Putting Canada in the Vanguard of the Internet Transformation*

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In August 1995 at the conclusion of my term as Clifford Clark Visiting Economist, I left behind at the Department of Finance an essay outlining some proposals as to Canada's policy priorities for the next decade. Included was the following statement: "Perhaps the most compelling phenomenon of our times is the emergence of the *information society* – based on microchips and communications – but far transcending those technological underpinnings. Shaping Canada's role in the information society according to our values, and assuring that we stay at the leading edge, are opportunities of sufficient breadth and potential to define a great national project (Nicholson 1995: 17; italics in original).

Much has happened in the intervening years. In 1995, it was still possible to write about the information society yet not associate that idea with the Internet. Netscape, the developer of the first web browser, was just a software start-up in the process of going public. Few people knew what an Internet service provider was. Email was an academic curiosity. Words such as e-commerce did not exist.

By 2001, we had gone through the dot-com bubble and its spectacular deflation. Nevertheless, the Internet-user population, which had soared to 300 million worldwide, is still projected to reach roughly a billion users by 2005. More than a trillion dollars of commerce will likely be conducted via the Internet this year.

Some commentators nevertheless believe that the collapse of Internet stocks – indeed, the entire implosion of investment in the telecom sector – marked the end of the Internet era. As I argue below, this event marked only the end of the beginning. In fact, the dot-com euphoria and subsequent meltdown were predictable (except for the precise timing), a consequence of the rapid expansion of a revolutionary new technology. History is replete with analogous experience.

The drivers of the continuing Internet transformation are ultimately technological, reinforced by demographic and behavioural shifts. These drivers continue to wax, not wane. Combined with the decentralized, innovation-friendly nature of the Internet, they will foment changes in business, government and society we can scarcely begin to imagine.

THE INTERNET'S FUNDAMENTAL CHARACTERISTICS

The Internet should be thought of as a new medium with a transformative potential based

* From Robert D. Brown, ed., Canadian Conundrums: *Views from the Clifford Clark Visiting Economists, Observation 43* (Toronto: C.D. Howe Institute, 2002); reprinted with permission.

on three fundamental characteristics:

- The Internet harnesses the exponentially growing power of communications and computing technologies combined.
- The Internet is based on open, global standards and is therefore a universal medium.
- The Internet is protean – that is, it adapts to an open-ended variety of purposes, much like human intelligence itself.

Each of these properties is remarkable and deserves a bit more consideration.

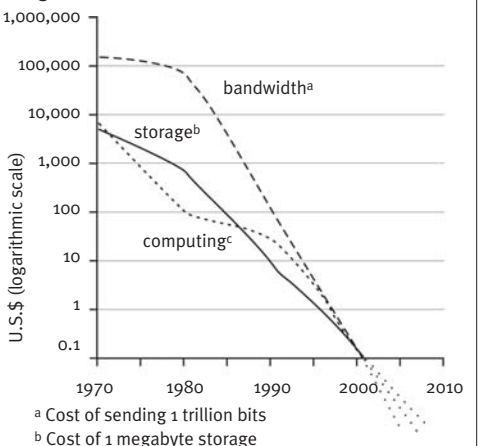
Technology

The transformative potential of the fundamental technologies underlying the Internet – computing, optical communications and electronic storage – cannot be overstated (see Figure 1). For more than 30 years, microchip technology has yielded a doubling of the ratio of computing performance relative to cost roughly every 18 months (Moore's Law). [Early in the computer revolution, Intel co-founder Gordon Moore predicted a doubling chip capacity (the number of transistors that can be put on a single semiconductor chip) would double every two years. It has actually doubled about every 18 months; see *Microsoft Computer Dictionary*, 4th ed.] Today's Pentium IV processor has 42 million transistors, and Intel confidently forecasts that by 2007 this number will rise 24-fold to a billion. Although that number is still well short of the roughly 100 billion neurons in the human brain, the next generation of chips will nevertheless be capable of remarkable feats of quasi-intelligence in view of the blinding logic speed of semiconductor devices.

No other technology has ever come close to the sustained productivity improvement of the microprocessor. A doubling of the performance-to-cost ratio every 18 months implies a thousandfold productivity improvement in just 15 years. Indeed, if Moore's Law applied to the auto industry, today's five-year-old could expect to buy a BMW for pocket change by the time he or she graduated from university.

Meanwhile, the performance-to-price ratio of electronic storage systems, such as hard drives, is improving even faster than Moore's Law,

Figure 1: Internet Cost Factors



[a] Cost of sending 1 trillion bits
[b] Cost of 1 megabyte storage
[c] Cost 1 MHz processor speed
Source: Federal Reserve Bank of Dallas

doubling roughly every 12 months. The bandwidth of optical fibre is increasing faster still. In 1970, it cost $150,000 to transmit a trillion bits of data (one terabit). By 2000, the cost of sending the same quantity of data – roughly equivalent to 100 million pages of text – had declined to about 15 to 20 cents. Today's leading-edge technology, employing digital encoding of information on multiple "colours" of light, could send that terabit of information in less than one second across a single strand of fibre, the width of a human hair. These technologies have inconceivable potential to change what is possible. Table 1 suggests some near-term implications.

Looking forward, we can see that the economic consequences of the Internet transformation will flow primarily from the fact that the cost of globally networked information is likely to decline by a thousandfold over the next 15 to 20 years. This decrease could put access to virtually all the codified information on the planet potentially within the grasp and affordability of a large fraction of humanity. Making productive use of that information and ensuring its broad accessibility in fact are, of course, huge challenges of a different kind.

Open Standards

The public Internet is really a vast number of networks that communicate via a common set of standards, of which the Internet Protocol (IP)

Table 1: Technology Trends and Projections

Trends	Current Standard	Projections	Some Implications
	Computing *(performance still doubling every 18 to 24 months — Moore's Law)*		
Moore's Law will continue for at least another 8 to 10 years based on recent announcements by IBM and Intel. Thereafter, "nano-scale" (molecular level) devices are likely to be used.	• Pentium IV becoming standard. • Speed of 1.8 GHz with 4.2 million transistors per chip. • Fierce price competition between Intel and AMD.	• 1 billion transistors per chip with a speed of 20 GHz by 2007 (i.e., 12 times faster than today with 24 times the density).	• Dramatic performance and cost reduction, particularly in non-PC devices (e.g., cell phones, PDA). • High-quality voice recognition. • "Reasonable" language translation for text on the Internet (e.g., website in language X automatically rendered in language Y). • Significantly more "intelligent" devices and netwoks.
	Communications *(performance doubling every 6 to 12 months)*		
Moving toward all-optical networks with "photonic switching," meaning no conversion between optical and electronic domains except at end-user devices. Dramatic increases in the number of wavelengths per fibre and number of bits carried per wavelength.	• 10 gigabits per second in extensive deployment. • Systems are available at 10 gigabits per second per wavelength and 160 wavelengths per fibre (total: 1.6 terabits per second per fibre), theoretically enough to carry 100 million calls at once on one fibre.	• 40 gigabits per second with 1,000+ wavelengths by 2005. • More than 40 terabits per second per fibre — 25 times the current maximum.	• Cost of "wasting bandwidth" becomes insignificant, leading to a fundamental rethink of network design and performance. • The true multimedia Internet arrives. • Large customers get their "own" wavelengths. • But rapid performance leap-frogging creates high uncertainty and reluctance to invest pending the next generation.
	Storage *(performance doubling every 12 months)*		
Acceleration of rate of improvement in storage density and cost with no let-up in sight. Optical and atomic-level storage could extend the trend almost indefinitely.	• Current mass storage devices achieve 25 gigabytes per square inch compared with 6 in 1999. • Cost per gigabyte in hard drives now about $6 compared with $37 in 1999. (Storing a movie requires about 5 gigabytes.)	• Capacity will be 100 gigabytes per square inch and cost $1 per gigabyte by 2003. (20 DVD-quality movies will be able to be stored on one tiny disc.)	• Personal video recorders and like devices will have almost unlimited storage at nominal cost. When combined with communications bandwidth, this trend will revolutionize distribution (and the revenue model) for media. • "Electronic paper" will become functionally and economically attractive (e-books, e-newspapers). • Mobile devices will have huge data functionality.
	Software *(no Moore's Law here)*		
Software development focuses on building components that connect through standardized interfaces. XML and related standards allow interoperable web services to expand capabilities of the Internet beyond the "web."	• Most current applications are written for Windows or the web — either limited to a single machine or constrained by the limits of HTML (the language used to describe web pages).	• XML-based web services will spark a new round of innovation in enterprise and e-business applications.	• Software will interact seamlessly across multiple computers and networks. • Innovative peer-to-peer applications will exploit the power of edge devices. • New services will develop that combine information and functionality from multiple providers.

Sources: Various industry reports; estimates from BCE Inc.

is the most prominent. These standard protocols – the data encoding and transmission conventions that allow computers to "talk" to one another – have had the revolutionary effect of allowing independently managed communications networks to interoperate worldwide. Thus, although Internet traffic is carried on thousands of physical networks (many of which are owned by phone companies and built originally to carry voice), no one actually owns the Internet. Fundamentally, the Internet represents a communications Esperanto whose standards are developed and maintained by a global network of volunteer groups of technical experts.

The Protean Internet

The design of the Internet does not presuppose how it will be used. Essentially, all it does is carry raw digital information (bits) from point A to point B. The meaning of those bits, how they are processed, and what they are ultimately used for is determined by the devices and users at the edge of the network.

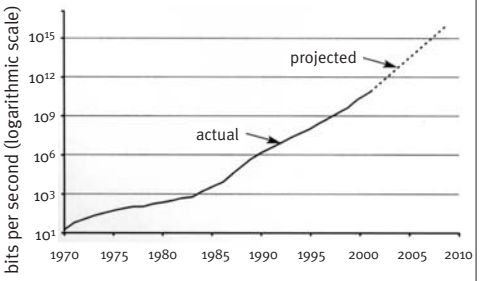
This freedom has permitted the key applications we now associate with the Internet to be developed independently of the physical network itself. First, email appeared during the 1970s (mostly for scientific communication), followed by a variety of additional text-based message and information applications during the 1980s. The

invention in the early 1990s of the World Wide Web – a software innovation – triggered mass mainstream adoption and a torrent of new applications and services. I expect that the applications of the Internet will continue to branch and mutate indefinitely. In effect, the Internet is becoming a global cyber nervous system.

BOOM AND BUST – AND THE FUTURE

In March 2000, the stock market delivered a deeply negative judgment of the Internet's future economic significance. The market's skepticism, which persists, reflects the dearth of Internet-based business models, without which the technological potential can never become reified in productive capital. But we should not be too impatient. The Internet, as a commercial phenomenon, is barely six years old, and already it has embedded itself in the daily routine of hundreds of millions of individuals and businesses. The volume of Internet traffic continues to double every 12 months, despite the dot-com eclipse (see Figure 2).

Figure 2: The Growth of Internet Traffic in the United States



Source: Roberts 2001

Economic history suggests that the introduction of a transformative technology often triggers a cycle of inflated expectations, hyper-investment, a riot of innovation and competition, and ultimately a Darwinian (more accurately, a Schumpeterian) shakeout into a relatively small number of viable entities.

The railway expansion in the second half of the 19th century and the automobile boom that followed are instructive examples. The turn of the 20th century saw a handful of U.S. automobile manufacturers, the majority of which were building cars powered by steam or electricity. During the next decade, the number of manufacturers boomed, peaking at close to 300 in 1911. The collapse of unsustainable competitors and the consolidation of the industry began well before Henry Ford developed the moving assembly line that ushered in a radical alteration of U.S. manufacturing. By the mid-1920s, most of the industry was concentrated in the "Big Three" companies. Yet the most profound impacts of the automobile – the creation of suburbia, the empowerment of the mobile individual, and the darker consequences of pollution and highway carnage – were still decades away.

Attempting to understand the long-term impact of the Internet from the perspective of 2002 would be like trying to have predicted in 1911 how the automobile would affect society. At present, we should think of the Internet as the "wheel" of the global information society. We now have a rudimentary wheel. The "car" is yet to be invented.

IMPACT ON PRODUCTIVITY

We can, nevertheless, make some broad economic generalizations that demonstrate the Internet's transformational significance. The role of the information and communications technology (ICT) sector in the growth of the past decade has been well documented. And although most of the recent impact on measured productivity has come via the electronic and communications equipment sector, the services that these technologies enable will eventually drive a much more significant transformation. The fact that the broader impact will occur with a relatively long lag is due to the inertial effect of installed capital, the ingrained habits of individuals and organizations, and simply the time it takes for society to climb a new learning curve. David and Wright (1999) extensively document this generic process, for example, in the context of the slow diffusion of electric power.

What we can now predict with reasonable assurance is that the sheer magnitude of productivity growth in the infrastructure technologies of the Internet will exert a growing impact on total factor productivity in the economy overall. The size of the direct contribution of these technologies to productivity growth

depends on their share in national expenditure multiplied by the rate at which the cost of their output is falling. We can expect the share of ICT and related services in national expenditure to continue to grow since the demand for that output is extremely elastic with respect to both price and income. The reason is twofold. First, the Internet (understood here as a broad proxy for the ICT sector) is an exceptionally versatile enabling technology, and thus, as related costs and prices fall, large new areas of application are opened up. Second, as incomes rise, the demand for luxury goods – which the Internet and related ICT gadgetry still are for many people – increases more than proportionally. Thus, the overall share of ICT output in national expenditure will increase while, as described earlier, the cost of that output falls rapidly. And as the Internet infrastructure proliferates, through, for example, broadband access, new terminal devices, and more functional and reliable software, the resulting network externalities will accelerate the social value of the medium. (The value of any network is roughly proportional to the number of interconnections and these grow approximately as the square of the number of connected users. Networks that connect relatively few users are of limited social and economic significance. But when whole populations become interconnected, the utility is greatly multiplied.)

The macroeconomic impact of the Internet will likely be felt primarily through two channels: (a) via its impact on the rate of productivity growth, which increases the per capita growth potential of the economy and thus the average material standard of living; and (b) by cutting the size of buffer stocks (inventories and so on) throughout the economy as networked information technology reduces the uncertainty against which such hedges are kept. This decrease in buffers would cut the deadweight cost of unused capital (a microeconomic effect) and should also mute the amplitude of the inventory component of the business cycle (a macroeconomic effect). (Alan Greenspan often cites this effect, with the caveat that it does not eliminate the traditional business cycle but should work to dampen it significantly.)

EFFECTS THROUGH FIRMS AND INDIVIDUALS

Analysts expect that by far the greatest economic impact of the Internet transformation will come from its effect on the behaviour of businesses and individuals. The international economics group of Goldman-Sachs has made one of the few credible attempts to quantify the impact arising from the systematic diffusion of e-commerce throughout the business sector of the Group-of-Seven (G-7) countries. That analysis (Brookes and Wahhaj 2000) concludes that the trend rate of GDP growth will eventually be boosted by about 0.5% per annum. Work commissioned by the Brookings Institution (Litan and Rivlin 2001) concludes that the Internet will increase productivity growth by a quarter to a half percentage point per year over the next five years. Longer term, these estimates are likely conservative since they are based on extrapolation of the efficiency potential, sector by sector, that can be roughly estimated now. Eventually, the prospect of a several hundredfold decline in the cost of globally networked information should open new channels of innovation that cannot be projected today.

To cite one currently salient example of the potential, consider the application of networked information technology to the apparently prosaic task of filling medical prescriptions. This process could improve in several ways. First, the doctor could prescribe via an electronic form that would be automatically forwarded to the pharmacist for fulfilment. Even such a simple step would largely eliminate the estimated 40% of prescriptions that now require reworking or follow-up. Second, an electronic record of a patient's other prescriptions would permit immediate identification of potentially harmful drug interactions as well as improper multiple prescriptions from several doctors. The process could be further enhanced by automated reminders to physicians of cheaper alternatives when provincial formularies provide them. And wireless devices could be used to send patients reminders prompting them to take their medication as scheduled.

The widespread deployment of such a procedure could save the Canadian healthcare system as much as $4 billion annually (privately

communicated estimates by McKinsey & Co.). This estimate of direct savings – for example, reducing the emergency and hospital care that result from prescription non-compliance – does not include the broader benefits of better overall health for Canadians or the reduction in indirect costs due to lost time and productivity of those who are sick.

For the most part, technology will not be the primary constraining factor in achieving benefits such as these when Internet access becomes virtually universal and costs continue to decline. Instead, the biggest challenge will be to work through the organizational and behavioural changes needed to convert institutionalized processes into their e-counterparts.

POLICIES

Canada has been a global leader in telecommunications, thanks in large part to policies that have fostered infrastructure investment, innovation and, more recently, competition. For example, Canada was the first nation to connect every school and library to the Internet. It has also been a leader in the enactment of legislation to foster electronic commerce. Today, Canadian telephone and cable companies compete vigorously to deploy high-speed Internet access, with the result that Canada has the world's second-highest penetration (behind South Korea), and double the U.S. rate. This position will permit Canada to lead in selected areas of development of the next-generation applications that will exploit higher bandwidth.

Canada will, nevertheless, be challenged to keep its position in the vanguard of the Internet transformation. A large part of the potential problem stems from the limited size of the domestic market. Most Internet-related business models are strongly scale dependent since they tend to involve high fixed costs (for creating technology, writing new software and developing content); the result is a growing advantage to markets in which those fixed costs can be spread across a broader base of domestic users. Of course, the Internet overcomes most of the usual constraints of geography and, in theory at least, turns the world into a "local" market. But with millions of websites competing for attention, brand and scale have become even more important in cyberspace than in physical space.

So how can Canada's Internet-related businesses achieve competitive scale? A promising strategy would be to exploit first-mover opportunities in application areas that can attract a global user base and then to use increasing returns to scale to build international market share through cost and performance leadership. Since a growing number of other small to mid-size countries – for example, the Scandinavian nations, the Netherlands and Australia – will likely adopt a similar strategy, Canada must pick its spots and focus.

Government's most important contribution to this strategy, apart from supportive business framework and regulatory policies, would be as a lead user, kick-starting significant market demand that was otherwise precluded by Canada's relatively small population. The broad public sector in Canada, including the federal, provincial and municipal levels, commands enormous spending power and could, in principle, be the kind of sophisticated and demanding customer that is needed to turn domestic suppliers into world-class competitors. (For example, public sector spending in health and education – both of which are information intensive and therefore amenable to Internet-based applications – was approximately $135 billion in Canada in 2000.) Properly focused public sector demand could, without subsidy, stimulate the dynamic process of increasing returns – continually falling average cost as output expands – and thus overcome the initial scale disadvantages of Canadian-based Internet businesses.

The potential application areas are extremely broad. Consider, for example:

- *Healthcare delivery.* The Internet could provide not only much-hyped applications such as remote diagnosis but, more significantly, applications in hospital administration and purchasing, drug prescriptions (as described earlier), outpatient monitoring and so on.
- *Distance learning.* Already one of the Internet's fastest-growing applications for large businesses, distance education has enormous potential to turn the phrase lifelong learning from rhetoric into reality.

- *Defence and other security applications.* The distributed, redundant nature of the Internet permits it to continue to function even when damaged. In future, it will be an essential component of national security infrastructure.
- *Delivery of services to citizens.* The Internet is ideally suited to any interactive and information-intensive task, such as e-filing of taxes, applying for permits of all types, requesting information on public services and so on.
- *Internal government operations.* The Internet has begun to transform the structure and function of all large organizations, and none is larger, more complex, or more in need of an internal nervous system than modern multilevel government.

This illustrative catalogue of potential Internet applications in the public sector points to the strategic potential of Canadian governments taking a focused initiative to become world leaders in Internet-enabled public services. All stakeholders would benefit. Citizens would obtain richer and eventually more accessible services. The providers of public services would get growing efficiency and capability (which would translate eventually in greater value for taxpayers). And Canada's nascent Internet-based industry would gain a large and sophisticated base of demand.

A note of caution is nevertheless warranted. Although government stimulus via arm's-length purchasing is, in principle, preferable to subsidies or tax breaks, ample opportunity would remain for waste and mischief. As the checkered history of public procurement demonstrates, pork-barrel favouritism can be all too tempting. And even the most well-intentioned policy would have to strike a delicate balance to ensure value for taxpayers while giving Canadian suppliers some benefit of the doubt. Since the Internet-based public services envisioned here would usually be breaking new ground – part of the most fertile domain of innovation over the next several decades – public sector customers would have to work hand-in-glove with suppliers to develop the right services. The risk that such a relationship could become incestuous would be ever present.

In short, no policy is without risk, but so is the status quo. Fortunately, we have learned much, through hard experience, about the risks of public sector procurement. Processes to ensure transparency and accountability have substantially reduced abuses. But implementing the course advocated here would significantly broaden the scope of strategic procurement by the public sector in Canada and would consequently require policy innovation to ensure heightened vigilance.

SUMMARY

Canadians have a once-in-a-generation chance to seize a moment of extraordinary opportunity in which the country's traditional strength in communications intersects a technological trajectory of unprecedented potential. Today's opportunity does not call for the creation of Crown corporations or the subsidization of national champions. On the contrary, the Internet transformation demands the innovative flexibility that only a competitive private sector can deliver. But Canada is still a smallish nation next door to a colossus. For that reason, we will always need something that might be called an industrial policy, even though that particular phrase is now largely discredited.

What I advocate here are proactive initiatives by the broad public sector to become world leaders in the application of the emerging Internet to the delivery of public services – whether in the domains of healthcare, learning, security or the more efficient administration of government. Leadership in areas such as these would position Canadian businesses of all sizes to tap early into a world market of unlimited potential and to translate such first-mover advantage into the growing scale economies that characterize the information economy. The role of government in this new industrial policy is not that of benefactor but rather that of customer. e

About the Author

Peter Nicholson is Special Advisor to the Secretary-General of the Organization for Economic Cooperation and Development in Paris. He earned a BSc and MSc in Physics from Dalhousie University and a Ph.D. (Operations Research) from Stanford University in 1969. Dr. Nicholson's varied career has spanned academia, government and business. He was a member of the Computer Science faculty of the University of Minnesota (1969-73); served in a number

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NILS CLAUSEN'S FAVOURITE WEBSITES

Nils Clausen is Country Manager for Global Healthcare Exchange, an Internet-based trading exchange for the healthcare system. Its Canadian members now include more than 30 suppliers who account for over half of the $4 billion market for patient care products in Canada and over 60 hospital sites.

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This site is perfect for the younger folks in the family. Interactive/educational games keep children busy for hours and it's not bad for parents looking to relive their childhoods.

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