments in both technologies and products over this same 36 year period, with the bar below it illustrating what in hindsight is labelled 'good times' approximately 25 years, from the 1970s through the early 2000s. This was followed by a period of about four years labelled as 'mistakes' and involved four CEOs over such a short period. What followed was about five years of effort to correct mistakes; but in the end failed to rescue the company. The bottom bar provides the name and duration of the CEO of the time.

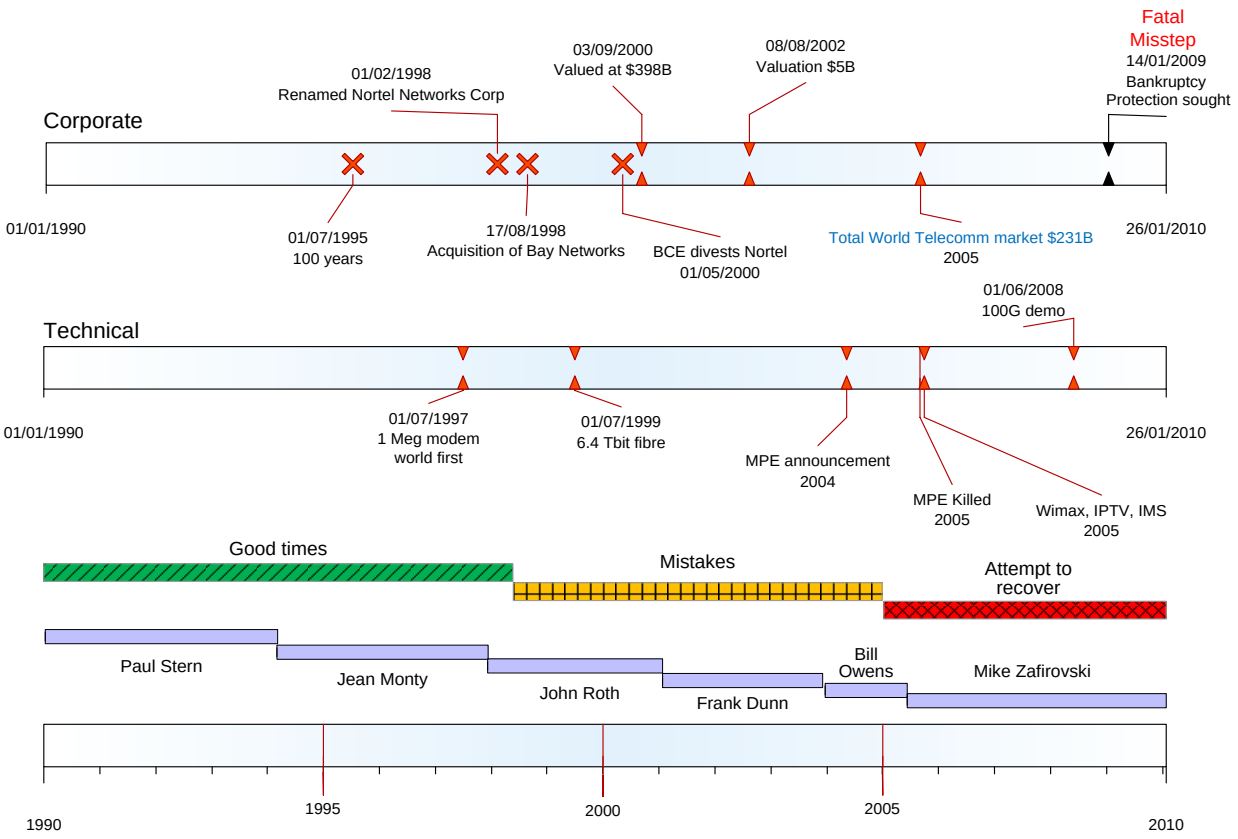
Exhibit 2
Key Technical and Corporate Milestones: The Long-view (1969 – 2009)



Using Exhibit 2 as a backdrop, Exhibit 3 telescopes into the period from 1990 to 2010 and presents a profile with more detail on corporate and technical events at Nortel over this time period. For example, on the corporate bar the acquisition/merger with Bay Networks, at a cost of $9.1 billion, resulted in little added value and significant added overhead costs as discussed in the section below on acquisitions, a decision we have labelled a 'misstep'.[3] Yet within four years after the Bay Networks acquisition, Nortel reached the peak of its market valuation at $398 billion by the end of the third quarter of 2000. Less than three years later the valuation of Nortel collapsed to some $5 billion during a period of tumultuous change in the industry and the market place. Ultimately, Nortel failed to adapt to that change.

[3] Note that all dollar values are quoted in US currency.

Exhibit 3
Key Technical and Corporate Milestones: Short-term (1990 -2009)



As an example of Nortel's innovation at the time, mid-1997, was its 1-Meg Modem early market entry digital subscriber line (DSL) products, a mass-market consumer product, that delivered Internet access more than 17 times faster than the standard 56K modem of the day, while at the same time it offered simultaneous voice service. In the first year of the 1-Meg model Nortel received more than $1 billion in orders for the product.

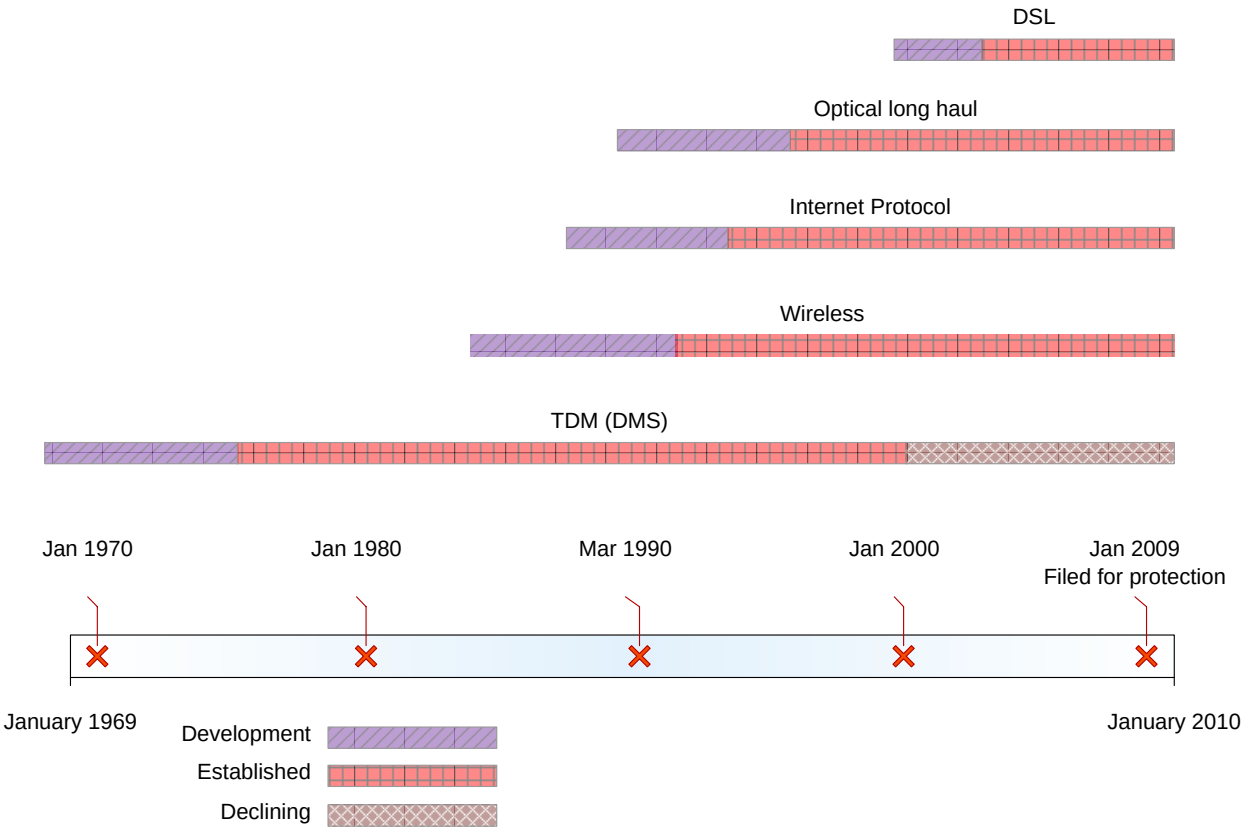
2.5 Technology-based Offerings

Exhibit 4 sets out an historical to contemporary macro picture of Nortel's technology-based offerings spanning some 30 years. Each bar represents a major technology defined product set that has up to three states noted on each. The first of these states relates to the emergence of a new technology-based product offering according to the technology label on the bar in what is referred to as 'development', when both products and markets are emerging through the actions of early adopters. Typically, Nortel was either early into this first phase of new products or was in fact the market leader and definer of new products.

The 'established' phase corresponds to general market acceptance and is dominated by early and late majority adopters. This is followed, in the case of time division multiplexing (TDM), the longest bar, by a 'declining' state of growth that set in around 2000 following the dot-com crash; however, products remained mature and sustaining until the end of Nortel.

The technologies mentioned in Exhibit 4 are further ordered from the bottom up beginning with the earliest technology offering and ascends to the latest offering illustrated, DSL. Each is shown by different shading according to the key for the Exhibit. This pattern represents the general condition with respect to emerging, sustaining and declining market conditions and the time when Nortel made its decision to engage in each of these areas.

Exhibit 4
Technology Offerings from Nortel



The longest bar also represents a full product cycle beginning in the late 1970s when initial R&D provided the basis for some 25 years of world-dominating technical product leadership, followed by a decline in market demand as Internet Protocol and wireless technologies began to make headway in both the conventional telco and emerging enterprise markets. Only the TDM era had reached a state of decline by the early 2000s while all the other technology and product offerings continued through to the demise of Nortel in 2009.

Wireless technologies at Nortel went through fits-and-starts beginning in the early-1980s. Although Nortel was an early player in wireless technology development, the company chose to initially focus on the North American market, which adopted a US corporate standard for wireless communications, namely CDMA, a proprietary offering from Qualcomm. The reason for this choice was based on the technical status of these two competing standards at the time; one closed, (CDMA) and the other (GSM) created by an open consortium. The proprietary approach worked at the time of Nortel's initial evaluation of these approaches. As a result, Nortel created wireless products for CDMA, notably base stations and related infrastructure, but chose not to supply access devises such as mobile phones. However, only the US, Canada and Israel adopted CDMA, whereas the rest of the world adopted the post 1G European standard referred to as the Global System for Mobile Communications, originally Groupe Spécial Mobile (GSM).

Example of Nortel Innovation Ahead of Demand

By 1996, Nortel was the first company to transport 10 gigabits of information per second along a fiber optic cable. Other fiber optics manufacturers only caught up to this benchmark some four years later.

At one point in 2002 a Nortel executive proclaimed to employees, "the world has spoken and they have chosen CDMA". This was claimed when CDMA represented about 10 percent of the 2G market and GSM about 80 percent of that market. The world had spoken but not in favour of CDMA. This is indicative of how US-focused and apparently out of touch with reality the executive team had become.

Licensing rights to CDMA technology by Nortel was a departure from the company's more traditional approach of developing such capabilities in-house. In the interest of shortening time-to-market, the company opted to license rather than develop its own proprietary approach or to adopt GSM at the time.

Wireless and Internet Protocol eras exploded in market demand from their time of commercial introduction, wireless in the late 1980s and Internet Protocol around the mid-1990s.

Over the period of investigation one can see that there were four generations of wireless technologies, namely 2G, 2.5G, 3G and the latest 4G, which is based on Long-term Evolution (LTE). In Nortel's case the company was unable to scale its 2G, 2.5G and 3G wireless infrastructure to become a top tier supplier in terms of market share. Recognizing this limitation a concerted effort was put into 4G technologies, notably in an effort to be an early mover using the LTE standard. In the end, Nortel was an early mover in LTE technology; and its product market was just starting to emerge at the time the company ceased trading.

Internet protocol (IP) was emerging as a new de facto industry standard around 1995. Although Nortel labs were knowledgeable about IP, it was not incorporated into Nortel products of the day. At the same time, IP was now being seen by senior management of the company as being a protocol that would form the basis of many new product offerings from both traditional competitors and new suppliers, mostly coming from the computer networking vendor community (e.g., Bay Networks). As a consequence, Nortel executive management decided to engage in a rapid path to IP-based technology and products by announcing to the world that the company was making a 'right angle turn' from traditional telco offerings (i.e., 'dial tone') to IP-based products (i.e., 'web tone') and launched a massive multi-year acquisition frenzy by acquiring a plethora of companies across the scale of enterprises from start-ups, SMEs to even larger firms with thousands of employees. Acquisitions and their consequences are discussed in more detail below.

Having recognized the emergence of IP in the industry Nortel embarked on a program to acquire IP products. Despite Nortel's own staff having the capability, Nortel executives felt that the time scales needed to develop their own products did not match their customers' needs. As a result they embarked on a hastily assembled program to acquire products through buying companies that already had such products. This program was in some part a result of observing others, notably Cisco, successfully acquiring companies, and with the observation that the stock market rewarded such acquisitions. It is also worth noting that the view of excessive time required to internally develop products was not generally shared by those tasked with developing those products. It was viewed as a 'vote of no confidence' by Nortel technical staff, in their ability to deliver.

Nortel dominated the market for long-haul optical for many years from its introduction to the market in the mid-1990s to the faltering years of the company after 2002/2003. Long-haul fiber is discussed in more detail further on in the report.

Although Nortel technology and product suites were widely available in the marketplace, by 2004 many major customers began to back away from strategic investments in longer-term relationships with Nortel and instead sought to buy replacements and parts related to existing Nortel products in the customers' asset inventories.

By 1997 Nortel had emerged as the clear global leader in a number of key areas, notably it had 26 percent of the global market in both SONET (Synchronous Optical Network) and SDH (Synchronous Digital Hierarchy) optical systems-- —SONET and SDH are extremely robust protocols for carrying high speed optical information across fiber networks.

As well as SONET and SDH, Nortel captured 32 percent of the global market in DWDM (Dense Wavelength Division Multiplexing) systems (the means by which different light waves, each carrying a separate stream of data, are closely combined along a single fiber).

2.6 Nortel's Right Angle Turn

The Right Angle Turn has been variously characterized as an aggressive business transformation aimed at shifting the company from a dependency on technologies and products for the world of copper wire to one with a world of fiber optics as the principal communications pipes. Nortel aimed to transform itself from an in-house developer of traditional products to an agile developer, acquirer and integrator of products for the new age of products and services driven by consumer and business pull rather than telco push. This also could be viewed as a dramatic shift from a dependency on voice processing technologies to one focused on mixed voice and non-voice processing technologies (e.g., multimedia data).

Customers' needs provide an interesting perspective as to why change was needed at Nortel. For many years Nortel had worked closely with their service provider customers (i.e., telcos) and was well aware of their needs. Nortel did not fail to listen to these customers. The problem was their telco customers were not listening to their own customers, at least not then. The notion of 'customer' changed from being a provider of "take it or leave it" to consumers and businesses to one were suppliers needed to listen to consumers and businesses because now they had a voice and a choice by the late 1990s. This is the change to which Nortel needed to be sensitive; but was not. Having abandoned any consumer products, telephone sets, wireless handsets and similar access products, Nortel lost touch with the rapidly emerging and demanding consumer base (e.g., wireless communications). Moreover, Nortel's traditional customers

actively avoided wireless and Internet Protocol, seeing them as parallel and threats to their traditional business.[4]

If one examines the markets for Nortel products since the 1970s, while comparing Nortel's product offerings with respect to the dominant telecommunications model over the same period, the one represented by the hierarchical stack promoted by the International Standards Organisation (ISO), one can see from Exhibit 5 that Nortel products were concentrated in the lowest two layers of the stack, the telecommunications hardware and networking layers.[5] In the 1970s through the emergence of the commercial internet in the late 1980s and early 1990s Nortel played a dominant role in these chosen growth markets. In the late 1980s, Nortel refocused its product lines and research to reflect a common message across several platforms, such as the Digital World initiative in 1986 to create the first end-to-end digital network.

However, by the early 1990s products based on these lower ISO layers (e.g., Nortel's) were becoming commoditized with many competitive choices, including entrants from the computer networking industry, such as Cisco and new telecommunications suppliers from China, such as Huawei. Nortel failed to see added-value by moving up the stack based on its own technologies (e.g., where companies such as Apple and Google have progressively moved up from their original positioning in the stack, consequently adding significant new value in the process). Instead, Nortel chose to move its focus from copper wire-based technologies to optical fiber-based technologies without moving up the stack to higher value-add opportunities in new and emerging markets. This decision is known as Nortel's Right Angle Turn.

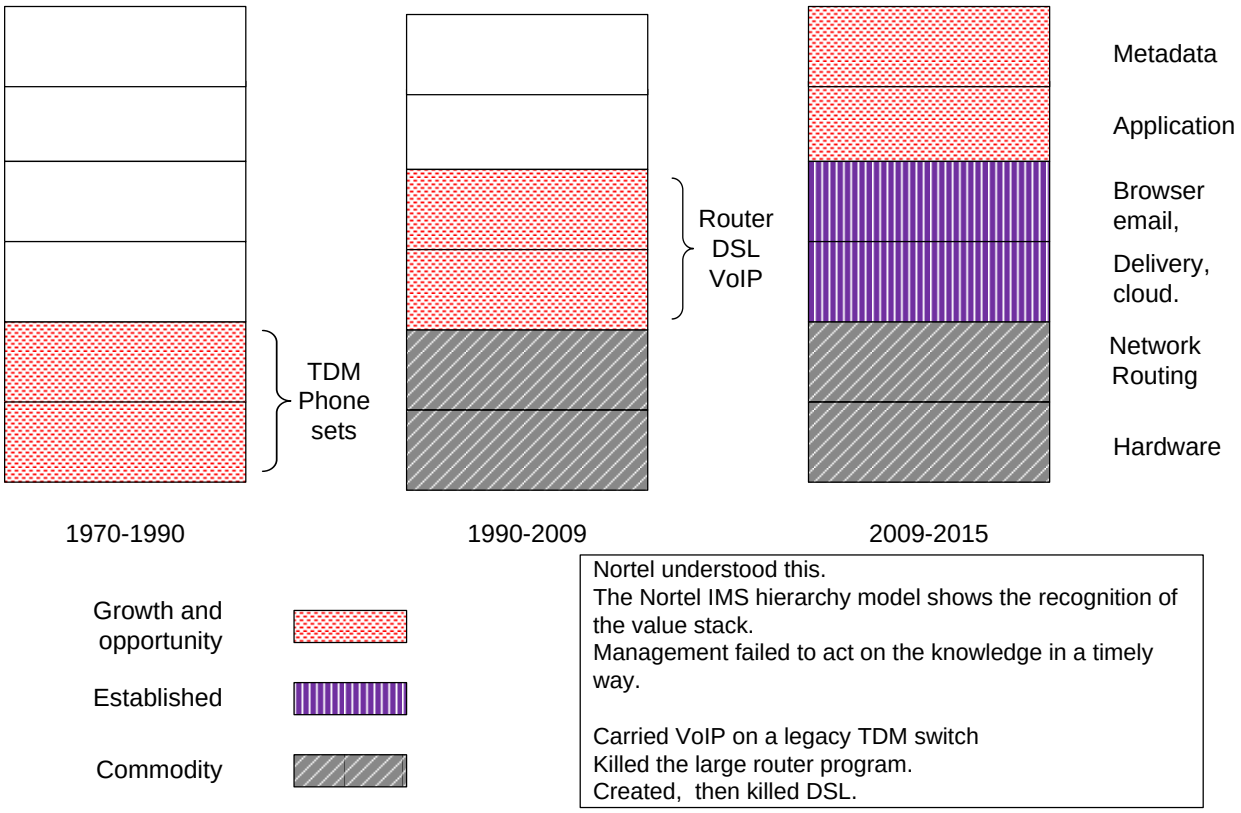
The company chose to only offer high margin products once the lowest layers transformed from high-value products to commodity products at commodity prices. This turned out to be a classic mistake for many reasons, well documented in management text books. Nortel also made the mistake of proudly announcing this philosophy, to the chagrin of their customers.

Exhibit 5 illustrates the progression and the fallacy of the so-called Right Angle Turn. The 'stack' view presented in here is a stylization of the OSI model as presented in Annex 3. The first layers to be developed and implemented in product functionality were layers one through three, the hardware and operating system layers added to this were various middleware options, some of which Nortel was a player and others, such as Internet Protocol, were technology staff were knowledgeable; but the company remained uncommitted with respect to introducing IP into Nortel products until Nortel took its Right Angle Turn in January 1998.

[4] As an example, British Telecom as recently as 2014 bought a major UK wireless company, having sold their wireless interests two decades earlier in 2005.

[5] The Open Systems Interconnection model (OSI) is a conceptual model that characterizes and standardizes the internal functions of a communication system by partitioning it into abstraction layers. The model is a product of the Open Systems Interconnection project at the International Organization for Standardization (ISO), maintained by the identification ISO/IEC 7498-1.
(Source: http://en.wikipedia.org/wiki/OSI_model)

Exhibit 5
Vertical Migration and Expansion - Not a 'Right Angle Turn'



Nortel sought to address this by buying companies whom they perceived as being agile and responsive. Employees in Nortel were assured that this change would provide complementary products which would integrate into Nortel's current product line. In reality these products did not integrate well, many simply did not work and almost invariably the engineering fell short of Nortel's high standards. Technical staff at Nortel were disillusioned with this change, which many perceived as negative and undoing the well established reputation that Nortel had built for creating solid products.

The term 'Right Angle Turn' was an unfortunate choice because it suggested abandonment of what had gone before rather than complementing and building on it. Soon the term 'wrong angle turn' began being heard in the corridors, which should have been a clear message of concern for the executives.

2.7 Skunkworks

Skunkworks were not uncommon at Nortel during the heady days, as noted elsewhere in this report. For example, Nortel came up with an iPhone-like device 15 years before its introduction by Apple in 2007. Phones are known as access devices (i.e., they are used to access wireline and wireless networks). Despite such inventions, Nortel chose to step out of providing access devices and concentrated on the infrastructure. That decision also constrained Nortel to operating in the lower layers of the ISO stack, as noted above.

2.8 Professional Services

As enterprise business developed, Nortel established a Professional Services group, primarily comprising network engineers to provide consulting in network design, sources, deployment, and maintenance. This was an emerging trend in industry as exemplified by IBM's re-focus from hardware to services. It had an added benefit of allowing engineering staff to experience firsthand working directly with customers and hearing of their needs directly rather than through sales and account management channels only. Professional Services was disbanded with the collapse in market demand in early 2002, having never met its intended business objectives.

What Nortel failed to grasp is that value had moved from lower layers ('bit hauling') to applications and services. Nortel's attempt to enter into applications and services was driven by their traditional customers' approach and implementation of integrated multimedia systems, or the so-called 'walled garden' whereby service providers' control their customers' Internet access to services. At the time the 'walled garden' was soundly rejected by consumers, businesses and regulatory authorities as a restrictive business practice.

2.9 The Changing Status of Nortel Technology & Product Offerings

Nortel has been an active technology innovator for many years. In respect to telecommunications, it is widely acknowledge that Nortel was a pioneer in the definition, development and introduction of digital telecommunications. This era began at Nortel in the 1970s and continued for the next 30 years before the company lost its way in the industry and market transitions that caused Nortel to step out of its traditional business model by going on an acquisition 'binge' to acquire technologies, products, and additional expertise. This was done because executive management perceived that a fundamental re-ordering of the entire telecommunications industry was underway as more and more of the marketplace moved to IP as the foundational protocol for communications.

By the early 2000s customers were emphatically clear to their suppliers that they were simply no longer accepting just any new technology their suppliers served up, no matter how good it might be. By example, here is a quote from the CEO at the time in a memo to file. "They're [customers] insisting the technology that companies like ours provide must help them gain tangible, competitive and profitable business advantages. They want value for their money -- and value on their terms. We're not selling technology for technology's sake; rather we're focused on selling technology that solves customer needs and problems."[6]

Using the general market situation throughout the study period, it became possible to map Nortel's offerings into the pattern as shown in Exhibit 6, which illustrates the changing status of Nortel product offerings across the same four time periods from pre-1996 through 2009. The colour key represents the various states in Nortel's ability to meet customer requirements as described by former large Nortel customers during the data gathering phase of the project and according to the following coding schema.

[6] CEO memo regarding reflections on the year 2002, dated December 16 2002.

Exhibit 6
Changing Status of Nortel Technology & Product Offerings

Code	Code Meaning
Dark green	Vastly exceeds customer requirements (e.g., dominant in the days when Nortel told customers what they needed)
Light green	Exceeds customer requirements
Yellow	Meets customer requirements
Orange	Falling behind customer requirements and/or competitors' products
Red	Does not meet customer requirements

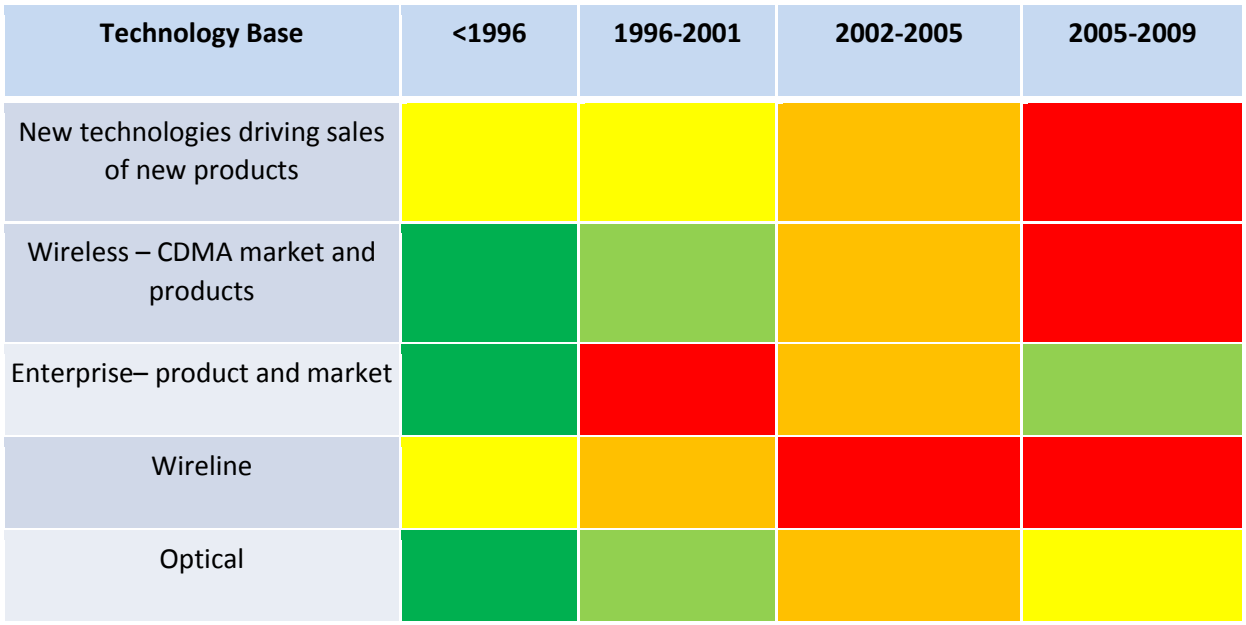


Exhibit 6 is telling with respect to illustrating in what areas and over what timeframes Nortel's product offerings waxed and waned. As can be clearly seen, the introduction of new technologies and associated products was meeting customer demand in 1996 through 2001 but began to ebb in 2002 through 2005 in respect to not meeting customer requirements while at the same time Nortel was falling behind in new product introductions in comparison to its rivals (i.e., there were no significant new products introduced between 2002 and 2009). By 2005 through to the final days of the company both technologies and product offerings were falling into the red, in other words not meeting customer requirements.

Wireless – CDMA market and products were exceeding customer requirements in the 1996 – 2001 timeframe; but began to lose that edge such that by the 2002 – 2005 timeframe leadership had slipped to falling short in meeting customer requirements. This downward trend in failing to meet customer needs was even more evident in the interval from 2005 – 2009.

The enterprise– product and market in the period from 1996 – 2001 was failing to meet customer needs, primarily due to software problems, and by 2002 – 2005 the company had improved its position with respect to this situation; but it was still failing to meet general customer needs. This situation was to improve further by 2005 – 2009 when Nortel finally began to exceed customer requirements. Consequently, this product line was improving throughout the general period when Nortel began to implode and then fail.

The wireline story is another one about lost opportunity. During 1996 – 2001 the company was falling short in meeting general customer requirements in wireline. This trend deepened in the remaining two study intervals from 2001 through to 2009 as illustrated in Exhibit 6, where Nortel generally failed to meet customer requirements across the board while cutting back on product offerings in this mature and declining market segment.

The optical business segment began the study period in a similar state to the wireless – CDMA market conditions in 1996 through 2001 and again 2002 through 2005 based on customer comments applicable to these intervals. In other words, in the first period Nortel's optical products were exceeding customer requirements and were seen as being ahead of competitors products; however, by 2002 – 2005 according to customer views, Nortel was beginning to fall behind in an ever increasing competitive optical market space. In recognition of this 'downturn', Nortel was able to redress customer issues and began again to meet customer requirements in the period 2005 – 2009. It is also telling in that the sale of the optical division was one of the cornerstones in the asset stripping of the company that ensued after the Board decision to dispose of assets.

2.10 Access Products & Technology

Access products and technology refers to equipment used to enable customers, be they business or residential, to connect to telco equipment (e.g., called the Central Office in North America and the Exchange in Europe). Today access is often by wireless means, but during the period of this study, wireline dominated.

Wireline

Nortel had been very successful in access products, from the early days of analog line interfaces, through the introduction of digital switching. Digital switching necessitated converting the analog signal and functions to those that can be implemented in a digital network; so, voice coding in both directions, ringing, dial tone generation, and on and off-hook status all needed to be implemented on a per line basis at the switch.

Nortel designed and built the most cost effective line card and continued development of this technology right through to a world-leading digital ISDN interface, a service adaptive line card that could self-sense its connection, to offering the first Digital Subscriber Line (DSL) technology operating at 1Megabit/second along with its complementary DSLAM (Digital Subscriber Line Access Multiplexer).

Telephone Sets

Nortel created telephone sets that were generally regarded as 'best in class', particularly by the business community. Residential telephone sets were liked by the telcos because of their ability to work on old infrastructure (wires) at long distances from the switch, as required by telco standards. This differentiated

them from low price consumer products. However, Nortel products were more expensive to produce. Once the market opened to enable consumers to connect their own products, Nortel products were uncompetitive except for consumers operating on difficult interfaces, typically remote rural customers.

First Data and Voice Terminal

Nortel created a terminal that could be used as a highly functional desk telephone set, or as a terminal for accessing information from remote computers. This was launched as an enterprise product in the early 1980s, years ahead of similar offerings from others.

Optical

Nortel created passive optical network (PON) technology for delivering high speed signals to and within subscriber's premises, both residential and business. Unfortunately, Nortel never invested in the commercialization of this technology to create viable products.

ISDN

Nortel created a chipset to provide then high-speed data and voice over subscriber lines. This was known as ISDN (Integrated Services Digital Network). The concept saw some success, notably in Japan and Germany, but in general it was a technology ahead of the applications to support it. It was generally less user friendly than Internet Protocol, though it had some advantages, notably, it could operate over maximum loop lengths as defined in the telco standards (i.e., distance of 18,000 feet from the Central Office), something which today's DSL technology still cannot achieve.

Digital Subscriber Line

Nortel was the first company to offer high speed Digital Subscriber Lines (DSL) by providing the residential modem and the access multiplexer, required by the telco to interface the DSL. This was a major technical and business breakthrough that enabled permanent connectivity and simultaneous voice and high-speed data over residential lines (e.g., copper wires). It enabled the emergence of the Internet that we know today.

In a few words, Nortel excelled at access technology and access products. Unfortunately, despite their leadership, it was decided by executives that access technologies had been relegated to 'commodity' status and did not enable the per unit margins Nortel desired for its products. In considering executive management decisions, access technology is an example of where Nortel could excel at a technical level but were cut off from this important area, at least in hindsight, due to a change in corporate strategy. Access has become a critical success factor in those companies that serve the Nortel market space today.

The success or failure of access products gives valuable insight into the thinking of consumers and business users. Additionally, during the 'over order' followed by 'reschedule or cancel', created by the exuberance of the dot-com boom, Nortel's competitors were sustained by their lower margin commodity products. Not so Nortel, which depended for a major part of its revenue on one product line, optical transmission, which was hit hard by the dot.com over order and then cancel cycle.

2.11 Long-Haul Optical

Long-haul optical transmission is the backbone for global telecommunications networks, carrying Internet traffic and traditional voice traffic that we use today. Nortel led in technology enabling high data rates as well as dense wavelength division multiplexing, facilitating today's ubiquitous Internet. At its peak it was estimated that 70 percent of Internet traffic was carried on Nortel optical transmission equipment.

2.12 Summary

Fundamentally, Nortel did not fail because of its technology or because of wrong choices in terms of specific technologies. The basic technology issue was the erosion over time in the senior management's confidence and willingness to continually recognize and appreciate the strength of the in-house technology capability. This was a consequence of attempts to change the internal culture of the R&D enterprise within the company.

This situation arose as a result of executive management misreading the pace of convergence between traditional telecommunications networks and the commercialization of the Internet, at the time a means of data communication and sharing that resided on leased lines from telecommunications networks. As such the early Internet was developed independently of telcos and their traditional suppliers, with much of the development work carried out in universities and government laboratories, primarily in the United States.

Nortel's technology managers identified the key emergent trends in the market sufficiently early to create both speculative and potentially competitive products, such as Internet Protocol routers and wireless access systems. However, by the mid-90s Nortel no longer created products speculatively; instead the company chose to wait for a clear market demand. As a result Nortel lost valuable time to market and at the same time lost its market leadership role.

By the mid-1990s Nortel withdrew from access products to concentrate on infrastructure. This was a corporate strategy decision, not a technology management issue. The success or failure of access products gives valuable insight into the thinking of consumers and business users. Additionally, during the 'over order' followed by 'reschedule or cancel' cycle created by the exuberance of the dot-com boom, Nortel's competitors were sustained by their lower margin commodity products. Not so Nortel, which depended for a major part of its revenue on one product line, optical transmission, which was hit hard by the dot.com over order and then cancel cycle.

Nortel also conceived and created various packet-based collision management standards, protocols and associated technologies in anticipation of potential market adoption regionally or globally. This approach to R&D was often pursued by Nortel labs as a way to hedge bets on market acceptance and to be ready with product before the competition. Thus, technology assessment was a key strength in the company and it spread its R&D resources across a range of anticipated technical choices for a range of applications.

As noted, Nortel led in technology enabling high data rates as well as dense wavelength division multiplexing, facilitating today's ubiquitous Internet. At its peak it was estimated that 70 percent of Internet traffic was carried on Nortel optical transmission equipment.

As enterprise business developed, Nortel established a Professional Services group, primarily staffed by network engineers, to provide consulting in network design, sources, deployment, and maintenance. It had an added benefit of allowing engineering staff to experience firsthand working directly with customers and hearing of their needs directly rather than through sales and account management channels only. However, Professional Services was disbanded with the collapse in market demand in early 2002, having never met its intended business objectives.

What Nortel executive management failed to grasp is that value had moved from the lower layers in the ISO model ('bit hauling') to applications and services. Nortel's attempt to enter into applications and services was driven by their traditional customers' approach and implementation of integrated multimedia systems, or the so-called 'walled garden' whereby service providers' controlled their customers' Internet access to services. At the time the 'walled garden' was soundly rejected by consumers, businesses and regulatory authorities as a restrictive business practice.

Fundamentally, the acquisition route was a radical departure from Nortel's traditional business model of leading by defining the direction of the industry rather than following. Nortel used to make 'everything' in the days when it defined the future; but came to make nearly nothing in the run-up to the dot-com boom and ultimately became a contractor, especially to its long-term customers such as the telcos, when Nortel shifted its product manufacturing offshore to contract manufacturers.

As noted, by the turn of the 21st Century some 70 percent of the world's telecommunications and Internet traffic flowing through Nortel supplied equipment and infrastructure. A clear sign of global leadership based on sound and reliable technologies packaged into world class products that were in demand.

At the time of filing for protection from creditors in 2009, Nortel held leading technology in a number of emergent areas, notably in 4G/LTE wireless, in long-haul optical and in other fiber-optic transmission technologies.

Chapter 3

Acquisitions and Strategic Alliances

3.1 Preamble

By the late 1990s, Nortel's executive management was convinced that the future of networking lay in the convergence of voice and multimedia (data) and that the underlying infrastructure to support that convergence would be based on Internet Protocol, a fundamentally different model of networking than the traditional voice communications infrastructure the world over. Given that vision, the next step was to formulate a way to implement it. It would take a three-pronged approach: acquisitions, alliances and internal re-orientation.

3.2 Acquisitions: An Overview

The principal reasons Nortel sought to acquire technology and products through acquisitions were threefold. Firstly, to narrow the gap in time-to-market while also trying to outmanoeuvre rivals that may also have wanted to acquire the same technologies, products and people that Nortel was targeting. For at that time infrastructure suppliers, both telecom and computer networking suppliers, were all engaged in transforming themselves through mergers and acquisitions (M&A) activities that were unparalleled in the history of the telecommunications industry.

Secondly, Nortel wished to establish technical, product and market leadership as a result of unifying voice and data network through a product set that let carriers, Internet service providers (ISPs) and corporate networks deliver data and voice traffic over the same Internet Protocol controlled infrastructure.

Thirdly, executive management wanted to change the culture of Nortel from that previously described to one that resembled an agile and dynamic organization that could both change speed and direction on a moment's notice. In order to inject this style into Nortel, particularly Nortel's R&D operations, it was deemed appropriate to acquire entrepreneurially driven companies, mostly from the US East and West coasts. This later point was a major reason for buying Bay Networks, the largest acquisition in the Nortel portfolio.

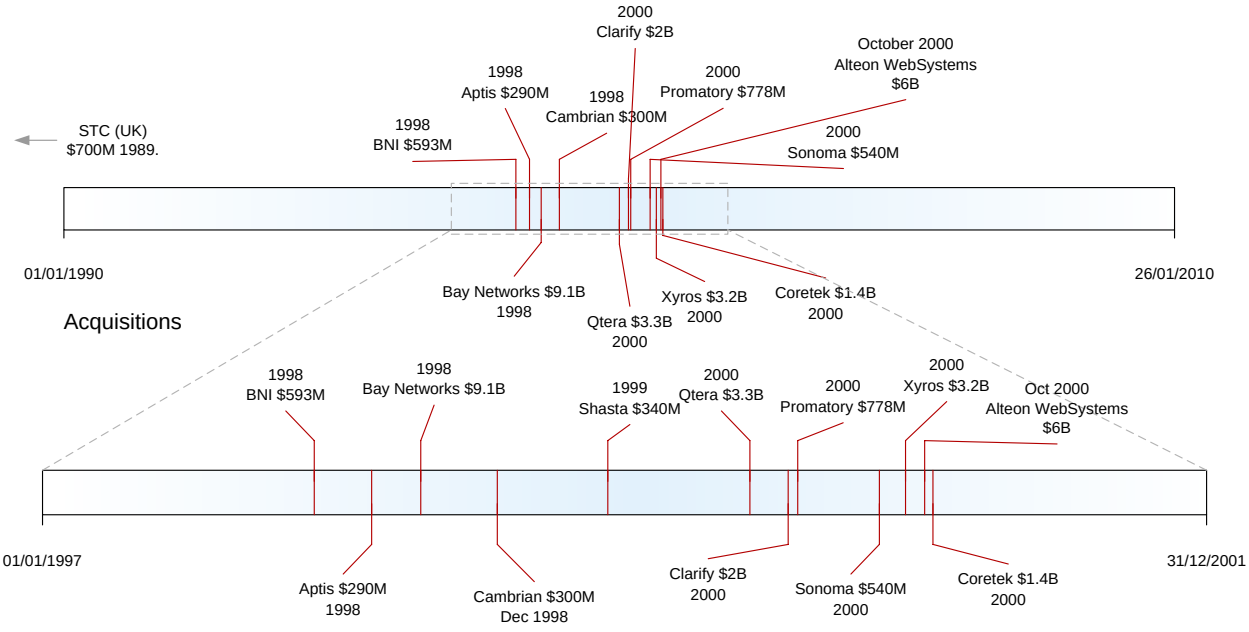
Nortel considered several options to fulfilling its IP vision of convergent networks, such as establishing a Nortel investment fund, a venture fund or a possible combination to offer support to companies that build technical solutions to Nortel specifications, to establish an internal acquisitions team that would source technology companies that meet certain Nortel technology and product requirements, and to work closely with key venture capital firms as strategic partners wherein the VCs would advise Nortel of promising companies that met the business needs given to these firms by Nortel. In the end, the third option was the primary vehicle used to undertake acquisitions. Nortel assigned nearly a dozen 'director level' managers to work and liaise full time with some eight to ten VCs. These staff would spend several days a week working on-site with the various VC partners. Among the VCs that Nortel worked with were Accel, Battery, Redpoint, New Enterprise Associates and VantagePoint in the U.S., and Ascend in Israel.

Executive management considered that Nortel's technical resources were not Internet protocol savvy to a degree sufficient to allow the company to simultaneously develop a number of IP-based products concurrently; moreover, management also felt that Nortel had a culture of taking its own time to develop and refine products in order to meet carrier grade requirements and the rush to address IP networks with both voice and data requirements was beyond its capacity to respond to market opportunities and create first mover advantage in a timely way. This made practical sense as a strategy; but the acquisition of companies was an entirely different business model and business practice that was fundamentally alien to Nortel. The company had little practical experience in acquiring and absorbing companies in terms of both the organizations as well as their product lines. These factors were to become the undoing of the company's M&A activities.

What follows is a brief examination of acquisitions noted in Exhibit 7, which illustrates the timeline for eleven acquisitions made by Nortel between March 1998 and October 2000, a period of just over two and a half years during which time the company dispensed some $27 billion in cash and stock. These companies were acquired primarily for their technology, technical know-how, and their agile business models. By the end of the acquisition binge in the early 2000s Nortel dispensed over $30 billion in cash and stock to acquire several dozen companies, many specific to their technology edge as deemed by Nortel and its advisors.

Exhibit 7

Timeline on Selected Nortel Acquisitions



These acquisitions ranged across a number of technical areas including IP networks, a variety of optical networking technologies, customer relationship management software, remote access data networks, and local multipoint distribution services, among others. Nearly fifty percent of the cost of acquisitions went to optical networking acquisitions such as Qtera, Clarify, Xyros, and CoreTek, which cost Nortel some $10 billion in stock and cash. This cost, along with those of other acquisitions, was further added to

through the process of absorption of people and technology and product integration efforts. This was followed by the additional cost of write-offs, as most acquisitions failed to yield revenues for Nortel.

On paper many of these acquisitions appeared to make sense as complements to Nortel's own technology and product offerings. However, Nortel failed to effectively absorb and integrate this diverse range of entrepreneurial companies. Fundamentally, this failure was a result of three broad issues: corporate culture across the ranks of Nortel staff, lack of an ability to effectively integrate acquisitions into Nortel due to poor choices with respect to technologies acquired, and misreading emerging market opportunities that failed to materialize, such as local multipoint distribution services.

During the mid-90s through the early 2000s M&A activities were at an all-time high across many industries; but especially among firms that were part of the convergence of telecommunications with computing and computer networking.

Four major acquisitions were completed in 1998, as discussed below, Winnipeg-based Broadband Networks Inc., a designer and manufacturer of broadband wireless communications networks (purchased for $593 million); Chelmsford, Massachusetts-based Aptis Communications, Inc., a start-up firm that concentrated on remote-access data networking (purchased for $290 million); and Kanata, Ontario-based Cambrian Systems Corporation, maker of an innovative technology to speed up Internet traffic (purchased for $300 million).

Purchases up until 1998 were then dwarfed by a $9.1 billion stock-swap for Santa Clara, California-based Bay Networks, Inc., which served the enterprise market with a range of data networking products and services.

In early 1999, Nortel announced it was investing $660 million to increase production capacity for its optical networking and components business, including the construction of a new laser fabrication facility in Ottawa. Then in November, Nortel announced a further $400 million expansion in optical networking, saying it would create 5,000 new jobs worldwide in systems integration and testing, engineering, supply chain management and customer service. This renewed drive into optical networking was the reason behind a number of significant Nortel acquisitions as discussed below.

Acquisitions continued in 1999 and featured three major buyouts. In January the company paid $3.25 billion in stock for Boca Raton, Florida-based Qtera Corporation, a manufacturer of long-distance optical networking systems. In March Nortel completed two acquisitions: the $2.1 billion purchase of San Jose-based Clarify, Inc., which specialized in customer relationship management software used in Internet communications; and a $778 million buyout of Fremont, California-based Promatory Communications, Inc., developer of high-speed digital subscriber line (DSL) Internet access platforms.

In July 2000 Nortel entered into discussions with Corning Inc., a major manufacturer of fiber optical cable, among other things, about selling its optical components unit to Corning in a stock swap. The deal could have resulted in Nortel owning a major stake in Corning; however, the talks failed to produce an agreement. Shortly after the Corning negotiations failed, Nortel announced its intent to acquire San Jose-based Alteon WebSystems, Inc. for more than $7 billion in stock. Alteon was a leading maker of specialized Internet switches used to speed response times at web sites. In August 2000 Nortel announced that it had agreed to buy Sonoma Systems Inc. for as much as $540 million in stock. Sonoma, based in Marina del Rey, California, produced integrated access devices for Internet access providers enabling them to simultaneously deliver high-speed video, data, and voice communications over a single connection.

3.3 Selected Acquisitions

Nortel made numerous acquisitions over the years with the most intense period of activity culminating with the implementation of the Right Angle Turn in the late 1990s and into the early 2000s. The following analysis looks at some $27 billion in acquisitions aimed primarily at access to technology and represented by the purchase of eleven companies between March 1998 and October 2000, a period of some 32 months. The acquisitions are presented in accordance with the timeline in Exhibit 7, above.

Broadband Networks

The *Broadband Networks Inc.* (BNI) acquisition was about broadband wireless. BNI was a Winnipeg, Manitoba based early stage private company with 240 employees at the time of its acquisition by Nortel. BNI manufactured RF equipment, network nodes and customer-provided equipment for radio systems ranging from 2 to 42 GHz. At the time of the acquisition BNI equipment was in commercial use in networks in Canada, the US, Korea and Japan. The deal was valued at $593 million.

Nortel's decision to buy BNI was in part influenced by a $780 million contract Nortel won to provide network equipment and services to Teligent, a privately held US telecommunications provided that was creating 28 GHz point-to-multipoint digital microwave networks to provide fixed voice, data and video services to businesses throughout the United States. As it turns out, BNI helped build a trial system for Teligent and was providing radios to Nortel for fixed wireless. Given the perception of increasing opportunities in broadband wireless, Nortel decided to acquire BNI rather than pursue product development through its own internal R&D.

The Teligent contract also was an important play for Nortel, particularly as the US Federal Communications Commission was, at the time, preparing to auction new spectrum for broadband wireless in what was referred to as the local multipoint distribution service (LMDS) frequency band, which was anticipated by Nortel to be replicated in many other markets throughout the world. Since Teligent was building a large-scale LMDS national network, with BNI help, what emerged for Nortel was a customer-driven opportunity to both acquire a strategic partner (i.e., BNI) and to position Nortel as a leader in a promising new market (i.e., LMDS).

LMDS showed great promise in the late 1990s and became known as 'wireless cable' for its potential to compete with cable companies for provision of broadband television to the home. Despite its early potential and the hype that surrounded the technology, LMDS was slow to find commercial traction. Consequently, the LMDS market failed to develop. As a result many equipment and technology vendors, including Nortel, simply abandoned their LMDS product portfolios (e.g., the essence of the BNI acquisition).

However, the view about BNI technology from Nortel engineering staff, as reported to us, was quite different. Nortel engineers examined BNI's multi-channel point-to-point wireless system prior to the purchase and reported that the engineering standards were such that it was unlikely to perform to specification. Nortel executives were warned of this. Non-the-less the decision was made to proceed with the purchase in order to secure the Teligent business. The technical staff were subsequently proved right. The technology never came close to meeting its design objectives.

Aptis

Aptis Communications, Inc., a start-up in Chelmsford, Massachusetts, founded in January 1998, concentrated on remote-access data networking. It was acquired by Nortel in June 1998 for $290 million in stock and cash. More specifically it was a developer of carrier-class access switches used by telephone companies and ISPs to integrate voice and data traffic on Internet Protocol networks, to create virtual private networks (VPNs), and to handle modem traffic. To offer Internet access and voice-over-IP networks, carriers needed a piece of equipment in their central offices to accept incoming transmissions and this was the purpose of the Aptis product.

Known as CVX 1800, the product was only in beta when the company was purchased by Nortel. The switch was designed to handle 6,000 simultaneous modem connections at an ISP or telephone carrier's central office. Nortel planned to add DSL capabilities and SONET connections, and SS7 interfaces as well as network management. The plan was to integrate the CVX 1800 product line into Nortel's Internet Thruway and Multi-Megabit network solutions, which were already in service with carriers and ISPs.

Aptis products became part of Nortel's 'just@sk Multi-Service Access' strategy, which allowed voice and data to share a common networking infrastructure using a variety of devices located in central offices of telcos and the data centres of ISPs and including dial-up, leased lines and high-speed access. Moreover, this approach allowed carriers and ISPs to initially deliver traditional narrowband services with a migration path to more advanced broadband access technologies.

Nortel's view of this acquisition was that it uniquely positioned the company to enable ISPs and carriers who needed products with scalability, performance, quality of service (QoS) and reliability to keep pace with the expanding Internet market.

Bessemer Venture Partners (BVP), one of Nortel's VC partners, invested in Aptis in 1996 and exited in 1998 with its purchase by Nortel.

Bay Networks

Bay Networks served the corporate market with a host of IP-based equipment for local area networks, something missing in the Nortel product portfolio. The addition of Bay provided Nortel with the ability to offer corporate customers integrated networks for sending voice, video, and data over the Internet. Nortel secured this Santa Clara, California based company in a $9.1 billion stock-swap in August 1998.

Bay Networks was a network hardware vendor formed in July 1994 as a result of the merger of Santa Clara, California based SynOptics Communications and Billerica, Massachusetts based Wellfleet Communications. SynOptics was an early contributor to the development of Ethernet products. Wellfleet was a competitor of Cisco Systems in the router market, ultimately commanding some twenty percent market share of the network router business worldwide.[7] The combined company was renamed Bay Networks.

With this acquisition the new parent changed its name from Northern Telecom to Nortel Networks. The deal was positioned to the market as a 'merger'; when in fact it was an outright acquisition by Nortel.

[7] Wikipedia http://en.wikipedia.org/wiki/Bay_Networks

Interestingly, Bay employees were under the illusion that their company had purchased a relatively small Canadian telecommunications company.

Nortel parachuted key executives from Bay into prominent positions in Nortel, a move that added to a growing discomfort among Nortel staff in having new bosses who were recently made multi-millionaires as a result of acquisitions. Adding to this growing frustration among the ranks of technical staff, was the additional expectation that these new executives and their cadre of former employees, now Nortel employees, were expected to change the culture of Nortel to become, in the words of executive management, agile and dynamic.

In December 2009, as part of Nortel's disposal of assets, the Enterprise Networking equipment and software business of Nortel was sold to Avaya. The sale included a few remaining Bay Networks' products that were still active in Nortel's portfolio at the time of the sale, such as the Ethernet Switch 450 and Backbone Concentrator Node router.

The Bay Networks small office and home office product line survives to this day as the Netgear products that are widely sold by electronics retailers. Example products include Gigabit Ethernet switches, cable modems, print servers, and similar inexpensive, consumer-oriented networking equipment. Bay Networks had originally launched Netgear as a product line/division in January 1996, but the product line was not core to the newly formed Nortel Networks operations and so was spun out as a standalone company in September 1999. This represents a further determination by Nortel to refrain from consumer products.

Within the ranks of Nortel technical staff there was disappointment with the Bay products. On news of the acquisition, staff had hoped that Bay products would complement Nortel products with leading-edge Internet Protocol networking capabilities. However, products from Bay were engineered to lesser standards than Nortel's and the much needed carrier-grade routing products were missing. It was generally felt by technical staff that the products from former Nortel marketing partners, Juniper Networks and subsequently Avici were better suited to Nortel than Bay products.

Cambrian

Cambrian Systems of Ottawa was a maker of metropolitan area network equipment that enabled businesses to communicate with their service providers. Specifically, Cambrian provided advanced photonic networking solutions based on dense wavelength division multiplexing (DWDM) for metropolitan access and interoffice networks. The company was originally started by ex-Nortel employees in 1996 and was purchased by Nortel in December 1998 for $300 million in cash.

What happened was this. As noted, Cambrian was founded in 1996 by ex-Nortel employees, so consequently it had a corporate culture that was common to and understood by Nortel. Of all the acquisitions by Nortel, Cambrian was one of the more successful integration efforts as compared to the many entrepreneurial driven start-ups that basically created culture clashes between employees from the start-ups and their new parent. The Cambrian deal gave Nortel what could be called an optical fiber Internet on-ramp in the form of a product that carried up to 160 gigabits of data per second for enterprise customers in metropolitan areas.

Shasta

Shasta Networks, a start-up based in Sunnyvale, California, was a pure play Internet Protocol acquisition by Nortel and announced in April 1999, within weeks of Shasta announcing its first product, which was yet to be introduced to the market. The deal was for $340 million, with $22 million in cash and $318 million in Nortel stock and subject to certain conditions related to Shasta's business performance. The company claimed to build software tools to give carriers the ability to create things like network-based firewalls, virtual private networks and support for e-commerce applications. As a result of the deal, Nortel touted that it was adding more IP-based systems expertise to its emerging portfolio of IP-based products; maybe so, but Shasta only had 70 employees at the time and had yet to ship its first product to market.

In March Shasta had announced its first product, for release later in the year, a Subscriber Service System (SSS), which was a central office DSL Access Multiplexer (DSLAM), and was designed to enable scalable deployment of network-based, value-added services. The Subscriber Service System integrated an IP service gateway with an operating system and subscriber management policy system. The SSS gateway was claimed to scale to support more than 160,000 subscribers.

The target market was ISPs and competitive local exchange carriers (CLECS), a relatively new class of telco operator arising from deregulation in telecommunications in the United States, Europe and Canada. The SSS allowed these IP service providers to logically aggregate tens of thousands of subscribers and centrally provision for those subscribers' customized IP services, such as virtual private networks, managed firewalls and quality of service management.

By 2004 Nortel's Services Edge Router 5500, formerly known as the Shasta 5000 Broadband Services Node, converged virtual private network (VPN), broadband aggregation, and IP-services capabilities onto a single platform at the network edge over a standards-based Multi-Protocol Label Switching (MPLS) infrastructure. This product line replaced Nortel's own DSLAM product line, a market from which Nortel had earlier withdrawn due to it being seen as a 'commodity' and not able to attract the profit margins that Nortel typically set for itself.

In August 2010, with Nortel in protection from creditors, the company moved to sell the Shasta data packet network and multi-service switches business for $39 million in a stalking horse bid, and was thus prepared to take a significant loss on the $340 million investment in Shasta about a decade earlier.

Qtera

In January 2000, Nortel acquired Boca Raton, Florida-based *Qtera Corporation*, a producer of long-distance optical networking systems. The price was $3.3 billion in common stock. Qtera produced networking systems that were designed to transfer optical signals as far as 4,000 kilometres without having to re-amplify the signal. Moreover, Qtera's solutions operated at 10 Gbps, the highest speed used by leading-edge Internet backbone networks of the day. The company was founded in 1998 under the name NextNet Technologies Corporation; but changed its name to Qtera Corporation in November of that year.

Qtera Corporation operated as a subsidiary of Nortel Networks Corporation. Consequently, on January 14, 2009, Qtera Corporation filed a voluntary petition for reorganization under Chapter 11 in the U.S. Bankruptcy Court for the District of Delaware as part of the overall Nortel move for creditor protection.

Clarify

Less than three months after purchasing Qtera, Nortel announced, in March 2000, its intent to acquire San Jose, California-based, *Clarify, Inc.* for $2.1 billion in common shares. The firm specialized in customer relationship management (CRM) software used in Internet communications, particularly for call centres. Moreover, Nortel saw the acquisition of Clarify and in particular its customer relationship management (CRM) solution as a means to build networks that link the sources of networked information with the users of such information.

What happened was this. Instead of taking on leading CRM firms such as Siebel and PeopleSoft with new offerings, under Nortel's ownership Clarify basically went underground. It was reported that industry analysts complained privately about a lack of visibility, press inquiries went unanswered, and the Clarify brand was lost in confusing ad campaigns that promised to put top-quality call centre agents on a CD-ROM.[8]

In mid-2001, Nortel sold the company for 10 cents on the dollar to Amdocs, which made Clarify's CRM the core of Amdocs' offerings. Nortel's trouble with Clarify was multifaceted, but boiled down to an inability to execute. Despite entering the market with a major splash, Nortel characterized itself as being out of the CRM business only 18 months after the Clarify acquisition.

Sonoma

Sonoma Systems produced a range of high speed Internet access devices. This privately held firm was founded in Marina del Rey, California in early 2000. By the fourth quarter of that year Nortel announced that it was buying Sonoma Systems for $540 million in an all-stock deal. Sonoma, with less than 100 employees, offered broadband integrated access devices that enable service providers to deliver Internet connectivity, voice, data and video over a single connection to business customers. More particularly, the company's products enable its clients to offer services, such as intranets, networked applications, virtual private networks, managed networks, video conferencing, Web-hosting, multimedia entertainment, telecommuting, branch office internetworking, and Internet access.

Nortel saw this acquisition as a quick means to extend its position in optical Internet service offerings to businesses, a short lived; but rapidly growing market segment at the time. As one executive involved in the deal is quoted as saying at the time "this acquisition represents another building block in our local Internet capabilities that will enable service providers to offer new, profitable services directly to businesses and consumers".

What happened was this. Nortel issued approximately 6.9 million shares at $78.13 per share. The company paid $480 million in stock and an additional $60 million in stock when Sonoma met certain business objectives during the first year after closing. Shares of Nortel closed up $3-1/4 at $79-1/4 netting about $7.7 million in increased value over the stock offered to Sonoma, with the company value increased many tens of millions of dollars more based on Nortel shares already in the market. This pattern was typical of what would happen to Nortel stock when the company announced the purchase of a technology company prior to the dot-com bubble burst and the related telecommunications crash.

[8] See for example *The Rise and Fall--and Rise--of Clarify* in CRM Magazine at: http://www.destinationcrm.com/Articles/Older-Articles/The-Edge/The-Rise-and-Fall--and-Rise--of-Clarify-47979.aspx

Technically, these were functionally identical to a range of Nortel products known as Edgeplex, which Nortel had recently discontinued due to falling sales. The acquisition team was well aware of the Edgeplex products and used the competitive analysis carried out by the Edgeplex team as a means of qualifying Sonoma.

This appeared to be an unusual acquisition in so far as Nortel acquired a start-up company with a product identical to a product that Nortel had recently withdrawn.

As of October 19, 2000, Sonoma Systems, Inc. operated as a subsidiary of Nortel Networks Corporation, the US subsidiary of Nortel. By January 2009, Sonoma filed a voluntary petition for reorganization under Chapter 11 in the U.S. Bankruptcy Court, as did Nortel.[9]

Xyros

In March 2000, Nortel announced it would acquire *Xyros, Inc.*, a Sunnyvale, California firm that was developing a photonic switching product that used tiny mirrors to redirect light waves without first having to convert them to electronic signals. The deal was set at $3.25 billion in Nortel common shares. Xyros had no commercial product revenue stream at the time.

Nortel said the deal would help it become the first provider of Internet components able to provide the building blocks for an all-optical Internet. Xyros's silicon-based micro-mirror technology was designed to allow data to be switched through large-scale optical networks entirely in the form of laser light pulses. Xyros also was seen as a good match for another recent Nortel acquisition, Qtera. Consequently, Nortel planned to couple Xyros technology with the long-reach networking product it acquired in the Qtera deal.

Nortel technical staff had evaluated the Xyros technology and concluded it was more 'laboratory curiosity' than product, with major challenges associated with converting it to product. They strongly recommended against the purchase. Nortel went ahead despite the technical objections. Up until the time Nortel ceased trading, the Xyros technology had not been converted to product.

CoreTek

The purchase of optical networking firms took centre stage at Nortel in June 2000 with the purchase of Wilmington, Massachusetts-based *CoreTek, Inc.*, for $1.43 billion in common shares. CoreTek was a 1994 start-up with 120 employees that specialized in advanced tunable lasers and next generation tunable optical components for fiber-optic communications. CoreTek specialized in tunable photonics and made components such as tunable lasers.

CoreTek was a pioneer in the use of vertical cavity surface-emitting laser and micro-electromechanical systems technologies for optical networking. Its solutions used tiny, movable mirrors to alter the wavelength of light emitted by semiconductor lasers and other optical components. The deal was intended to enhance Nortel's laser technology capabilities and to extend Nortel's leverage in the optical Internet market.

[9] Source: *First Monitor's Report,* released February 2009, with respect to Nortel filing for bankruptcy protection, which can be found at: http://documentcentre.eycan.com/Pages/Main.aspx?SID=89&Redirect=1.

What happened was this. CoreTek had neither revenue nor a marketable product at the time of acquisition. However, it was working on promising optical technologies that Nortel hoped to use to speed up data traffic and increase its volume, while simultaneously reducing costs, as in the case with the Xyros purchase. CoreTek and Xyros assets and teams were combined into a CoreTek operation serving the Optical division of Nortel. By September 2002, Nortel closed the CoreTek laser operations it had purchased only 2 years before.

Alteon

In October 2000, Nortel acquired four year old *Alteon WebSystems*, Inc., of San Jose, California for $6 billion in stock. When the intent to acquire the company was announced earlier in the year, the stock value was then $7.8 billion; but it dropped in value over the ensuing months before the deal closed. At the time, Alteon was a maker of specialized Internet switches used to speed response times at web sites. For example, Alteon introduced the first network switch products to deliver Ethernet with selectable speed, 10/100 or 1000 Mbit/s, on every port via auto-negotiation. In addition, Alteon offered a Layer 4-7 switch, which was designed as an integrated services front-end and server load balancer.

Nortel opted to sell Alteon switching line to Radware in February 2009 for only $17.65 million, a fraction of what it had paid for the firm a few years before.

3.4 Acquisition Summary

There were numerous other acquisitions in addition to the selection discussed above. For example, in November 1999 there was the $436 million acquisition of NASDAQ listed *Periphonics*, a supplier of voice-enabled call-centre software. According to Nortel, the acquisition of Periphonics added to its efforts to link call centres with the Internet and further allowed it to bill itself as a full-service, end-to-end supplier. Periphonics was headquartered in Bohemia, N.Y., and operated as a wholly owned subsidiary of Nortel.

In January 2000 Nortel announced the purchase of *Promatory Communications*, a former strategic partner, for $778 million. Previously, Nortel had a non-exclusive deal to use Promatory's carrier-class broadband Internet access switch, which enabled a single enterprise phone line to handle multiple transmissions of voice and data (e.g., support for multiple DSL transmission types with ATM switching). The company was acquired because Nortel decided that it did not want Promatory technology and products in the hands of competitors.

As a final example, in February 2000 Nortel purchased Virginia-based *Dimension Enterprises*, a consulting and e-business firm specialized in the design of Internet data centres and integrated IP networks. Nortel paid $64.5 million, a modest amount given the deal values over the past few years.

Exhibit 8, on the next page, presents a summary of the eleven principal acquisitions discussed above.

Exhibit 8
Summary of Selected Nortel Acquisitions

Acquired Company	Date	Deal Offer	Technology Domain	Outcome
Broadband Networks Inc.	March 1998	$593 million	Digital point-to-multipoint microwave networks for fixed voice, data and video services	• Technology failed to work • LMDS market failed to materialize
Aptis Communications	June 1998	$290 million	VPN	• Nortel's view of this acquisition was that it uniquely positioned the company to enable ISPs and carriers who needed products with scalability, performance, quality of service (QoS) and reliability to keep pace with the expanding Internet market.
Bay Networks	August 1998	$9,100 million in common shares	integrated voice, video, and data networks	• Poorly executed integration effort with limited net benefit to Nortel • Sale of Netgear product unit illustrates determination by Nortel to refrain from consumer products • Technical staff disappointed
Cambrian Systems	December 1998	$300 million	DWDM	• A successful integration • High speed optical fiber Internet on-ramp • Displaced Sonoma
Shasta Networks	June 1999	$340 million, ($22M cash & $318 million in common shares)	Subscriber Service Systems & DSLAM	• In August 2010, Nortel sold the Shasta data packet network and multi-service switches business for $39 million for a significant loss on the original investment
Qtera Corporation	January 2000	$3.3 billion in common shares	Long-haul optical components	• Qtera operated as a subsidiary of Nortel and in January 2009 filed a petition for reorganization under Chapter 11 in the U.S. as part of the overall Nortel move for creditor protection
Clarify, Inc.	March 2000	$2.1 billion	CRM	• Inability to integrate • Sold at 90% loss in mid-2001
Sonoma Systems	August 2000	$540 million in common shares	broadband integrated access devices	• Acquired after Nortel killed its own similar product to Sonoma • Deal superseded by the Cambrian product for MANs
Xyros, Inc.	September 2000	$3.2 billion in common shares	silicon-based micro-mirror optical switches	• Technology never materialized in Nortel products
Alteon	October 2000	$6.0 Billion	maker of specialized Internet switches used to speed response times at web sites	• Nortel opted to sell Alteon switching line to Radware in February 2009 for only $17.65 million, a fraction of what it had paid for the firm a few years before.
CoreTek, Inc.	October 2000	$1.4 billion in common shares	tunable lasers and associated optical components	• CoreTek had neither revenue nor a marketable product at the time of acquisition • By September 2002, Nortel closed the CoreTek laser operations it had purchased only 2 years before

As can be seen from this Exhibit, Nortel's foray into acquisitions was dominated by a desire to acquire a range of technologies that were dominantly focused in long-haul fiber optics communications and in Internet-enabling infrastructure with a view to allowing Nortel to offer the market a full range of IP-based networking solutions for telcos, ISPs and enterprises.

Soon after the announcement of the Sonoma acquisition, Nortel's market capitalization hit $240 billion. The plan was to continue the acquisition pace, by spending ten percent of the company's market cap each year to purchase new technology it deemed it needed to keep pace with the other leading networking companies, most notably Cisco Systems, Ericsson; and Lucent Technologies.

In addition to its clear focus on optical technology, at the turn of the millennium Nortel also was working to establish a more significant presence in the undersea-fiber business and was gaining a reputation as a leader in the area of wireless Internet technologies.[10]

It is clear that most acquisitions fitted within the ISO stack in the same layers where Nortel already operated rather than making investments by moving up the value chain (e.g., Google and Apple). Instead Nortel acquired technologies, products and people primarily operating in its space with each deemed to offer Nortel a competitive edge in time-to-market and technical know-how. A more general internal management problem was foreseeing the consequences of the over hyped market demand Nortel was serving as the Internet truly began becoming of value to economies in general.

Nortel became so entranced with acquisitions that some executives had 'buy a company' as one of their annual objectives. However, the objective of buying a company was not matched with effective due diligence in respect to value for money from a purely investment perspective. As a result many acquisitions turned out to be a poor fit. Due diligence over the acquisitions seemed to be confusing, as for example in a number of cases Nortel's technical teams said no to specific acquisitions on the grounds of technical merit, yet the company went ahead and made the purchases for other business reasons (e.g., prevent competitors from accessing a given company's technology by buying it).

3.5 Strategic Alliances: A Sample

Nortel undertook a variety of strategic alliances during the study period, most of which were related to marketing and sales; however a few were technology specific, such as the following examples.

One of the earliest alliances was the 1982 deal with *Motorola* regarding early developments in cellular phone technologies. This was followed in 1988 with an agreement with Motorola Semiconductor for the manufacture of custom semiconductors for use by Nortel, together with some technology exchange agreements.

In June 1998 *Microsoft* and Nortel announced that they would jointly market consumer applications that employed Nortel's 1-Meg Modem and Microsoft products such as the Windows NT Server operating system and NetShow; streaming media services. The focus of this strategic alliance involved unified communications, which allows for seamlessly blending together e-mail, voice, video and data. It was anticipated by Nortel that this four-year deal would generate more than $1-billion in sales.

In January 2004, *Avici Systems*, a supplier of core routers for large networks since April 1998, formed a 3-year strategic partnership agreement with Nortel. Nortel agreed to integrate, sell, and support Avici core routers as part of its overall marketing and sales strategy. Avici became Nortel's preferred partner for IP core routers, and the two companies worked together to integrate the Avici products into Nortel's existing product family. At the time of the alliance, Nortel already owned a five percent stake in Avici. Avici only had one major customer at the time, AT&T. By the time Nortel divested of Avici, Nortel had accumulated about 20 percent ownership of the company.

Terabit routing had become the latest battleground for carrier equipment vendors spurred on by growing demand for high speed Internet applications. Consequently, the partnership with Avici gave Nortel a routing solution that was intended to integrate into its own product portfolio. This reseller relationship

[10] Source: http://www.fundinguniverse.com/company-histories/nortel-networks-corporation-history/

provided Nortel with an alternative IP routing product. However, this deal eclipsed an existing distribution and sales agreement with Juniper Networks, a leading big router maker at the time and key competitor to Cisco. Interestingly, Nortel and Avici had a reseller agreement in place prior to Nortel's acquisition of Bay Networks and as a result of the Bay acquisition the Avici deal was dropped.

In August, 2005: *LG Electronics* and Nortel formed, a joint venture with Nortel owning 50 percent plus one share, to offer telecom and networking solutions in the wireline, optical, wireless and enterprise areas for South Korean and global customers. The primary markets for this company's products were small businesses and consumers; a market segment Nortel had consistently avoided in the past.

In 2006, Nortel and *Huawei* formed a Nortel controlled joint venture company to develop 'ultra-broadband access solutions' for the global service provider market. Located in Ottawa, the new venture was intended to drive the deployment of a splitterless DSL technology based on emerging Universal ADSL specifications. Part of the motivation behind this deal was that Nortel as a contributing member to the Universal ADSL Working Group, had previously made a commitment to the industry and to its customers to support Universal ADSL through its high-speed access portfolio.

By early 2006 Nortel was rationalizing some of its acquisitions and assorted product lines, such as the sale of its blade server business to Garnett & Heinrich, a private US equity firm. The new company was called *Blade* and it specialized in software and devices that routed data and transactions to and from servers. Nortel retained an equity stake in the business, which was renamed Blade Network Technologies Inc. In late 2010 Blade was sold to IBM as an aid to its cloud computing and data analytics product offerings.

3.6 Sell-off of Assets

Following the collapse in demand in the market in the early 2000s, Nortel began to rationalize its acquisition and product portfolios in order to save money and simplify its holdings.

In late 2006, Alcatel-Lucent signed an agreement to buy Nortel's UMTS (3G) radio access business, including technology, products and customer contracts, for $320 million. At the time the UMTS business was losing money on an estimated $250 to $400 million annual revenue stream. In addition, about 1,700 people were transferred to Alcatel-Lucent, including 1,100 R&D engineers based mainly in France, Canada and China. Some views were expressed that divesting of UMTS would complicate the transition to 4G wireless infrastructure. This of course was a moot point by 2009 when Nortel filed for creditor protection and never came out.

In fact, by 2006 a number of industry analysts and industry watchers were beginning to forecast the possible breakup or merger of Nortel with any number of partners or buyers. This was 'common talk' among the trade press. We learned from this investigation that many of the companies alleged to be in possible merger discussions or engaged in the possible purchase of Nortel assets were indeed happening. In fact, this was an industry phenomenon with the perception of a major shakeup happening across the industry (e.g., the merger that created Nokia-Siemens Networks and the acquisition by Alcatel Lucent of the UMTS access unit from Nortel). For a list of disposal of Nortel assets through public auction, see the end of Annex 4.

3.7 Summary

By 2000, Nortel had licensed its routing codes to more than 200 companies with the view of creating 'routing' as a function and not a product per se (e.g., allowing Intel to embed routing code on a chip).

By 2004 Nortel's end-to-end optical network portfolio included the next generation of SONET/SDH optical switch products, photonic signalling via WDM and optical Ethernet products as a result of internal development, acquisitions and strategic alliances. Despite offering such a broad portfolio, a so-called 'black cloud' was developing over Nortel with respect to many of its strategic long-time customers.[11]

Thus, by this time Nortel's product portfolio, including from acquisitions, placed it such that it was number one in VoIP, number one in multi-service WAN switching with the Passport MSS portfolio, number one in IP service routing with the Shasta portfolio, number one in DWDM and SONET, number two in Ethernet switching, and number two in optical Ethernet and was a player in wireless.

By the mid-2000s Nortel may have been open to the idea of acquisitions; but in reality its ability to buy companies was reduced in both scope and scale (i.e., number of annual deals and in size of deals) because of its weak balance sheet. With its cash position shrinking, no one was longer willing to accept Nortel stock as a part of a deal, and the company had so many shares outstanding, that consequently, it could not even contemplate undertaking an offering that would dilute its existing shareholders even more.

In late December 2005, despite the generally weak Nortel balance sheet, Nortel acquired Tasman Networks for $99.5-million to build a presence in the corporate router market.

[11] The 'Black Cloud' is discussed at some length in our initial report titled *An overview of the demise of Nortel Networks and key lessons learned* and available at: http://sites.telfer.uottawa.ca/nortelstudy/

Chapter 4

Technology Management

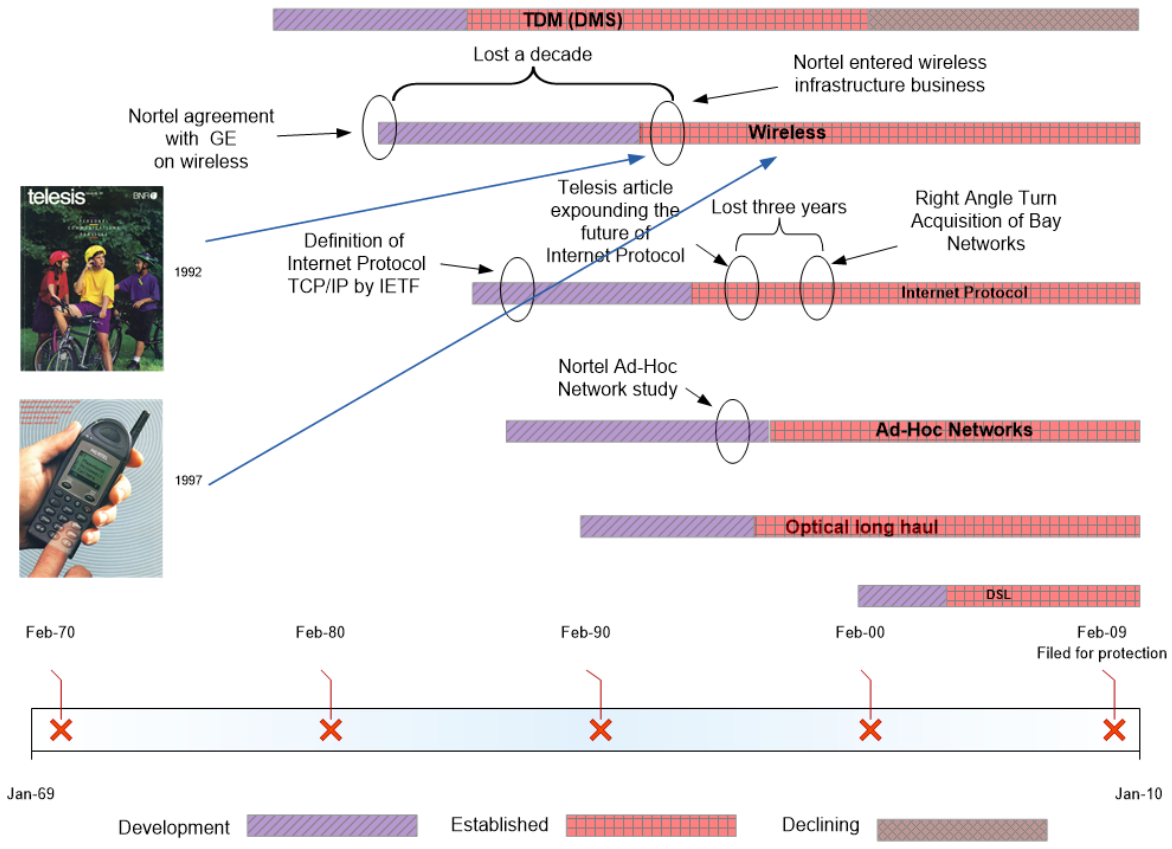
4.1 Preamble

In respect to technology management, we looked at fundamentals and we heard through interviews about ways around the 'rules', such as hoarding funds for pet projects, covering costs for one project with funds from another; but we did not consider these to be mismanagement in an extremely dynamic business environment. We do not believe what we heard had any bearing on the overall demise of Nortel. Moreover, some of the 'skunkworks' actually had a positive impact on the bottom line.

4.2 Time to Market: Some Technical Delays & Missed Opportunities

Exhibit 9 presents an overview of where Nortel both dominated and lost time to market as a result of its actions regarding various technologies and perceived market openings. Each of these points required corporate commitment at the highest level to pursue as business opportunities.

Exhibit 9
Nortel & Lost Time to Market



Nortel led the world in TDM and optical-long haul, and as a result set the global pace in getting to market. Equally, Nortel was an early commercial adopter of DSL technology. Despite the market for DSL being vast and active, Nortel effectively withdrew on the grounds that it was becoming a commodity, a class of products the company generally distanced itself from (e.g., as in other forms of access products).

We present three examples of technology-driven opportunities Nortel was late to embrace as a corporate direction. Exhibit 9 illustrates with ovals critical events that shaped Nortel's response to three key emerging technologies: wireless, Internet Protocol, and ad-hoc networks. In all three cases we found that Nortel R&D was well aware and engaged in understanding, experimenting and in prototyping products applicable to these areas. Each of these is illustrated in Exhibit 9 along with the gap in years between technical engagement and corporate buy-in. Nortel knew about these technologies, had lab capabilities in support of them; but failed to commercialize them, or to do so, in a timely fashion.

Cellular Technology Misstep

Cellular technology was an opportunity Nortel chose deliberately to downplay following an early foray into the field (e.g., beginning in the early 1980s) before it again came around to becoming part of corporate strategy again around 1992, ten years after the first efforts in this burgeoning field. However, it was fundamentally too late to gain any first mover advantage, again despite considerable knowledge and expertise in the company's labs.

Although Nortel was presented with cellular technology by their own innovation staff as early as 1982 and a smartphone concept in 1997, executive management did not embrace either of these initially. Despite the clear trends in cellular telephony, Nortel executives did not appreciate the speed with which costs would fall and acceptance would increase.

A senior executive initially rejected the concept with the remark "who would ever want to walk around with a phone in their hand?" When Nortel finally accepted the inevitable opportunity that cellular telephony promised, for second generation digital (2G) the company chose a proprietary technology almost exclusively limited to the North American market, CDMA; while the rest of the world adopted an open standard developed in France and known as GSM. At the time CDMA addressed less than ten percent of the world market with GSM addressing over seventy percent. Moreover, Nortel licensed this technology from Qualcomm, the US-based developer of CDMA.

Internet Protocol Misstep

It is widely reported and believed that Nortel missed the Internet Protocol (IP) explosion. The company did not miss it; but instead, chose to not take the industry in that direction initially. Nortel understood IP and its limitations only too well. Nortel had considerable skills in packet switching, of which Internet Protocol was a particular implementation. Nortel, had instead concentrated their packet switching thrust on Frame Relay, ISDN and ATM technologies, these being more secure and predictable than Internet Protocol. Nortel considered IP to be less suitable for telecommunications, relegating it to a higher layer protocol to provide ad hoc data communications. Others in the industry were promoting Internet Protocol as an alternative means of telecommunications routing, a philosophy to which Nortel did not initially subscribe.

Ad Hoc Networks

As an example of depth in Nortel's engineering capacity, its engineers identified the need for ad hoc networks along with recognizing and identifying technology to realize them, based on the original collision management protocols that enable independent devices to share a medium. Nortel both understood and defined these protocols too.

An ad hoc network is composed of suitably and similarly equipped devices that can communicate with each other for the purpose of exchanging information. Such a network is distinguished from other local area networks by there being no device that assumes central administrative control (e.g., the environment is infrastructureless). In an ad hoc network, devices typically self-discover the network and other devices in order to initiate communication. The only requirement for communication between devices is they are each suitably equipped, are within link range of each other and there being sufficient capacity on the shared channel for communication to take place.

Nortel had identified and proposed creating technologies and products to meet emerging requirements based on ad hoc networking, a large opportunity that was never commercially successful. However, from a strategic commitment perspective, the company chose not to introduce ad hoc networking products. Again, this was not a technology issue per se; but rather a matter of corporate commitment to an emerging market opportunity.

Nortel also conceived and created other packet-based collision management standards, protocols and associated technologies in anticipation of potential market adoption regionally or globally. This approach to R&D was often pursued by Nortel labs as a way to hedge bets on market acceptance and to be ready with product before the competition.

As a whole, Nortel never perceived end-users as their ultimate customers; but rather saw the telcos as the company's primary base, which traditionally operated on long amortization times for telecommunications equipment. As a result of this business factor, telcos operated on slowly changing requirements for new products. Although Nortel attempted to shorten this buying cycle by telling telcos what they needed, Nortel took its time to refine, test and get its technologies and products just right. Thus, Nortel lost time to market as the market conditions changed with the rapid growth in enterprise networks and the emerging focus on access devices for end-users, especially in wireless, during the 1990s.

4.3 R&D Expenditures

For many years Nortel was the largest industrial R&D performer in Canada. This analysis is not intended to present detailed assessment of Nortel's R&D budget and expenditures. This is covered in part in the source linked to the data provided below. The intent here is to provide a few highlights and trends in the overall magnitude of Nortel's efforts to carry out R&D investments, especially in the late 1990s and through to the wind-up of the company.

As noted in the discussion on acquisitions in Chapter 3, most of the billions of dollars were spent to acquire access to technologies and knowhow, especially with the various acquired start-ups. These costs were not part of the R&D spend presented below.

The stage for the formal study period, 1996 through to the end, began with new leadership in 1995. At the time the R&D budget was bolstered to nearly 15 percent of revenue, which amounted to $1.58 billion for that year.

What follows in Exhibit 10 is an account of the R&D expenditures from 1999 through 2009. One can see that Nortel peaked in R&D spending during the height of the dot-com bubble in 2000. The market started a severe downturn in early 2001. In that year Nortel dropped one billion dollars from R&D spending. Between the peak and 2008, the year before filing for bankruptcy protection, R&D expenditures dropped to the lowest level in over a decade to more than $4 billion below the 2000 figure, a 72 percent drop. These data can be seen in Exhibit 10.

Exhibit 10
Nortel R&D Expenditures from 1999 to 2009[12]

Year	Rank in Canada	R&D Expenditures	R&D Ratio R&D as % of Revenue
1999	1	$4,548,000,000	_
2000	1	$5,948,200,000	13.2
2001	1	$4,992,000,000	18.4
2002	1	$3,501,992,000	21.1
2003	1	$2,788,985,000	20.3
2004	1	$2,549,639,000	19.9
2005	1	$2,248,730,000	17.6
2006	1	$2,199,020,000	17.0
2007	1	$1,851,880,000	15.7
2008	1	$1,677,884,000	15.1
2009	2	$864,494,000	18.5

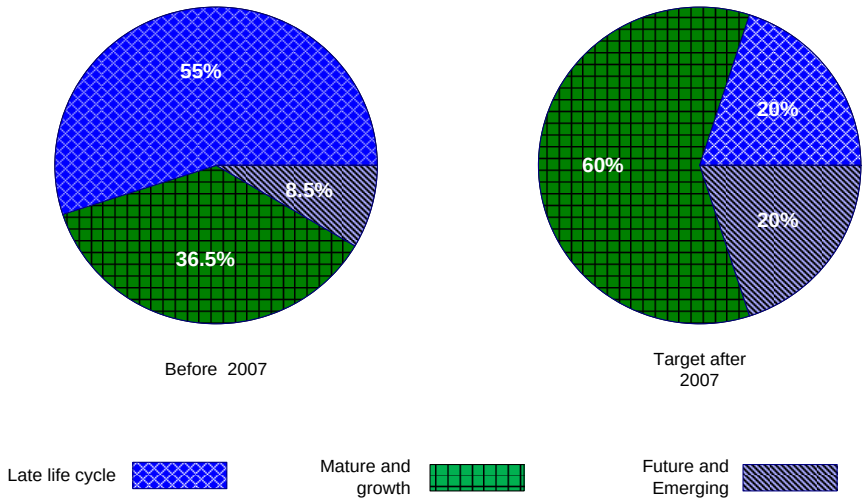
4.4 Research & Development Priorities

During the study period, 1996 – 2009, increasingly R&D resources were allocated to legacy and mature products with such activities as feature addition and cost reduction initiatives. The scale of this activity starved the company of innovation and its ability to gaze into the future. Traditionally the company allocated about 15 percent of its R&D resource to 'capability' activities, meaning activities to which there was no immediate product. During this period the 'squeeze' on funding futures R&D dropped to less than 10 percent of the overall R&D budget.

[12] Data compiled and presented by Research Infosource, Inc. at http://researchinfosource.com/top100_corp.php

Figure 11 illustrates, on the left, the state of R&D resource allocation had become by 2007, when investments in emerging technologies and products were only a small fraction of what had been a traditional R&D investment profile for the company. The right side shows the re-orientation proposed by a new CTO in 2008, a resource profile similar to the traditional past when times were good. Here some 20 percent of R&D resources were devoted to 'over the horizon' thinking and planning. However, this re-focus was too late. The company had been stuck on the left since the turn of the century. Consequently, between the years 2002 and 2008, Nortel announced no significant new products.

Exhibit 11
R&D Resource Allocations



4.5 Nortel as 'Definer' versus 'Contractor'

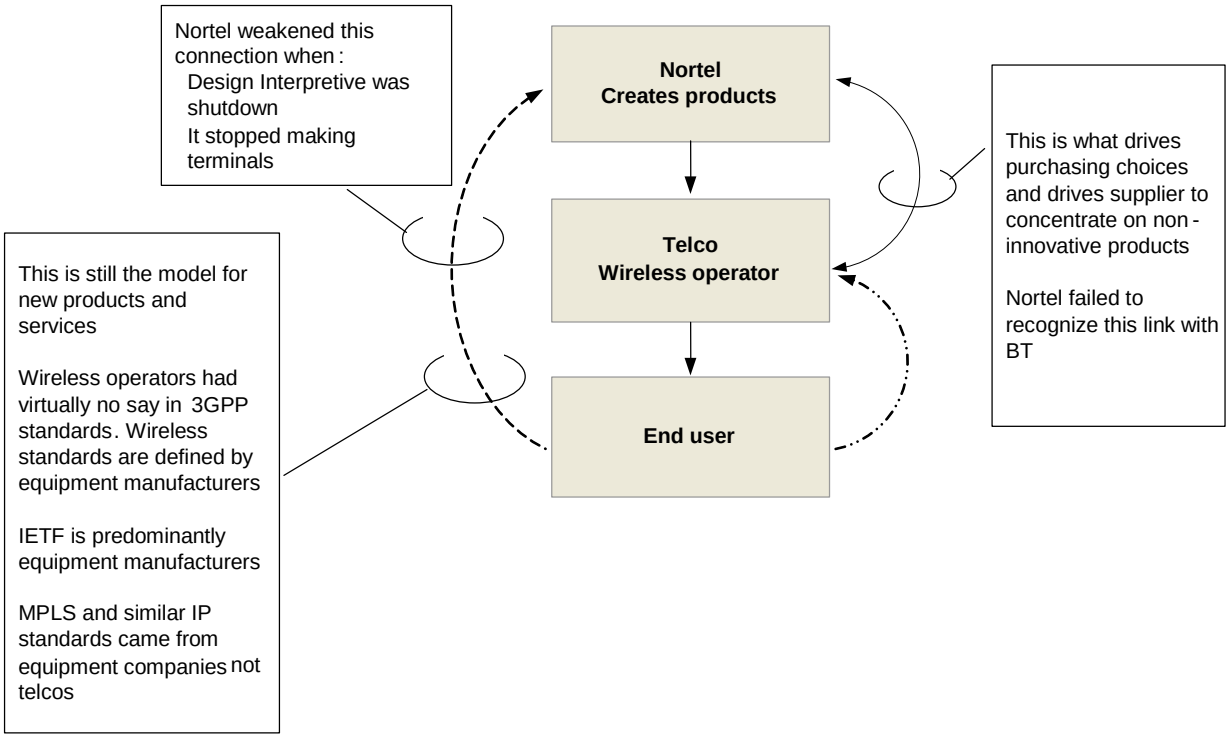
There are companies that define products and companies that provide components and services to those definers of products. Nortel was a long-time supplier to Bell Canada, Bell Canada being the definer for many years. However, with Nortel's development of digital switching and beyond and with Nortel's customer base expanding, the company moved into the role of definer. In this role it was successful. The telcos were no longer leading the thinking on future products and services. Consumers and businesses had become the definers in their demand for more diverse and more advanced services. Nortel was well equipped to identify these and did so. We have noted many leading innovations that Nortel championed. These were well documented in the BNR journal called *Telesis*.

We examined issues of *Telesis* from the early 1980s through to the late 1990s, when it ceased to be a paper-based publication. Issues are full of innovative ideas, in many cases well ahead of the industry adopting them. For example, there is an issue dated 1992 which describes in detail the wireless world we have come to know today. This was some 15 years ahead of the smart phone hitting the market. Not only was it predicted; it was published in the public domain. Nortel understood and defined the future. In some cases these ideas were turned into product and were successful. However, many opportunities were lost because the executive team either did not believe they would happen or because their traditional customers were not asking for them. See Annex 4 for a description of Nortel products identified in *Telesis*.

Nortel successfully changed from being a contractor to being a definer when their traditional customers were no longer leading the definition of products and services. However, it reverted to the role of contractor in the years following the drive to reduce R&D costs and only delivered products which it was being asked directly to produce. In this role the company lost its competitive edge, which had become that of defining the future. Many customers were loyal to Nortel because they felt that the company would show them the future. Once this benefit disappeared the only differentiator was product life cycle cost. However, Nortel was unable to compete with new competitors from low cost production areas, even after outsourcing manufacturing to 3rd parties.

Exhibit 12 illustrates Nortel as Definer versus Contractor of products and services. When Nortel was listening to the needs of the end user they were successful. In later years, when Nortel was dependent on the requirements of the service provider or telco they were not successful as a contractor – designing and building to customer specifications.

Exhibit 12
Nortel as Definer versus Contractor



This exhibit uses wireless technologies as a meaningful example. These technologies and standards are almost completely defined by the equipment companies. Operators' needs are restricted to defining operational issues, such as features and billing, not to fundamental technologies. Note that telcos and service providers do not like the model where the equipment companies and consumers are defining to them what the telcos need to offer the consumers.

4.6 Systems Engineering

Bell-Northern Research created a Systems Engineering group with the mandate to look at overall network architectures and compatibility between components. In reality the group spent much of its effort in carrying out projects, paid for by Bell Canada, in such areas as management of international standards. In the process the group developed detailed technical knowledge on overall network characteristics and performance.

The disbanding of the group in the late 1990s meant a loss of knowledge and a corporate view of overall systems and network products resulting loss in a loss in compatibility between products. It also contributed to a duplication of products performing the same function under the direction of different business units.

4.7 Corporate Culture with Respect to R&D and Commercialization

BNR was an intellectually stimulating environment. Attendance and presenting at conferences was encouraged, as was filing of intellectual property. Also, it was recognized that not all routes to successful product were optimized and competing product developments addressing the same market opportunity were encouraged, it being recognized that the trade-off of reduced R&D efficiency was more than offset by the assurance of the best solution and being an early market maker. The culture in R&D was of a cooperative team with a 'can do' attitude, right until the end.

As has been noted elsewhere the drive for R&D efficiency, to some extent to appease the stock market, resulted in a loss of readiness and resultant time to market of products, which meant when the sudden market demand appeared, Nortel was not ready with products. Nortel's response to this lack of readiness was to buy whole companies, which produced only limited positive results.

To the end, Nortel technology, people and adaptability remained among the best in the industry. Once the company returned to its roots and returned to developing technology in-house rather than pursuing the acquisitions route, it revived its former leading-edge capability. At the time of filing for protection from creditors, Nortel held leading technology in a number of emergent areas, notably 4G/LTE wireless, long haul optical and other fiber optic transmission technologies.

From a technology perspective there were some indications that some damage had been repaired by the time of filing for protection from creditors. However, not all was clear. The centralized CTO position had been eliminated, which seemed a bizarre decision given the clear progress that had been made in realigning strategy with R&D resources and capabilities. The return to focusing on in-house leading-edge technology was clearly a step in the right direction as indicated by the value that the Nortel patent portfolio realized in the sale of the assets of the company. Despite a turnaround effort, it was rather too little, too late.

An intangible valuable asset the company had was the R&D teams. It takes decades to hire, train, motivate and build trust between team members. BNR and later Nortel had achieved this. It is our view that this was clearly not recognized in the transition to the 21st Century as important by executive management, the Board of Directors, or in the end, the Government of Canada when approving the dismemberment of the company.

4.8 Management Awareness of Nortel Technologies & Technical Strengths

Part of the reason for the problems at Nortel were associated with the management of the company becoming somewhat detached and even hostile to the culture within R&D that had made the company successful. The duplication of effort addressing the same market space came to be considered inefficient. More seriously, however, was the lack of confidence shown by executive management at the time in the diverse R&D capability within the company. This resulted in the decision to buy companies as an alternative to in-house product development, a business decision that turned out to be disastrous for Nortel for a number of reasons. Massive amounts spent and nothing gained; in fact, ground was lost both internally through ineffective integration of technologies, products and people acquired; and through failure to address emerging market trends and demands (e.g., wireless hand-sets and associated infrastructure).

Executive management had become detached from the working level in the R&D laboratories. For example, Nortel had a program for exchanging technical competence between various groups and key customers; an example being an in-house exposition where each department showed their technology to others. Management was noticeably absent from these events in later years. Instead they were comparing Nortel with other companies and deciding that, rather than recognize the unique values in Nortel's culture; they would transform Nortel to become like some of the companies Nortel was acquiring.

It was observed that had the executives stood in the coffee line or eaten in the cafeteria in the main R&D facility in Ottawa, they would have got a much more accurate perspective of how well advanced the ideas on the future of the industry and product concepts needed to fill emerging industry needs, than they were getting from their traditional customer base.

It was reported that prior to the announcement of the Right Angle Turn the Training Department was asked how long it would take to train people in Internet Protocol. They replied that it would take close to a year. In reality the people in R&D were already well up to speed on Internet Protocol. Neither the Training Department nor executive management knew this. Had executives asked R&D staff for the products they envisioned they needed, it is most likely they could have got them in a timely way. Instead the executives acquired companies believing that would be a faster route to those products, a decision that contributed to the demise of the company. Senior executives trusted 'outsiders' to deliver, over their own people. However, most of the outsiders failed. The message here is to seek out and trust your own people.

For example, both executive management and the Board observed that *Cisco* acquired much technology by buying companies and decided to emulate that model, believing it to be a way to get to market faster and more cost effective at the same time. The effect of this was to disillusion Nortel's own R&D staff. This was compounded by reported comments by senior executives to the effect that in-house R&D was a 'multi-billion dollar sink hole' and the technical staff were 'dinosaurs'. In addition, R&D staff saw the employees in the acquired companies becoming instantly rich at the cost of Nortel while creating products that many considered, with some justification, to be inferior to Nortel products developed in-house.

4.9 Product Commercialization

Typically Nortel was relatively slow to commercialize technology. This was in part due to extremely high engineering standards, strict requirements on documentation maintainability and product qualification.

A philosophy that served the company well in the past, resulting in products that were maintainable and reliable. In later years some start-ups and newcomers were able to get products to market more quickly than Nortel; but not necessarily at the high quality standards of Nortel.

4.10 Outsourcing & Headcount

Outsourcing, an industry trend that Nortel was adept at practicing, was primarily outside the scope of R&D. It was concerned more with manufacturing and support services in the sales and after sales channels. Consequently, it was anticipated that outsourcing would reduce the company's staff complement.

It is interesting to note that the move to outsourcing did not result in a reduction in headcount. In fact Nortel headcount peaked around the year 2000 with just under 100,000 employees along with an additional contract cohort of several thousand more. Compare this staff size with the company, which in 1985 employed under 30,000 and made everything themselves. Growth in headcount was largely fuelled by acquisitions, a liability which the executive team appears to have failed to consider when approving those acquisitions.

4.11 Setting the Stage for Unanticipated Troubles

Fundamentally, the acquisition route was a radical departure from Nortel's traditional business model of leading by defining the direction of the industry rather than following. Nortel used to make 'everything' in the days when it defined the future; but came to make nearly nothing in the run-up to the dot-com boom and ultimately became a contractor, especially to its long-term customers such as the telcos, when Nortel shifted its product manufacturing offshore to contract manufacturers.

In addition to the strategy of growth through acquisitions launched in the mid-90s, Nortel made a series of product-related decisions that would prove to be problematic by the early 2000s, these included the following:

- The 'Right Angle Turn' of 1998 was marketed as a change in technical direction, shifting from 'dial tone', meaning the traditional voice centric switched network, to 'web tone', meaning the Internet and moving from 'copper wire' to 'fiber optics', and from voice to multimedia communications. Yet, it was 'much more' than that. The 'Turn' was a message to both the market and to employees, especially R&D – change was coming and fast. The 'much more' relates to three other elements of the strategy to implement the Turn. All three were internally focused and promoted the need to be more *agile* in projects, *more dynamic* in organization, and *more responsive* to customers' needs, especially the emerging enterprise market, a potentially large market for Nortel and its competitors;
- By 2000 Nortel's competitive advantages were in a declining market (i.e., wireline) and in saturated markets (i.e., optical);
- Nortel primarily served a North American-centric market and relied heavily on a small number of customers (i.e., telcos) that had dramatically increased their orders in anticipation of the dot-com demand; then cancelled orders, when it was apparent that the demand failed to materialize, leaving Nortel with large inventories, rescheduled or cancelled orders and an interruption in its revenue stream;

- Although Nortel was investing in a growing enterprise market at the time, its telco-grade products were often seen as offering more functionality for a given price than cheaper alternatives from competitors such as Cisco;
- It is often mistakenly believed that the enterprise market is different from the telco market, in not requiring such high reliability. This is simply not true; enterprise customers are very demanding in reliability. Enterprise products differ in that they are usually not required to offer full standby redundancy, not required to be 'hot swappable' (i.e., components replaced without disconnecting the power), and require shorter life cycles before they are superseded. In addition, the enterprise market being more diversified and depending on third party resellers, means a different approach to maintenance, upgrades and support is needed. These differing requirements make it difficult for a company skilled in addressing the telco market, to create products for the enterprise market;
- Consequently, providing carrier featured products and procedures in an enterprise market led to significant delays in new product releases and even in meeting product requirements, for by this time Nortel had unwittingly switched from the 'definer' role to the 'contractor' role, as noted above;
- Nortel had early technology leads in wireless but consistently bet against emerging global standards (e.g., supported CDMA versus GSM)[13] and failed to achieve differentiation, although the company did offer 3G products and the labs pressed ahead with 4G based on an emerging telecommunications industry standard known as Long Term Evolution (LTE), then in early development. However, the company did not move to commercialize LTE despite an early technology lead and successful deployment tests.[14] This was in part due to the technology being in advance of market readiness; and,
- Nortel invested heavily in worldwide interoperability for microwave access (WiMax), but divested of these assets only a few years later at a considerable financial loss when the WiMax market failed to materialize. Other companies developing WiMax products similarly abandoned their efforts.

During the good times leading to 2000, Nortel's cost structure grew more quickly than its revenues. In particular, growth through acquisitions was a departure from Nortel's culture of internal technology development. As a consequence the company acquired massive overhead and liabilities, primarily headcount and related liabilities that eroded its competitive advantage. In addition, Nortel introduced a number of operational changes that impaired innovation and the ability to discern and respond to emerging industry and customer changes. Specific examples include the following:

- Dismantling the company's centralized R&D laboratories (BNR), which was culturally and structurally optimized to create, innovate and develop telecommunications

[13]Nortel focused on Code Division Multiple Access (CDMA) rather than on Global System for Mobiles (GSM) to serve less than 20% of the market (i.e., North America) when in fact GSM had emerged as the global standard with nearly an 80% share of the market. Nortel failed to appreciate the rapid growth in GSM

[14] The subsequent sale of Nortel intellectual property assets around LTE generated more than a billion dollars, a clear indicator of perceived value in Nortel technology, despite Nortel's failure to get LTE to market.

products using cooperative teams. This included disbanding the Systems Engineering group, which had responsibility for viewing Nortel as a whole across all product lines;

- Business units increasingly focused limited R&D resources on optimising and enhancing their then current products, while starving future initiatives by no longer operating in a collaborative sense with other business units. From an accountability perspective each business line was running independently of the rest of the company. A dramatic cultural change from the days of technical and marketing leadership;
- Removing several key financial controls and procedures and then introducing a system that favoured legacy products with a predictable market need over radical innovation (i.e., high risk); and,
- Reduction in the role of the Competitive Intelligence team, elimination of Design Interpretive, a unit within BNR that focused on product concepts for the future, and dismantling other strategic planning functions.

The effect of the dot-com bubble and burst hit Nortel indirectly. Nortel's traditional customers had placed large orders on Nortel for infrastructure upgrades to anticipate the demand for capacity. When these orders were rescheduled or cancelled due to the demand not materializing. Nortel's revenues dropped dramatically, almost instantly. Nortel 'panicked' and tried to rein in its expenditures. A major significant R&D program for a core router, a much needed product, was cancelled. Real estate was closed. Headcount reductions were accelerated.

Customer financing, whereby Nortel provided equipment on deferred terms which Nortel financed, has been blamed for part of the problem. However, the ratio of sell price divided by actual marginal production cost for this type of equipment is so high, it would have needed many companies to seriously default for this to be a problem, which did not happen. However, customer financing appeared on Nortel's books as bad debt. The perception of customer financing causing problems was more significant than the reality of the situation.

This period coincided with the full-fledged entrance of Chinese competitors into the global marketplace. However, it should be noted that the Chinese suppliers were basically excluded from the North American market, which was the major focus of Nortel, particularly the United States. There have been suggestions in the media that Chinese or other foreign espionage agents penetrated internal Nortel networks and computers in order to acquire technology and strategic information and that such action contributed to the downfall of the company. We found no evidence of this and consider it unlikely. Nortel protected most of its technology with patents which were placed in the public domain, so unless these could be obtained and acted upon prior to filing, they would be of no value. We found no evidence of Nortel ideas or original technology being implemented or filed ahead of Nortel filing.

Nortel entered this new competitive environment ill prepared. The cumulative effect of its previous decisions, noted above, forced it to become internally focused – dealing with massive downsizing, financial restatements and regulatory issues, as well as losing sight of the changing business environment. Customers noted that beginning around 2002 Nortel was no longer behaving in the same way that it had in the past. Nortel's unending customer support, confidence and technical advances were no longer evident. In looking at Nortel's R&D commercialization road-maps, customers did not see new products; but instead were mainly offered software upgrades. In particular, customers noted that Nortel did not

release any major new products between 2002 and 2008. This was a dramatic shift from past performance when new products were routinely being introduced by the company.

4.12 Summary

Technology management, in a general sense was two-tiered within Nortel. Day-to-day management and oversight on strategic technical opportunities was a bread-and-butter activity within Nortel's globally distributed labs. This we consider as the 'foundation' tier. Our assessment is that this tier performed in accordance with its mandate and its efforts fluctuated with the cycle in annual R&D funds as illustrated in Exhibit 10.

The top tier that had a bearing on R&D mandates and performance was executive management. They influenced R&D primarily through strategy, policy and setting corporate goals and business practices. At various points along the curve of Nortel's evolution these top tier influences had a profound impact on technology choices and the ways and means by which technology should be developed and acquired. For example, Nortel introduced a number of operational changes that impaired innovation and the ability to discern and respond to emerging industry and customer changes. These include the following three examples:

- Dismantling the company's centralized R&D laboratories (BNR), which was culturally and structurally optimized to create, innovate and develop telecommunications products using cooperative teams. This included disbanding the Systems Engineering group, which had responsibility for viewing Nortel as a whole across all product lines and dealing with international telecommunications standard;
- Business units increasingly focused limited R&D resources on optimising and enhancing their then current products, while starving future initiatives by no longer operating in a collaborative sense with other business units. From an accountability perspective each business line was running independently of the rest of the company. A dramatic cultural change from the days of technical and marketing leadership; and,
- Removing several key financial controls and procedures and then introducing a system that favoured legacy products with a predictable market need over radical innovation (i.e., high risk).

The 'Right Angle Turn' of 1998 was marketed as a change in technical direction; but it was much more than that. The 'Turn' was a message to both the market and to employees, especially R&D – change was coming and fast. The 'much more' related to three other elements of the strategy to implement the Turn. All three were internally focused and promoted the need to be more *agile* in projects, *more dynamic* in organization, and *more responsive* to customers' needs, especially the emerging enterprise market, a potentially large market for Nortel and its competitors. This process was intended to create a degree of disruption; however that degree was much larger than anticipated within the company's engineering community, primarily because of acquisitions that suddenly fed technologies and primarily early stage products into Nortel's internal R&D efforts with various unintended consequence as noted above.

Shifting the company from a 'definer' to a 'contractor' had the unintended consequence of moving Nortel off its leadership position into the ranks of a 'me too' company by reducing its focus on future

considerations and accelerating its efforts to satisfy customer wants as opposed to a more traditional and reliable approach of satisfying customers' real needs. Thus, by the early 2000s Nortel was losing its leadership position and in so doing building early warning signs with long-time strategic customers (e.g., the emergence of the 'black cloud'). The company seems to have shifted from sharing its visionary technology roadmaps with key customer to basically offering short-term vision and solutions to pressing problems of the day. Furthermore, by 2000 Nortel's competitive advantages were in a declining market (i.e., wireline) and in saturated markets (i.e., optical).

In regard to a popular myth that Nortel was crippled by industrial espionage; in our view, this is a misplaced bogyman. We found no evidence of Nortel ideas or original technology being implemented or filed ahead of Nortel filing. Patents are in the public domain and they are far more valuable to a patent holder than even fore-knowledge of a competitors bid. Moreover, the telecommunications industry is one of the most interoperable infrastructures in the world with equipment suppliers working to global standards and meeting regulatory requirement for equipment performance and reliability, in addition to frequently cross licensing patents to other industry suppliers.

Chapter 5

Technology & Engineering Lessons Learned from the Collapse of Nortel

> "Nortel was a business failure. . . Nortel was not a technology failure. The sale of its patent portfolio for a record-setting $4.5 billion must end all argument on this point."
>
> *Eclipsing the memories of Nortel*
> OBJ Contributor
> February 10, 2012

5.1 Technology Turning Points at Nortel

During the study period Nortel faced a number of major decisions related to technology choices and approaches to technology management. Major technology choices that proved to be turning points in the study period were the decision to: (i) address long-haul optical as a transmission medium for packet-based traffic, regardless of the supporting protocol (e.g., ISDN, IP); (ii) to ultimately embrace Internet Protocol (e.g., Right Angle Turn); and (iii) to abandon access products (e.g., 1-Meg Modem, handsets, and mobile phones).

Long-haul Optical

Long-haul optical has become the transmission backbone for global telecommunications networks, carrying Internet traffic and traditional voice traffic that we use today. Nortel led in technology enabling high data rates, using various packet switching protocols, including IP, as well as dense wavelength division multiplexing. As mentioned, at its peak it was estimated that 70 percent of Internet traffic was carried on Nortel optical transmission equipment. This was a strategic business area for Nortel, one it dominated until fiber became a 'commodity' by the early 2000s, yet the company held a technical lead in many optical transmission technologies through to the end.

Right Angle Turn

In hindsight, the Right Angle Turn was a defining moment for Nortel. The company had a respected reputation for bold and dramatic claims; such as its visionary role in both laying the foundations for and providing key parts to the world's digital communications and fiber infrastructures. The Right Angle Turn was generally seen in similar light – Nortel saw the way. Consequently, the 'Turn' was marketed as a change in technical direction, shifting from 'dial tone', meaning the traditional voice centric switched network, to 'web tone', meaning the Internet and moving from 'copper wire' to 'fiber optics', and from voice to multimedia communications.

Yet, it was much more than that. The 'Turn' was a message to both the market and to employees, especially R&D – change was coming and fast. The 'much more' relates to three other elements of the strategy to implement the Turn. All three were internally focused and promoted the need to be more *agile* in projects, *more dynamic* in organization, and *more responsive* to customers' needs, especially the emerging enterprise market, a potentially large market for Nortel and its competitors.

The perception of customers' needs provides an interesting perspective as to why change was coming. For many years Nortel had worked closely with their service provider customers (i.e., telcos) and understood their needs. Nortel did not fail to listen to its customer. The problem was Nortel's telco customers were not listening to their own customers, yet (e.g., many telcos saw wireless as a threat to their core wireline business so they were pushing back on wireless solutions from their suppliers whereas the corporate and consumer markets were proactively interested in using wireless access products).

Consequently, the notion of supplier began to change in the late 1990s from being a provider of "take it or leave it" products for consumers and businesses to one that needed to listen to consumers and businesses because now they were exercising a voice and had an increasing choice in a rapidly deregulating telecommunications industry. This was a change which Nortel needed to be sensitive to; but was not particularly attuned to until it was perhaps too late. Having abandoned any consumer products, telephone sets, wireless handsets and similar products a few years before, Nortel lost touch with the emerging demands of a rapidly changing consumer base. Neither were Nortel's traditional customers sensitive to this change as they were initially avoiding wireless and Internet Protocol, seeing them as parallel and threats to their traditional business.[15]

Nortel's problem was not, not listening to its customers, as many have speculated. It was listening too closely to their current customers without recognizing the rising tide of network users with requirements that were not being addressed. A number of management texts[16] have warned of the danger of listening "too closely" to your customer, or of pandering to their wants rather than their needs.

Nortel sought to address this by buying companies whom they perceived as being agile and responsive. Employees in Nortel were assured that this change would provide complementary products which would integrate into Nortel's current product line. In reality these products did not integrate well, many simply did not work and almost invariably the engineering fell far short of Nortel's traditional high technical and manufacturing standards. At Nortel, technical staffs were disillusioned with this change, which many perceived as negative and undoing the well established reputation that Nortel had built for creating solid reliable products.

The term 'Right Angle Turn' was an unfortunate choice because it suggested abandonment of what had gone before rather than complementing and building on it. Soon the term 'wrong angle turn' began being heard in the corridors, a clear message that should have been of concern for the senior executives.

These themes were internally focused and quite dramatic in scope and scale for a firm with a somewhat traditional large corporation hierarchical structure and a culture dominated by a pride of often leading and rarely following. This state of leading was typified by the company often being ready to address new opportunities, even if they failed to materialize as sustainable markets (e.g., ATM, WiMAX). The anticipation was made, requirements defined and R&D undertaken with ample internal expertise, yet some markets failed to develop. This failure is simply part of the risk of anticipating markets to develop while inventing products to meet these emergent and evolving needs as a first mover or market leader.

To kick-start the 'agile' thrust, Nortel launched an aggressive program of technology-based acquisitions aimed at helping achieve the 'Turn' through acquisition of at-hand technical advances. A second order

[15] For example, British Telecom as recently as 2014 bought a major UK wireless company, having sold their wireless interests two decades earlier in 2005.

[16] See for example Christensen, *The Innovator's Dilemma*.

effect of the acquisitions was the inherent attempt to emphasise the agile, dynamic and responsive practices of the acquired companies as a means to instil the same spirit in the Nortel culture and way of working. This did not go well in most cases as noted elsewhere in this report.

The kinds of companies purchased all had promising or demonstrable technologies; and in some cases products in the market. Most acquisitions were privately held start-ups and early stage VC backed firms. Nortel worked in a formal relationship with a number of VCs to identify firms in areas of interest to it.

In most cases Nortel bought technology, people, good will, and sometimes product. Most transactions were Nortel common stock or a combination of stock and cash. There were some large cash deals. All deals were deemed essential to winning the race of 'time-to-market', especially in the early days of the commercial Internet when most of Nortel's competitors were also on aggressive acquisition campaigns.

Trying to become more 'dynamic' coupled with 'agile' was in part the intent behind the breakup of BNR and distributing most R&D resources to business units beginning in 1996. This did not have a positive effect on the morale of many R&D staff, leading to departures and redeployment of talented researchers, (e.g., engineers, physicists and mathematicians). Furthermore, the elimination of BNR as a central research organisation blinded the company in its ability to anticipate technical advances beyond the rush to achieve the objectives of the Turn internally while trying to be number one externally.

The Turn also had an impact in marketing and sales messaging with a consequently affected R&D. In the pre-Turn days Nortel was famous in the industry for listening to its customers' needs. With the Turn the messaging became more short-term and more focused on listening to customers' needs more closely. This was in part understandable because many of Nortel's customers were long-time buyers of Nortel equipment. Consequently, these customers had an investment in infrastructure that Nortel was saying will be different in the near future. Customers wanted to know what was happening. At the same time, Nortel was aggressively pursuing a new enterprise market represented by the telecommunications needs, including Internet requirements of large corporations. At the time this was a market less focussed on 'here's what we need, go invent a solution' to one of 'here's what we need, so how can you fill the order'.

This shift was in part driven by the style of marketing and sales prevalent among the computer network equipment vendors, where customers tended to have less concern about futures and more concern with buying what is at hand. The business relationships resulting from the above posturing are akin to a partner versus a supplier. The former was the Nortel way pre-Turn and the latter became the Nortel way by the early 2000s.

As enterprise business developed, Nortel established a Professional Services group to provide custom consulting in network design, sources, deployment, and maintenance. This was an emerging trend in industry as exemplified by IBM's re-focus from hardware to services. This unit was disbanded with the collapse in market demand in early 2002, having never met its business objectives.

Skunkworks were not uncommon at Nortel during the heady days, as noted elsewhere in this report. For example, Nortel came up with an iPhone-like device 15 years before its introduction by Apple in 2007. Phones are known as access devices (i.e., they are used to access wireline and wireless networks). Despite such inventions, Nortel chose to step out of providing access devices and concentrated on the infrastructure. That decision also constrained Nortel to operating in the lower layers of the ISO stack What Nortel failed to grasp was that value had moved from lower layers ('bit hauling') to applications and

services. Nortel's attempt to enter into applications and services was driven by their traditional customers' approach and implementation of Integrated Multimedia Systems, or the 'walled garden' whereby service providers' contained their customers' Internet access. The 'walled garden' was soundly rejected by consumers, businesses and regulatory authorities as a restrictive business practice.

With an industry shift to outsourcing manufacturing and related services in full gear by the late 1990s, Nortel followed suit and by 2004 had withdrawn from any mass manufacturing and a number of related services. In so doing it was able to further capitalize on its outsourcing by streamlining its supply chains and improving its margins; particularly following the 2001/2002 downturn.

Nortel closed its factories in Canada, the United States and Mexico, and handed production to contract manufacturers such as Flextronics and San Mina, both headquartered in Singapore. From 1999 through 2004 Nortel transformed from a company that made nearly everything it sold to one that outsourced all its manufacturing, and much of its testing and product integration to 3rd parties. For example, in 2001 Nortel ceased most of its manufacturing, product integration, configuration, and testing of its DMS circuit-switching products to 3rd parties.

It is interesting to note that this move to outsourcing did not result in a reduction in headcount. In fact Nortel headcount peaked around the year 2000 at just below 100,000, and exceeding well over 100,000 when contract employees were included. Compare this with the company which, in 1985 employed under 30,000 and made everything themselves. Growth in headcount was largely fuelled by acquisitions, a liability which the executive team seems to have failed to consider when approving those acquisitions.

This delayering of the enterprise and moving out of manufacturing with a concentration on design and R&D was also in vogue as a new kind of business model associated with being agile and dynamic while allowing routine functions to be performed on a mass scale by a performance-based contractor. The move to outsource manufacturing and related services, coupled with the elimination of a central research perspective is surmised to have had, at a minimum, negative operational impacts on engineering design and process engineering with respect to designing new products for building by contractors. Previously, there was an almost seamless link between those who develop new products and those in the company that manufactured them. With outsourcing, this link was replaced with contract negotiations at a distance. The nature and implications of a change in this link, as noted above, will be a topic for further investigation.

Access Products

Nortel had been very successful in access products from the early days of analog line interfaces through to the introduction of digital switching. For example, Nortel designed and built the most cost effective line card and continued development of this technology right through to offering the first DSL technology operating at 1 Megabit/second along with its complementary Digital Subscriber Line Access Multiplexer (DSLAM). At the time most Internet connections were at 56 Kbps. Nortel changed the landscape; but failed to remain active in the access market.

Nortel created telephone sets that were generally regarded as 'best in class', particularly by the business community. In addition, Nortel's residential telephone sets were liked by the telcos because of their ability to work on old infrastructure (wires) at long distances from the switch, as required by telco standards. This differentiated Nortel from low price consumer products. However, Nortel products were

more expensive to produce. O nce the market opened to enable consumers to connect their own products, Nortel products were basically no longer competitive except for consumers operating on difficult interfaces, typically remote rural customers.

Nortel excelled at access technology and access products. Unfortunately, despite their leadership, it was decided by executives that access technologies had been relegated to 'commodity' status and did not enable the per unit margins Nortel desired for its products. In considering executive management decisions, access technology is an example of where Nortel could excel at a technical level but was cut off from this important area, at least in hindsight, due to a change in corporate strategy. Access has become a critical success factor for those companies that serve the Nortel market space today.

The success or failure of access products gives valuable insight into the thinking of consumers and business users. Additionally, during the 'over order' followed by 'reschedule or cancel', created by the exuberance of the dot-com boom, Nortel's competitors were sustained by their lower margin commodity products. Not so Nortel, which depended for a major part of its revenue on one product line, optical transmission, which was hit hard by the bursting of the dot.com bubble.

5.2 General Comments from Interviews & Surveys

The following is a brief synthesis of comments from the several hundred participants who contributed to this investigation through interviews and an online survey. 'Technology was always reliable and at the research level highly advanced in terms of meeting actual and anticipated customer needs'. 'Although Enterprise and Optical products were strong in terms of technology and meeting customer needs, the products in wireline and wireless were not as strong'. This was supported by survey results that cited a poor approach to technical decision making and setting the balance between external and internal R&D. There were comments about a lack of central control on R&D, lack of R&D leadership (at the senior executive level) and a negative impact of limiting technology personnel's interactions with clients was deemed by some to be the detriment to Nortel's product development efforts by not getting sufficient technical requirements of customers.

5.3 Summary Perspectives on Nortel Technology

Nortel fundamentally depended on creating and/or gaining access to technologies essential to its various product offerings throughout the world. Therefore, in assessing Nortel's technology with a view to learning lessons about its possible contribution to the company's failure, we examined technology and conditions and processes dealing with technology from some eight different perspectives according to the following themes:

- Creating an innovative environment and capability
- Competence
- Range of technical skills
- Corporate culture with respect to R&D and commercialization
- Management awareness of Nortel technologies and technical strengths
- Research and development priorities
- Product commercialization, and
- Missed trends and opportunities.

Each theme was examined in terms of its possible role in the demise of Nortel with a view of identifying what lessons could be gleaned accordingly. The first three themes are encapsulated below, with the rest presented at different places throughout the report.

Creative and Innovative Environment and Capability

Bell-Northern Research was an R&D company owned jointly by Bell Canada and Nortel; then known as Northern Telecom. It was created to be a joint research and development company. This meant that culturally and structurally it was optimized to create, innovate, and develop telecommunications products. Creativity and product innovation were encouraged and rewarded. It was considered by many in the telecommunications industry to be one of the finest telecommunications R&D facilities in the world, comparable to that of Bell Labs in the US, on which it was initially modelled.

Competence

BNR hired the best and brightest. Not just on academic ability but on creative and innovative abilities too. The mood this approach fostered in the company was one of 'we can do anything better than anyone else'. It was a successful model resulting in significant technological breakthroughs between the mid-1980s through the late 1990s:

Examples of high levels of competency in R&D:

- TDM switching and transport technology
    - Semiconductor technology to facilitate TDM leadership
- Optical transmission
    - Leading-edge optical component development
- Innovative handsets
- Pioneering email network
- Access technologies: ISDN and DSL, 1 Meg modem, and
- Packet switching: Frame Relay, ATM and Internet Protocol
    - Semiconductor technology to facilitate large packet routers.
- Creation of optical components, and
- SONET and SDH

Range of Technical Skills

Not only did Nortel possess significant skills in product, networks and systems engineering, but in all aspects of engineering related to its products. For example, Nortel designed, built and manufactured: seismic (earthquake tolerant) frames for its equipment, leading-edge thermal engineering features in its products, proprietary semiconductors, and automated testing and manufacturing capability and capacity.

Nortel researched and published original work in a number of telecommunications fields; including voice quality, psychoacoustics and video compression. The skill range was wide and deep.

5.4 Overall Summary & Observations

Nortel depended on creating and gaining access to technologies essential to its various product offerings. Our research shows that to the end, Nortel technology, people and their adaptability remained among the best in the industry.

Acquiring technology by acquisition was generally a failure at Nortel. Once the company began to return to its roots circa 2004 and re-focus on developing technology in-house rather than trying to acquire technology by acquisitions, it revived its leading-edge capability of the past.

At the time of filing for protection from creditors, Nortel held leading technology in a number of emergent areas, notably 4G/LTE wireless, long haul optical and other fiber optic transmission technologies.

In the end, our analysis shows that Nortel did not fail because of its technology nor were specific technologies necessarily the wrong choices. The fundamental issue regarding technology was all about the continual recognition and appreciation, by executive management, of the strength of the in-house technology capability. In the days when the company faltered there was a clear disconnect between executive management and in-house technical staff and a lack of respect by executive management for the in-house capability.

Executive management recognized that in high technology it is the 'calendar' that kills you, rather than the dollars. If you do not have the right product at the right time it is difficult to catch up. For this reason they decided to acquire products, having realized they had missed the opportunity. We discovered that their pessimism in fearing not being able to create products in time, using their internal capability, was largely unfounded.

A drive towards R&D efficiency hurt Nortel as mentioned earlier. As we noted, in technology based products it is the calendar that an organization needs to shrink, not the dollars. In shrinking the dollars one invariably stretches the calendar and it is that stretching that cost Nortel dearly.

Many lessons were learned with respect to both technology decisions and technology management. A fundamental lesson learned is not to lose sight of the fact that technology companies need forward looking technology vision and technology-oriented decision making in key points of the organization. In the case of Nortel, as one executive put it, of the fifteen top officers, only one had any technology background. This does not mean that the CEO needs to be a technology visionary but it has to be somewhere at the top in a central decision making ability and in the case of a company like Nortel with strong P&L divisions, it also needs to be in a central role in each of the business lines.

5.5 Key Lessons Learned

In the end, a number of key lessons were learned in respect to how Nortel fell from global dominance to emerge as a transformed phoenix with its assets distributed as spoils among its competitors. Here is a list of the ten most significant lessons.

- Nortel did not fail because of technology nor because of its products. We found no systemic problem with Nortel's own technologies nor technology management processes;

- It is essential to avoid losing sight of the fact that technology companies need strong forward-looking technology vision and technology-oriented decision-making at key points within the organization;
- Nortel/BNR had world class engineers, scientists and product visionaries. The breakup of BNR created a gap in the company's ability to continue fostering a visionary and innovative R&D environment producing a capacity to 'see the future';
- Like partnerships, acquisitions require a degree of symbiosis between the companies involved. The more strategic the importance of the acquisition the more carefully the integration process needs to be effectively managed and nurtured. Nortel had a reasonable targeting plan to seek out acquisition target; but it had no apparent plan to effectively integrate acquisitions into the Nortel fold;
- Technology management as an engineering enterprise was well run and subject to the priorities of corporate strategy and budgets. The corporate strategy to change direction while remaining focused on 'bit hauling' with new technologies limited the value-add Nortel could offer its customers; especially as corporations and end-users and their intermediaries (ISPs and telcos) became more astute customers about access devices and telecommunications and networking infrastructure;
- Abandoning the development of access technologies and products, especially personal devices, was a serious technical and business oversight, which led to efforts to catch up without success before it was too late, particularly in wireless;
- Nortel's choice of CDMA wireless technologies and products 'ham-strung' the company to basically a North American market. At the same time, Nortel was late into GSM and never became a significant player;
- Nortel was a world leader in the development of LTE intellectual property for the next generation of mobile communications;
- Nortel remained to the end a world leader in optical technologies and related telecommunications products and had a treasure trove of technology patents worth billions of dollars; and,
- Technologies and products acquired through M&A initiatives were difficult to integrate and failed to gain market traction for a range of technical, cultural and management reasons.

The failure of Nortel is a complex and dramatic story in the annals of Canadian corporate history. We hope that this report, in complement with the other reports in the uOttawa series along with a number of academic papers arising from this research, will assist people; in particular business executives and their cadre, policy makers and students of business, in being better prepared for unintended consequences of rapidly changing markets, technology convergence, the marrying of different business cultures and responding to dynamic transformations in many directions concurrently.

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Annex 2

Acronyms & Glossary

Ad hoc network	A wireless ad hoc network is a decentralized type of wireless network. The network is ad hoc because it does not rely on a pre-existing infrastructure, such as routers in wired networks or access points in managed wireless networks. Instead, each node participates in routing by forwarding data for other nodes, so the determination of which nodes forward data is made dynamically on the basis of network connectivity. An ad hoc network typically refers to any set of networks where all devices have equal status on a network and are free to associate with any other ad hoc network device in link range.
ADSL	Asymmetric Digital Subscriber Line (See DSL below)
BCE	Bell Canada Enterprises
Black Cloud	A Nortel customer-defined expression used to characterize the gradual shroud of growing doubt about the strategic survivability of Nortel in weathering the turbulent times following the burst of the dot-com bubble and the consequent impacts on telecommunications industry.
CDMA	Code Division Multiple Access (CDMA) is a channel access method used by various radio communication technologies. CDMA is an example of multiple access, which is where several transmitters can send information simultaneously over a single communication channel. This allows several users to share a band of frequencies. To permit this to be achieved without undue interference between the users, CDMA employs spread-spectrum technology and a special coding scheme where each transmitter is assigned a code. CDMA is used as the access method in many mobile phone standards such as cdmaOne, CDMA2000 (the 3G evolution of cdmaOne), and WCDMA (the 3G standard used by GSM carriers), which are often referred to as simply CDMA.
CLECS	Competitive local exchange carrier, a telephone company that competes with an incumbent local exchange carrier (e.g., Bell, Verizon, Telus, Sprint).
CPE	Customer-premises equipment or customer-provided equipment (CPE) is any terminal and associated equipment located at a subscriber's premises and connected with a carrier's telecommunication channel at the demarcation point ("demarc"). The demarc is a point established in a building or complex to separate customer equipment from the equipment located in either the distribution infrastructure or central office of the Communications Service Provider. CPE generally refers to devices such as telephones, routers, switches, residential gateways, set-top boxes, fixed mobile convergence products, home networking adaptors and internet access gateways that enable consumers to access

	Communications Service Providers' services and distribute them around their house via a Local Area Network (LAN). Also included are key telephone systems and most private branch exchanges.
CRM	Customer relationship management (CRM) is a system for managing a company's interactions with current and future customers. It often involves using technology to organize, automate and synchronize sales, marketing, customer service, and technical support.[17]
DMS switches	Digital Multiplex System was a series of Nortel central office switches (i.e., public switch) used by both wireline and wireless operators. Among them were the DMS-1 (originally named the DMS-256, which Rural/Urban digital loop carrier, DMS-10 telephone switch, the DMS SuperNode family of telephone switches, which included DMS-100, DMS-200, DMS-250, DMS-300, DMS-500, DMS-GSP, DMS-MSC, and DMS-MTX), and the S/DMS optical transmission system.
dot-com bubble	The dot-com bubble (also referred to as the dot-com boom, the Internet bubble and the information technology bubble) was a historic speculative bubble covering roughly 1997–2000 during which stock markets in industrialized nations saw their equity value rise rapidly from growth in the Internet sector and related fields. While the latter part was a boom and bust cycle, the Internet boom is sometimes meant to refer to the steady commercial growth of the Internet with the advent of the World Wide Web, through the 1990s. The period was marked by the founding (and, in many cases, spectacular failure) of a group of new Internet-based companies commonly referred to as dot-coms. Companies could cause their stock prices to increase by simply adding an 'e' prefix to their name or a 'com' to the end, which one author called 'prefix investing'. (Source: http://en.wikipedia.org/wiki/Dot-com_bubble).
DSL	Digital subscriber line is a family of technologies that provide Internet access by transmitting digital data over the wires of a local telephone network. DSL service is delivered simultaneously with wired telephone service on the same telephone line. This is possible because DSL uses higher frequency bands for data. On the customer premises, a DSL filter on each non-DSL outlet blocks any high frequency interference, to enable simultaneous use of the voice and DSL services. The term 'DSL' is widely understood to mean asymmetric digital subscriber line (ADSL), the most commonly installed DSL technology. (Also, see below, Universal ADSL).
DSLAM	A digital subscriber line access multiplexer is a network device, located in telephone exchanges that connects multiple customer digital subscriber line (DSL) interfaces to a high-speed digital communications channel using multiplexing techniques.
DWDM	Dense Wavelength Division Multiplexing is used in fiber-optic communications. Wavelength-division multiplexing is a technology that multiplexes a number of

[17] Shaw, Robert, *Computer Aided Marketing & Selling* (1991) Butterworth Heinemann ISBN 978-0-7506-1707-9, sourced from: http://en.wikipedia.org/wiki/Customer_relationship_management

	optical carrier signals onto a single optical fiber by using different wavelengths (i.e., colors) of laser light. DWDM enables bidirectional communications over one strand of fiber, as well as increasing its capacity to carry traffic.
Frame Relay	A standardized wide area network (WAN) technology originally designed to work with ISDN (see below).
Gbps	Gigabits per second
GSM	GSM (Global System for Mobile Communications, originally Groupe Spécial Mobile), is a standard developed by the European Telecommunications Standards Institute to describe protocols for second generation (2G) digital cellular networks used by mobile phones. By the early 2000s it became the de facto global standard for mobile communications with over 90% market share. The GSM standard was developed as a replacement for first generation (1G) analog cellular networks, and originally described a digital, circuit-switched network optimized for full duplex voice telephony. This was expanded over time to include data communications, first by circuit-switched transport, then packet data transport (source: http://en.wikipedia.org/wiki/Customer-premises_equipment).
IETF	Internet Engineering Task Force, an organisation that develops and promotes Internet standards, particularly around Internet Protocol
IMS	IP Multimedia System, a general purpose open industry standard for voice and multimedia communications using Internet Protocol
IP	Internet Protocol also referred to as Intellectual Property, depending on its context.
IPTV	Internet Protocol Television, a means of delivering television via Internet Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
Kbps	Kilobits per second
LAN	Local Area Network
Layer 4-7 switch	This is a multilayer computer networking device that switches on OSI layer 2 like an ordinary network switch and provides extra functions on higher OSI layers (i.e., 4 through 7).
LMDS	A Local Multipoint Distribution System was capable of offering subscribers a variety of one- and two-way broadband services, such as video programming distribution; video teleconferencing; wireless local loop telephony; and high speed data transmission, (e.g., internet access). Because of its multi-purpose applications, LMDS was anticipated to be a major competitor to local exchange and cable television services. It was conceived as a fixed wireless, point-to-multipoint technology for utilization in the 'last mile'. LMDS commonly operates on microwave frequencies.

	Distance is typically limited to about 1.5 miles (2.4 km) due to rain fade attenuation constraints. (Source: http://en.wikipedia.org/wiki/Local_Multipoint_Distribution_Service)
Load balancer	In computing, load balancing distributes workloads across multiple computing resources, such as computers, a computer cluster, network links, central processing units or disk drives. A load balancer is the device that manages load balancing. The fundamental feature of a load balancer is to be able to distribute incoming requests over a number of 'backend' servers in the cluster according to a scheduling algorithm.
M&A	Mergers and Acquisitions
Mbps	Megabits per second
MPE	Multi Service Provider Edge, a Nortel product family for 'voice grade' IP/MPLS
MPLS	Multiprotocol Label Switching
(Number) G	Reflects the generation in respect to global wireless technologies and products. Specific generations referred to in this report are 1G, 2G, 2.5G, 3G and now 4G.
Optical Long Haul	Refers to the transmission of visible light signals over optical fibers for great distances without or with minimal use of repeaters.
OSI Model	The Open Systems Interconnection model (OSI) is a conceptual model that characterizes and standardizes the internal functions of a communication system by partitioning it into seven abstraction layers. The model is a product of the Open Systems Interconnection project at the International Organization for Standardization, maintained by the identification ISO/IEC 7498-1. See also Annex 3. (Source: http://en.wikipedia.org/wiki/OSI_model). Also, see Annex 3.
PBX	Private Branch Exchange, a switch typically used within an organisation for purposes of conducting its own business, as opposed to public switches (see DMS switches).
PON	Passive Optical Network technologies support telecommunications networks that use point-to-multipoint fiber to the premises in which unpowered optical splitters are used to enable a single optical fiber to serve multiple premises.
QoS	Quality of Service is the overall performance of a telephony or computer network, particularly the performance seen by the users of the network. To quantitatively measure quality of service, several related aspects of the network service are often considered, such as error rates, bandwidth, throughput, transmission delay, availability, jitter, etc. QoS is particularly important for the transport of traffic with special requirements. In particular, much technology has been developed to allow computer networks to become as useful as telephone networks for audio conversations, as well as

	supporting new applications with even stricter service demands (Source: http://en.wikipedia.org/wiki/Quality_of_service).
RF equipment	Radio Frequency equipment (e.g., wireless equipment)
SDH	Synchronous Optical Networking (related to SONET), see below
SL switches	SL-X series of private branch exchanges (PBXs), the first of which was the SL-1 (Stored Logic - 1)
SMS	Short Message Service (commonly referred to as 'texting')
SONET	Synchronous Optical Networking (SONET), as used in North America, and Synchronous Digital Hierarchy (SDH), as used in Europe, are standardized protocols that transfer multiple digital bit streams over optical fiber using lasers or highly coherent light from light-emitting diodes (LEDs). At low transmission rates data also can be transferred via an electrical interface. The exact rates that are used to transport the data on SONET/SDH are tightly synchronized across the entire network, using atomic clocks. This synchronization system allows entire inter-country networks to operate synchronously, greatly reducing the amount of buffering required between elements in the network.
Splitterless DSL	A DSL splitter is a standard telephone filter that allows multiple devices to be connected to a standard telephone jack. A splitterless DSL is a filter that does not require a physical splitter at the user's home or business.
SS7	Signalling System No. 7 (SS7) is a set of telephony signaling protocols which are used to set up most of the world's public switched telephone network telephone calls. The main purpose of the system is to set up and tear down telephone calls. Other uses include number translation, local number portability, pre-paid billing mechanisms, short message service (SMS), and a variety of other mass market services (Source: http://en.wikipedia.org/wiki/Signalling_System_No._7).
Tbit	Terabit or Tb which is 10^{12} bits also referred to as Tbps
TCP/IP	The Internet protocol suite is the networking model and a group of communications protocols used for the Internet and similar networks. It is commonly known as TCP/IP, because it represents the most important protocols, the Transmission Control Protocol (TCP) and the Internet Protocol (IP), were the first networking protocols defined in this standard.
TDM	Time-division multiplexing is used primarily for digital signals, but may be applied in analog multiplexing in which two or more signals or bit streams are transferred appearing simultaneously as sub-channels in one communication channel, but are physically taking turns on the channel.
UMTS	The Universal Mobile Telecommunications System (UMTS) is a third generation mobile cellular system for networks
VoIP	Voice over Internet Protocol

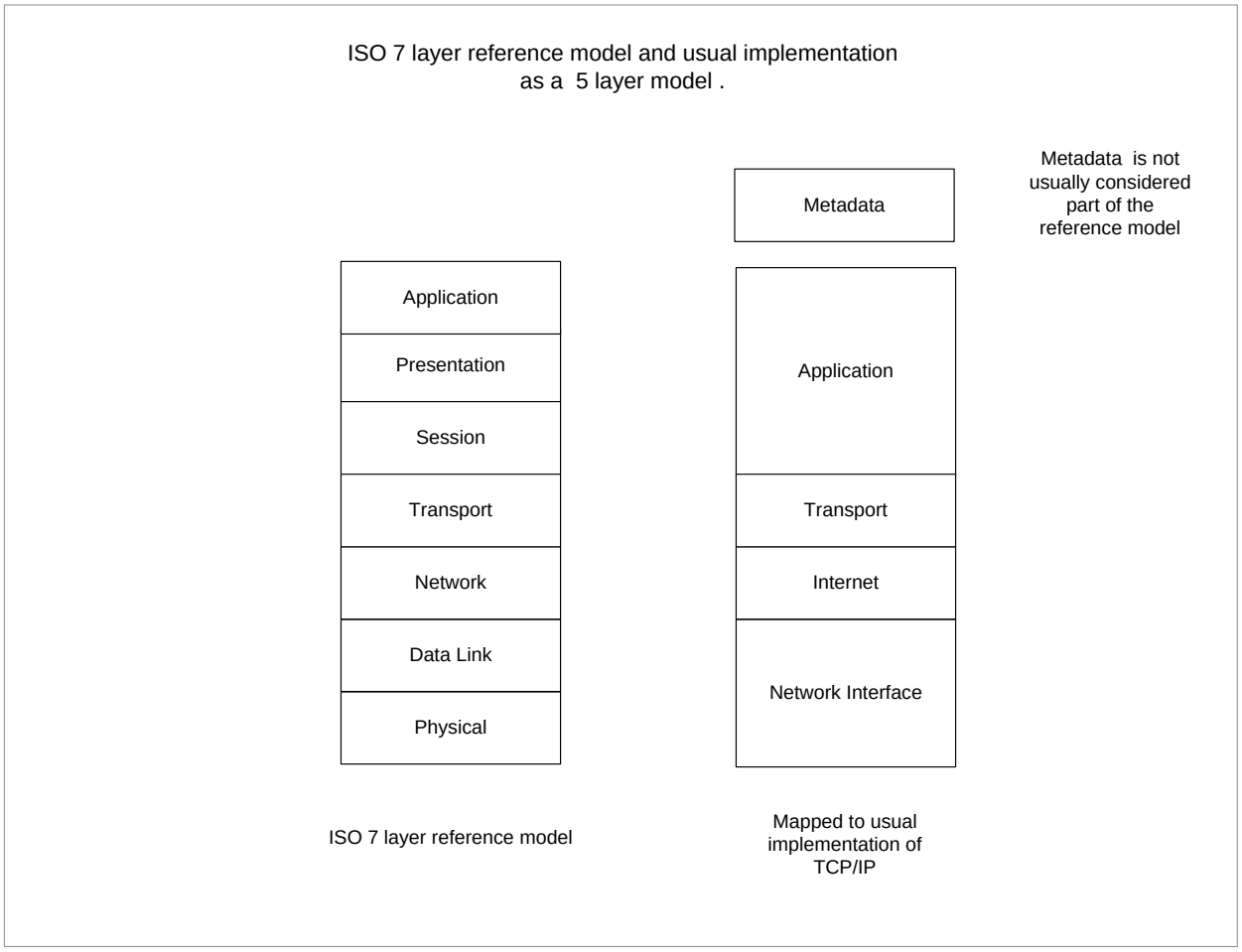
VPN	A Virtual Private Network. A means of establishing a secure network (or 'tunnel') superimposed on a public network, ensuring only authorized users can access information travelling within the VPN.
Walled Garden	A closed platform, walled garden or closed ecosystem is a software system where the carrier or service provider has control over applications, content, and media, and restricts convenient access to non-approved applications or content. (Source: http://en.wikipedia.org/wiki/Closed_platform)
WAN	Wide Area Network
Wi-Fi	A local area wireless technology branded Wi-Fi rather than having to refer to the coded technical standard's name
WiMAX	Worldwide Interoperability for Microwave Access, a wireless communications standard

Annex 3

ISO Stack: Open Systems Interconnect Model

The Open Systems Interconnection model (OSI), is illustrated schematically in the Exhibit A-1. It consists of seven layers as set out below. The left stack is the classic 7-layer model and the right stack is a frequently used simplification of the 7-layer model by reducing the layers down to five with slightly modified labelling. Typically, moving up from the bottom of the stack increases the value-add.

Exhibit A-1
The OSI Model



Annex 4

Profile of Nortel Leadership as Industry Definer
Selected Highlights from *Telesis* – The BNR Technical Journal

Telesis - by definition "planned progress"

We examined a set of *Telesis* journals from 1983 to 1997, when the journal stopped publication, and present a selection of highlights below.

Year	Technical Vision & Leadership Benchmarks
1983	Filter codec and line card chips: the new generation
1984	Fiber optics of local area networks
1985	Meridian integrated voice, text graphics and image terminal Touchphone: handset activated by touching a screen Digital microwave radio incorporating 64 QAM modulation technique
1986	ISDN - Integrated Services Digital Network DMS-MTX Cellular Mobile telephone system
1988	Local area network technology Speech recognition
1989	Innovative telephone handsets and key systems Fiber to the home Security and voice cryptography
1990	The *FiberWorld* concept – a world connected by optical fiber communications
1992	SONET SDH Personal communications services - a detailed vision describing the wireless world we know today, kids with phones, touch screens, handwriting recognition
1993	Long-haul high speed fiber optics *Orbitor* - the world's first smartphone
1994	The information superhighway - ubiquitous high bandwidth wide area networking
1995	Wireless data
1996	The Internet
1997	Voice over IP

Nortel Internal Communication Messages – A Sample

The Nortel Edge, 1998, Issue Two

This document, designed for internal communications with staff, was subtitled *Fulfilling the Promise of Webtone* and contains insightful articles describing the goal to:

> "Make the Web something the world will take for granted at prices the world can afford"

This edition says all of the right things in defining the future as seen from a 1998 perspective. Although Nortel said the right things, it subsequently did not follow through on its own vision. See Below as a sample of articles from this issue of the journal.

> Quote: "A sampling of Nortel's IP related initiatives, focusing on a broad cross-section of activities that range from innovative end-user applications to next-generation infrastructure developments."
>
> The "Nortel Bay merger" was introduced and positioned as a merger, when in fact; it was not a merger but rather an acquisition of Bay Networks by Nortel. This no doubt reflected executive managements view to both the marketplace and to its own employees as to how fundamentally the company was transforming as a direct consequence of the Right Angle Turn.
>
> The 1-meg modem is described, as is broadband wireless access, high bandwidth mobile network capacity developments to accommodate traffic (These projects were all subsequently cancelled).
>
> The 'rotator' concept was an innovative means of routing mixed TDM, IP, Frame Relay, and ATM traffic on a single infrastructure. However, this project was cancelled during the panic to cut R&D expenditure following the sudden drop in revenues in 2001.
>
> Handwriting recognition on a GSM handset was described; but never turned into product. Similarly, high quality voice over IP was laid out; but it too never materialized as a product.

Profile of Nortel Leadership as Industry Definer
Selected Highlights from Nortel History

Sources: www.nortel-canada.com/about/history/1970-to-1999/

www.nortel-canada.com/about/history/2000-to-present/ ***1996 – Top Canadian R&D spender***

In 1996 Nortel topped the national list of Canada's leading R&D spenders at $2.6 billion, more than eight times the amount spent by the second-ranked firm. Nortel held this position as the county's largest R&D spender well into the early 21st Century.

1996 –Nortel offers all major digital wireless technologies

Nortel is the only supplier offering a complete portfolio of network solutions around the world in all major digital wireless technologies including GSM, CDMA, TDMA and CDPD

1997 – World's first 1-Meg modem for 'always-on' Internet connections

Nortel introduces the world's first 1-Meg modem service – a mass-market, plug-and-play modem replacement technology to be built into Nortel's current telephone switching equipment. The service delivers a secure, 'always-on' connection that is 22 times faster than a 56 Kbps modem.

1997 – First public demo of simultaneous text messaging

Nortel demonstrates publicly for the first time a simultaneous text messaging capability that delivers a text message to the home, the office, and even to a wireless PCS phone – all at the same time.

1998 – Optical IP networks for advanced research

Nortel is involved in some of the world's most advanced collaborative optical IP network applications projects. The projects include — Abilene (one of the backbone networks for Internet2 in the U.S.); CA*net 3 (a pure IP research and education network being developed in Canada); and DARPA (the Defense Advanced Research Projects Agency) which is developing the next-generation Internet that will include a backbone that is 1,000 times faster than today's fastest backbone networks.

1998 – Strategic acquisition: Internet protocol networking

Nortel merges with Bay Networks, an industry leader in worldwide IP networking. Along with a complete line of products for enterprises and carriers, Bay Networks brings thousands of seasoned IP professionals into the company. The merger so profoundly changes the company that the name is changed to Nortel Networks.

1999 – World's fastest, highest capacity Internet technology

Nortel, whose optical networking equipment carries 75 percent of North America's backbone Internet traffic, introduces a fiber-optic technology that increases the Internet's backbone speed and capacity by 640 times. OPTera 1600G is an optical amplification system that can support 28 million simultaneous Internet connections over a single fiber.

1999 – Redefines speed of networking

Nortel Networks breaks its own speed and capacity record by introducing optical Internet capabilities that will carry up to 6.4 terabits per second (Tbps) of Internet and other traffic over a single, hair-thin strand of fiber.

1999 – First in world to provide four-fiber rings on 10 Gbps solution

Nortel delivers a technology breakthrough by supplying bi-directional four-fiber rings for 10 Gbps networks. The company maintains leadership in 10 Gbps and D-WDM worldwide with more than 90 percent market share, throughout the two years since first introducing its S/DMS TransportNode OC-192 solution.

1999 – World's first converged wireless/wireline packet network

Spain's Airtel Movil S.A. selects Nortel to supply the world's first converged wireless/wireline packet network. The network will be deployed across Spain's 50 provinces, including the islands, and will provide innovative Internet telephony and wireless Internet services.

2004 – First networking company to complete IPv6 tests

Nortel becomes the first networking company to complete the University of New Hampshire InterOperability Laboratory (UNH-IOL) phase II test regimen for IPv6 – the next generation Internet Protocol. IPv6 enables the Internet to continue to grow, accommodating new addresses for users and destinations that would not be available with current technology.

2004 – End-to-end VoIP solution certification by JITC

Nortel is the first networking vendor to provide an end-to-end VoIP solution certified by the U.S. Defense Department Joint Interoperability Test Command (JITC).

2008 – Nortel announces strategic agreement with Alvarion

Nortel is aligning its 4G wireless broadband strategy to address early market opportunities that are emerging for WiMAX and LTE. In addition Nortel and Alvarion Ltd. entered into a joint strategic WiMAX agreement to create an end-to-end WiMAX solution to meet the needs of the evolving wireless broadband market.

2008 – Nortel Acquires DiamondWare

Nortel announced it acquired DiamondWare, a pioneer in high-definition, proximity-based 3D positional voice technology that brings life-like sound to virtual web and voice communications. The acquisition furthers Nortel's drive to transform communications to allow people to collaborate in more interactive and immersive ways.

2008 – LG-Nortel Acquires Novera Optics

LG-Nortel announced that it has closed the acquisition of Novera Optics Inc., a developer of fiber-optic access solutions that extend high-speed carrier Ethernet services from optical core networks to customer premises. LG-Nortel is a joint venture of LG Electronics and Nortel.

The Beginning of the End

2009 – Nortel Obtains Court Orders for Creditor Protection

Certain Nortel entities in Canada, the United States, and United Kingdom filed for creditor protection under the Companies' Creditors Arrangement Act in Canada, filed voluntary petitions in the United States under Chapter 11 of the U.S. Bankruptcy Code, and certain of the Company's EMEA subsidiaries made consequential filings in Europe.

2009 – Nortel Divests Various Business Units

Nortel and its Board decide to divest virtually all corporate assets as follows:

- March 2009 – Divestiture of Certain Layer 4-7 Data Assets to Radware
- November 2009 – Divestiture of CDMA and LTE Access Assets to Ericsson
- December 2009 – Divestiture of Next Generation Packet Core Network Components to Hitachi
- December 2009 – Divestiture of substantially all of Enterprise Solutions Business to Avaya, including Nortel's shares in Nortel Government Solutions and DiamondWare
- March 2010 – Divestiture of Optical Networking and Carrier Ethernet business to Ciena
- March 2010 – Divestiture of GSM/GSM-R business to Ericsson and Kapsch
- May 2010 – Divestiture of Carrier VoIP and Application Solutions business to GENBAND
- June 2010 – Nortel sells its 50% plus 1 share interest in LG-Nortel to Ericsson
- 2011 – The End of an Era
- As 2011 drew to a close, all substantial assets of Nortel had been sold to other entities
- March 2011 – Nortel completes sale of Multi-Service Switch business to Ericsson
- May 2011 – Nortel sells assets of the GDNT Joint Venture to Ericsson
- July 2011 – Nortel sells all remaining patents and patent applications to a group of mostly foreign companies known as the Rockstar Consortium consisting, which consisted of Apple, EMC, Ericsson, Microsoft, Research in Motion (now Blackberry), and Sony.