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CONSULTING LIMITED

Regional Broadband Investigation

Needs, Opportunities, and Approaches At the Local Level and for the Calgary Region

Landscape Issues

Calgary Regional Partnership

Prepared for The Calgary Regional Partnership
by Craig Dobson – Taylor Warwick Consulting Limited

September 28, 2016

Calgary Regional Partnership

August 2016

A note of introduction and thanks.

Existing communications networks are transitioning from copper to fibre as the world evolves to a knowledge-based economy. Important decisions will be made in every community and region about how, and how quickly that happens, and by whom. Certain community benefits may be realized or lost in the transition depending on how it takes place.

Many municipal leaders are considering what role their municipalities could or should take in ensuring enhanced broadband services and digital connectivity networks evolve to support local businesses, residents, municipal service delivery and capacity for distance learning, home-based health care and other web-based public services. "What to do about this transition to fibre? Is it more risky to jump in, or more risky to be left behind?"

To better inform decision-makers in the Calgary Region we commissioned Craig Dobson, Principal at *Taylor Warwick Consulting*, to develop a broadband "backgrounder" that could help us better understand what this is all about, why municipalities and regions should become engaged in this transition, and what municipal involvement could look like.

We appreciate the financial and staff contributions our partners have made in supporting the development of this document. We hope that it will be widely shared and thoughtfully read.

Sincerely,

Mayor Bill Robertson, Town of Okotoks

and Chair, *Calgary Regional Partnership* and
Calgary Region Economic Development Alliance (REDA)
Calgaryregion.ca

Alberta Economic Development and Trade

BOW VALLEY COLLEGE

Calgary

Calgary Regional Partnership

Okotoks

PALLISER ALBERTA SOUTHEAST

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1 Executive Summary

Because of the Internet and related technologies, the world is now transitioning to more complex economic systems built around *knowledge*.[1] The most significant impacts of this unfolding transition relate to economic innovation, productivity, and societal organization. As a foundational cornerstone of these emerging systems of wealth creation, access to information and communications technology (ICT) has become critical to sustainable economic development in virtually every community and society on the planet.

In spite of the foundational nature of the required underlying connectivity infrastructure, Canada has yet to develop meaningful related technology policy or sway from its half-century-old policy of facilities-based competition in the telecom space……. and the results speak for themselves. According to the Organization for Economic Co-operation and Development (OECD) and the Conference Board of Canada respectively, Canada now ranks 14th in Broadband and in Innovation. More telling is a comparison between Internet service availability here and in, say, Västerås, Sweden. Whereas at most locations in Canada one may have the option of two wire-line providers, in Västerås, there are over thirty.

For the benefit of all communities within the region, the Calgary Regional Partnership (CRP) has elected to face and deal with the issues head-on. The importance of perspective cannot be understated and this report brings together the underlying context, rationale, and related data and statistics to provide an overall view of the landscape that frames both the issues to be dealt with and the potential solutions that will be found.

2 Problem Definition

Recognizing both the opportunity and challenge associated with facilitating advanced fibre optic-based broadband infrastructure and services within the CRP region, the CRP commissioned this study to identify and organize a research and analysis framework for moving the discussion in the Calgary Region forward. It's overall purpose is to generate new information about Broadband availability throughout the region, identify and explore key strategic opportunities and, ultimately, inform decision-makers around the types of choices they might consider at local and region-wide levels to strengthen the delivery and affordability of high-speed broadband services across the Calgary region.

Recognizing the importance of being inclusive, for the purposes of this study, CRP has invited all incorporated entities in the region to participate – both Partnership members and non-members alike. The study therefore incorporates the aggregated issues and wisdom encompassing the 3 cities, 12 towns, 5 villages, 2 summer villages, 2 municipal districts, and 2 counties within the Calgary region.

The overall project has been broken into three parts – (1) Landscape Issues, (2) Municipal Opportunities, and (3) Regional Opportunities. This document is Part 1 and focuses on the landscape Issues and context. It is intended to provide overall perspective and context to the work that will follow.

[1] Toffler, A&H; Revolutionary Wealth; Knopf; 2006-04-25.

3 Key Take-Away Points

- ***Our system of wealth is changing –*** Compounding the impacts of both the Industrial and the current Information & Telecommunications revolutions is the fact that they ushered in a new system of wealth. With a change in the wealth system, what made communities successful in the 20th century no longer works today. We are moving from a world in which scalable efficiency generated the most value to one in which scalable peer learning does. (p. 5)
- ***Transitioning to higher skilled workforce –*** While the 'hollowing out' of the middle class is not as evident in Canada as it is in the US, the number of medium and low skilled jobs is declining relative to those requiring higher skill levels. From both the perspective of retraining the folks displaced and creating higher skilled jobs for them, broadband is key. (p. 56)
- ***Canada is losing ground –*** As of early 2016, Canada ranked 14th in terms of mean available download bandwidth, 18th in terms of cost, and 23rd in terms of fibre penetration. Whereas in Korea, the average download bit rate of 23.6 Mb/s is available for $ 1.77/mo. (13.3 Mb/s/$), in Canada, one can only expect 9.7 Mb/s for $8.00/mo. (1.21 Mb/s/$). (p. 7)
- ***Alberta is not keeping up –*** Alberta ranks 11th out of 13 provinces and territories based on download speed – and Alberta has the SuperNet. Alberta's two largest cities do not fair well either – Calgary and Edmonton are respectively ranked 11th and 21st out of 25. (p. 9)
- ***Everyone could win –*** Economic development is not a zero-sum game in which the winning community takes all. Together, the CRP members and non-members can raise the 'tide' of prosperity across the region so that all can benefit. (p. 40)
- ***Accomplish more together –*** The municipalities, municipal districts, and counties can accomplish more together than separately, ensuring that none are left behind. (p. 58)
- ***Too important to miss! –*** As the required infrastructure upgrades represent a once in a century opportunity, it is worth getting this right. (p. 25)
- ***Fibre as a utility –*** Scalable broadband connectivity is critical civic utility infrastructure and should be treated as such. In the US, 25 of the 48 states reporting have a broadband office. (p. 7)
- ***Reduced rates as a long-term investment –*** As municipalities and regions can fund fibre infrastructure over 20+ year periods, they can provide the infrastructure much less expensively than can a private interest firm intent on recouping its capital in, say, five years. Monthly payments by a community on a $1M infrastructure loan over 20 years at 2.602% from the Alberta Capital Finance Authority (ACFA) are $5,349 versus the $18,417/month payments required of a private firm paying 4% on the same amount over a five year term. (p. 68)
- ***Update Provincial and Federal Frameworks –*** Both federally and provincially, funding and debt limit policies need to be updated to help enable municipalities to deploy the required infrastructure; regions are an important voice for change. (p. 68)
- ***Promoting services-based competition –*** Federally, the Canadian Radio-television and Telecommunications Commission's (CRTC's) options are inhibited by the facilities-based framework under which it operates. Moving to a services-based framework in which the required underlying fibre infrastructure is provided on an open basis as a fourth utility over which all providers can compete on services would enable ubiquitous deployment and help eliminate the existing digital divide. Under a services-based model, private providers would get

access to infrastructure superior to that which they themselves could afford to deploy and could then re-direct the capital saved to innovate and compete on services. (p. 13)

- ***Independent triple-play service providers are now available*** – As independent triple-play service providers such as O-Net, VMedia, and Novus are now available, the options available to underserved communities wishing to deploy their own fibre-based networks are expanding. (p. 14)
- ***Enhancing broadband is a largely social enterprise –*** It has been said that community fibre endeavours are likely 80% social and 20% technical and the Olds' experience supports this from several perspectives. (p. 58)
- ***Required Internet capacity continues to grow geometrically –*** Both Internet and mobile traffic growth remains robust at a compound rate of21% and 69% annually. The video portion of that traffic is increasing at 64% and 55% respectively – and not all of this is Netflix. (p. 11)
- ***Wireless has limits; fibre does not –*** The trade-off between fibre and wireless tends to change over time and depends on available capital, local priorities, and the relative importance of off-balance benefits. A common misconception is that wireless systems are less expensive. While they may be so over a 3 to 5 year period, their ability to expand is limited and over a ten year timeframe when capacity expansion is considered, can prove to be even more expensive than fibre networks. (p. 40)

4 Context

4.1 Project[2]

The Calgary Regional Partnership, in collaboration with local member and non-member municipalities, municipal districts, and counties, Provincial staff, and partner organizations in the Calgary Region, has initiated an exploration of very high-speed broadband fibre opportunities, needs, benefits and strategic approaches relevant to the Calgary Region and its environs.

Accessible, affordable and reliable high-speed Broadband services, provided in a coordinated and interconnected system, is seen as foundational to supporting economic prosperity locally and regionally, enabling greater social connectedness and well-being of the region's population, and promoting environmental integrity across the region.

High-speed Broadband services provide foundational infrastructure for community prosperity, resiliency and quality of life – not unlike roads, electricity, water and wastewater and other essential utilities that support economic activity and community life – all supportive of achieving shared regional Vision and outcomes as expressed in the *Calgary Metropolitan Plan (CMP)*[3].

Recent preliminary discussions, benefiting greatly from the active support of the Olds Institute (and O-Net), the Alberta Southwest Regional Economic Development Alliance (REDA), Bow Valley College, and staff from the Province's SuperNet initiative have together begun to frame a series of strategic opportunities worth exploring at both local and region-wide scales. Subsequent discussions with the author have further focused the information to be researched and documented, describing the questions to be analysed and the types of strategic choices that could be available to communities in the region.

4.2 A Techno-Economic Framework

Over the past three hundred years, the robust links between innovation, technical and institutional change, and economic development have played out in the first four techno-economic revolutions outlined in the table below and are currently playing out in the fifth – the Age of Information Technology and Telecommunications.[4]

1771 The 'Industrial Revolution' (machines, factories, and canals)

1829 Age of Steam, Coal, Iron, and Railways

1875 Age of Steel and Heavy Engineering (electrical, chemical, civil, naval)

1908 Age of the Automobile, Oil, Petrochemicals, and Mass Production

1971 Age of Information Technology and Telecommunications

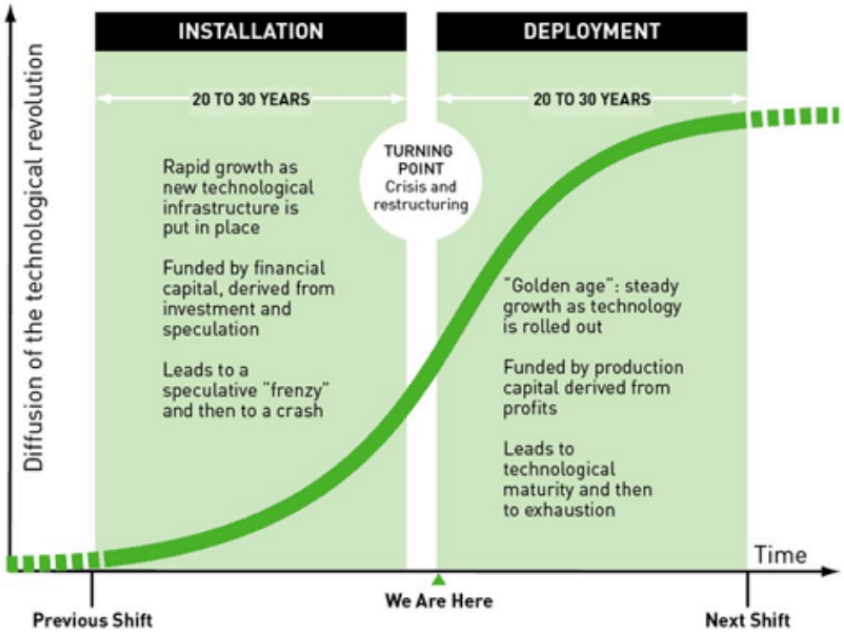
20?? Age of Biotech, Bioelectronics, Nanotech, and new materials?

[2] Miller, B.; *Preliminary Scoping Documents to Explore HighSpeed Broadband Needs, Opportunities and Approaches at the Local Level and for the Calgary Region*; CRP; 2015-07.

[3] Calgary Regional Partnership; *Calgary Metropolitan Plan*; 2012-07-21.

[4] Perez, Carlota; Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages; Edward Elgar Publications; 2003.

Each technological revolution lasts between 40 and 60 years and propagates through two strikingly different stages – the installation and the deployment phase. As illustrated in the figure,[5] based on the introduction of a new technology, during the installation phase, entrepreneurs move in to capitalize on it. They attract new investment capital away from existing businesses and based on market experiments, establish new types of business organizations to deal with it. The resulting maelstrom of activity eventually reaches a climax and ends in a stock market crash.



Industrial/production capital then comes to the table and finances the reasoned deployment of the underlying infrastructure required to enable the full economic and social potential of the new paradigm. In this second – deployment – stage, innovation occurs across all economic sectors and the social benefits become widespread. As the commercial benefits take hold, the collective interests of the populace at large become part of the equation and state capital comes to the table to complete the deployment in commercially unattractive areas.

From this perspective, the five techno-economic revolutions to date map out as shown in the figure on the next page.[5] The displacement of the older established order as the new technology wave develops is not typically smooth. Compounding the impacts of both the Industrial and the current Information & Telecommunications revolutions is the fact that they ushered in a new system of wealth [see Sec. 7.1, The Knowledge Economy].

The congruency here with the development of the Internet and the underlying enabling broadband infrastructure is striking. The crash took place in 2001 and now, some 15 years later, the true benefits of the ICT revolution are impacting every sector of the economy. The positive externalities[6] are becoming self-evident and governments are stepping in to ensure near ubiquitous deployment (at least those outside North America). Aligning these events with this timeline indicates that we are about 60% of the way through the ICT revolution. As discussed in the following sections, developing technology, financial, economic, and policy objectives to maximize the benefits of the new paradigm as broadly as possible is an interesting challenge.

It is at this stage – where we are now – that the debate as to whether this new technology will focus largely on private benefits (broadband fibre as a market commodity) or public benefits (broadband fibre as a utility to achieve purposeful public benefits) will be decided. Who owns and controls the fibre assets will be key to how well they achieve broader public benefits now that the emerging technology is more available.

[5] Trends Magazine; *A New Golden Age… When People Least Expect It*; AudioTech Inc.; 2010-04.

[6] Externalities relate to side effects or consequences of industrial or commercial activities that affect other parties without this being reflected in the prices or costs of the goods or services involved. [Wikipedia]

Technology is not kind…

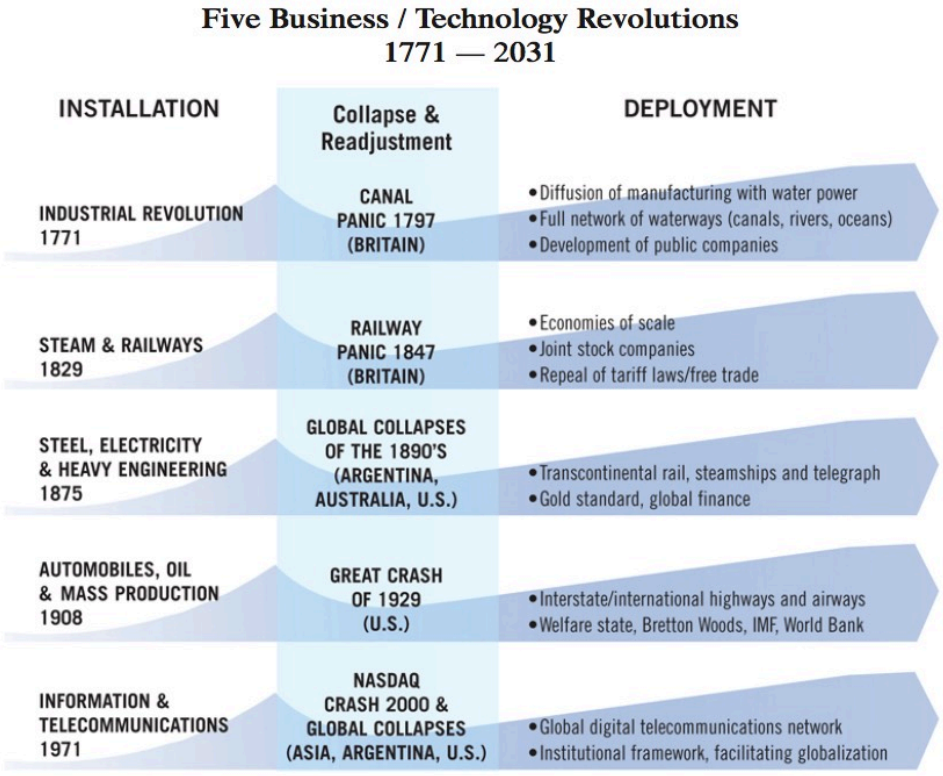
It does not wait…

It does not say please…

It slams into existing systems…

And often destroys them…

While creating a new system.[7]



4.3 Technology as Policy

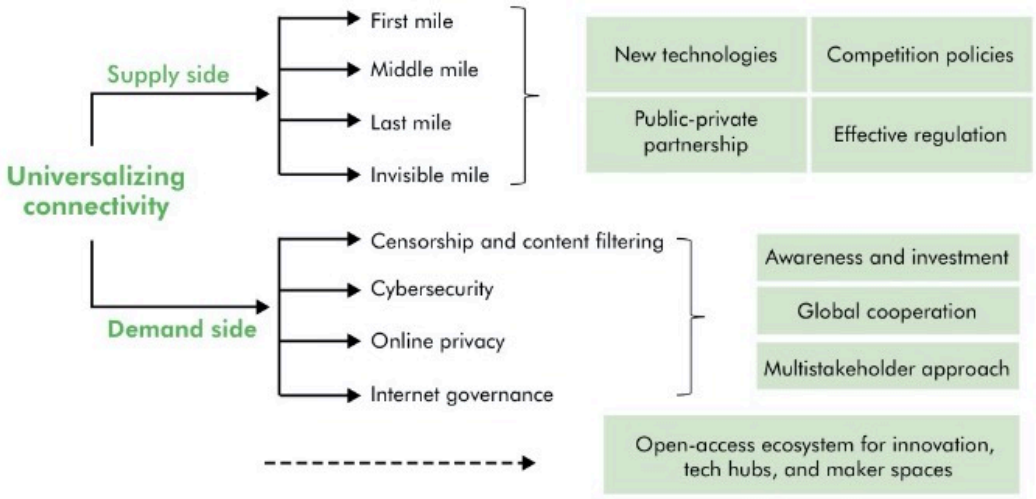
The complexity and depth of the required alignments is brought home in the recently released World Development Report on the *Digital Dividends*.[8] According to the report, while *digital technologies have spread rapidly in much of the world, digital dividends (i.e., growth, jobs, and services) —the broader development benefits from using these technologies—have lagged behind. In many instances digital technologies have boosted growth, expanded opportunities, and improved service delivery. Yet their aggregate impact has fallen short and is unevenly distributed. For digital technologies to benefit everyone everywhere requires closing the remaining digital divide, especially in Internet access. But greater digital adoption will not be enough. To get the most out of the digital revolution, countries also need to work on the "analog complements"—by strengthening regulations that ensure competition among businesses, by adapting workers' skills to the demands of the new economy, and by ensuring that institutions are accountable.* These 'analog complements' will be discussed in Sec. 7: Infrastructure vs. Digital Dividends.

According to *Digital Dividends*, there are two sides to the connectivity piece. While our primary focus here is resolving supply side issues in ways that both maximize the benefits while minimizing the risks mentioned above – and sections dealing with the key components of the connectivity issues follow[9] – many issues on the demand side are serious and, while well beyond the scope of this work, need to be noted before moving on.

[7] Enriquez, Juan; As the Future Catches You: How Genomics & Other Forces Are Changing Your Life, Work, Health & Wealth; Crown Business; 2005-10-25.

[8] World Development Report; *Digital Dividends*; World Bank; 2016-03.

[9] The invisible mile refers to wireless access and the associated spectrum management policies.



The challenges facing Internet stakeholders [on the demand side] *today are as much about how networks are used (demand) as how they are built (supply). Global interconnectedness introduces new vulnerabilities in areas where coordination mechanisms are weak, still evolving, or based on nongovernment models. Threats to cyber- security, and censorship are undermining confidence and trust in the Internet and increasing costs to businesses and governments, resulting in economic losses as well as higher security spending. For privacy and data protection, different countries are taking quite different approaches. That makes it harder to develop global services. Ensuring safe and secure access will require enhanced international collaboration, based on a multi-stakeholder model.*

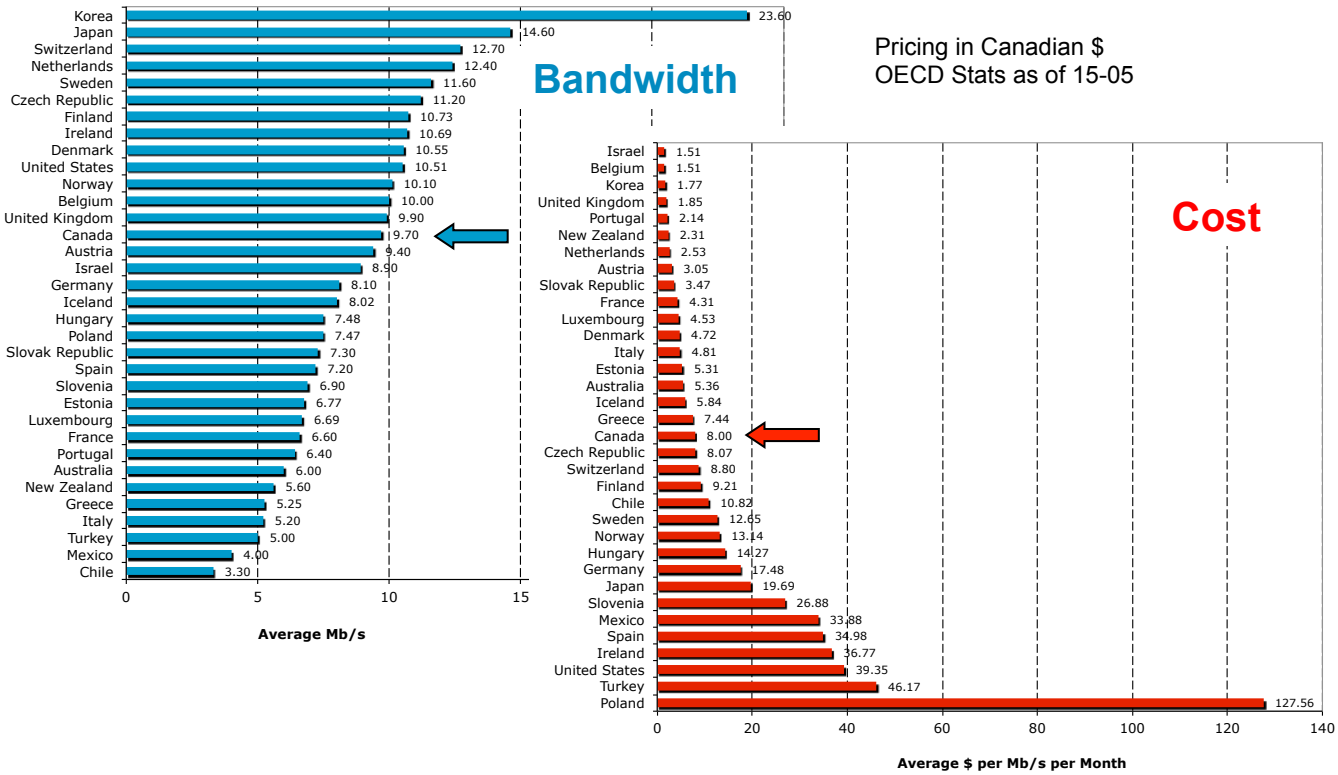
4.4 Political

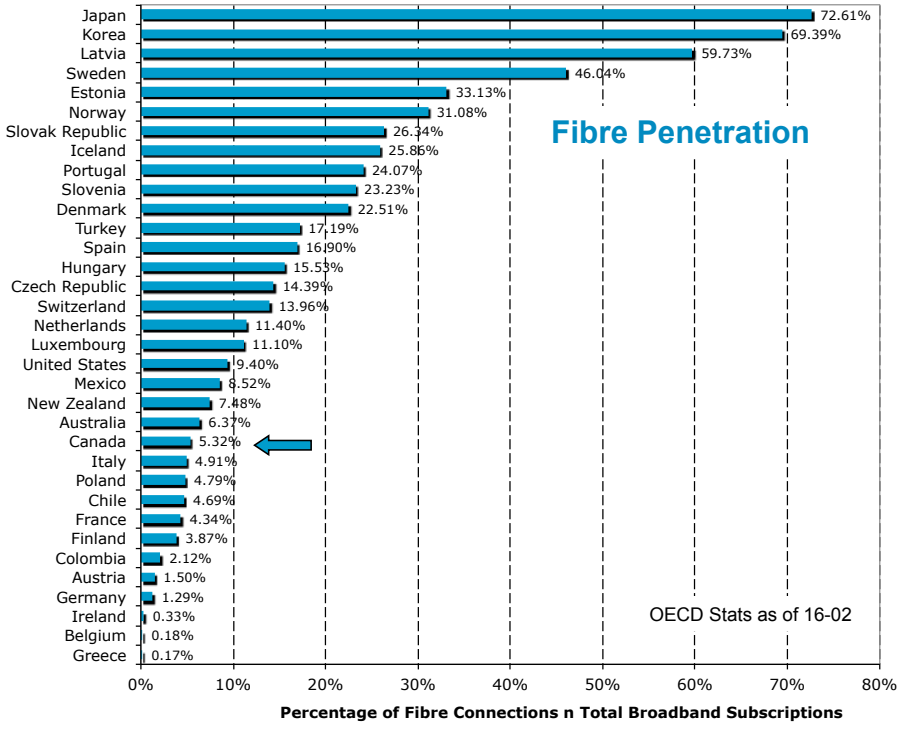
As foreign governments recognize the merits of open utility-based fibre infrastructure, Canada is falling increasingly behind. To date, neither the federal nor provincial governments have yet placed the emphasis on technology policy to address broadband to the extent evident internationally. Though the initiative has since changed course, in 2009, Australia announced plans to spend AUD$31 billion on a National Broadband Network. In 2013, France pledged €20 billion for superfast broadband. In the US, of 48 reporting states, 25 have established a broadband office.

The impact of this lack of policy is evident in the OECD statistics charted below[10]. As of early 2016, Canada ranked 14th in terms of mean available download bandwidth, 18th in terms of cost, and 23rd in terms of fibre penetration. Whereas in Korea, the average download bit rate of 23.6 Mb/s is available for $ 1.77/mo. (13.3 Mb/s/$), in Canada, one can only expect 9.7 Mb/s for $8.00/mo. (1.21 Mb/s/$). Fibre penetration in Korea is 69.39% compared to 5.32% in Canada. Even more telling is a comparison between Internet service availability here and in, say, Västerås, Sweden. Whereas at most locations in Canada you may have the option of two wireline providers (TELUS and Shaw in Western Canada), in Västerås, there are over thirty.

At least part of the issue is the Federal government's belief in facilities-based competition – versus a services-based regime in Sweden – and the incumbents' concomitant refusal to provide services to those communities that manage to deploy fibre infrastructure themselves. While the incumbents cannot justify fibre builds in the less populous areas from a business perspective themselves, they boycott community networks that make the infrastructure available for them to compete on.

[10] http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm#map



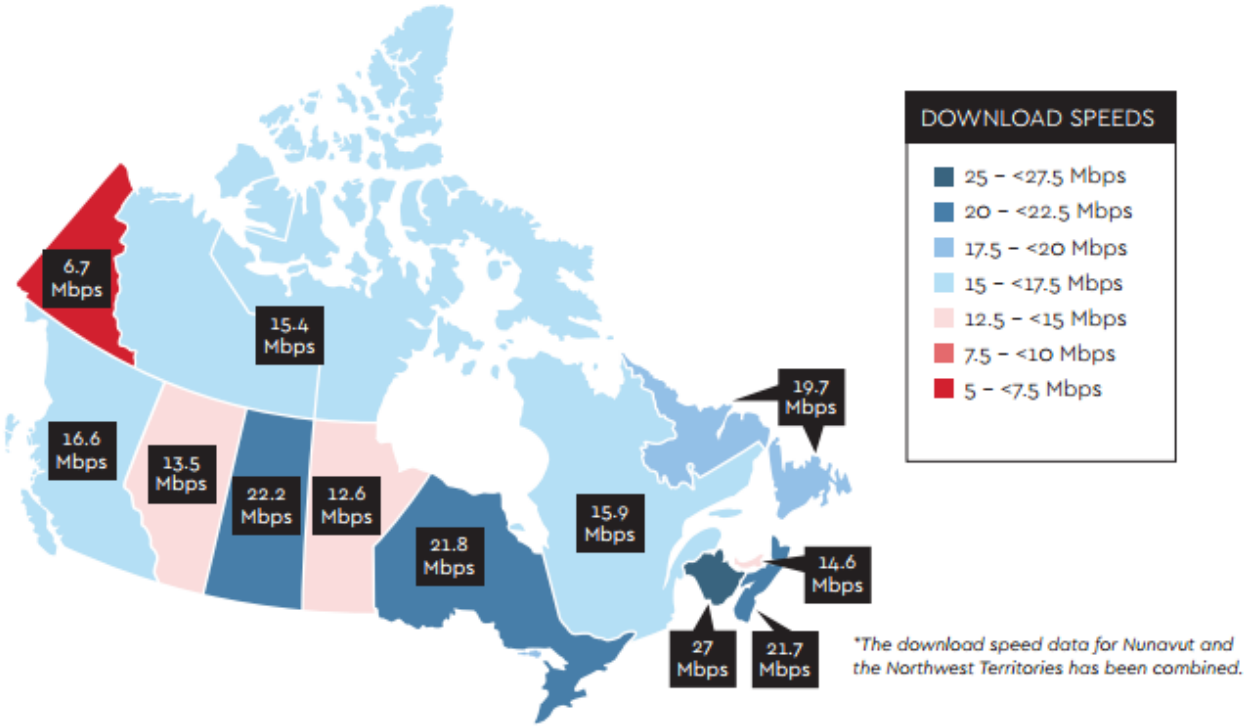


The federal government's Connecting Canadian's program which closed in 2015 focused on the provisioning of wireless broadband speeds of 5 Mb/s down/1 Mb/s up to all rural locations in the country. In today's world, 5/1 Mb/s is sorely inadequate from many perspectives and wireless systems

do not scale well. For economic development, anything less than symmetric 100 Mb/s service is no longer considered competitive.[11]

Ottawa's recent 2016 budget proposed up to $500M over five years, starting in 2016-17, for a new program to extend and enhance broadband service in rural and remote communities.[12] In contrast to the Connecting Canadians program, their current discussion document proposes a focus on the backhaul links required to connect remote communities to the global Internet. Irrespective of its shortcomings, as Alberta's SuperNet was deployed to do just that, it may be difficult for Alberta-based organizations to qualify.

As shown in the figure on the next page, Alberta ranks 11th out of 13 provinces and territories based on download speed – and Alberta has the SuperNet. Even Alberta's two largest cities do not fair well – Calgary and Edmonton are respectively ranked 11th and 21st out of 25.[13] A more detailed city comparison from the report appears in the chart on the next page.[14]



4.5 Social

As we move from an industrial to a knowledge-based society, from a society based on physical effort to one based on mental effort, and from reliance on limited material resources to dependence on virtually unlimited intangible resources, we fundamentally enable the acceleration of change. – Fred Harmon

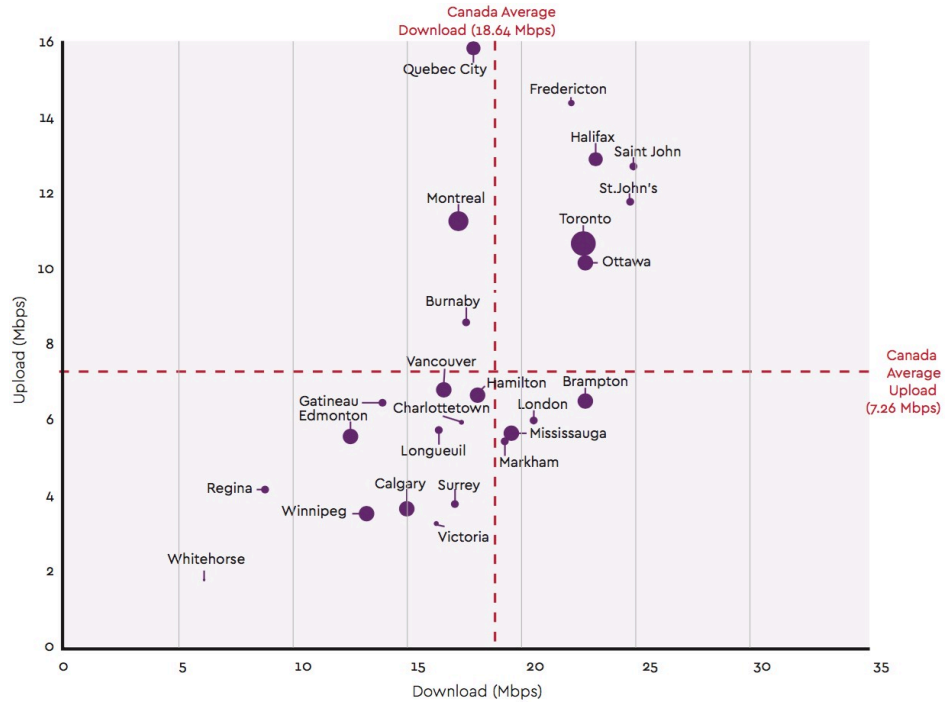
[11] Settles, Craig; *Broadband and Economic Development: The Real Deal*; Broadband Properties; 2010-11/12.

[12] Innovation, Science and Economic Development Canada; *Increasing High-speed Broadband: Dialogue with Telecommunications Providers*, Spring 2016.

[13] CIRA; *Canada's Internet Performance: National Provincial and Municipal Analysis*; 2016-04.

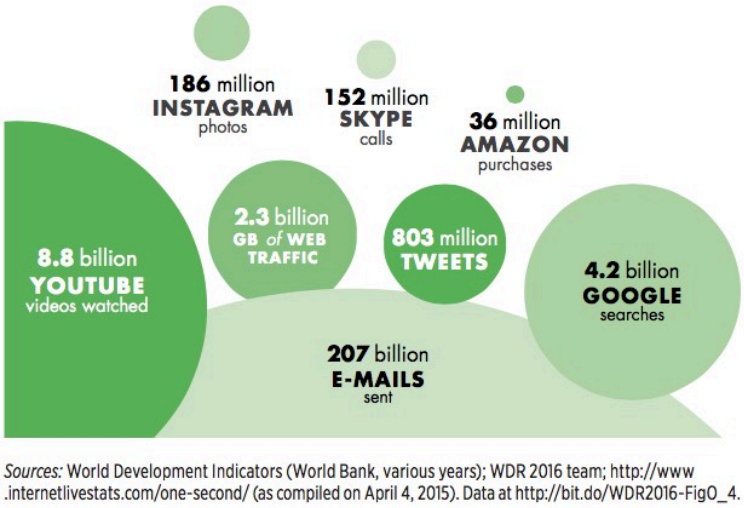
[14] In the chart, the size of the circle is proportional to the size of the city.

The great value of the Internet is that it provides a substrate that not only connects more people and devices (and allows more applications to flourish), but that it enables new ideas and new forms of social organisms to emerge. – Susan Crawford



Shifts in economic and social organization among online communities have produced fundamentally new kinds of institutions for creating culture and exchanging knowledge. The rise of "nonmarket and nonproprietary" peer production by volunteers cooperating via the Internet on such projects as Linux and Wikipedia is the wellspring of all sorts of hope. Such voluntary global collaboration has the power to act as a mechanism to achieve improvements in human development everywhere. – Yochai Benkler

Sector of Economy / Society, USA	Internet Impact, to Date
Consumer	
Business	
Security / Safety / Warfare	
Education	
Healthcare	
Government / Regulation / Policy Thinking	

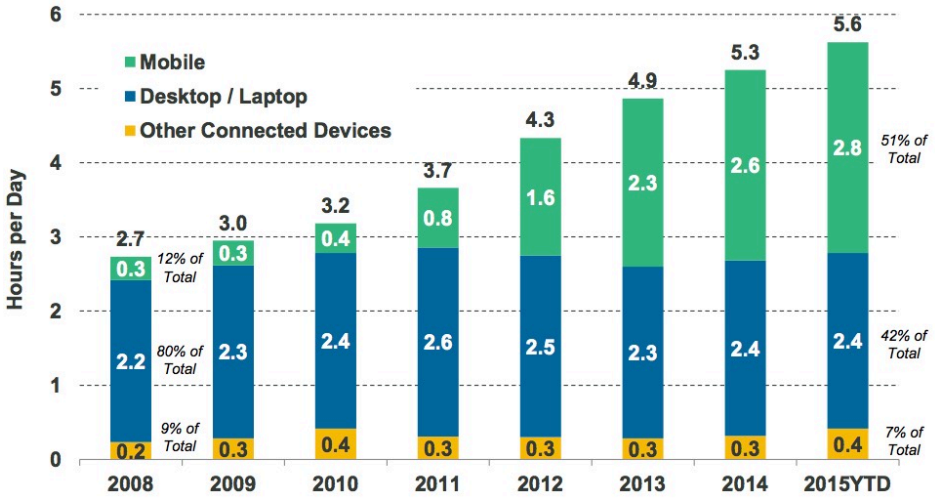


Sources: World Development Indicators (World Bank, various years); WDR 2016 team; http://www.internetlivestats.com/one-second/ (as compiled on April 4, 2015). Data at http://bit.do/WDR2016-FigO_4.

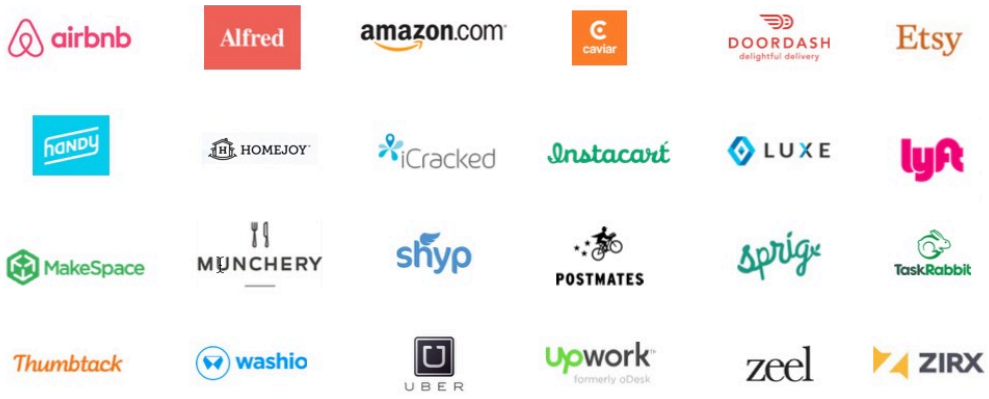
When social communication media grow in capability, pace, scope, or scale, people use these media to construct more complex social arrangements—that is, they use communication tools and techniques to increase their capacity to cooperate at larger and larger scales. Human history is a story of the co-evolution of tools and social practices to support ever more complex forms of cooperative society. – Institute of the Future.

Though the impact of the Internet on Society has been both extraordinary and broad, we are still early in the deployment phase and the impacts will only increase. According to Harvey Balls, the benefits and key impacts to date have largely been in the consumer and business sectors – the gains in the other sectors are yet to be realized.[15] This is discussed further in Sec. 7.5.

Both Internet and mobile traffic growth remains robust at 21% and 69% annually. The video portion of that traffic is increasing at 64% and 55% respectively – and not all of this is Netflix. Views of user generated or shared content is continuing to grow. Most recently, Facebook video views grew to 4 billion per day, a 400% increase from six months prior.[15] On a daily basis, the average US adult now spends 5.6 hours interacting with digital devices.[15]



This usage is impacting many aspects of how we live and work. *A majority of US consumers are multichannel shopping, with 69% Webrooming (browse products online and buy in-store), and 49% Showrooming (browse products in-store and buy on-line)*.[16] 97% of all consumers search for local businesses online.[17] People are increasingly creating supplemental incomes through online platforms and market places like Airbnb, Etsy, Thumbtack, Uber, and Upwork.[13] As business adapts, many products, services, and even work engagements are becoming available almost on a demand or as needed basis.[14w]

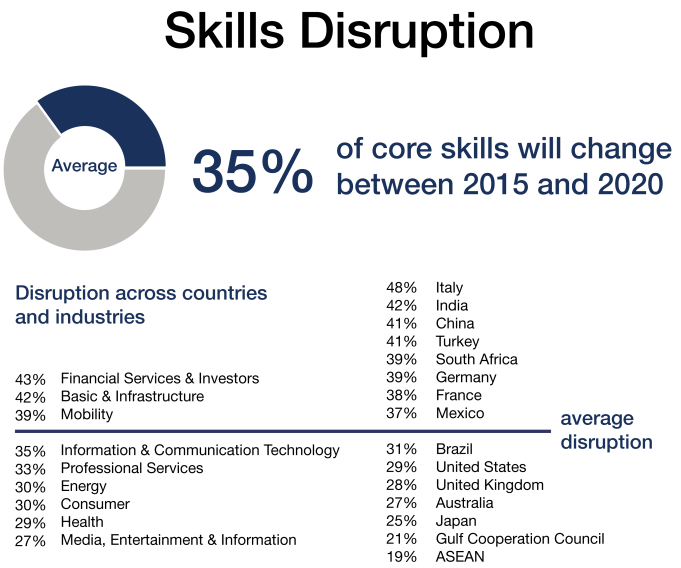


[15] Meeker, Mary; *Internet Trends, 2015 – Code Conference*; KPCB; 2015-05-27.

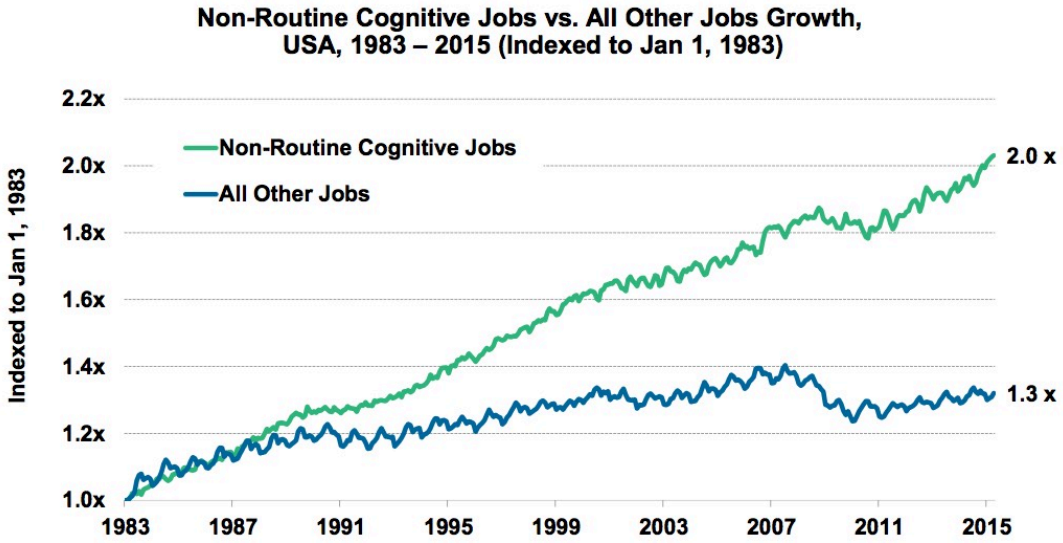
[16] Harris Interactive; *Showrooming and Webrooming in the 2014 Holiday Shopping Season*; 2015.

[17] SocialTimes; *Social Media Business Statistics, Facts, Figures & Trends*; 2015.

In terms of work, according to the World Economic Forum, *we are seeing an era of unprecedented change in the way we work. Rapid advancements in the fields of technology, such as artificial intelligence and machine learning, and in how we create things, such as robotics, nanotechnology, 3D printing and bio-technology, will dramatically change the characteristics of the global workforce.* Indeed, 35% of the required core skills will change between 2015 and 2020.[18] *Goods-producing jobs have been declining for decades and now represent only 15% of all US* jobs.[15] *50% of the US jobs lost in the 2008 recession were middle-skilled jobs, but only 2% of the jobs gained since the recession have been middle-skilled*.[19]



Knowledge-based, non-routine cognitive jobs requiring high skill levels, flexibility, creativity, and problem solving are growing faster than routine ones.[15] These types of work lend themselves to more flexible working relationships and freelance workers now account for 34% of the US workforce.[11] *By 2019, approximately one quarter of the entire US workforce will be independent workers (self-employed, independent contractor, freelancer, temp contractor, etc.).*[20] By 2030, 10% of the largest companies in the US will be virtual corporations (less than 10% of their workers will be in an office at any point in time).[21] Without broadband, participating in this economy will not be possible.



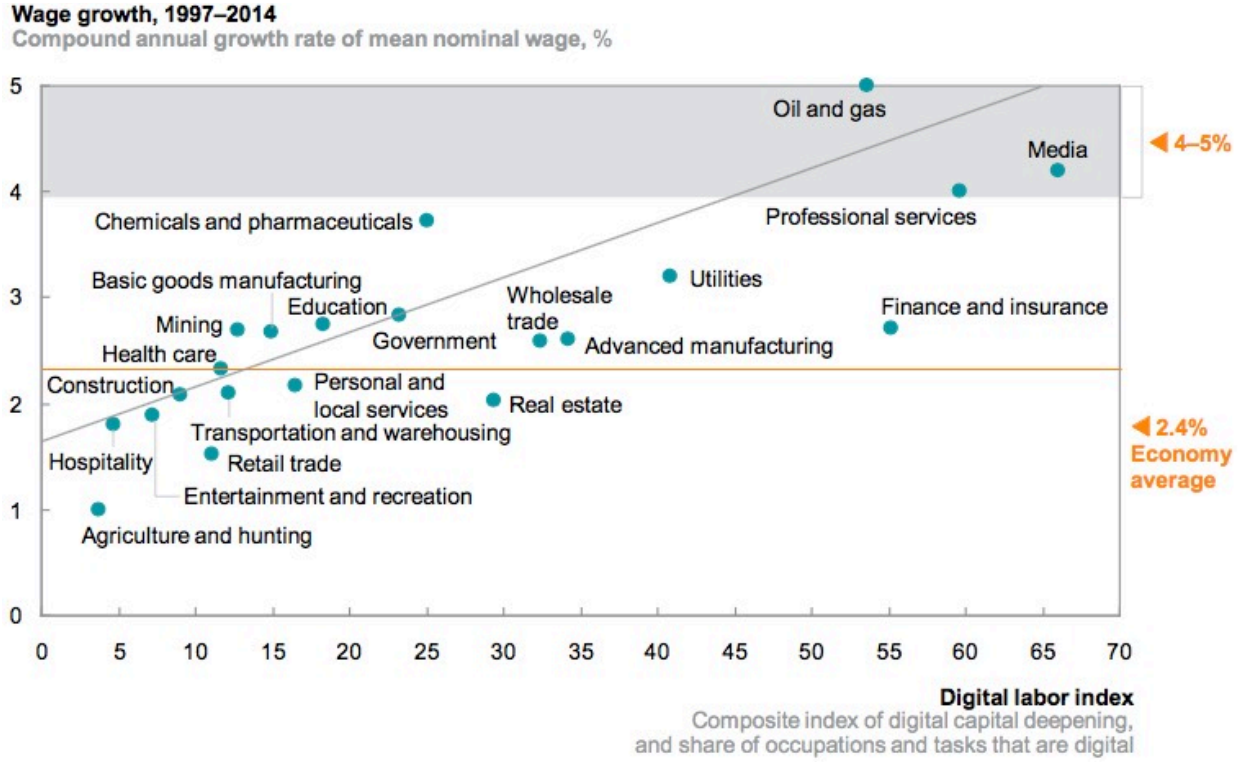
[18] Gray, A.; *5 million jobs to be lost by 2020*; World Economic Forum; 2016-01-16.

[19] http://futurehrtrends.eiu.com/infographics/the-cratering-of-the-middle-class/

[20] MBO Partners; *Independent Workers and the On-Demand Economy*, & US Bureau of Labour Statistics.

[21] Rawson, R.; *20 Dramatic Predictions for 2030*; Staff.com; 2013-04-13.

Not surprisingly, wage growth directly correlates with the increased penetration of digital tools and technologies in business. Specifically, wage growth is 70 to 100 percent higher than the national average in industries with higher levels of digital adoption. [22]

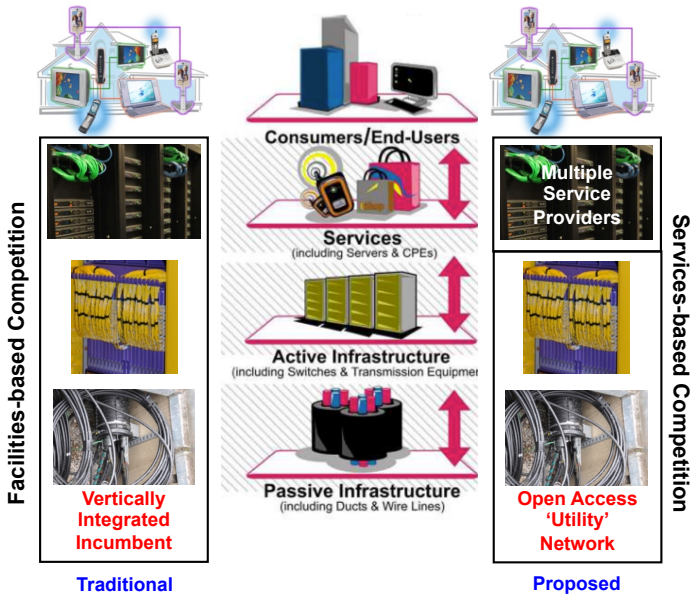


4.6 Regulation

4.6.1 Telecommunications Regulation

4.6.1.1 Facilities-based Competition

Developed under a federal policy of facility-based infrastructure competition dating to an era in which telecommunication and broadcast networks could only support the services for which they were designed, incumbent telecom and cable companies operate on a vertically integrated basis and, as illustrated on the left side of the adjacent figure, only provide services to customers over facilities they own and operate[23]. As any potential new entrant must therefore build its own physical network in order to provide services, the net result of this practice is severely restricted competition and redundant (often inferior) infrastructure.



[22] Manyika, J., et al; *Digital America: A Tale of the Haves and Have-Mores*; MGI; 2015-12.

[23] The carriers themselves do use wholesale relationships to interconnect their networks.

Given the significant capital expenditures associated with deploying civil infrastructure, the services-based models becoming prevalent in Europe, and depicted on the right hand side of the above figure, may now make sense. In this model, a single capable fibre-optic based network is deployed as an open access utility and to which any service provider so inclined can connect and provide services. This removes the expense of building multiple networks and opens up market competition (and promotes innovation) in the services space. This has not worked in Canada to date, as independent service companies willing to provide services over community networks have not been available. Without services, community networks cannot achieve the revenue streams required to service the debt acquired to deploy their networks. As independent triple play service providers such as O-Net, VMedia, and Novus are now available, however, the options available to underserved communities wishing to deploy their own fibre-based networks are expanding.

4.6.1.2 Wholesale Fibre Access Hearings

The telecommunication and broadcast industries in Canada are governed by the CRTC. To help promote services-based competition in Canada, the CRTC spent much of the 2014-15 period evaluating policies related to mandating wholesale service provider access to underlying incumbent fibre access networks and, in the end, elected to do so.[24] According to their July 22, 2015 ruling[25], the incumbent carriers will have to provide wholesale access to their access fibre networks to competitive service providers. The details on how this is to be done are still being worked out.

At this point, it is worth noting four points:

- The ruling will only apply to incumbent carriers. It will not apply to smaller carriers such as the Olds Institute for Community & Regional Development's (OICRD's) fibre network in Olds or, in all likelihood, to Axia Connect.
- The wholesale services made available by the incumbents may not provide bit rates over and above those which the incumbents themselves provide on a retail basis.
- In 'opening' up the access network, the CRTC 'closed' wholesale access to the middle mile or distribution portions of the incumbent networks. In other words a competitive carrier wishing to utilize access fibre on a wholesale basis will need to arrange connectivity to everyone of the incumbent's local/central offices to which their client base connects.
- The incumbents may take the view that as they will be forced to share their fibre access facilities, they can no longer afford to deploy fibre access in smaller centres. Given the operational cost savings fibre provides, however, such rhetoric is just that. Fibre will be deployed regardless.[26]

4.6.1.3 Basic Service Hearings

On April 9th, 2015, the CRTC issued a Telecom Notice indicating that it was undertaking a review of basic telecommunication services to address, in essence, the question of whether or not Internet

[24] http://www.crtc.gc.ca/eng/archive/2013/2013-551.htm

[25] CRTC; Telecom Regulatory Policy CRTC 2015-326: *Review of wholesale wireline services and associated policies*; 2015-07-22.

[26] Geist, M.; *Ignore the Scare Tactics: The Real Future of Bell Investment in Fibre Networks*; Michael Geist Blog; 2016-06-22.

services of some flavour should be regarded as basic, and therefore subject to universal service provisions.[27] The process was to proceed in two phases:

- *"In phase 1, the Commission will review its policies regarding basic telecommunications services in Canada. The Commission will also gather information from the industry to better understand which telecommunications services are being offered across Canada and whether any areas in Canada are underserved or unserved."*
- *"In phase 2, the Commission will ask Canadians to provide their opinions on the telecommunications services they consider necessary to participate meaningfully in the digital economy today and in the future. Specific details regarding the scope and procedure for this phase of the proceeding will be released at a later date."*

Phase 2 was followed by a set of public hearings which completed in April, 2016. No date has been set for the ruling.

4.6.1.4 Enhanced 911

On March 29th, 2016, the CRTC issued a Telecom Notice of Consultation regarding the Establishment of a Regulatory Framework for Next Generation 9-1-1 in Canada.[28] Given the evolving nature of telecommunications and proliferation of smart phones and other connected devices, the *hearing looks to take into account the evolving public safety needs of Canadians. NG9-1-1 will provide Canadians with access to new and innovative 9-1-1 services and capabilities.*

4.6.2 Electrical Regulation

4.6.2.1 Smart Grid

The electric grid is a network of generators, transmission lines, substations, transformers and distribution wires that deliver electricity from power generation plants to homes and businesses. In Alberta, these activities have been deregulated into the four areas of generation, transmission, distribution, and retail as shown in the next figure. Regulatory oversight is variously provided by the Alberta Electric System Operator (AESO) and the Alberta Utilities Commission (AUC). With availability of fibre, the power grid can be upgraded and become 'smart'.

Quoting from Lobo's 2015 report on Hamilton County[29]: *What makes a grid "smart" is the digital technology that allows for two-way communication between the utility and its customers. Like the Internet, the Smart Grid consists of controls, computers, automation, and new technologies and equipment working together. In particular, these technologies work with the electric grid to respond digitally to quickly changing electric demand.*

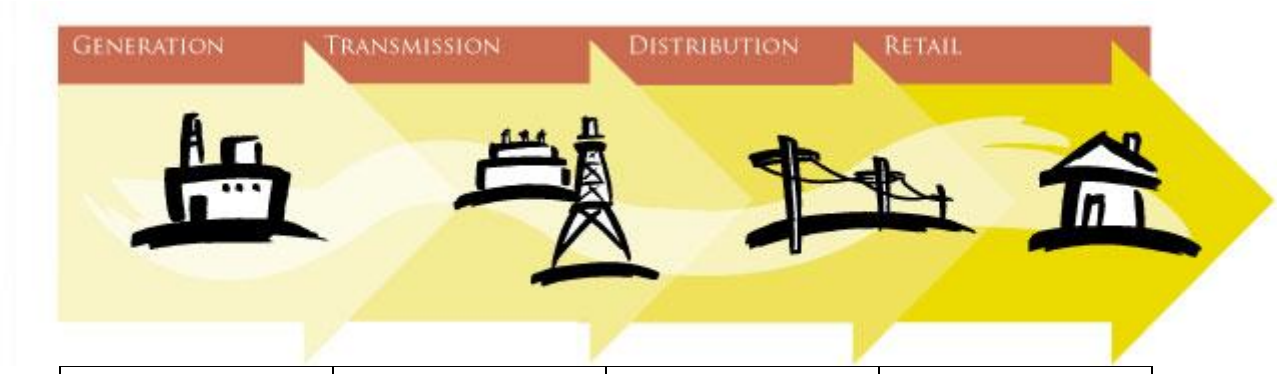
A smart grid permits a cleaner and more resilient and efficient electrical system. As pointed out in Lobo et al (2011) the Smart Grid plays an important role in mitigating electrical system emergencies, avoiding blackouts and increasing system reliability, reducing dependency on expensive imports,

[27] CRTC; *Telecom Notice of Consultation CRTC 2015-134: Review of basic telecommunications services*; 2015-05-11.

[28] CTRC; *Telecom Notice of Consultation CRTC 2016-116: Establishment of a regulatory framework for next-generation 9-1-1 in Canada*; 2016-03-29.

[29] Lobo, B.J.*; The realized value of fibre infrastructure in Hamilton County*; Tennessee; Dept. of Finance, The University of Tennessee at Chattanooga; 2015-06-18.

providing relief to the power grid and generation plants, avoiding high investments in generation, transmission and distribution networks and thereby leading to environmental protection.



Produce power	High voltage long haul distribution	Low voltage local distribution	Sell to and invoice consumers
Private, controlled by AESO	Regulated by AUC & AESO	Regulated by AUC	Regulated (AUC) & Competitive

As a result of these benefits, justification for upgrading to fibre infrastructure is often provided by noting and accounting for the benefits of the smart grid, and power companies often become key partners in the deployment of municipal fibre systems. Unfortunately, due to the deregulated nature of the power supply chain and the wholesale pricing policies for power in Alberta, investment in smart grid initiatives within the province have been minimal. Worse, due to industry uncertainty resulting from the Alberta government's green energy initiative to see 30% of the provinces energy grid go green by 2030, current investment in the provincial power infrastructure has been substantially curtailed. There remains the opportunity, therefore, to position smart grid initiatives as a component of the provincial green power strategy and leverage them to further enable fibre deployment throughout the province.

4.6.2.2 LED Lighting

Fortis Alberta operates as an electricity distribution utility within the province and serves more than half a million homes and businesses in 200 communities across Alberta.

As of January, 2016, Fortis changed its street lighting standards to light-emitting-diode (LED) based units. Not only does LED street lighting reduce power costs by ~50%, but being electronic, the new lighting comes with a Wi-Fi option and the potential to both transition to adaptive street lighting and enable community-wide Wi-Fi throughout the province. Given the small incremental cost of Wi-Fi enabled units relative to both the costs of the LED light and the retrofit or installation costs, Wi-Fi units could be provided with every, say, ten streetlamps that are retrofitted at a very low marginal cost. While groups of Wi-Fi units can connect to each other wirelessly, one in every ten or so would need to be directly wired to the Internet.

At this point, Fortis will work with communities to install Wi-Fi units and provide conduit to connect every ten or so to the Internet, at the community's expense, after the LED upgrades have been completed – thus negating the savings that could be associated with installing the units when the lamps are retrofitted. From their perspective:

- With their current practice of deploying a lighting sensor with each lamp, there is little to no advantage in enabling adaptive lighting.
- As Fortis electrical operations are tightly regulated by the AUC, Fortis could not provide Wi-Fi services itself unless a separate non-regulated division or subsidiary were to be established to 'house' the operation and isolate it from their regulated operations.

- Their LED retrofit agreements with contractors are so cost efficient, that complicating them with a Wi-Fi installation step would increase their costs significantly.

4.6.2.3 A New SuperNet

To bond adjacent high voltage power transmission towers to earth ground and protect the lines from lightning strikes, conductive ground wires are run along the topmost portion of the transmission towers. To enable data transfer and telemetry required to help protect and control their facilities, in lieu of a simple grounding wire, power transmission companies routinely install composite cables consisting of both the required conductive and fibre optic lines called optical ground wires (OPGW) along the top struts of their transmission towers. As multiple fibre optic lines are contained within each OPGW, there is an opportunity to use these capabilities to supplement the connectivity requirements between communities adjacent to the transmission lines. As with deploying Wi-Fi units with LED lighting, both operational and regulatory hurdles will need to be worked though if access to these fibre capabilities are to be made available to communities.

The significance of this possibility lies in the fact that transmission facilities now provide electricity to every municipality in Alberta. Through a network of transmission lines, substations, and OPGWs, there is the potential to create a new fibre backhaul system to connect all municipalities utilizing underutilized fibre assets that are already in place across Alberta.

4.7 Environmental

Climate change has finally made it to the global agenda and CO_2 reduction has become a key focus of governments everywhere. Though ICT-related equipment can be regarded as power-hungry, the use of ICT has the potential to reduce ten times more CO_2 than it consumes.[30] In line with Alberta's Climate Leadership report, ICT offers a way of *'separating economic growth from energy use'*.[31]

Impact areas include:

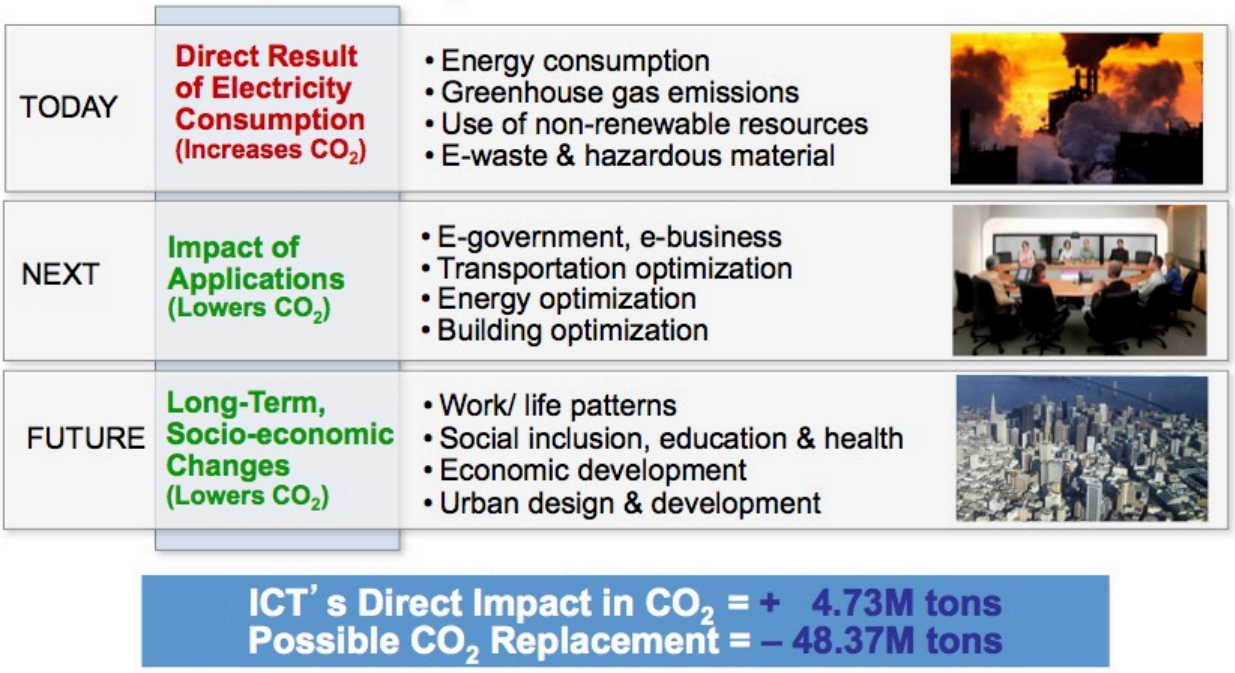
- Smart Public & Private Transportation and Traffic Management
- Connected, Lower Emission Buildings

[30] Gartner Group, April 2007; *Saving the Climate at the Speed of Light*; WWF and ETNO, 2007.

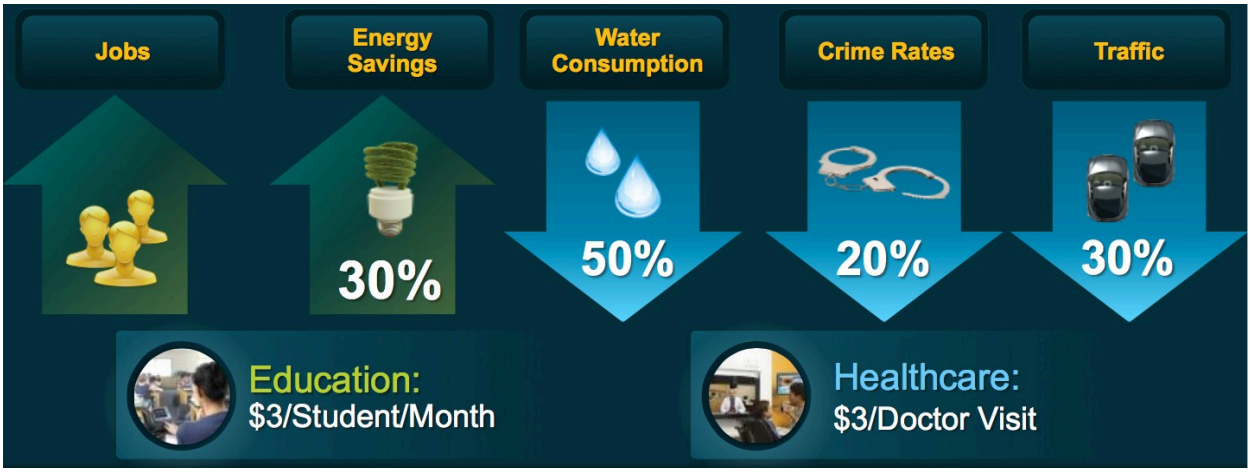
[31] Leach, A., et al; *Climate Leadership – Report to Minister*; Alberta Government; 2015.

- Green Urban Planning
- Smart Work Centers
- Cleaner, More Efficient Power Generation
- Smart Grid
- Teleworking
- Green Information Technology

Overall, ICT's impact on CO_2 reduction is some ten times more than it consumes.[32]



When combined with developments from the Internet of Everything, the potential benefits expand.[33]



[32] Gartner Group, April 2007; *Saving the Climate at the Speed of Light*, WWF and ETNO, 2007.

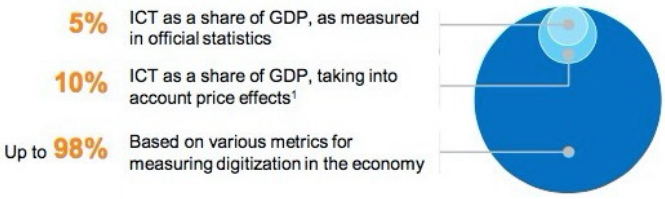
[33] Elfrink, W.; *The Internet of Everything – Connecting the Unconnected*; Meeting of the Minds; 2013-09-11.

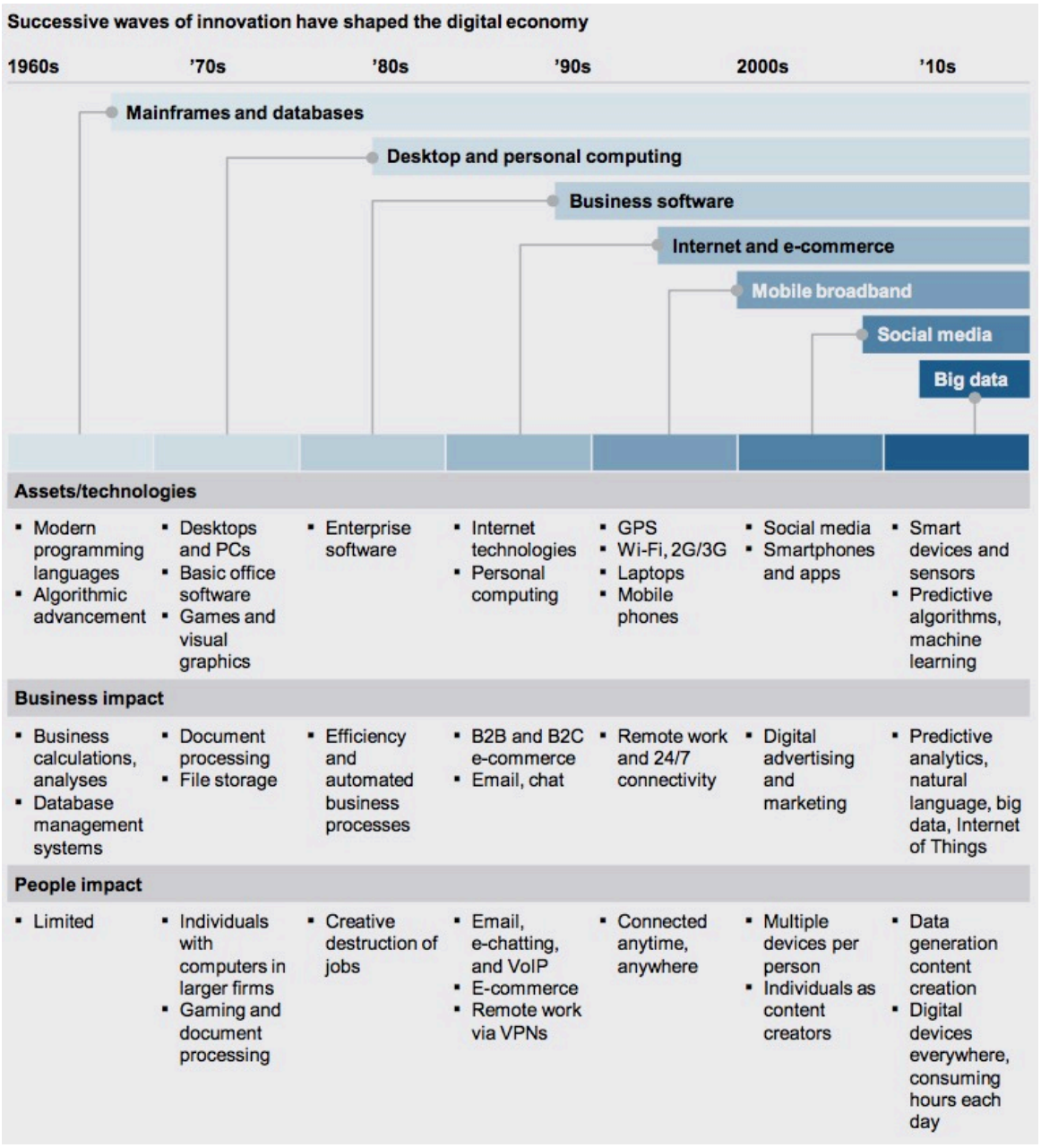
5 Trends

5.1 Technology

5.1.1 The Age of Information Technology and Telecommunications So Far

Prior to looking forward, a brief overview of the progress of the digital revolution and its impacts to date is captured in the figure from the McKinsey Institute below.[22] From mainframes to smartphones and from FORTRAN to machine-learning, progress to date has already impacted up to 98% of the (US) economy.[15]

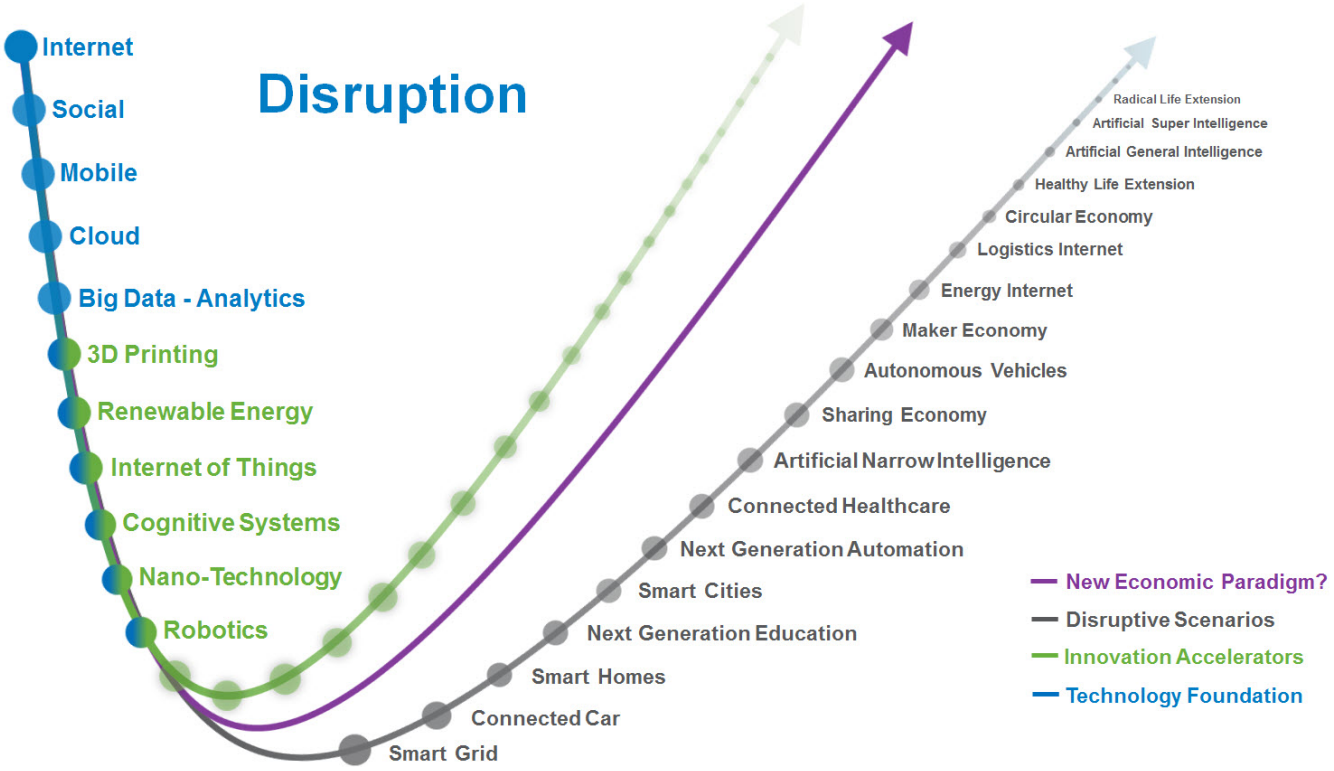




Over time, digital technology has moved from highly centralized, but somewhat remote, mainframes to highly decentralized desktops to a hybrid state in which innumerable capable end devices and sensors jointly interact in real-time with vast centralized and remote cloud computing centres. With this evolution has been an increasing demand for ubiquitous, always-on, higher bandwidth connectivity. Network capacity demands have been doubling every 2-3 years now for over two decades.

5.1.2 The ERaCha Era

According to the Strategic News Service, we are now living on the edge of radical change (ERaCha). Indeed, when the set of potentially disruptive technologies and their applications shown in the figure below are considered, one begins to appreciate the true scope of the impending change.[34]



According to Singularity University, the six technology enablers likely to make the biggest impact over the next decade are:[35]

- 3D Printing – Additive Manufacturing
- Networks and Sensors – The Internet of Everything
- Infinite Computing
- Artificial Intelligence
- Robotics
- Synthetic Biology

Each is an exponentially driven digital-based technology with the potential, both individually and synergistically with others on the list, to truly disrupt the status quo across many sectors. With true

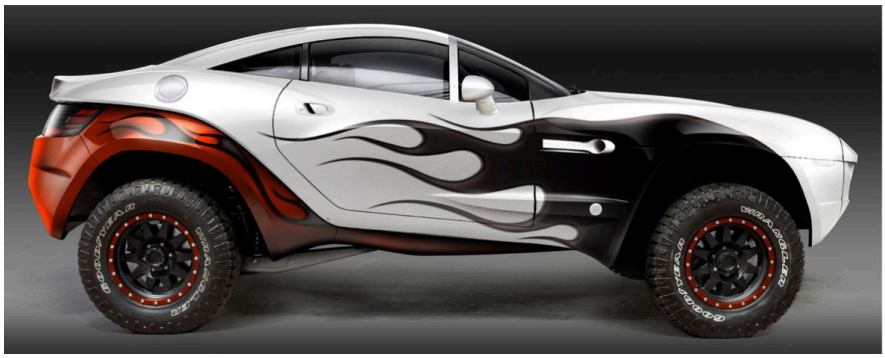
[34] Dianna, F.; *The Maker Economy*; Frank Dianna's Blog; 14 11 10.

[35] Diamandis, P., and Kotler, S; Bold: How to go Big, Create Wealth, and Impact the World; Simon & Schuster; 2015.

broadband networks, these disruptions may be orchestrated from anywhere – that is, anywhere where the network capabilities exist.

Together with 3D printing, for example, ICT and the knowledge economy are rendering the traditional Daimler-Chrysler model for automotive manufacturing obsolete and opening up the very real possibility of a competitive manufacturing facility in, say, the Town of Granum (their former Mayor was quite interested in the possibilities that 3D manufacturing offered). The potential has spawned the so-called 'maker' movement, examples of which exist in Calgary and are developing towns such as Pincher Creek.

The poster child for 3D printing might be Local Motors. In a manner analogous to the open-sourced software model in which a large group of disparate individuals with a common interest collaborate to produce great work like Linux and Apache, Local Motors[36] has created an open-sourced platform linking 30,000 individuals with an interest in designing and building things that move – cars, bikes, trucks, and so on. Their platform is called *'The Forge'* and several years ago, a group of individual widely dispersed car enthusiasts used it to design the first community designed vehicle – The Rally Fighter – an off-road, street ready powerhouse. They then designed a combat vehicle for DARPA and were introduced to President Obama. Development time was five times faster and one hundred times less expensive than traditional defence development cycles. In both cases, the resulting vehicles were then manufactured in a micro-factory – the first of which was constructed in a refurbished 40,000 square foot building in Chandler, AZ for US$300,000. The development economics are such that Local Motors breaks-even on production runs of less than 200 vehicles.



Recent developments in additive manufacturing are now even rendering the 40,000 square foot factory redundant – indeed, a home garage with a broadband connection to download design files will suffice. On Sept. 14th, 2014 at the International Manufacturing Technology Show in Chicago, Local Motors 3D-printed a functional vehicle, the 'Strati' in front of a live audience. Once printed, their CEO, Jay Rodgers, took it for a spin. Change the files, and you end up with a boat, or farm implements, or, whatever.

Turning to the second item on the list, consider the Internet of Everything (IoE). According to the Cisco Visual Networking Forecast, the number of networked devices in Canada will increase from 167 to

[36] http://www.localmotors.com/

313 million over the 2013 to 2018 period.[37] The 313 million device estimate above translates to over eight networked devices per person in Canada and partially results from the proliferation of sensors and the linking of the Internet to the physical environment for purposes of monitoring, automation, and intelligence. Together these trends are leading to the development of the so-called Internet of Things or the Internet of Everything.[38]

The IoE not only enables disruption in the Smart Grid, Smart Home, and Smart Cities areas, but also in enabling the connected car, next generation automation, and connected healthcare, including personalized medicine and the quantified self. Further out, it will enable the energy and logistics Internet, and with contributions from artificial intelligence (AI), autonomous vehicles.

According to Cisco, some 50 billion smart objects will be connected globally by 2020 and enable everything from smart power, transportation, water, and so on. Of these, 601 M will be personal wearable devices, for which the compound annual growth rate (CAGR) is expected to be 44%.[39]

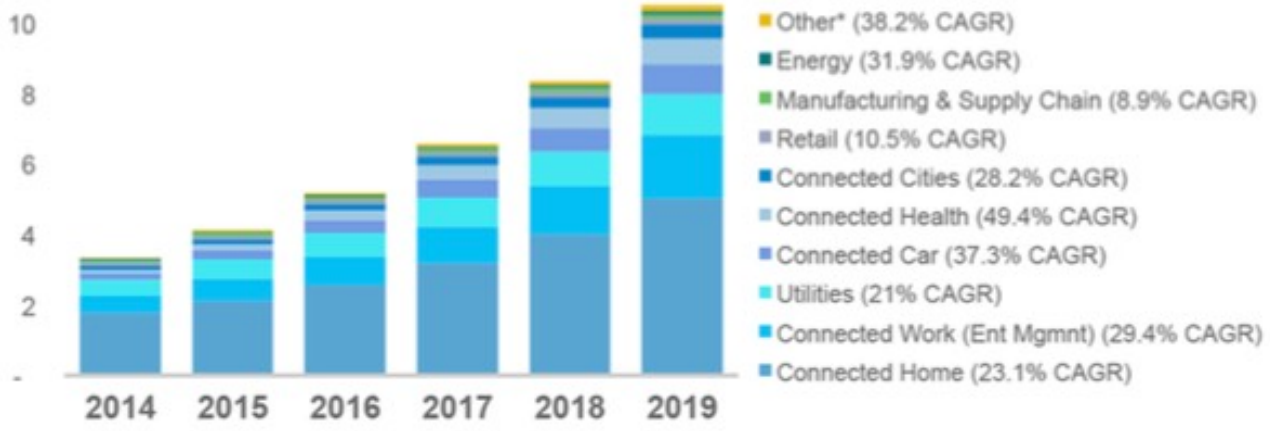
[37] Cisco; *Cisco Visual Networking Index: Forecast and Methodology*, 2013-2017; Cisco; 2014

[38] Gartner Group poster: *The Intelligent City of the Future*.

[39] Cisco; *The Zettabyte Era: Trends and Analysis*; Cisco; 2015.

Picture courtesy of Credit Suisse

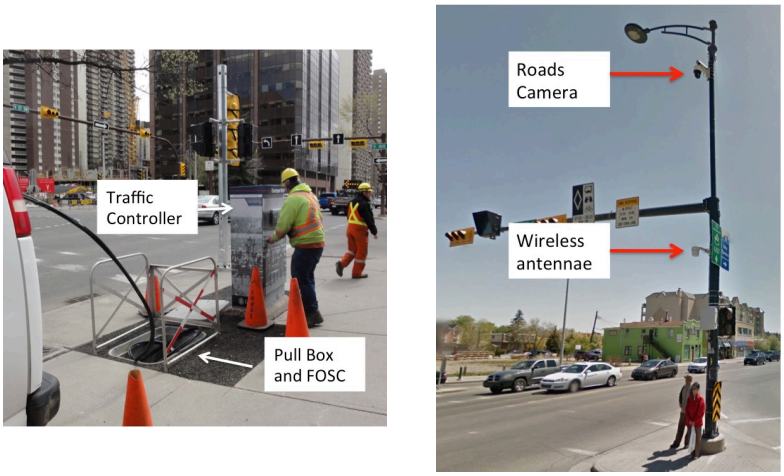
The distribution of the remainder, together with the expected growth-rate over the 2014-2019 period, by sector appears in the graph. The largest category will be the connected home, followed by enterprise management systems in the work environment, utilities, and the connected car. Wearables fall under Connected Health.



Global machine-to-machine (M2M) connection counts, billions. [37]

Current late model cars contain over 400 sensors that generate 20+ GB of data/hr. Each of the 5000 jet engines leased out by GE contain some 250 sensors that monitor every aspect of each engine's operation in real time. Current generation smart phones contain pressure sensitive touch-screens, microphones, accelerometers, magnetometers, gyros, and cameras. Globally, the network value of the IoE is estimated to hit CDN$15.6 trillion by 2022.[33]

The City of Calgary has embraced the connected city idea and is currently deploying traffic controllers and road cameras.



Photos Courtesy of the City of Calgary

To realize the benefits of the connectedness the IoE offers, large amounts of data must be collected over time and analyzed. As particular applications typically require data from multiple sources, open data initiatives are needed to ensure the data generated by multiple sets of sensors are all available to the analytics software employed to examine the data and produce useable results. St. Albert has also been active in this space and already has a few applications up and running.[40] The Calgary Region recently created an open data site focused on municipally-generated data.

On the home front, the possibilities are only limited by one's imagination – as exemplified below by the artists concept of a future kitchen.

Infinite computing is becoming available via the 'Cloud'. Cloud computing is the delivery of computing resources as a service, whereby processing power, software, storage, information, and related services are provided over a network by a third party utility service provider similar to the way in which power is delivered over the electrical grid.[41]

[40] Heron, C.; *Planning for a 'Smart' Future – St. Albert's Approach*; Smart City Alliance Symposium; 2016-04-13.

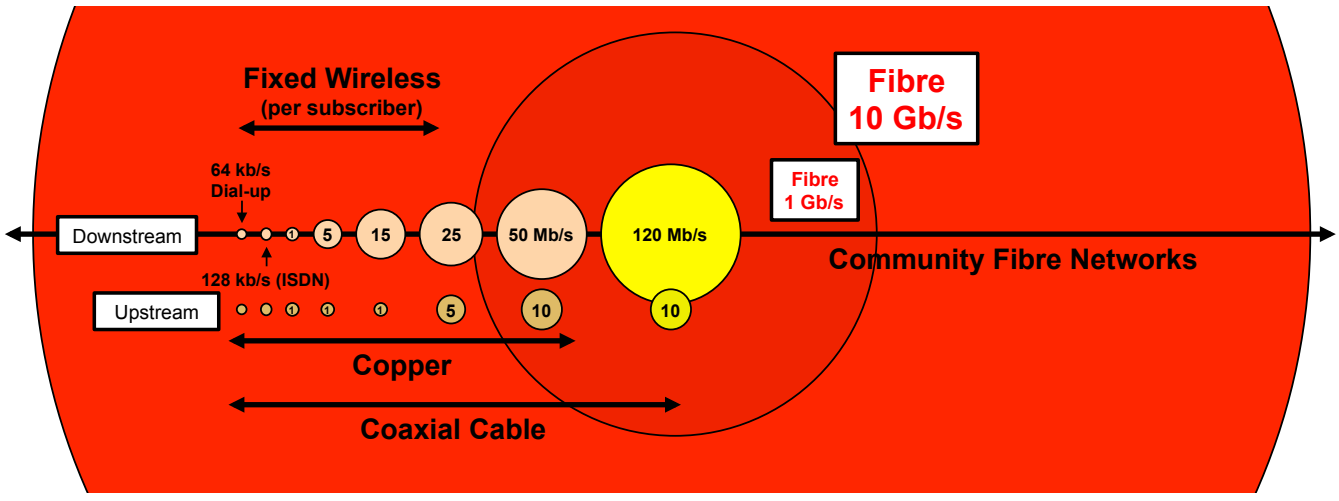
[41] http://en.wikipedia.org/wiki/Cloud_computing

Picture courtesy of Wareables

In this real and quickly evolving context, it is not surprising that annual Internet and mobile traffic is growing at compound annual rates of 21% and 69% respectively. The message here is that the rate of growth in what will be needed for digital connectivity even five or ten years from today is going to be orders of magnitude greater than what we have experienced to date. That level of connectivity and capacity requires a fibre-based infrastructure whether constructed on a private, public/private partnership, or on a public fibre utility basis. Either way, the existing copper/coaxial cable infrastructure is about to be replaced and, depending on how that takes place, broader public benefits may be widely achieved or more limited as a result.

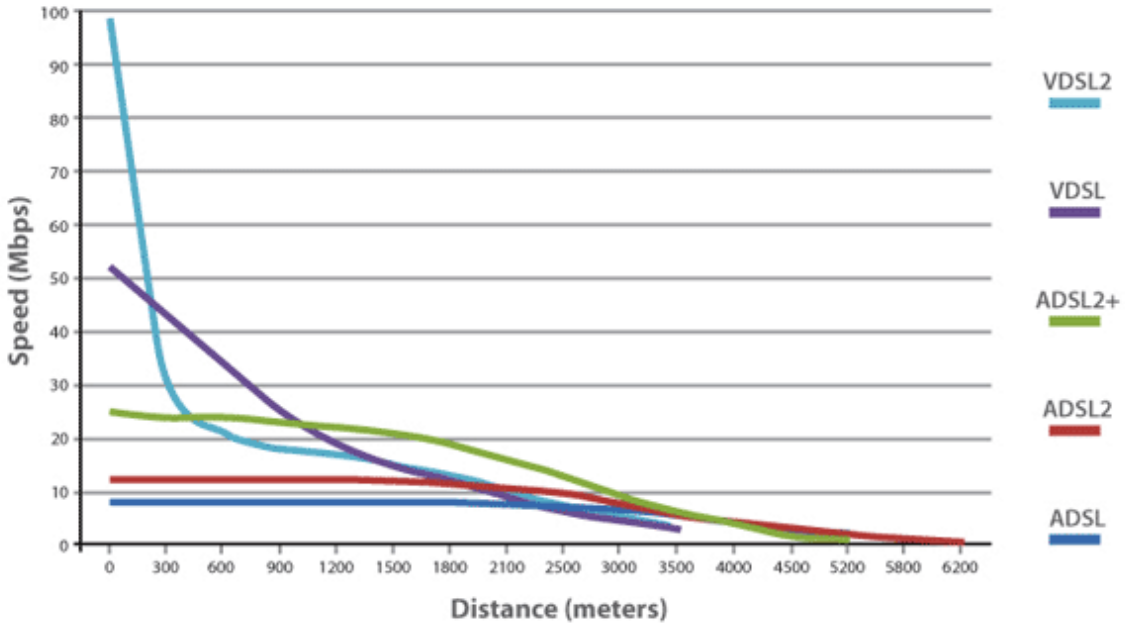
5.1.3 Network Connectivity

A visual comparison amongst the capabilities of the four major transmission technologies – wireless (tan), copper (tan), coaxial cable (yellow), and fibre (red) appears below. In the figure, unless otherwise specified, the numbers shown are in Mb/s.



New fixed wireless LTE systems will do up to 100 Mb/s per antenna. This bandwidth is split amongst downstream (from the network to the client, like a Netflix stream) and upstream (from the client to the network, say for uploading photos or backing up data to the cloud) link requirements as needed and would typically be split into something like 75 Mb/s down and 25 Mb/s up. As the available bandwidth is then shared amongst all the homes taking service within the coverage area, if 50 homes took service and happened to be streaming media content concurrently, the maximum available to each would be 1.5 down by 0.5 Mb/s up.

Internet data services over the copper plant deployed by the telecommunication incumbents are provided via an evolving family of digital subscriber line (DSL) technologies. Due to the attenuation of higher frequencies required to support broader bandwidth signals, the higher the supported bit rates, the shorter the possible serving distance between the incumbent equipment and the client's home or office. As shown in the Ofcomm chart below, DSL technologies have evolved over the years, but with the increasing speeds, come shorter serving distances – so each upgrade requires the incumbents to deploy fibre deeper into the access network – i.e., closer to the end client before transitioning to copper. Whereas initial asymmetric DSL (ADSL) equipment offering 6 to 8 Mb/s down and 0.512 Mb/s up could be served from central offices within 4 km of the client, more recent very high bit-rate DSL (VDSL) supporting 13-52 Mb/s down by 1.5-2.3 Mb/s up requires fibre to the neighbourhood. VDSL2 supporting symmetric 100 Mb/s services requires fibre-to-the-block.



In urban centres, lengths are typically short enough to support 50 Mb/s down by 10 Mb/s up. With longer drops in the rural areas, the higher bandwidth services are simply not supported.

As the coaxial cable plant deployed by the cable operators can support bandwidths exceeding 1 GHz, to keep things simple, all available cable television signals are transmitted to every home – it's then left to the cable box to direct only the user selected channel to the television. To enable Internet data services, the available bandwidth is partitioned or split into two components – the lower one (5 – 42 MHz) is used to support upstream data transmission via the data over cable service interface specification (DOCSIS, currently version 3.0) and the remaining upper band (50 – 860 or 1 GHz) is used to transmit the downstream data and television signals. As these bandwidths are shared amongst many homes, subscriber bit rates are typically limited to 120 Mb/s down by 10 Mb/s up. Changing that split to increase upstream bit rates requires changing every diplexer in every active component in the network,

as well as the cable modem boxes. Hence, even though DOCSIS 3.1 has become available and would enable more symmetric and higher speed Internet offerings, the cable companies are only likely to provide the upgrades in exceptional circumstances.

By comparison, fibre used in community fibre deployments will theoretically support bit rates up to 2,800 Gb/s[42], its capacity is in essence, unlimited. Once deployed (buried civil works are ~70% of the cost), fibre network capacity can simply be increased by updating the opto-electronics at each end of the cables as needed. Currently deployed opto-electronics provides for symmetric 1 Gb/s services to each premise or 2.5 Mb/s down by 1.5 Mb/s up shared amongst up to 64 premises. The new XG-PON technologies enable up to 10 x 2.4 Gb/s links shared amongst up to 128 homes. To provide more bandwidth per premise, lower split ratios can be used (e.g., 1:2, 1:4, 1:8, 1:16, or 1:32).

According to the Fiber to the Home Council:[43]

> *So much data zips around the world today in commerce, education, entertainment and personal communication that copper wires and radio waves could carry only a fraction of it. Because fiber optic cable has so much capacity, it now forms the backbone of the Internet, cable TV networks, telephone (including cellular) networks, private business networks and even data center networks. Without fiber optic cable, none of these systems would work.*
>
> *FTTH offers far more bandwidth, reliability, flexibility, security and longer economic life than alternative technologies, even though its price is comparable. On average, it is slightly more expensive to build, but it is far less expensive to operate and maintain than copper.*

Relative to wireless technologies, both on a cost and bandwidth basis, there is no comparison. In a sample design for a 200 mi^2 rural area in Chamberlain, S.D., Vantage Point Consulting found that whereas the least expensive wireless deployment came in at $370 per Mb/s per client, fibre came in at $9 – and fibre scales (capacity and reach can be expanded with minimal cost), but wireless does not.[44] In this comparison, the wireless network was designed to support 4 Mb/s per client whereas the fibre network could support 1 Gb/s.

In the US, community fibre networks have become a popular way to improve connectivity – even in states which actively inhibit such approaches. In addition to the over 200 community networks shown in the figure on the next page, for example, 77 communities have publicly-owned cable networks and over 185 serve at least some portions of their community with fibre. [45] To date in Canada, there is only one community-owned FTTP network offering 1 Gb/s services (Olds) and maybe 5 with dark fibre. Furthermore, some 25 of the 48 US states reporting have established a broadband office – in Canada, none have.

5.1.4 Recent Advances in Traditional Technologies

5.1.4.1 Copper – Fast DSL

The evolution of DSL technologies continues. VDSL2 speeds are increasing with the introduction of 'vectoring', a scheme which helps minimize interference effects from signals in adjacent copper pairs.

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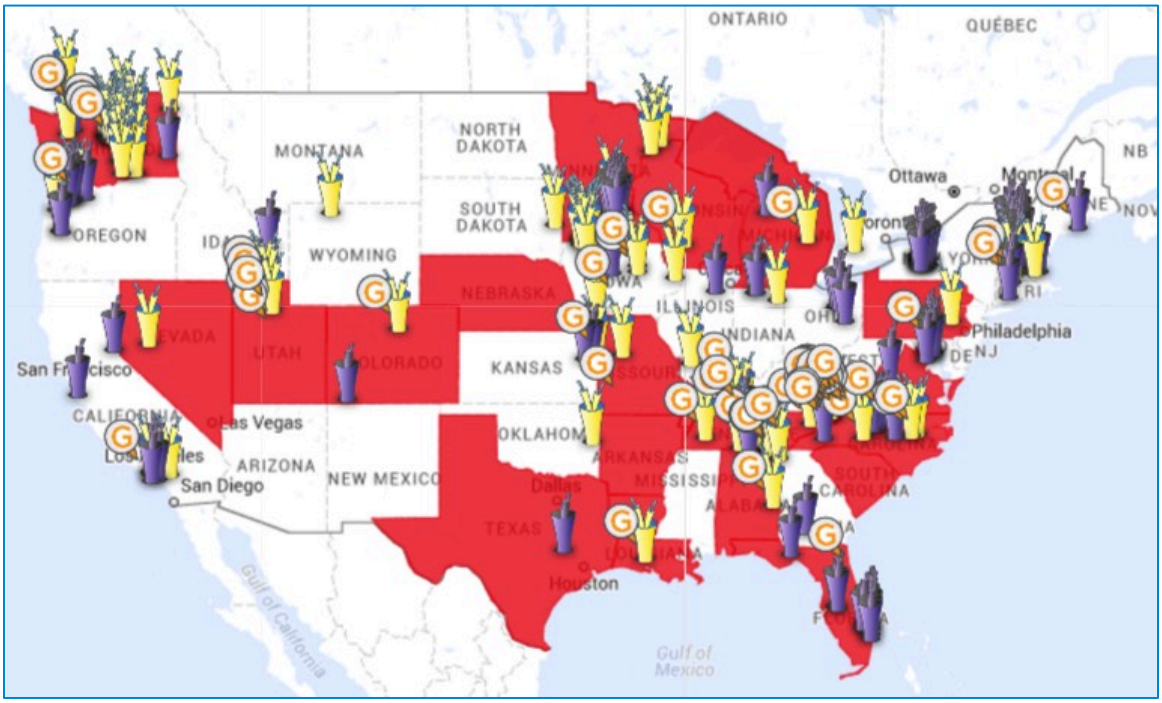
[42] Bandwidth estimate assumes 256 QAM at λ =1.55 µm

[43] Broadband Communities; *What Fiber Broadband Can Do For Your Community*; 10th Edition; Fibre to the Home Council; Americas Fall, 2014.

[44] Thompson, L., et al; *Comparing Wired and Wireless Broadband; Broadband Communities*; 2015 05/06.

[45] https://muninetworks.org/communitymap

As well, G.fast (G.970x fast access to subscriber terminals) compliant equipment became available earlier this year. G.fast equipment supports bit rates symmetric 100 Mb/s bit rates on links up to 200m.



	83 Communities with a publicly owned FTTH network reaching most or all of the community.
	Over 115 communities with publicly owned dark fibre available

	Over 50 communities in 19 states with a publicly owned network offering at least 1 Gb/s services
	Nineteen states have barriers in place that discourage or prevent local communities from deciding locally if such an investment is a wise decision.

5.1.4.2 Coax – DOCSIS 3.0 and 3.1

The evolving DOCSIS specifications are summarized in the table below.[46] As mentioned earlier, the North American 42 MHz subsplit affects almost every component in cable system distribution networks, making upgrades beyond current implementations expensive. On a relative basis, however, as it's 'only' electronics, the required upgrades are much less expensive than those involving the deployment of additional access (fibre) infrastructure. Note that as cable is a shared infrastructure, the aggregate bit rates appearing in the table are shared amongst however many client premises that segment of the distribution/access plant connects to.

5.1.4.3 Fibre

Current G-PON optical electronics support bit rates of 2.488 Gb/s down by 1.244 Gb/s up on a shared basis as well as symmetric 1 Gb/s dedicated links. Opto-electronics supporting the new 10G-PON or XG-PON standards became available in early 2016 and support 10 Gb/s down by 2.5 Gb/s up on a

[46] Zhao, R., et al; *White Paper: Broadband Access Technologies*; FTTHC Europe; 2013.

shared basis. XG-PON is, in essence, an interim technology on the way to XGS-PON and NG-PON2 capable equipment, with XGS-PON simply being a single wavelength implementation of the 4 wavelength capable NG-PON2 equipment. In these standards, each wavelength will support symmetric bit rates of 10 Gb/s.

	DOCSIS 3.0		DOCSIS 3.1	
	Current	Phase 1	Phase 2	Phase 3
Downstream: Gb/s	0.3	1.0	5.0	10.0
Assigned Band: MHz	54–1002	108–1002	300*–1152	500*–1700
Upstream: Gb/s	0.1	0.3	1.0	2.0*
Assigned Band: MHz	5–42	5–85	5–230*	5–400*

* to be determined

5.1.5 Exotic Technologies

5.1.5.1 Micro-satellites

Over the years, there have been a number of initiatives focused on deploying a constellation of low earth orbit satellites (LEOS) capable of providing Internet services with global coverage. While the initial Motorola Iridium program did partially succeed, the later Teledesic and Skybridge efforts did not. As technology has evolved, smaller, higher capacity satellites have become possible and costs have decreased significantly. The two current incarnations, OneWeb and SpaceX's, both involve constellations of hundreds of micro-satellites. Both are still in their concept phase and the satellites have not yet been designed. At this point, one is banking on 640 or 700 satellites, while the other is suggesting 4,000. The former is already behind schedule and the latter will require a breakthrough in launch technology.

5.1.5.2 Starry

A particularly interesting, well funded startup in Boston, called Starry[47], is developing what is in essence a fixed point-to-multipoint wireless system operating at 37–40 GHz, focused on delivering symmetric 1 Gb/s access to homes in urban areas – thereby obviating the initial requirement for FTTP.[48] With a range of 1 km, each central antenna can serve between 600 and 900 premises. Beta testing to Boston area residents began in July.

5.2 Application Trends

Growth in aggregate backbone data traffic based on US statistics slowed to 21% in 2014, while growth rate of the video streaming component of that increased to 64%. Smart phone subscribership is growing twice as fast as Internet (20% versus 10% annually) and at a CAGR of 52%, tablet shipments are going through the roof. These growth rates together with the growth in mobile video usage are resulting in mobile data traffic increases of nearly 69% per year[49]. As 80% of mobile data is received via Wi-Fi

[47] https://starry.com

[48] Talbot, D.; Wireless, *Super-Fast Internet Access Is Coming to Your Home*; MIT; 2016-05-16.

[49] As of 2014, the video component of the mobile data usage is growing at 55%.

connections to fixed networks (OECD) and 100% of backbone mobile traffic carried over landline networks, the demand for the higher bandwidth connectivity available from fibre is increasing.

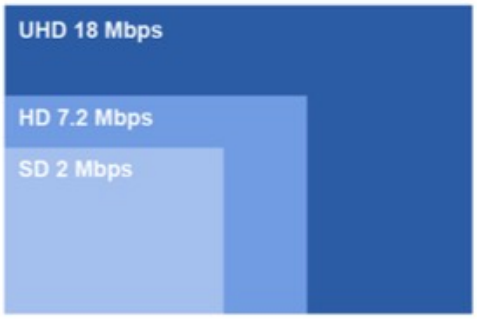
Phones for a Six Year-old

Circa 1965

Circa 1990

Circa 2015

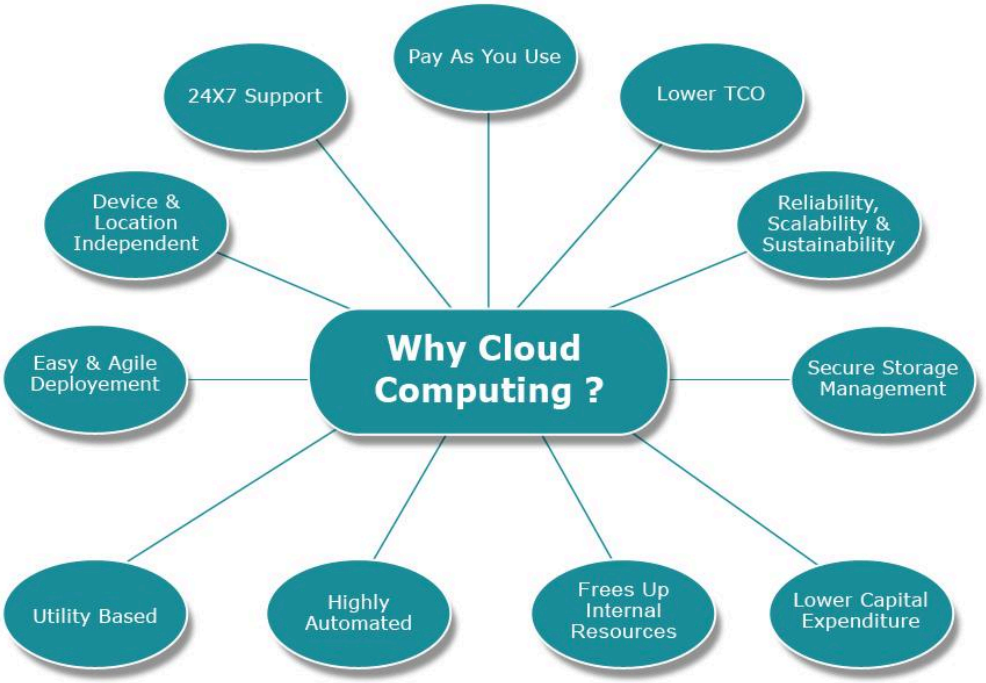
Internet video traffic is expected to increase at a CAGR of 14% over the 2014 to 2019 period. The high definition (HD) component of this will increase from 55.8% to 69.9% while the Ultra-HD component will increase from 0.2% to 21.0%. On a per household basis, the average Internet user generated traffic will increase 152% – some 20%/yr over the five year period.



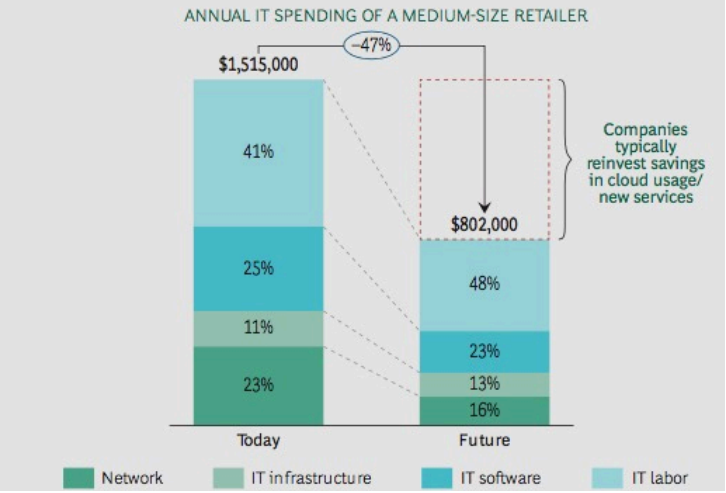
As in the early days of single purpose networks, corporate computing departments struggled with arrays of computing hardware, each component of which ran different application sets. As the application sets typically did not tax the capabilities of the underlying hardware, costs were high and efficiency was low. The development of virtualization software made it possible to run each of the application sets on one powerful hardware platform. To each application set, the virtual computing environment on which it ran simply looked like the single purpose platform it was used to. Using this type of software, O-Net runs over a hundred virtual machines on one platform.

As virtualization software matured, it became possible to scale the underlying hardware platforms running virtualization software to encompass very large computer arrays and Cloud computing was born. Anytime a smartphone user activates one of the more powerful apps on their phone, say Siri, for example, they are directly interacting with a cloud computing environment.

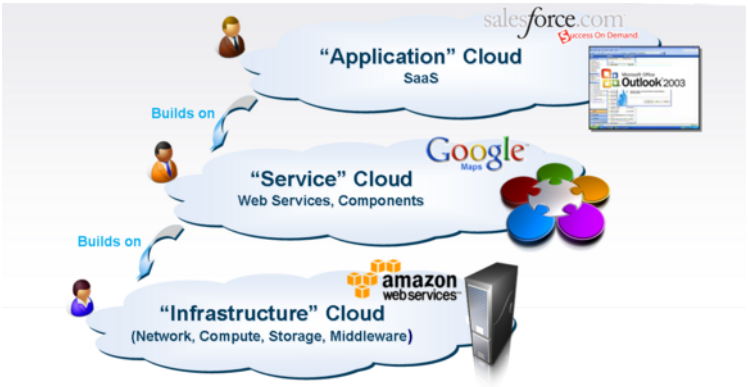
Cloud computing allows firms to lease storage and processing capacity from others, rather than buying and maintaining their own internal servers and data centres. Clouds can be private, public, or a combination of both. The many benefits of using cloud computing infrastructure appear in the next figure, courtesy of MagTech Solutions. Small and medium-sized firms use clouds to ensure they can scale quickly to meet demand. Larger firms are looking at cloud computing as a way to reduce computing costs. Outsourcing computing services reduces costs, helps keep software up-to-date, and encourages collaboration.



According to one estimate, cost reductions for a medium-sized retail firm consisting of 40 stores and 500 employees run in the range of 47%.[50] IDC estimates that big companies will spend $100 billion on cloud computing services in 2014. As prices come down and security fears are addressed, this number will likely grow significantly. Mark Hurd, CEO of Oracle suggests that, over the next ten years, all corporate computing will be moved to the cloud.



Cloud computing infrastructure is typically configured to run as three layers – infrastructure, platform, and applications.

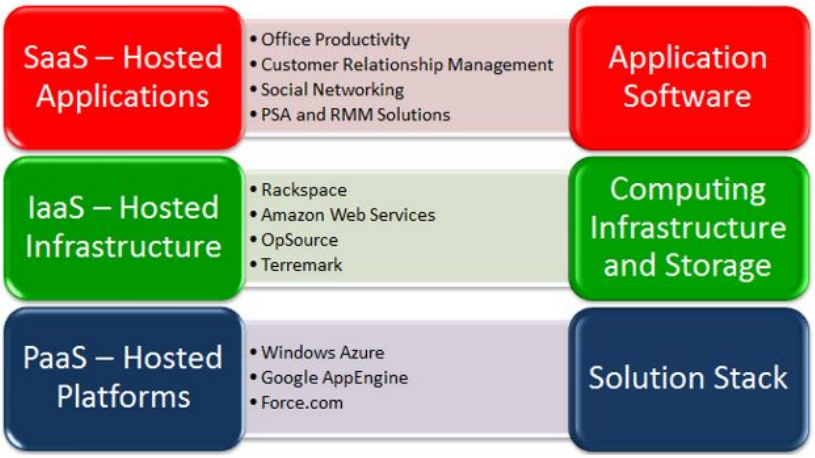


Infrastructure: includes the hardware infrastructure components such as the network optical-electronics and routing infrastructure, and data-centre computing infrastructure.

Platform: a common integrated set of software, application programing inter-faces (API's), and platforms that tie all underlying infrastructure components together on the one side and presents it to the applications/software layer on the other.

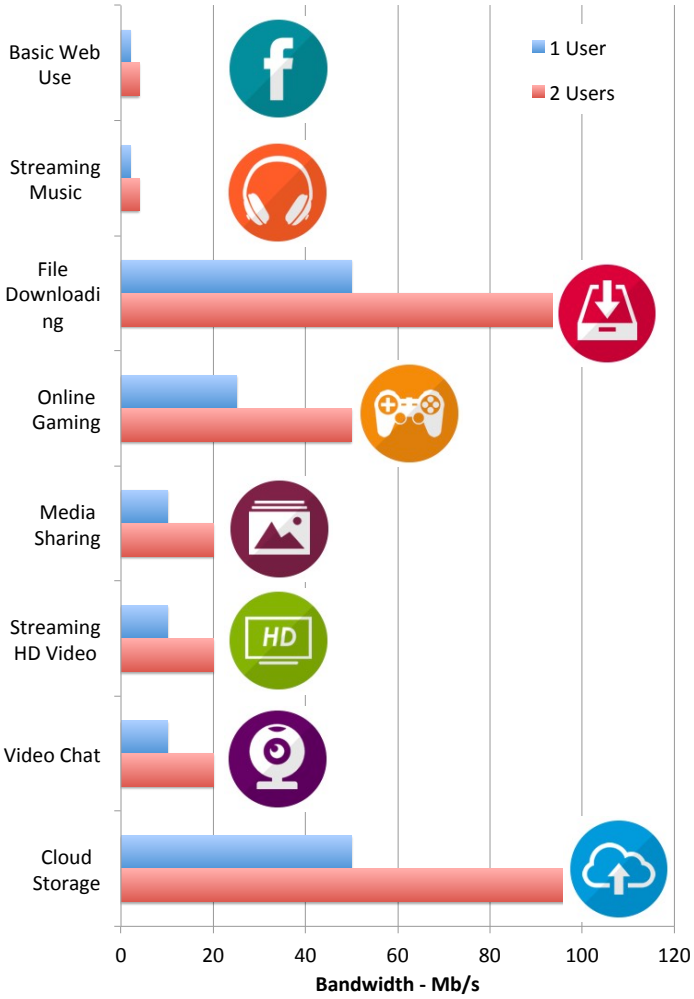
Applications/services (Software): Commercial and crowd-sourced software suites that empower revenue generating, marketable services. Integrated applications currently being investigated are in the areas of e-Government, e-Health, Digital Education, Smart Homes, and a Town Portal.

When standardized access to the individual components comprising each layer is made available as a service, that capability is denoted as the layer's name followed by 'as a service' (aaS). Hence, the terms IaaS, PaaS and SaaS, or collectively XaaS. Examples of services by layer appear in the adjacent figure.

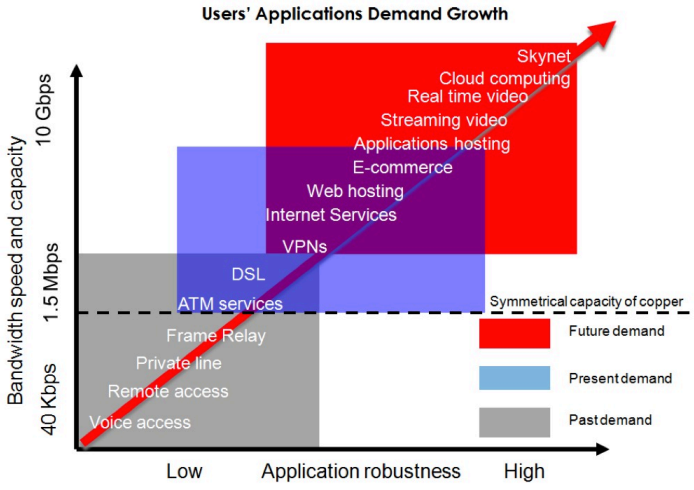


[50] Eazor, J.F. & Gilliland.G.; *Can Your Network Deliver the Potential of the Cloud*; BCG Perspectives; 2016-02.

Whereas access to Internet services has traditionally been provided on an asymmetric basis in which downstream (to the client) bandwidths significantly exceeded upstream (from the client) capabilities so as to enable the consumption of content, cloud computing requires symmetric bandwidth and fibre. Though video streaming services – YouTube and Netflix in particular – typically dominate both overall and aggregate down-stream bandwidth requirements, business services, partly due to cloud requirements, dominate upstream requirements. These results are supported by the strong response from local business in Olds to the upstream bandwidth potential offered by O-Net. As business-related services such as remote backup move into the consumer space – say, for example to back up home computer-based photo libraries – upstream requirements on the consumer side will likely increase as well. Indeed, hundreds of millions of consumers already store their data files in the 'cloud', using services such as Apple iCloud, Microsoft OneDrive, Google Drive, and Dropbox.



In summary, the evolution of applications and bandwidth demands over time are summarized in the adjacent chart.[51] The initial always-on services appear in the grey square, current applications in the blue square, and current largely unmet demands for significant bandwidth appear in the red square. Skynet refers to the self-aware artificial intelligence system which features centrally in the Terminator movie franchise and serves as the franchise's main antagonist – perhaps not the best example of where we might want things to go.

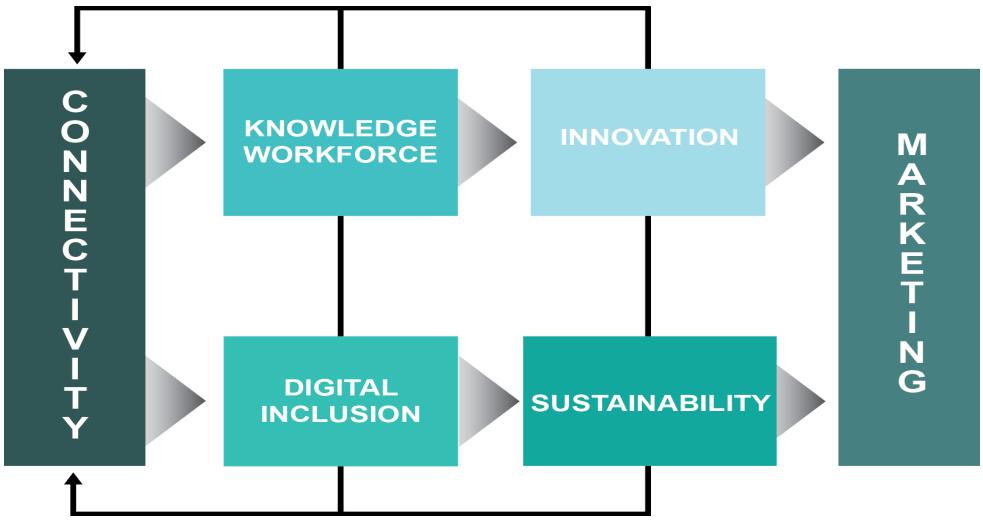


5.3 Intelligent Communities / Smart Cities

Established as a nonprofit policy research organization in 1999, the Intelligent Community Forum (ICF) focuses on the economic effects of broadband together with community-based best practices, and invites communities to compete for an annual Intelligent Community Award.

[51] Western Ontario's Wardens Caucus (WOWC); *Regional Broadband Feasibility Study*; WOWC-02-12; 2013 08 / Taylor Warwick Consulting

Intelligent Communities turn to technology not just to save money or make things work better: they create high-quality employment, increase citizen participation and make themselves great places to live, work, start a business and prosper.[52]



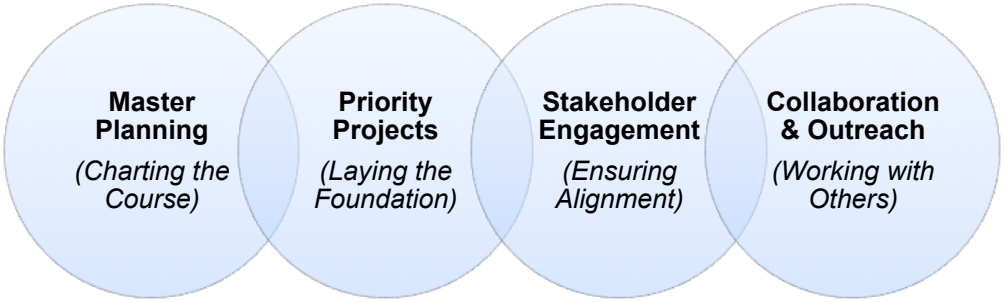
Under the IntelligentYQL banner, Lethbridge initiated their quest to become an Intelligent Community in 2014. Led by a partnership between their internal IT and Economic Development departments, a twenty person community-wide steering committee was established. Using the Integral Strategy Roadmap methodology and extensive community engagement, an elaborate Master Plan was created and details are available at www.intelligenctYQL.ca. Last October, the ICF recognized Lethbridge as a top 21 ICF community. Lethbridge is now focused on developing integrated connectivity and open-data strategies.

Whereas the ICF embraces the effects of ICT as an enabling technology to improve the quality of life for a community's citizens, the more recently coined *Smart City* concept is significantly more encompassing, and thus less focused, in scope – both in terms of the underlying enabling technologies and in terms of the impacts sought. Popularized by the original IBM Smarter Cities 2010 Challenge, Wikipedia defines a Smart City as:

A smart city is an urban development vision to integrate multiple ICT solutions in a secure fashion to manage a city's assets – the city's assets include, but not limited to, local departments information systems, schools, libraries, transportation systems, hospitals, power plants, water supply networks, waste management, law enforcement, and other community services. The goal of building a smart city is to improve quality of life by using technology to improve the efficiency of services and meet residents' needs. ICT allows city officials to interact directly with the community and the city infrastructure and to monitor what is happening in the city, how the city is evolving, and how to enable a better quality of life. Through the use of sensors integrated with real-time monitoring systems, data are collected from citizens and objects – then processed and analyzed. The information and knowledge gathered are keys to tackling inefficiency.[53]

[52] http://www.intelligentcommunity.org

St. Albert initiated a Smart City initiative a few years ago and, with Cisco, hosted a Smart City symposium in September, 2014. They then founded a Smart City Alliance mentioned earlier. There are four parts to their multi-pronged 'Smart' approach:



The key Master Plan objectives are:

- Generate opportunities for efficiencies
- Support economic differentiation, attraction and diversification
- Improve asset management and service delivery
- Foster culture of innovation, and testing (a "living lab")
- Use data and analytics to make better decisions

Priority areas are: Economy, Mobility, Governance, Living, People, and the Environment. To date, over 20 strategies and 75 action items have been identified. The draft Master Plan has been completed and was released for comment in May, 2016.

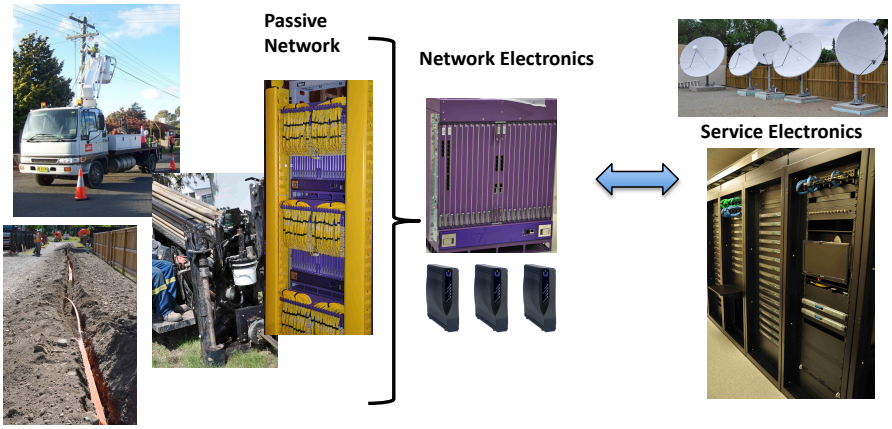
Open data, or the ability for all municipal stakeholders to be able to access and analyze the many data sets created via the underlying connectivity and sensor systems being established to enable a city to be smart is therefore a key enabling technology for the Smart City concept. Open data initiatives are underway in Calgary, Edmonton, Lethbridge, and St. Albert. St. Albert is focused on becoming a Smart City and in 2014 established the Smart City Alliance focused on developing the cross-sector collaboration needed to support Alberta communities in their quests to become 'Smart'. Spruce Grove could become a member of the Smart City Alliance and information is available at: https://smartcityalliance.ca

6 Networks as Utility Infrastructure

6.1 Networks versus Services

As discussed earlier, under the facilities-based competitive structure that exists in Canada, competing broadcast or telecommunication companies must own the networks over which their services are provided. Given today's fibre networks can carry any digital media one can imagine, this is equivalent to requiring that each car (Honda, GM, …) manufacturer own the road system over which their cars travel. Under this regime, the bigger cities would likely end up with multiple systems of roads, while the smaller centres might go without. Long ago, communities realized that by providing one road system for all to use, competition in vehicle production would flourish, and the benefits to the community would be many.

[53] https://en.wikipedia.org/wiki/Smart_city

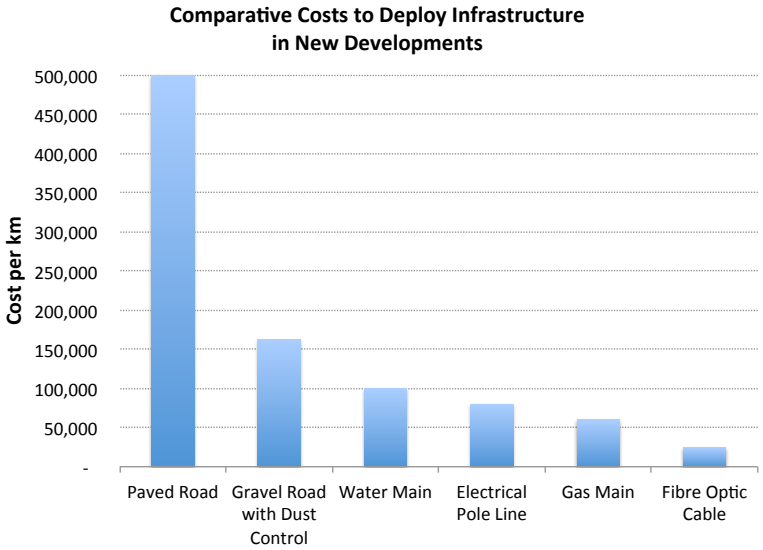


Analogously, many European communities have moved from facilities-based competition in the ICT space to one of services-based competition in which a single broadband network is deployed as a utility in each community and any company that is interested in providing services over it, is welcome to do so. Competition has flourished and in many communities, over thirty service providers compete with a wide range of services. Under a services-based competition model in which communities provide utility fibre infrastructure for all to use (like roads), communities are only competing with private enterprise if they choose to enter the services space as well. In pursuing this type of model, community options range from offering wholesale access to passive (conduit, dark fibre) or lit fibre networks, to providing both the network and services themselves.[54] Wholesale arrangements can be configured in at least two ways:

- If a services ecosystem exists, then the service providers interested in serving the area covered by the network would simply contract for wholesale access on some basis.
- If a services ecosystem has not been established, the community could either outsource retail service operations, establish their own, or contract for wholesale Internet, telephony, and television services and develop in-house administration, marketing, maintenance, and sales capabilities.

6.2 Comparative Costs

While the far reaching positive benefits of roads, water, power, and gas are accepted to the extent that the associated infrastructure is deployed without the need for return on investment or business case calculations, the fibre optic cabling required for broadband enablement is not – even though, as shown in the next chart, fibre is the least expensive to deploy.[55] Though difficult to quantitatively capture and include in an associated business case or plan, these off-balance sheet items should



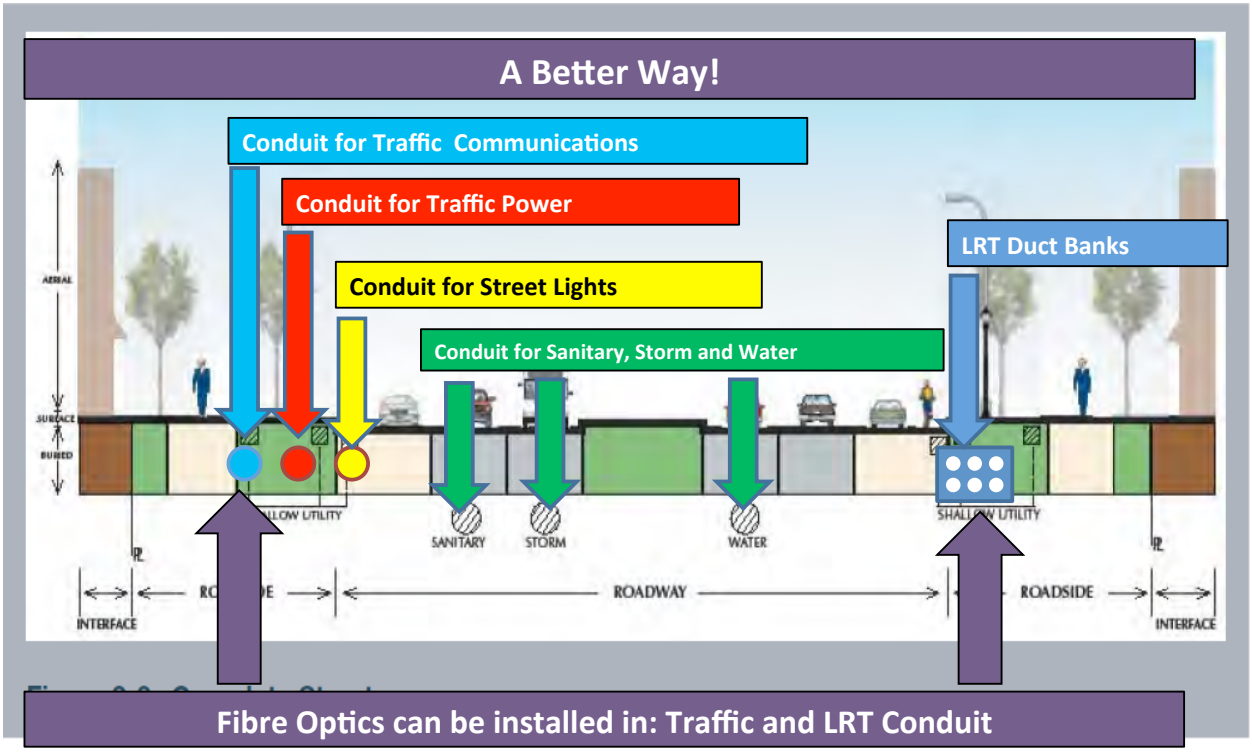
[54] Once services competition develops, these communities may provide access on an open basis in which all service providers are welcome to connect. Today, competitive service providers are few and far between.

[55] WOWC; *Regional Broadband Feasibility Study*; WOWC-02-12; 2013 08 / Taylor Warwick Consulting

be noted. Indeed, positive externalities associated with adequate broadband connectivity and services infrastructure will occur in areas such as education, health, agriculture, tourism, resource monitoring and management, emergency services, government, improved prospects for employment, and regional economic development. When a targeted benefits study was completed for communities in the Wood Buffalo region, the benefits more than justified the cost differential to move from a fixed wireless to a full fibre deployment.[56]

6.3 Connectivity vs Broadband

In September, 2015, the City of Calgary adopted a dark fibre strategy based on the argument that facilitating Internet-based services is only one of six networks requiring connectivity in The City and that providing the required connectivity for all networks is The City's responsibility, particularly as space in their rights of way is limited and The City does not wish to have their streets continually dug up.



From The City's perspective, connectivity to some 230 remote offices, 450 traffic controllers, dozens of lift stations, and a multitude of transit and bus stations, traffic and security cameras, and so on is required.[57] Upon review, The City of Calgary found their four biggest challenges to be:[58]

- Managing the Rights of Way (ROW) – challenging now and will only get worse as duplicate infrastructure accelerates.
- Cost effective Connectivity for The City – Internet of Things (IoT) and Smart City Trends are drivers.

[56] Dobson, Craig; *The True Economics of Broadband – A Benefits Analysis*; Taylor Warwick Consulting Limited; 2013 09 29.

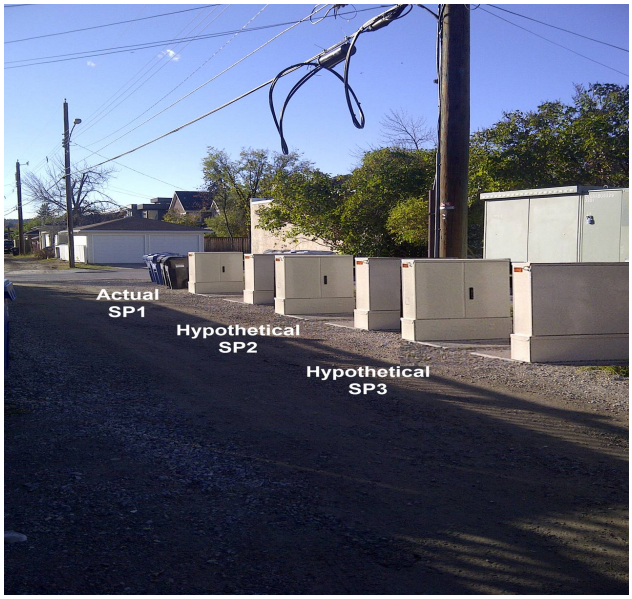
[57] A video presentation on their strategy is available at: https://youtu.be/dQMzkz6oaqg

[58] Basto, David; *Building the Business Case for a Connected City*; City of Calgary; 16-03-10.

- Protecting City's ability to self-provision services – relies on infrastructure and access to ROW's.
- Community inequities are inevitable – What's the plan?

Their solution was to adopt a city-wide dark fibre strategy based on rich connectivity. Approved last September, the strategy aims to enable the connectivity required to create a healthy digital ecosystem and minimize disruption due to the civic construction required to provide it. The City will deploy dark fibre infrastructure and any others needing access to it will be able to.

The network will be run on an equitable, open access basis and will connect all communities in Calgary. The City will not be entering the retail telecommunication services arena, nor providing fibre to the home. Competitive providers will be able to extend The City fibre to the business for those purposes and The City will buy the last mile fibre back over time, so that all fibre will remain the property of The City and The City can therefore retain control of what it sees as critical civic infrastructure.



A presentation outlining The City of Calgary's approach can be viewed at:

https://youtu.be/dQMzkz6oaqg

Though the approach makes sense for larger centres and there are now three such efforts underway in Canada – Coquitlam, New Westminster, and most recently Campbell River – it is less applicable to smaller centres as those markets are not likely large enough to support more than one provider lighting up the network – in which case the "first provider in" gains a de facto monopoly.

6.4 Open Access

According to the Institute for Local Self-Reliance (ILSR), open access can be defined as:

> *An arrangement in which the network is open to independent service providers to offer services. In many cases, the network owner only sells wholesale access to the service providers who offer all retail services (ie: triple play of internet, phone, tv). Open access provides much more competition from which potential subscribers can choose.*

The ILSR then goes on to say: *in the competitive marketplace created, ISPs compete for customers and have incentives to innovate rather than simply locking out competitors with a de facto monopoly.* To date, in the US, some thirty open access networks are operational and some nine more are in

development.[59] Adding credibility to the open access model, in March, Google announced that it would provide services to the open access network being deployed in Huntsville, Alabama.[60]

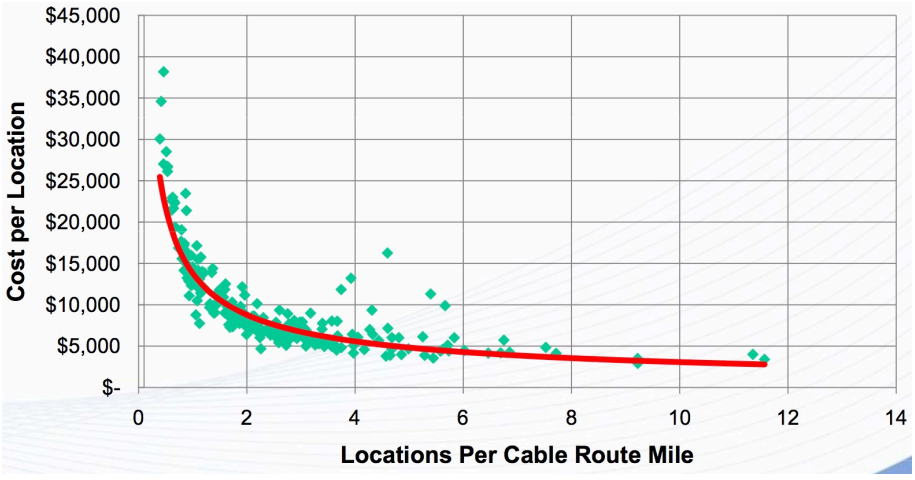
With an insufficiently developed services market in North America, many communities like Olds have elected to position for open access down the road (the fibre network and ISP services are provided by separate entities), but initially sole source services to reduce risk and help ensure revenue streams sufficient to service the debt incurred to deploy the network. Once the debt has been retired or a competitive services ecosystem develops, the sole source arrangements may be revisited.

To ensure a level and transparent playing field, open access networks are best provided via structural separation in which wholesale-only providers remain wholly independent from the service providers using their network. Though the wholesale or carrier services divisions within the incumbent telecom and cable providers are not structurally separated, the CRTC requires operational separation between the divisions. Though the intent of the Alberta SuperNet agreements with Axia was to ensure wholesale-only operations, Axia has interpreted the agreements in a way that enables them to provide both wholesale and retail services – which is one of the issues Service Alberta will have to deal with as it evaluates contract renewal scheduled for June 30, 2018.

A similar issue has arisen with Axia Connect – the non-arm's length retail division of Axia NetMedia that offers FTTP networks to small communities. In this case, Axia Connect's definition of open access is that their wholesale and retail rates for their (lit) Internet connectivity services are available at the same rate to clients and service providers. Hence their 'open access' service only applies to the provisioning of voice and television services as their wholesale service includes Internet. On the other hand, Axia's alternate dark fibre leasing option does align with the traditional open access definition.

6.5 The Rural Challenge

In using Internet revenue to justify a network build, client density matters. Specifically, as the number of premises in a given area increases, the deployment cost per premise decreases while the potential revenue increases. The impact of this can be seen in the next chart from VantagePoint.[61] As the number of premises per cable route mile decreases, the cost per premise to deploy fibre increases. While the cost impact remains relatively small down to about 4 premises/mile, below that, it increases sharply. By one premise per mile, the cost has increased to US$14k/premise. A recent study for Clearwater



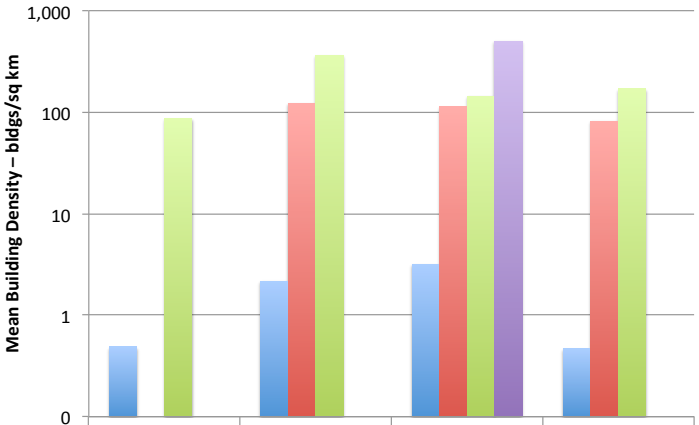
[59] https://muninetworks.org/content/open-access

[60] https://potsandpansbyccg.com/2016/03/16/new-life-for-open-access-networks/comment-page-1/

[61] Thompson, L., *Highly Demanding FTTH Deployments*; VantagePoint Consulting; BB Properties Summit; 2011-04-27.

County indicated an acceptable business case down to about 4 premises/mile.

Premise density across the CRP region varies by just over a 1000-fold, from a low of 1 premise/two miles to the higher urban densities seen in Calgary and Airdrie. These differences will necessitate different strategies for the urban and rural areas in the region. Whereas fibre can be justified in clustered rural areas, wireless will be needed to cover lower density areas. In the chart, the crown-land in Bighorn has not been included and the premise counts in Wheatland were adjusted based on the number of Hutterite colonies.



	Bighorn	Foothills	Rocky View	Wheatland
County	0.49	2.16	3.16	0.47
Villages		122.66	115.32	81.63
Towns	87.30	367.96	145.08	170.89
Cities			505.10	

The trade-off between fibre and wireless tends to change over time and depends on available capital, local priorities, and the relative importance of off-balance benefits. A common misconception is that wireless systems are less expensive. While they may be so over a 3 to 5 year period, their ability to expand is limited and, over a ten year timeframe, can prove to be even more expensive than fibre networks.

The issue is that client's usage and the bandwidth required to run increasingly sophisticated applications increases over time – and not by a little. As mean usage is increasing by 21%/yr, a premise that's happily using a 5 Mb/s connection today will likely require 30 Mb/s within 10 years. Of course, if the family expands from two parents to include 3 children, the bandwidth requirements will be 3 or 4 times that. When the overall cost of scaling wireless systems to meet that demand is compared to the higher upfront cost of deploying fibre in the first place, fibre will win almost every time.

7 Benefits of Broadband

7.1 The Knowledge Economy

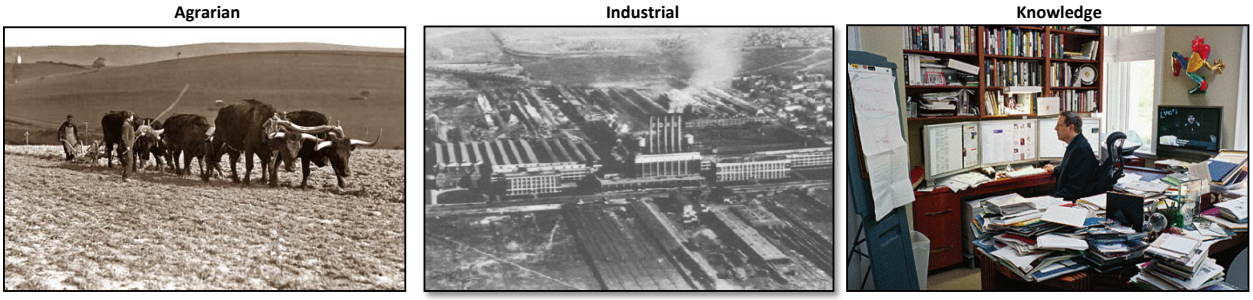
The wealth of nations is changing. While prior centuries were dominated by nations with superior industrial or agricultural capabilities, the innovation age rewards new competencies and strengths. Knowledge – ideas and the people who generate them – is the new coin of the realm. Innovative capacity is the key driver of future economic prosperity… Our ability to remain a global technology (and thereby economic) leader will depend upon a variety of factors including our ability to maintain a world-class information infrastructure.

In the old economy, building a billion-dollar fortune required decades of hard work, a powerful host country, thousands of workers, and thousands of storefronts. Today, a kid with a smart idea, a couple of friends, and some luck can make a lot of money… very quickly. – Juan Enriquez

With respect to this last point – maintaining a world-class information infrastructure – there may be no element more critical today than ubiquitous and affordable high-speed Internet – broadband. The deployment and usage of broadband networks will significantly impact the global competitiveness of nations and businesses in the 21st Century.[62]

[62] *Understanding Broadband Demand*; US Office of Technology Policy; 2002 11.

In their book, Revolutionary Wealth[63], the Toffler's argue that the impact of the information and communications technology (ICT) revolution is much deeper than commonly appreciated as it underlies a change in our system of wealth. Specifically, the world is in the process of transitioning to its third wealth system ever – from Agrarian (based on land/agriculture) to Industrial (based on machines) to Knowledge (based on ideas).



With a change in the wealth system, what made communities successful in the 20th century no longer works today. We are moving from a world in which scalable efficiency generated the most value to one in which scalable peer learning does.[64] The most significant impacts of this unfolding transition relate to economic innovation and productivity and societal organization. As a foundational cornerstone of these emerging systems of wealth creation, access to ICT has become critical to sustainable economic development in virtually every community and society on the planet.

7.2 Economic Development

The deep fundamental economic, environmental, and social changes enabled by developments in information and communications technology have been well documented and are recognized by the CRP. Indeed, broadband initiatives have the potential to dramatically and positively impact the fabric of life throughout a community by offering exceptional network services; learn-in-place, work-in-place, and age-in-place opportunities for all generations; innovation and diversification in every economic sector; and enabling any municipality to position its brand as dynamic, progressive, and relevant to the future.

There are perhaps two perspectives to economic development. One, which is dealt with below, is the rear-view mirror approach which evaluates the evidence of benefits realized to date. While the evidence exists, it is not as striking as one might like. Issues include:

- Attribution – as economic development is driven by many factors often acting in unison, isolating just the benefits associated with higher speed broadband is often difficult.
- Based on the techno-economic framework presented earlier, the broadband evolution is only now entering its 'golden age'. The best, therefore, is still yet to come.

The second approach is to look forward and establish the case for the scenario in which the broadband infrastructure does not become generally available. Looking forward is not typical of traditional economic studies, but the case can to some extent be surmised by estimating the impacts of your residents and business not being able to participate in the virtual workplace of 2020+ as outlined in Sec. 4.5 on social implications, missing out on the Consumer Surplus (Sec. 7.3) and being precluded from both capitalizing on the developments outlined in Subsec. 5.1.1 – The ERaChA Era and missing out on the opportunities discussed in Sec. 7.5.

[63] Toffler, A.&H.; Revolutionary Wealth; Knopf; 2006-04-25.

[64] John Hagel III; *The Shift Index*; 2009 07.

So what is broadband? To many, including the Federal Government, broadband is simply the next step above dial-up services in which you move from having to dial-up and establish a connection to the Internet every time you wish to check email or surf – and then hang-up afterwards, to an always-on service that is permanently connected to the Internet. Whereas dial-up connections had bit rates up to 56 kb/s, initially deployed always-on services typically sported bit rates of 1.5 to 5 Mb/s in the downstream (Internet to client) direction and 0.2 – 0.5 Mb/s in the upstream or reverse direction. This uneven provisioning of two-way bandwidth was intended to accommodate media consumption activities such as web-surfing and the downloading of software, files, music, and video versus more symmetric (equal up and down bit rates) communication services such as video conferencing, the uploading of client files for back-up or remote use, and cloud-based services.

The step-change from dial-up to these always-on services was and is significant. Though by today's standards, these always-on services are relatively low in bandwidth, they remain widespread and were sufficient to facilitate many of the productivity gains realized in the commercial sectors. Having been around the longest, they provide the basis on which many of the economic impact statistics quoted today were developed. According to these statistics, some 2.7% of GDP in Canada is attributable to the Internet (2009) and 75% of the Internet's impact arises from productivity impacts in traditional (non-ICT) industries.[65]

The impact on businesses that these statistics represent is profound. According to Fred Harmon:[66]

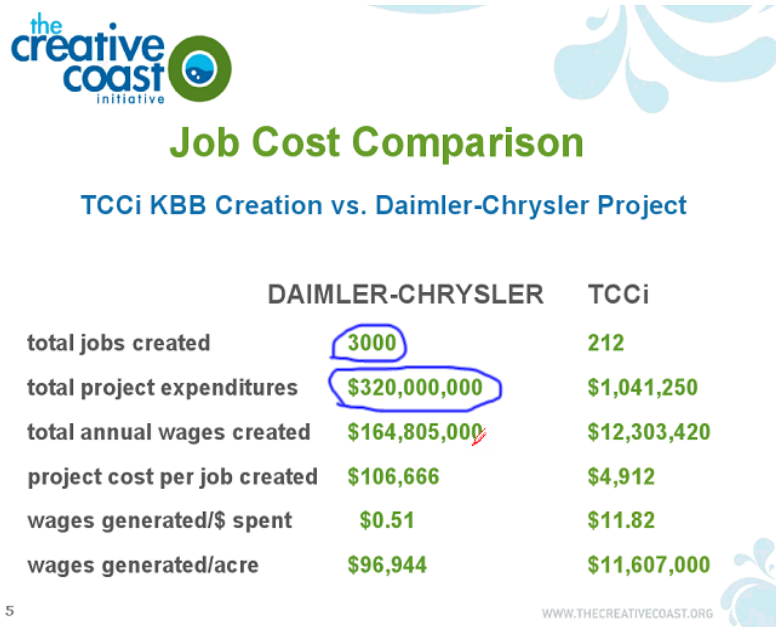
Internet facilitates the move from an industrial to a knowledge-based society, from a society based on physical effort to one based on mental effort, and from reliance on limited material resources to dependence on virtually unlimited intangible resources.

Not only does this enable the acceleration of change, it fundamentally changes the parameters of business.

Consider the Creative Coast comparison in the adjacent chart. According to this comparison:

- TCCi created over 200 jobs in the knowledge sector with only $1M.
- Daimler-Chrysler's $320M auto manufacturing plant created only 3,000 jobs, meaning each job cost over 20 times more to create than a job in the knowledge sector.
- A dollar invested to create a knowledge job yielded 23 times more real wages.

While the table-stakes to partake in and benefit from these changes is always-



[65] Pélissié du Rausas, Matthieu, et al; *Internet Matters: The Net's sweeping impact on growth, jobs, and prosperity*; McKinsey Global Institute; 2011 05.

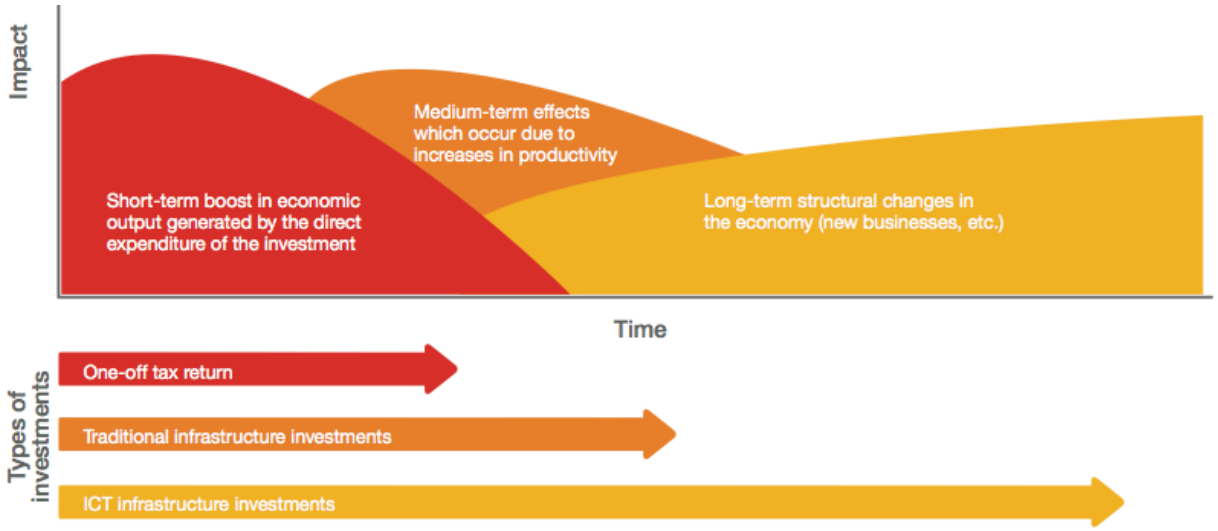
[66] Harmon, Fred; Business 2010: Positioning Your Company and Yourself in a Rapidly Changing World; Kiplinger Books; 2001.

on access to the Internet platform, in today's world, symmetry and bandwidth matter too – and the higher the available speed and bandwidth, the better. Access, so to speak, has not been created equal and in a very fundamental way, not only does bandwidth matter, as shown below, it matters a lot. To attract business, minimum access bit rates of 100 Mb/s are typically required.[11]

		CRP					Target
Speeds Needed by 2013 to:	**2–4 Mb/s**	**10–12 Mb/s**	**20–25 Mb/s**	**100–120 Mb/s**	**500 Mb/s**	**1 Gb/s**	**100+ Mb/s**
Attract business	17 (8%)	26 (12%)	30 (13%)	43 (19%)	33 (15%)	77 (34%)	68%
Retain business	13 (6%)	35 (16%)	50 (22%)	57 (25%)	33 (15%)	37 (16%)	56%
Make business more competitive	12 (5%)	29 (13%)	53 (23%)	55 (24%)	33 (15%)	44 (19%)	58%
Revive business districts	13 (6%)	34 (15%)	50 (23%)	53 (24%)	34 (15%)	38 (17%)	56%
Revive communities	14 (6%)	40 (18%)	47 (21%)	55 (25%)	27 (12%)	37 (17%)	52%
Improve training	14 (6%)	33 (15%)	48 (22%)	54 (24%)	40 (18%)	33 (15%)	57%

Note that this survey was completed in 2010 and indicated that to be competitive, minimum speeds of 100 Mb/s would be required by 2013. It's now 2016 and the fastest upstream bandwidth generally available outside of Calgary is still only 10 Mb/s.

According to an Ericsson study[67], the economic impact of bandwidth upgrades spread throughout the economy via direct, indirect, and induced effects as shown below.

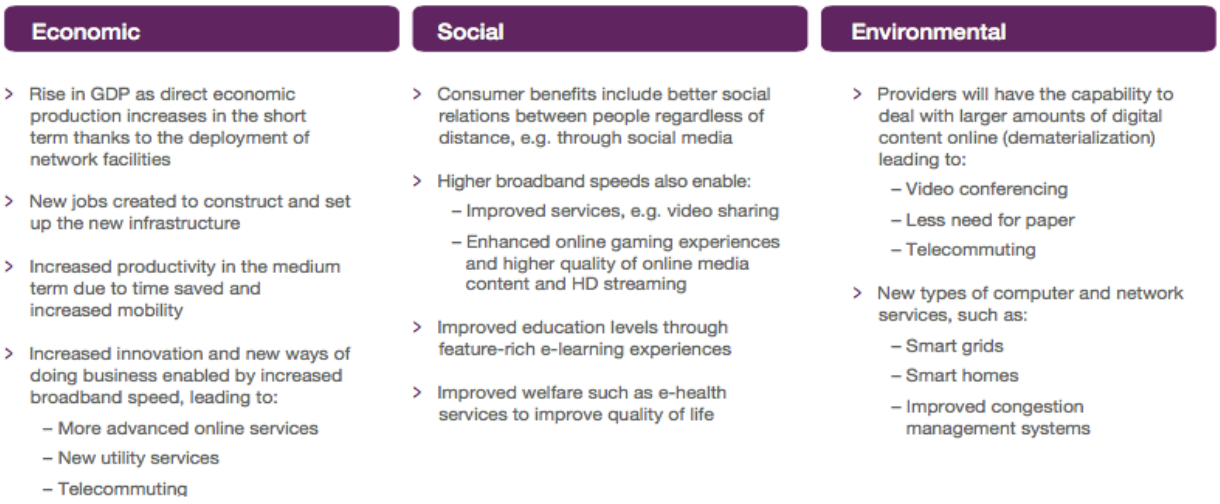


The benefits of faster broadband can be categorized as:

- Economic effects, including increased innovation and productivity in business
- Social effects, including better access to services and improved healthcare
- Environmental effects, including more efficient energy consumption

Economic, social and environmental impacts are outlined in the table below.

[67] Ericsson, Arthur D Little. & Chalmers University of Technology; *Analyzing the Effects of Broadband on GDP*; 2013.



Quantifying these off-balance-sheet benefits is difficult, but according to the detailed Ericsson study, doubling broadband speeds for an economy can add 0.3 percent to GDP growth.[68]

In a study by Stephen Ross[69], the 1,500-plus US counties, in the top half of their states in terms of access to at least 25 Mb/s broadband, enjoyed 10 times the percentage population growth of the bottom half. The bottom 10 percent in each state, in aggregate, actually lost population.

Returning to the Ericsson study, upgrading from 0.5 Mb/s to 4 Mb/s in OECD countries increases income by around US$322 per month, and gaining 4 Mb/s of broadband increases household income by US$2,100 per year. Faster broadband speed:

- boosts personal productivity and allows for more flexible work arrangements;
- opens up possibilities for more advanced home-based businesses as a replacement, or complement to, an ordinary job; and
- enables people to be more informed, better educated and socially and culturally enriched – ultimately leading to a faster career path.

According to recent surveys, fibre-to-the-home (FTTH) communities realize significant economic benefit:[70]

- 11% of FTTH users have a home-based business averaging CDN$10,700 in estimated incremental income from outside the community. Assuming 50% take-rates (half the potential client base takes service), these activities increase community revenue by an average of CDN$0.59 million per 1,000 homes passed.
- FTTH drives as many as 65 new traditional jobs per 1,000 homes passed when leveraged. At a more conservative 25 new jobs per 1,000 homes passed and CDN$49,000/worker/year in wages, this means $1.2 million in new income to the community per 1,000 homes passed.

Estonia, Slovenia, Slovak Republic, and Turkey are among the 16 countries that outrank Canada in percentage of FTTH connection.

[68] Ericsson, Arthur D Little. & Chalmers University of Technology; *Socioeconomic Effects of Broadband Speed*; 2013 09.

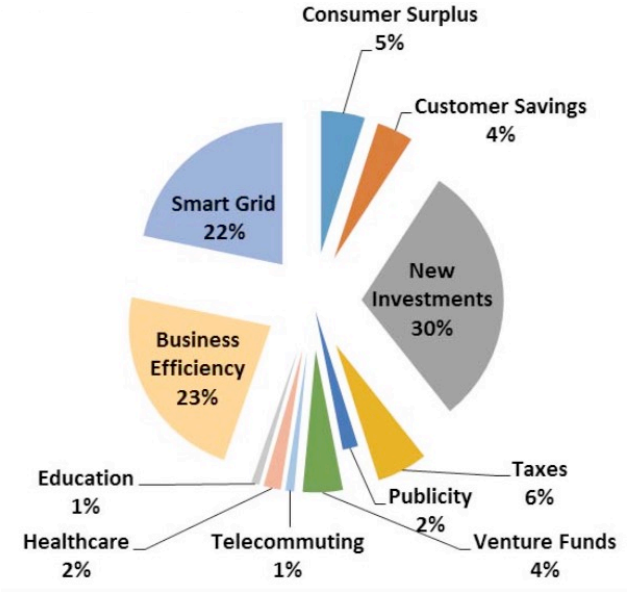
[69] Ross, Stephen; *Bad Broadband Equals Low Population Growth*; BBC; 1411/12.

[70] Render, Michael; *FTTH and Economic Impact*; RVA LLC; Broadband Summit, 2013 04.

- In total, FTTH therefore increases aggregate household income by $1.79 million per 1,000 homes passed.

In rural areas, results suggest that high levels of broadband adoption in rural areas do causally (and positively) impact income growth as well as (negatively) influence unemployment growth. Similarly, low levels of broadband adoption in rural areas lead to declines in the number of firms and total employment numbers in the county.[71]

A more recent US review of the benefits accruing to Chattanooga and the surrounding Hamilton County based on the availability of broadband speeds at symmetric rates of 100 Mb/s and up were found to be widespread. The mean premise density across the County is 48 premises/km^2 and that in Chattanooga is 226. Overall population is 351k. Economic and social benefits were estimated to be CAD$2900 annually per home passed. As can be seen, value arose from many unexpected places.[29]



When asked if Olds had seen an increase in business attraction over the past year due to the availability of community-based Gb/s O-Net services, Mitch Thomson, Executive Director of the Olds Institute for Community & Regional Development (OICRD) – the economic development organization behind the fibre initiative – replied:

'Yes absolutely, we perhaps could have been better prepared to capitalize on interest. Our lack of serviced available land has hindered some. We are fielding lots of interest.'

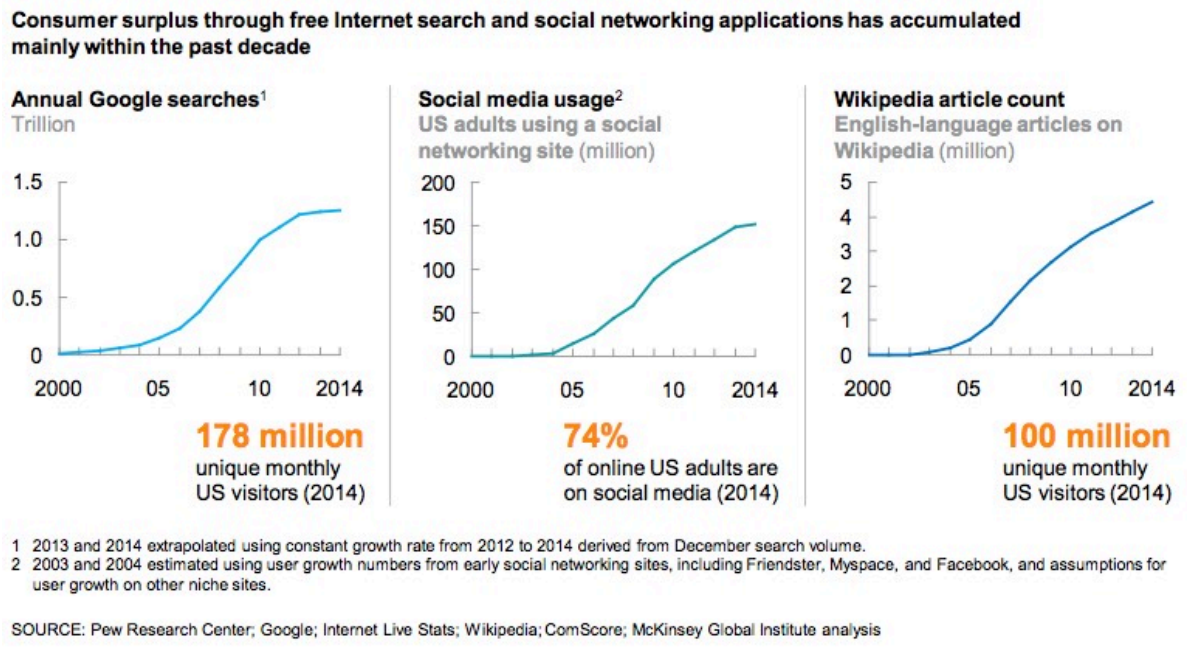
The availability of gigbit services ubiquitously throughout Olds has enabled Olds College to revamp its educational delivery platforms and the local hospital to provide unprecedented levels of wi-fi service to both patients and staff.

7.3 Consumer Surplus

Consumer surplus relates to the difference between what the true value of an item is and what it is bought or sold for. '*The value of Google or Facebook to users relative to their price, which is nearly free, is enormous. The founders of these companies may get rich, but they capture only a fraction of the value created by their innovations*.' Consumer surplus is the difference between the true value to the consumer relative to the actual cost. While important, obtaining firm numbers relating to consumer surplus, as is evident, is tough. However, assuming consumer surplus scales with usage, given usage has exploded since 2000, the value of consumer surplus created via free Internet search and social media must be very large and growing. In the following figure[21], based on population, the Canadian equivalent numbers would be about 11.2% of those for the US.

For these values to be fully realized, ubiquitous connectivity is required – and those not able to participate are significantly disadvantaged.

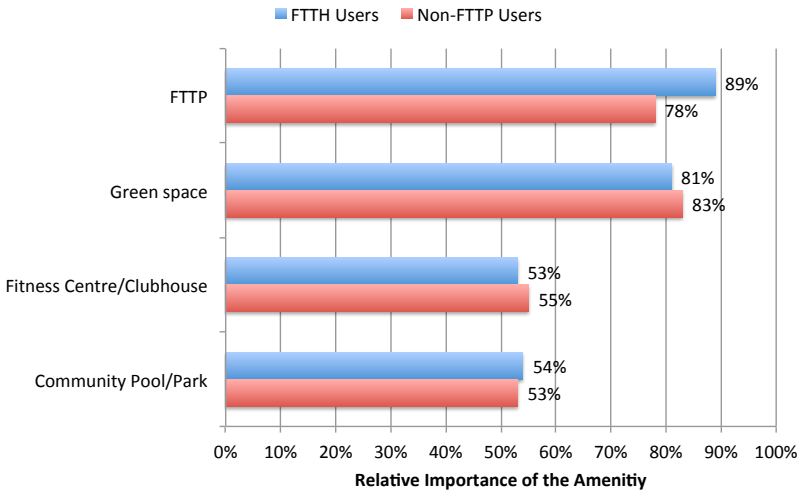
[71] Whitacre, B.; et al; *BB's Contribution to Economic Health in Rural Areas: A Causal Analysis and an Assessment of the Connected Nation' Program*; Telecommunications Policy Research Conference; 2013-09-27/29.



7.4 Impact of Home Values

When shopping for a new home, the availability of FTTP-based services has become important. Interestingly, it's more important for those who have benefited from the services before – it's not something they wish to give up.[72]

The availability of FTTP services in a neighbourhood and Gb/s services to the home adds 1.3% and 1.8% respectively to the retail value of a home.[73] Together, these effects would add $15,500 to the value of a $500k home.



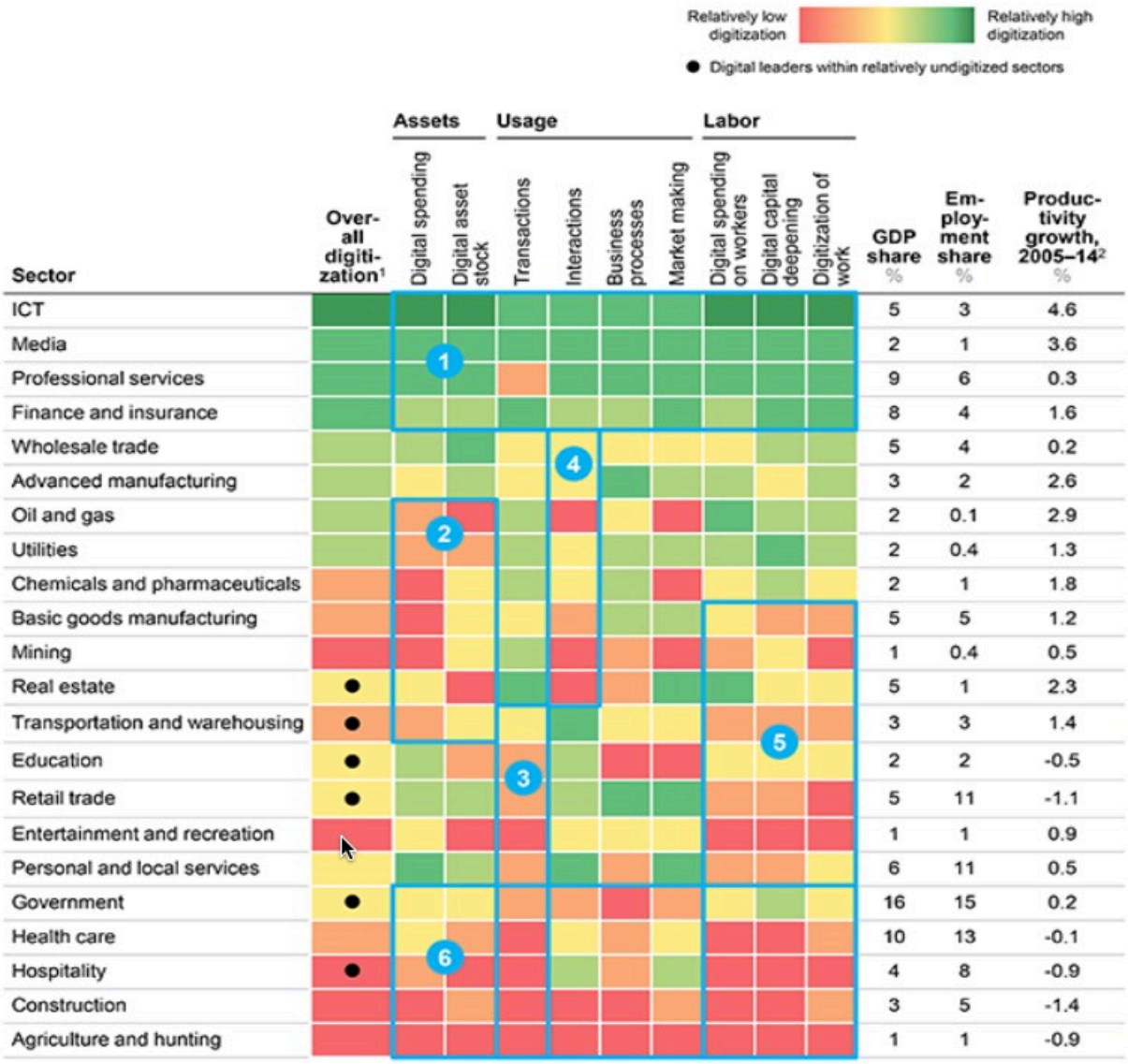
7.5 Opportunity

The benefits of ubiquitous, affordable broadband are many and varied. Indeed, many have already been mentioned – but we have only just begun. In late 2015, the McKinsey Global Institute released the results of survey indicating where a number of industries were with respect to 'digitization' and how much remains to be done. The results appear in chart below.[22] In the chart, green is good and red leaves room for improvement. As can be seen, many of the industries that impact rural Canadians, such as mining, hospitality, entertainment and recreation, construction, and agriculture are shaded red. Also red are a number of public services such as government and healthcare. In these, there is an interplay between internal IT services and external connectivity. According to McKinsey, areas numbered 2 through 6 will benefit from increased digitization and broadband.

[72] Render, M.; *The FTTH Revolution*; RVA LLC; 2013-05.

[73] FTTH Council; *What Fiber Broadband Can Do For Your Community*; Broadband Communities; 2015-11.

The MGI Industry Digitization Index
2015 or Latest Available Data



Sector	Overall digitization[1]	GDP share %	Employment share %	Productivity growth, 2005–14[2] %
ICT		5	3	4.6
Media		2	1	3.6
Professional services		9	6	0.3
Finance and insurance		8	4	1.6
Wholesale trade		5	4	0.2
Advanced manufacturing		3	2	2.6
Oil and gas		2	0.1	2.9
Utilities		2	0.4	1.3
Chemicals and pharmaceuticals		2	1	1.8
Basic goods manufacturing		5	5	1.2
Mining		1	0.4	0.5
Real estate	●	5	1	2.3
Transportation and warehousing	●	3	3	1.4
Education	●	2	2	-0.5
Retail trade	●	5	11	-1.1
Entertainment and recreation		1	1	0.9
Personal and local services		6	11	0.5
Government	●	16	15	0.2
Health care		10	13	-0.1
Hospitality	●	4	8	-0.9
Construction		3	5	-1.4
Agriculture and hunting		1	1	-0.9

1 Based on a set of metrics to assess digitization of assets (8 metrics), usage (11 metrics), and labor (8 metrics); see technical appendix for full list of metrics and explanation of methodology.
2 Compound annual growth rate.

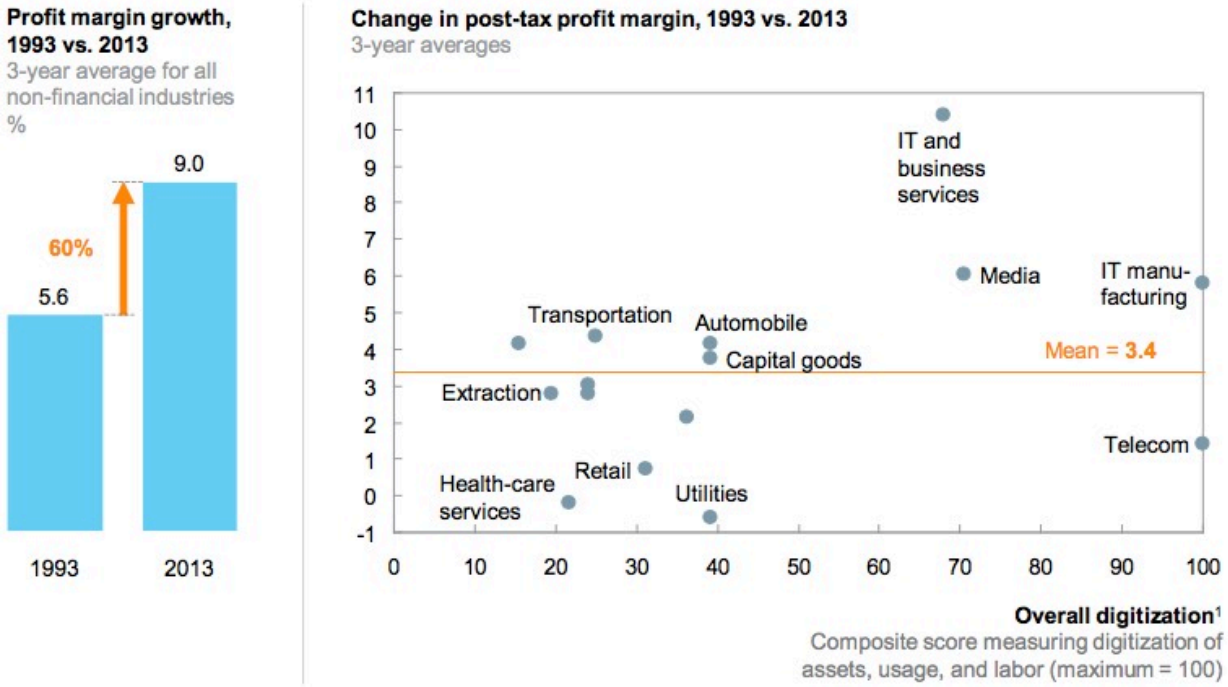
SOURCE: BEA; BLS; US Census; IDC; Gartner; McKinsey social technology survey; McKinsey Payments Map; LiveChat customer satisfaction report; Appbrain; US contact center decision-makers guide; eMarketer; Bluewolf; Computer Economics; industry expert interviews; McKinsey Global Institute analysis

1. Knowledge-intensive sectors that are highly digitized across most dimensions
2. Capital-intensive sectors with the potential to further digitize their physical assets
3. Service sectors with long tail of small firms having room to digitize customer transactions
4. B2B sectors with the potential to digitally engage and interact with their customers
5. Labor-intensive sectors with the potential to provide digital tools to their workforce
6. Quasi-public and/or highly localized sectors that lag across most dimensions

As shown below, the benefits or opportunity to be realized are real and directly affect both corporate and municipal bottom lines.[22] Profit margins in Health-care, resource extraction, transportation, and utility industries – all of which have a significant presence in many rural areas – remain to be significantly improved.

US profit margins have risen 60 percent in two decades, with industries on the digital frontier at the forefront

Growth in profit margin vs. digitization, select US non-financial industries

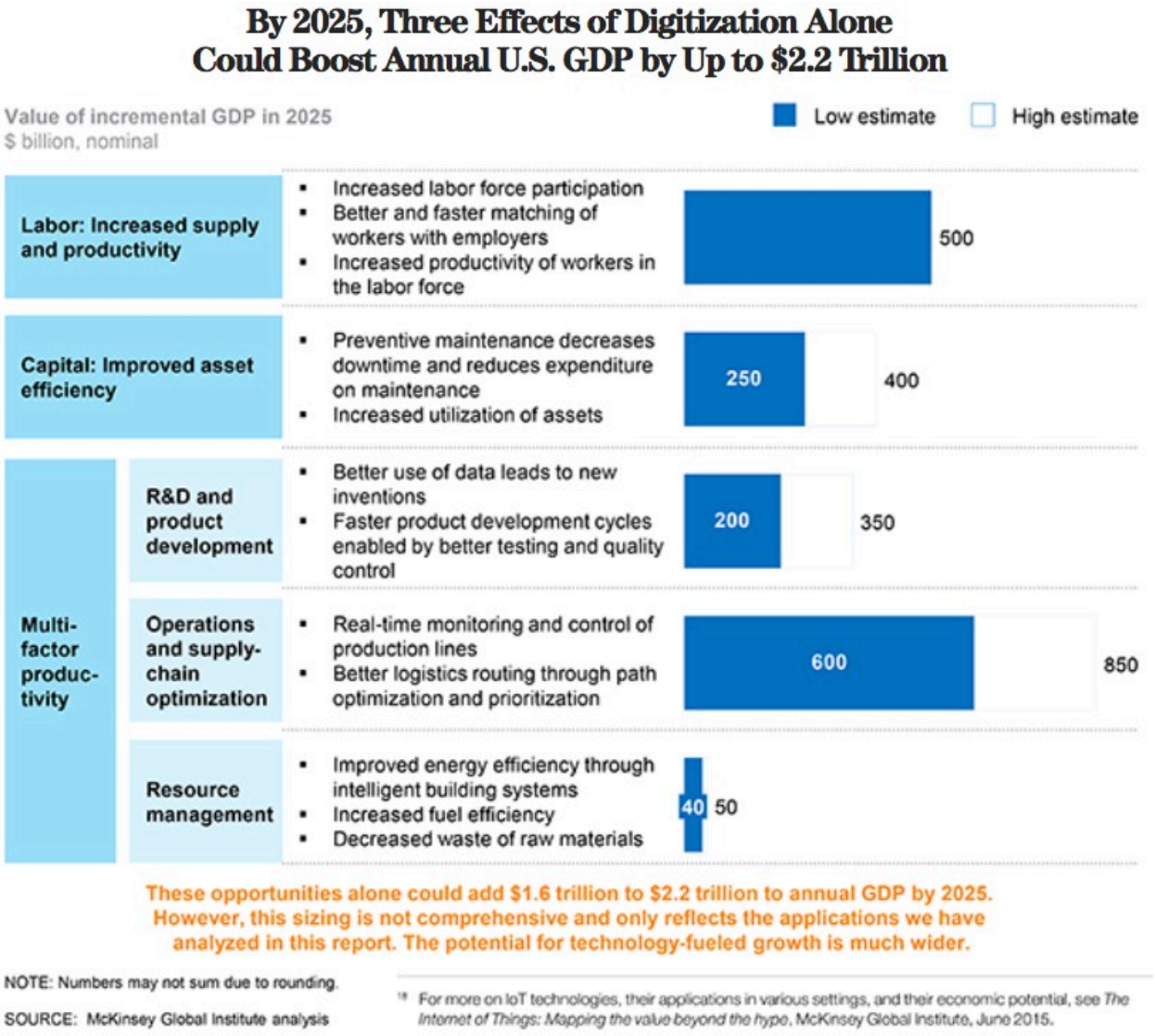


1 Measured using a set of 27 metrics spanning the three dimensions of digitization: assets (eight metrics, including spending on digital assets and the stock of digital assets), usage (11 metrics, including transactions, business process, interactions, and market making), and labor (eight metrics, including digital capital deepening, share of occupations that are digital, and share of tasks that are digital).

As shown in the next chart, overall, McKinsey estimates that the US GDP could be improved by some $2.2 trillion dollars by 2025 based on only three effects of digitization.[22] Given the 2015 US GDP of US$17.9T, this represents a CAGR of 1.16%. With Canada's 2015 GDP estimated to be US$1.55T, comparable growth would add US$190G. The two biggest contributors to this increase come from Labour and operations & supply chain, both of which significantly benefit from improved broadband.

At a more personal level, typically mentioned considerations are:

- Earning a living (making money)
- Learning (inside and outside the classroom)
- Health care (inside and outside the clinic)
- Civic engagement (democratic participation)
- Commerce (shopping, e-commerce)
- Recreation (gaming, gambling, puzzle solving, etc.)
- Security (remotely monitoring shut-ins, livestock, property, etc.)
- Lifestyle (where do you want to live?)
- and so on...



Given the issues of isolation and distance, the availability of broadband is perhaps even more critical in the rural areas. A recent information pamphlet out of North Carolina expressing their concern appears on the next pages.[74]

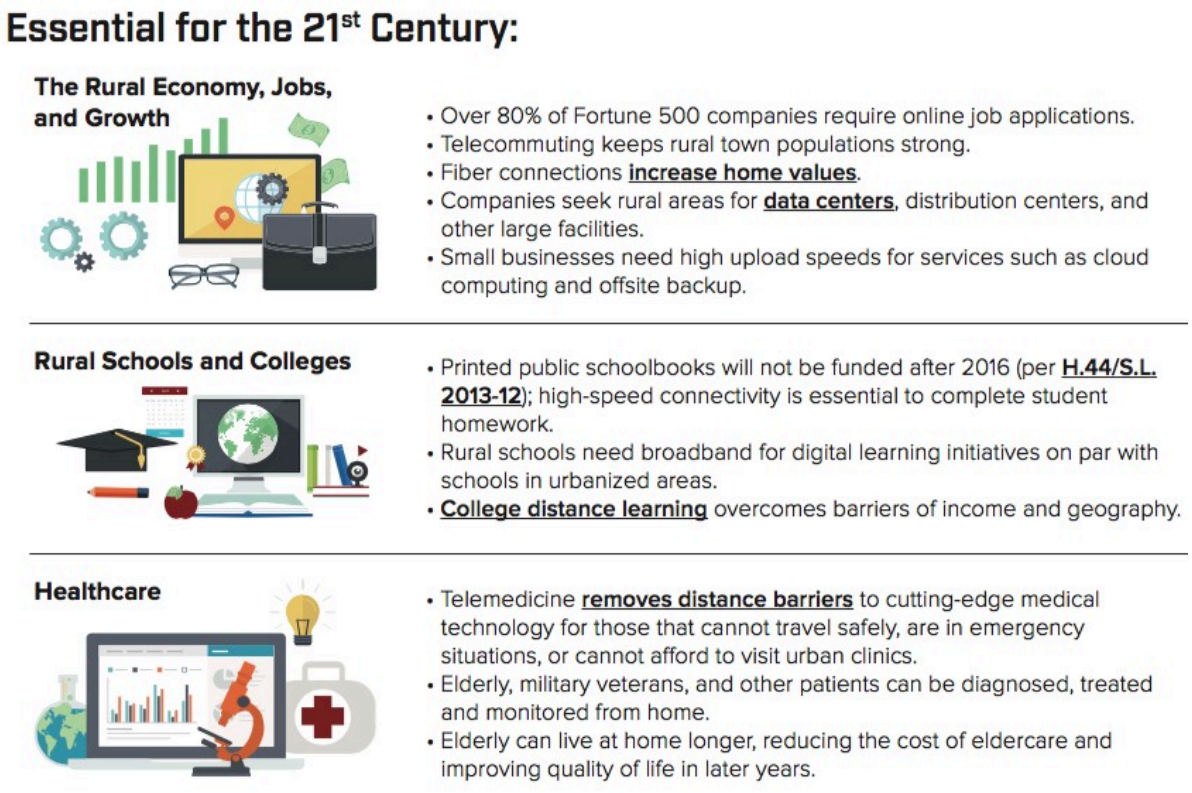
More generally, for rural and remote communities, broadband creates opportunities to:

- Reduce or eliminate social and economic limitations of isolation
- Access broad new frontiers of social and economic development
- Greatly improve the development, retention and attraction of youth, workers and enterprises
- Bring balance and vibrancy to urban-rural dialog
- Improve access to government services, reduce cost of services.
- Improve access to ratepayers, and responsiveness to local needs and opportunities.
- Reduce municipal operating costs (travel to meetings, etc.)

[74] *Rural NC Deserves Modern Broadband*; GLIC-NC, ILSR, & Community Networks; 2015.

- Enable fuller participation in economies, societies and politics of the 21st century and beyond.
- Reduce financial, social and environmental costs of participation.

Fast, Affordable, Modern Broadband: Critical for Rural North Carolina – While urban centers get superfast Internet networks, rural regions of North Caroline depend on sluggish DSL, ancient dial-up, or have no connectivity at all. Rural access to modern, broadband Internet is more important that ever in North Carolina, where 80% of the counties are rural.

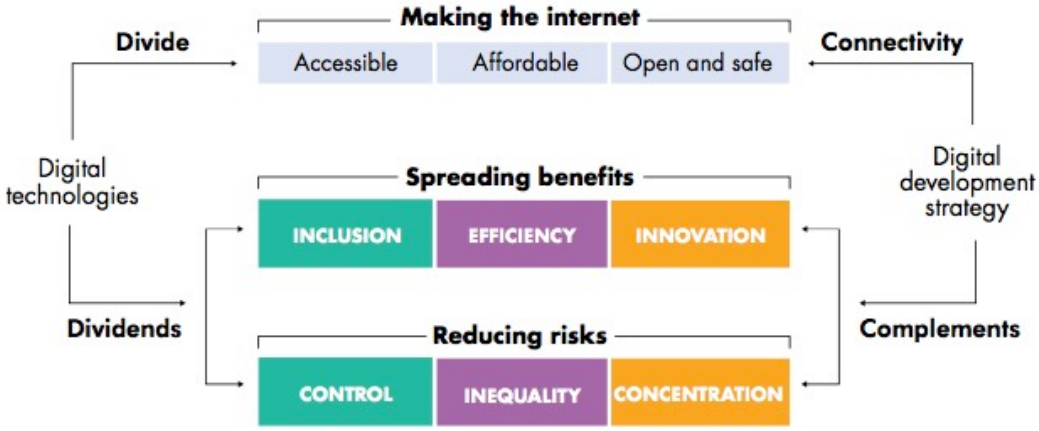


8 Infrastructure versus Digital Dividends

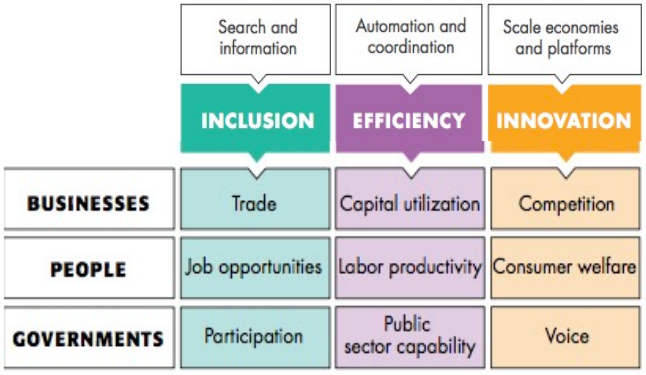
8.1 A Culture of Use

In the framework established in the recently released World Development Report on the Digital Dividends[8] and appearing below, the connectivity piece, the primary focus of this CRP project, is but one of three components to realizing the full potential of the transformations enabled by digital technologies and connectivity. As communities move to resolve their connectivity issues, for the benefits to be most broadly realized, concomitant digital enablement programs and policy to mitigate the risks will be required as well.

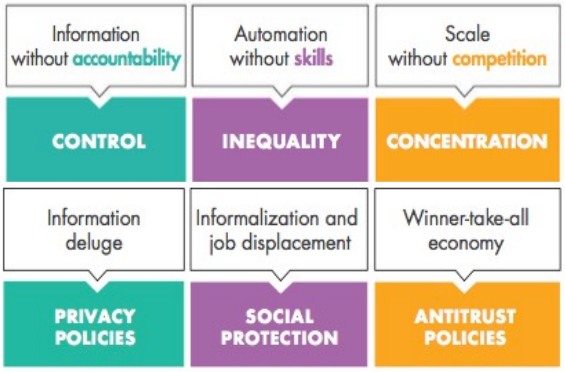
By reducing information costs, digital technologies greatly lower the cost of economic and social transactions for firms, individuals, and the public sector. They promote innovation when transaction costs fall to essentially zero. They boost efficiency as existing activities and services become cheaper, quicker, or more convenient. And they increase inclusion as people get access to services that previously were out of reach.



The benefits of digital technologies filter throughout the economy. For businesses, the Internet promotes inclusion of firms in the world economy by expanding trade, raises the productivity of capital, and intensifies competition in the marketplace, which in turn induces innovation. It brings opportunities to households by creating jobs, leverages human capital, and produces consumer surplus. It enables citizens to access public services, strengthens government capability, and serves as a platform for citizens to tackle collective action problems. These benefits are neither automatic nor assured, but in numerous instances digital technologies can bring significant gains.



Spreading the Benefits



Reducing the Risks

So, the Internet can be an effective force for development. But as the Report documents, *the benefits too often are not realized, and the Internet sometimes makes persistent problems worse. Why? The key insight is that for complex occupations, business activities, or public services, the Internet usually can make only a portion of tasks cheaper, more efficient, or more convenient through automation. Another portion still requires capabilities that humans possess in abundance but computers do not. Many traditional tasks of an accountant or bank teller are now automated, such as making calculations or processing withdrawals. Others require complex reasoning or socio-emotional skills, such as designing tax strategies or advising clients. Likewise, many public services involving provision of information or*

routine permissions can be automated. But others, such as teaching or policing, need a high degree of human discretion, tacit knowledge, and judgment.

Many problems and failures of the Internet surface when digital technology is introduced but the important analog complements remain inadequate. What are these complements? The main ones are regulations that ensure a high degree of competition, skills that leverage technology, and institutions that are accountable.

- *When the Internet delivers scale economies for firms but the business environment inhibits competition, the outcome could be excessive* ***concentration*** *of market power and rise of monopolies, inhibiting future innovation.*
- *When the Internet automates many tasks but workers do not possess the skills that technology augments, the outcome will be greater* ***inequality****, rather than greater efficiency.*
- *When the Internet helps overcome information barriers that impede service delivery but governments remain unaccountable, the outcome will be greater* ***control****, rather than greater empowerment and inclusion.*

The interplay between Internet investments and reforms in complementary areas is at the core of policy debates about technology impacts. A 2008 study by Claudia Goldin and Lawrence Katz, drawing on earlier work by Jan Tinbergen, framed these dynamics in the labor market as a "race between education and technology." As technology progresses, some skills become obsolete. Workers must acquire new skills that help them become more productive with the help of that technology. Adjustment takes time and will be painful for many, but this is how economies progress. The sections that follow discuss risks and complements in the private sector, in labor markets, and in the public sector.

Strengthening analog complements will ensure a high social and economic return from digital investments. But a downside risk remains. Returning to the Report's framework, *large-scale collection of identifiable information creates privacy and security concerns. Automation changes work in ways that challenge existing social protections and reveal the inadequacy of existing labor laws. And scale economies create antitrust concerns. Digital safeguards that mitigate these risks become increasingly important as the digital transformation proceeds.*

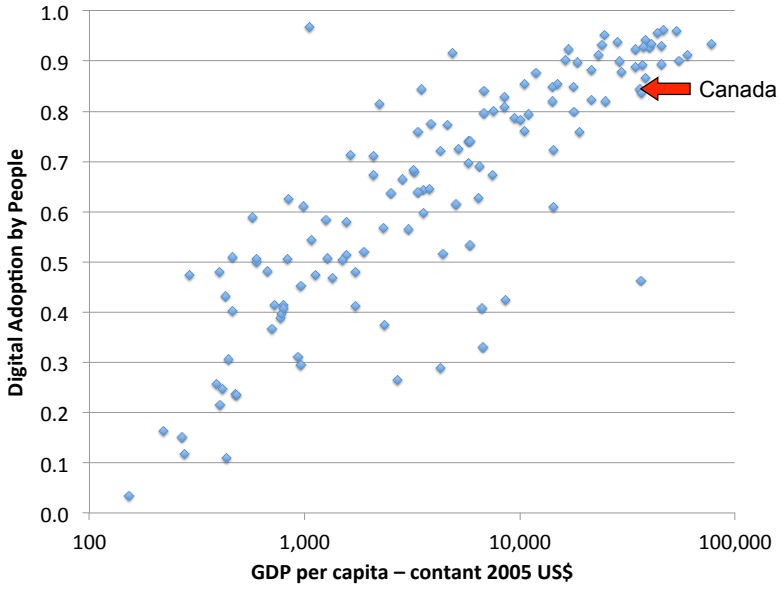
8.2 Digital Divides

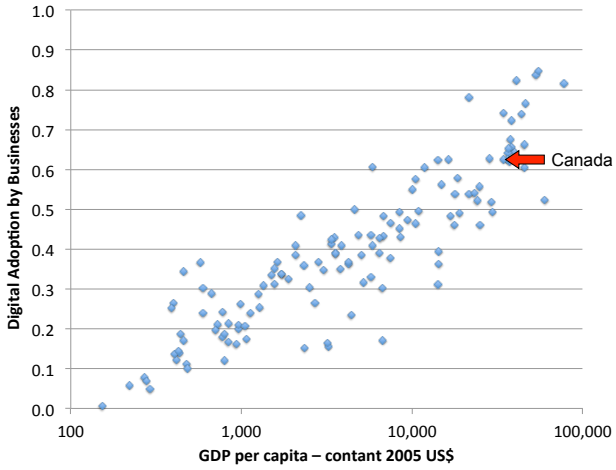
8.2.1 Definition

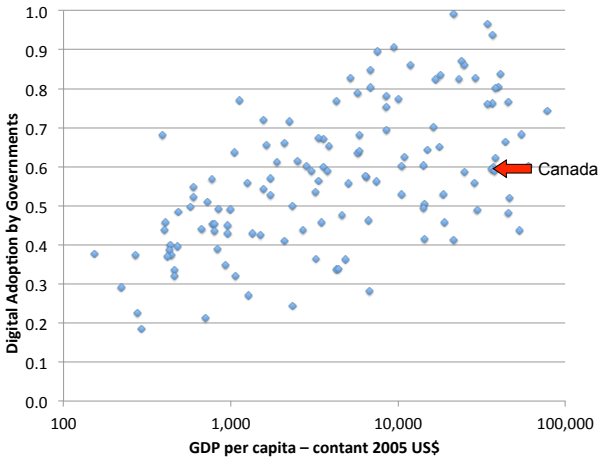
A digital divide is an encompassing term that generally refers to economic or social inequality with regard to access to, use of, or impact of ICT. The divide within countries may refer to inequalities between individuals, households, businesses, or geographic areas, usually at different socioeconomic levels or other demographic categories.

8.2.2 Adoption

Adoption rates of digital technologies are highest at the individual level, lower for businesses, and lowest with governments. In Canada, the rates come in at 84.4%, 62.6%, and 59.3%, respectively.[8] As correlations to GDP are weakest for Governments, it is not a significant concern. The low business rating, however, is and a more detailed discussion of the resulting opportunity areas can be found in Sec. 7.5.







8.2.3 Age & Income

That digital adoption tends to decrease with age is well known. The divide between Internet usage between 16-24 year olds and 65-74 year-olds for a selection of countries appears in the next chart. In Canada, the gap is about 40%.[8] An interesting side-effect of this divide is the propensity of those under 24 to either give up traditional telephone and cable subscriptions or never subscribe in the first place.[75]

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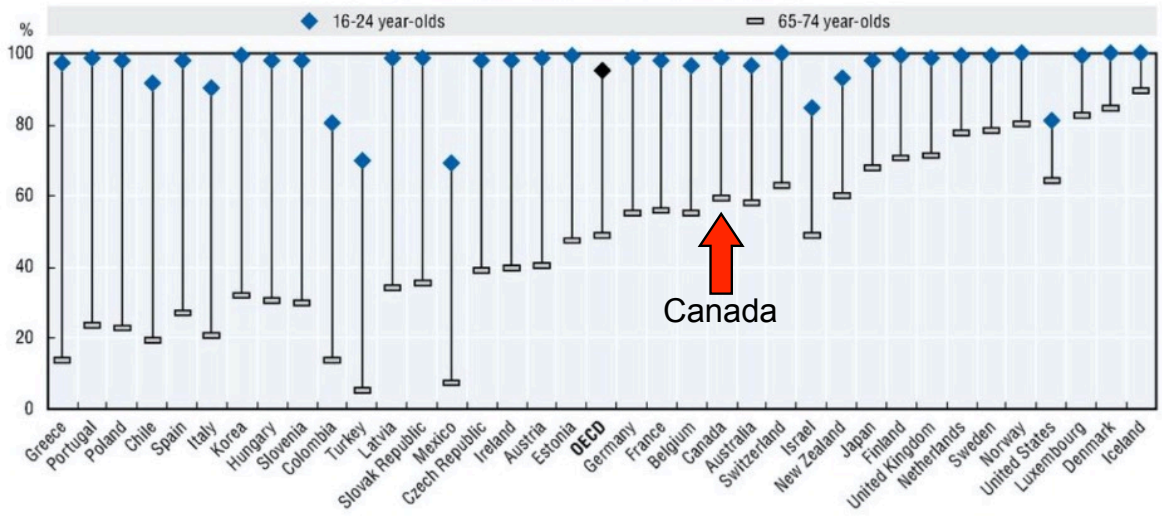
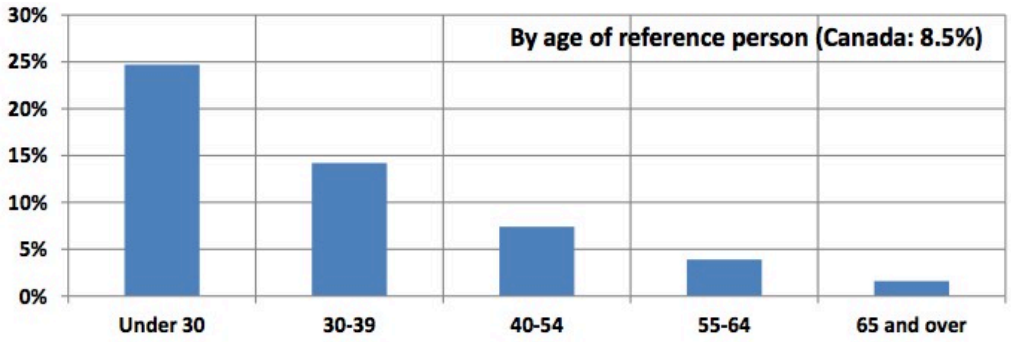
[75] Communications Management Inc.; *Canada's Digital Divides*; 2015-08-20.



A more detailed breakdown by age and income for Canada indicates that: *The digital divide remains consistent across all demographics with wealthier households far likelier to use the Internet than poorer ones regardless of their age. For example, Statscan reports that 47.5 per cent of Canadians aged 65 and over use the Internet (up from 40.2 in 2010), the biggest jump of any age group. However, there is a major divide in Internet use based on household income. While 66.7 per cent of households over the age of 65 in the top half of income use the Internet, that number drops to only 28.5 per cent for the poorest quartile of households.*[76]



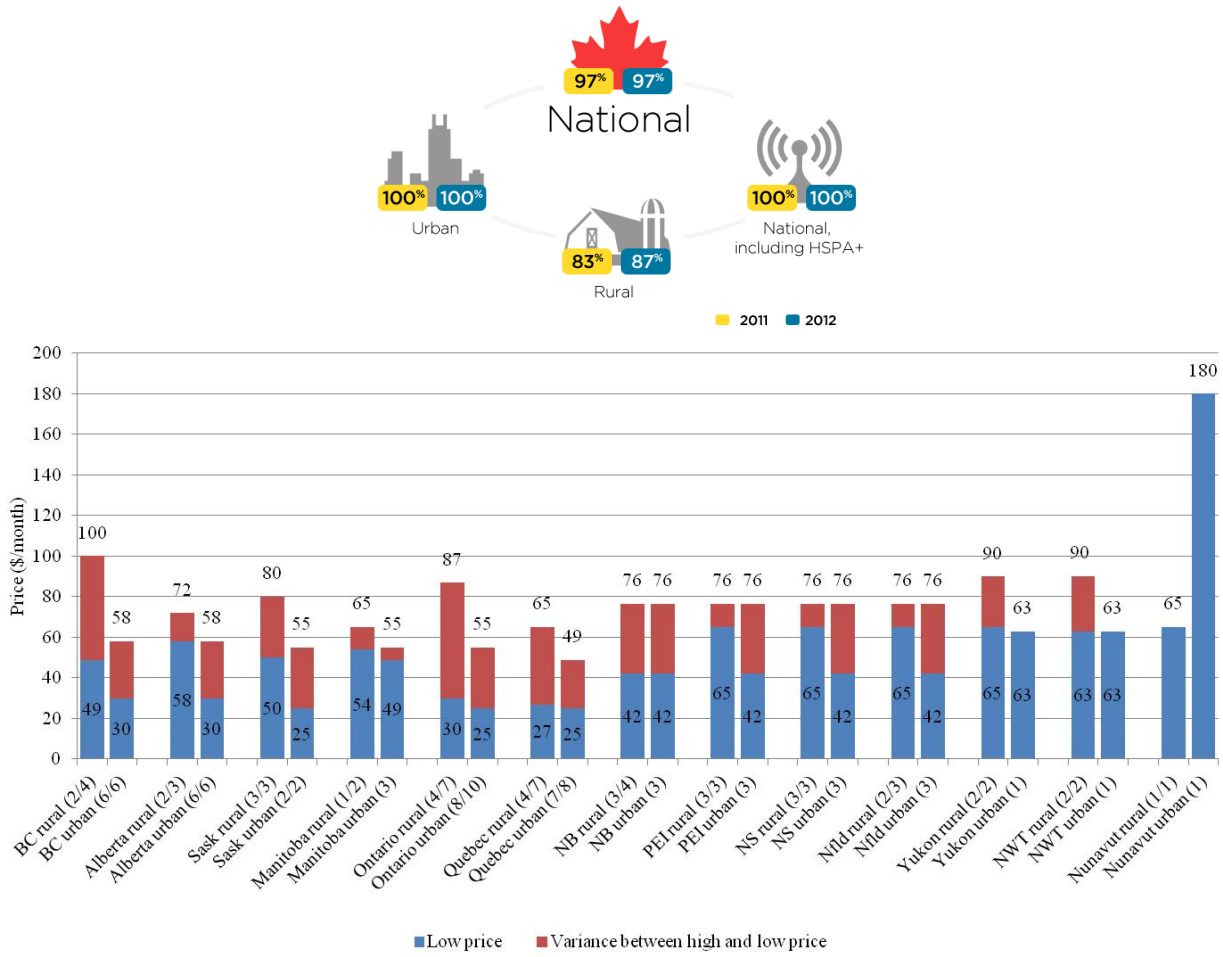
High-speed home Internet connection

Age group of reference person	Total	Income quintile				
		Lowest	Second	Third	Fourth	Highest
All households	80.1%	54.6%	72.0%	85.5%	92.1%	96.1%
Under 30	87.0%	74.4%	85.7%	91.8%	95.1%	97.2%
30-39	89.5%	71.3%	86.9%	90.9%	96.5%	95.6%
40-54	88.0%	66.0%	79.5%	92.4%	92.8%	97.2%
55-64	80.6%	55.8%	73.7%	83.8%	88.4%	96.6%
65+	58.2%	30.5%	52.7%	71.6%	86.4%	89.4%

[76] CIRA; Internet Fact Book 2014: see: https://cira.ca/factbook/2014/the-canadian-internet.html

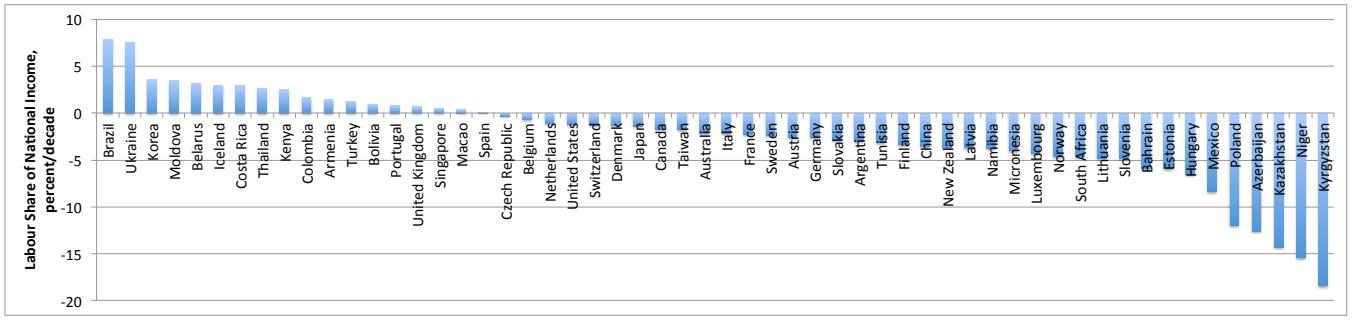
8.2.4 Urban/Rural

Broadband is available to 100% of Canadians in urban areas, compared to 85% in rural areas.[74] It is also more expensive.[77]



8.2.5 Labour

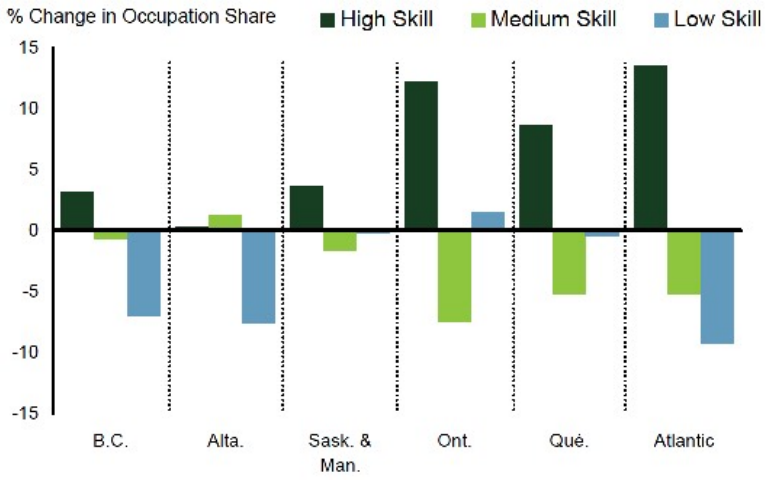
With increasing automation and the realignment of how companies create value in knowledge-based economies, the make-up of Canada's labour force is changing. Since 1975, labour's share of the national income has declined 1.73%.[8]

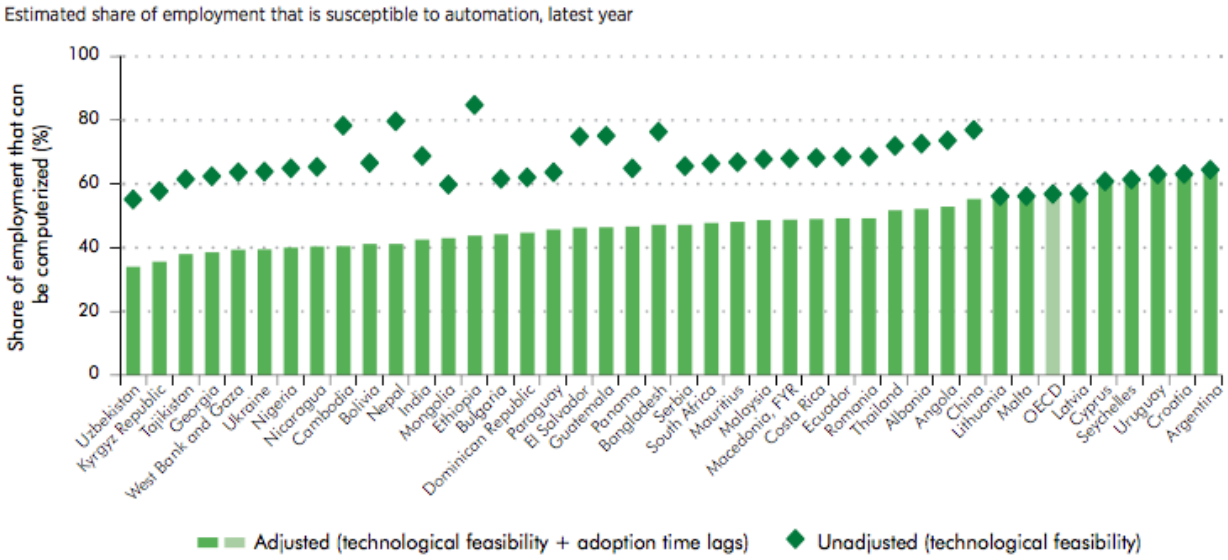


[77] CRTC; *CRTC' Communications Monitoring Report*; CRTC; 2015-10

While the 'hollowing out' of the middle class is not as evident in Canada as it is in the US, the number of medium and low skilled jobs is declining relative to those requiring higher skill levels.[78] From both the perspective of retraining the folks displaced and creating higher skilled jobs for them, broadband is key.

Perhaps more distressing is that with the developments in both robotics and deep learning, some two-thirds of all jobs are now at risk of being automated.[8]





9 Learnings

9.1 Context

Over the past several years, broadband conversations in the province have shifted from *Why is this important?* to *Given this is critical civic infrastructure, how and when can we make it happen?*. In general, the "How" is via the provisioning of fibre-based infrastructure where possible on a utility basis. "When" depends on financing in relation to other civic priorities. Over the past year, both the AUMA and the AAMDC have passed resolutions relating to providing member support for enhancing broadband services throughout their communities. Three key initiatives include the community initiative in Olds, the regional initiative undertaken by AlbertaSW, and the Fibre Strategy adopted by The City of Calgary.

[78] TD Economics; *Are Medium-skilled jobs in Canada Experiencing a Hollowing Out, US Style?*; TD Economics – Special Report; 2013-02-26.

9.2 Olds

In the early 2000's, the Town of Olds, The Olds Chamber of Commerce, The Olds Agricultural Society, and Olds College partnered to establish a non-profit community development organization, the Olds Institute for Community and Regional Development (OICRD). The brilliance of the OICRD is that by combining the expertise from the public and private sectors, its activities became inclusive, could be more broadly supported and, without the encumbrances of local election cycles, were better able to take on longer-term projects. Over time, a dozen committees were formed under the auspices of the OICRD, each focused on a different aspect of community development – from community engagement, to business retention, to, well, technology.

Shortly after its inception, the Technology Committee, chaired by Joe Gustafson, settled on the notion of enabling superior broadband throughout the region via the deployment of fibre optic cabling. The idea was that if the OICRD got the fibre in the ground, they could then connect it to the newly created Alberta SuperNet and things would take-off from there. Reality struck quickly:

- Regional fibre estimates for Mountain View County came in shy of $100M. The focus then changed to Olds itself, with the regional option to be re-evaluated later.
- The SuperNet only provided backhaul connectivity (e.g., SuperNet could connect an Old's network to Calgary) but was not established to either light community fibre networks or to provide Internet services over them.

From the SuperNet, the Technology Committee then approached Shaw and TELUS. Shaw declined upfront, but TELUS indicated that should the network be deployed to their specifications, TELUS would consider lighting it and providing services. That did not materialize and they explored potential partnerships. In the end, the Technology Committee undertook to both deploy and light a state-of-the-art fibre network in Olds. When Bell, Navigata, Allstream, and Rogers then also declined to provide services, the OICRD established a wholly owned for-profit subsidiary to develop, provide, and operate a full set of triple-play (Internet, telephone, and television) services over the open, passive, OICRD network under the O-Net brand. In July, 2012, Olds became the first community in Canada with community-wide gigabit per second Internet. Last fall (2015), O-Net became cashflow positive.

O-Net Internet Services:

RUSH	ZOOM	GIG
$90/MO†	$100/MO†	$120/MO†
50 Mbps Download†	**100Mbps Download†**	**1000Mbps Download†**
50 Mbps Upload†	**100Mbps Upload†**	**1000Mbps Upload†**
500GB Monthly Usage	**1TB Monthly Usage**	**2TB Monthly Usage**
Wi-Fi	Wi-Fi	Wi-Fi
2 Email Addresses	2 Email Addresses	2 Email Addresses
Local Support	Local Support	Local Support

The Olds' Connected Community Network (OCCN) illustrates by example how a small town community with a population of ~8,700 people can take ownership of ensuring its businesses and residents have access to global standard IT infrastructure and services as the foundation for their

economic, social, cultural and environmental sustainability. It also demonstrates a potential path that Canada might take to regain its past position in the global telecom space. Modeled on the European services-based competition model, the Olds fibre network is separate from the services company. Established as a largely social enterprise, O-Net is now available to provide similar services to any municipality that is able to deploy lit fibre optic network within their community. Further, the Olds' folks are willing to share their learnings with any community that is interested – as outlined in the following video from the OICRD:

http://youtu.be/Uc_plnE3W5U

In it, Olds specifically offers to share their experience and expertise with any community interested in enabling state-of-the art fibre-based services within their communities.

It has been said that community fibre endeavours are likely 80% social and 20% technical and the Olds' experience supports this from several perspectives. First, the community-wide inclusive nature of the OICRD enabled coordinated long term planning and broad-based support for projects like the OCCN. It enabled complementary support for key related initiatives such as community engagement. Being leading edge, mistakes were expected and no blame was attached. Issues from rights-of-way to financing were encountered and the cross-disciplinary nature of the OICRD enabled efficient resolution.

9.3 Alberta SouthWest

The Alberta SouthWest Regional Alliance initiated the first regional broadband strategy encompassing the member municipal districts of Pincher Creek, Cardston, Willow Creek, Crowsnest Pass, Ranchland, and Waterton together with the Towns of Claresholm, Fort Macleod, Granum, Nanton, Pincher Creek, and Stavely, and the Villages of Cowley, Glenwood, and Hill Spring. The initial work focused on community engagement, education, and strategy. Once completed, the focus shifted to individual community support. Once completed, the final phase was to refine the regional strategy and facilitate implementation. While well-intended, an unintended consequence of their focus on helping individual members move forward, was that some of their larger members then did so – on their own – to some extent stranding both the smaller members and inhibiting a more regional approach. Axia's concurrent offer of 'free and hassle-free fibre' to communities in the Region that could show 30% of their addressable premises interested in Axia services simply compounded the problem. With the defacto foreclosure of a more regional approach, the regional level work did not proceed to implementation.

Of the communities moving ahead on their own, the current success story is Waterton. Leveraging a Shared Services Canada project to upgrade water facilities throughout the Waterton townsite, the town moved to deploy fibre to every premise in Waterton and now provides a rich set of both fibre and wi-fi based Internet services throughout the town and campground. Now that the TELUS backhaul links have been upgraded to 1 Gb/s, O-Net will begin providing a full triple-play (Internet, Telephone, and Television) portfolio to residential clients when the tourist season begins to wind down this fall.

Perhaps partially in light of their experience, there is a growing recognition of the importance of multi-community scale. Indeed, the sharing of resources and expertise from dense to less dense areas enables a broader deployment of fibre in the areas to be served. Earlier this year, the Alberta Government introduced a new grants program aimed at facilitating regional scale planning-level broadband studies. Under the program, matching grants of up to $20 000 are made available to interested Regional Economic Development Alliances (REDAs). Applications are due by September 1st, 2016 and the work must be completed by March 31st, 2017.

9.4 City of Calgary

Please see Sec. 6.3 – Connectivity vs Broadband.

10 Provincial Context[79]

10.1 SuperNet

The Alberta SuperNet is a broadband superhighway, conceived by the Government of Alberta (GoA) in the early 2000's to connect public institutions, collectively termed the GLHLM (GoA, Learning, Health, Library, and Municipality) clients, to a broadband network for high-speed Internet access, video conferencing and other services. It also enables rural Internet Service Providers (ISPs) to connect their access networks back to a peering point in Edmonton and Calgary at reasonable cost. The SuperNet links 4,200 GLHLM facilities in 429 communities and brings affordable high-speed network access options to nearly the entire province. A map of the SuperNet appears on the next page. While it mostly consists of fibre-optic backbone facilities, wireless links are used to complete the network in the most rural areas.

The Alberta SuperNet consists of the Bell-operated Base Area Network (BAN), shown in green and serving 27 of the larger urban centres, and the Axia-operated Extended Area Network (EAN), covering the rest of the province – shown in blue. The 27 Bell-operated base area network communities are:

Airdrie	Drumheller	Leduc	Sherwood Park	Vegreville
Bonnyville	Edmonton	Lethbridge	Spruce Grove	Vermilion
Brooks	Fort McMurray	Lloydminister	St Albert	Wainwright
Calgary	Grande Prairie	Medicine Hat	Stony Plain	Wetaskiwin
Camrose	High River	Red Deer	Strathmore	Whitecourt
Cold Lake	Lacombe			

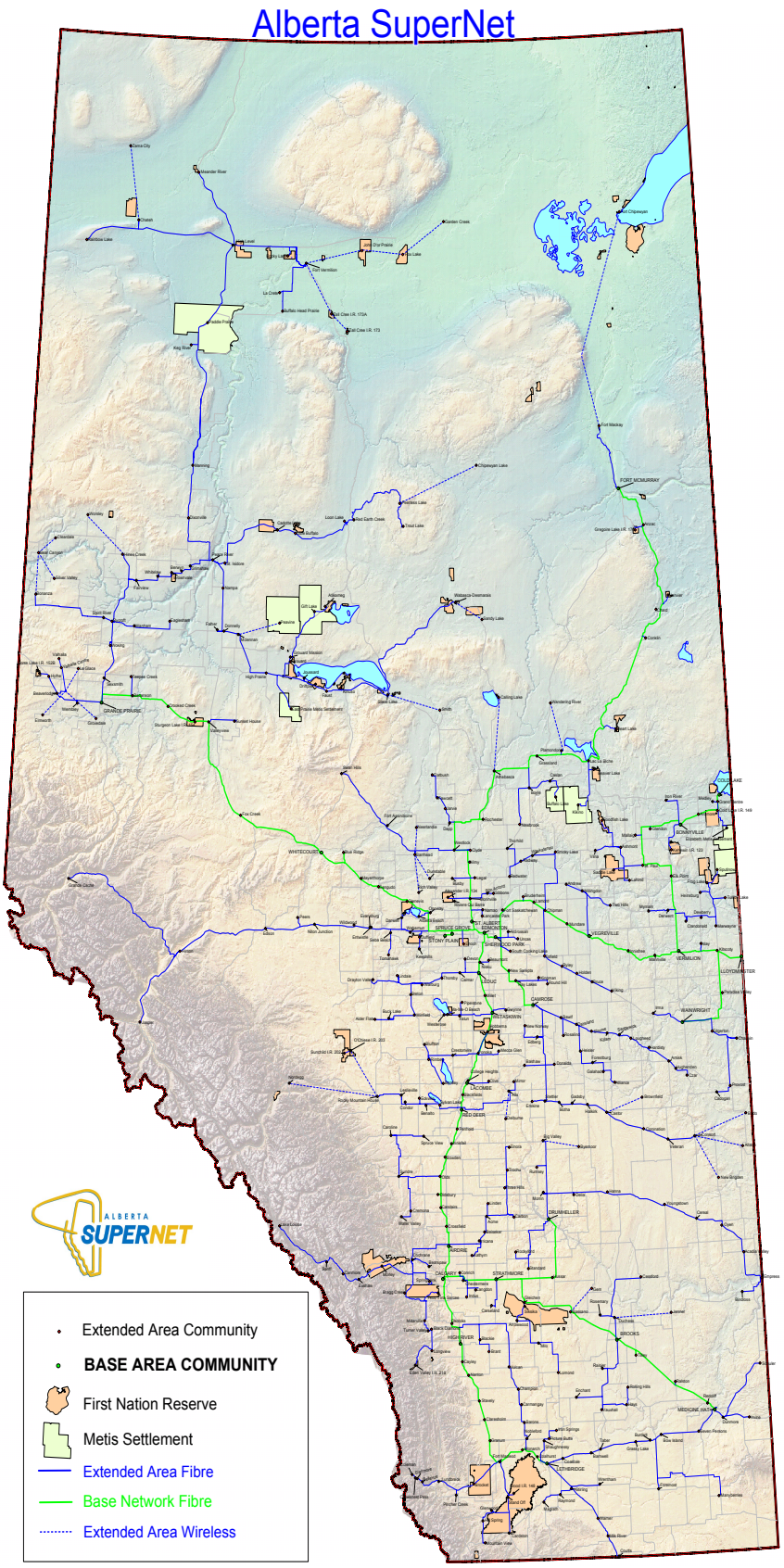
As the SuperNet is operated on an open access basis (its services are available to all service providers on a comparable basis), to preclude any conflicts of interest, neither Bell nor Axia can offer retail services such as Internet within their SuperNet footprint. To date, Bell does not offer retail services within the province, but Axia NetMedia does provide retail services to corporate clients and, through Axia Connect, provides retail Internet services in smaller communities.

Though Bell was contracted to build the SuperNet, Bell did subcontract the construction of the EAN to Axia. As issues arose as the initial EAN segment was deployed, however, the subcontract was revoked, and remainder of the EAN was deployed by Bell. In return for operating the network free of charge for the first ten years of the SuperNet contract, Bell received full ownership of the BAN. Ownership of the EAN portion of the SuperNet depends on whether a legal or financial perspective is taken. In essence, Bell owns the EAN, but the GoA has an indefeasible right-of-use (IRU) covering the asset and retains the option to buy it back for $1 when the IRU expires in 2035. Should the Government exercise this right, though, it will end up with a set on non-contiguous network segments – as all EAN segments home on the BAN (see the blue vs green segments on the map). In other words, the BAN assets are required to connect the EAN segments together and provide a usable network.

Operationally, the EAN interconnects with the BAN at 27 locations. While Bell has the overall operations and maintenance contract with the GoA, Bell has subcontracted the operations and maintenance of the EAN portion to Axia. As all these operating agreements expire at midnight, June 30, 2018, Services Alberta is currently considering whether to renew the Axia and Bell contracts "as is",

[79] Government of Alberta; *Harnessing the SuperNet Advantage*.

update the terms, or possibly sign operating agreements with other providers. Interestingly, Axia has stated that its Axia Connect activities are contingent upon retaining the SuperNet operating contract.



10.2 Rural Economic Development Action Plan

Over the 2014-15 period, the GoA developed a Rural Economic Development Action Plan focused on ensuring the ongoing success of rural economies across the province. The resulting five focus areas are:[80]

1. ***Industry and Business Development***
   - Enhance the capacity in rural Alberta to establish and grow innovative, next-generation and value-added industries.
   - Assist rural businesses with capitalizing on opportunities in new local, domestic and international markets.
   - Increase tourism and culture-based business opportunities in rural communities.
2. ***Financial and Capital Access***
   - Improve access to capital for rural entrepreneurs and businesses.
3. ***Attraction, Retention and Entrepreneurial Development***
   - Implement policies and programs that attract and retain families, skilled workers, new graduates, immigrants and Aboriginal people to rural Alberta.
   - Expand business coaching services that help connect emerging and established entrepreneurs and business leaders through mentorship, leadership and skill development programs.
4. ***Rural Business Infrastructure Capacity***
   - Increase the capacity of industry to efficiently capitalize on value-added processing and manufacturing opportunities.
   - Enhance innovation and technology infrastructure to ensure rural businesses are positioned to be effective, efficient and competitive.
   - Create alignment with the Water for Life Action Plan for a sustainable water supply to support economic activity.
5. ***Regional and Cross-Regional Collaboration***
   - Enable collaboration within and between regions in Alberta to better focus planning, service delivery and project development.

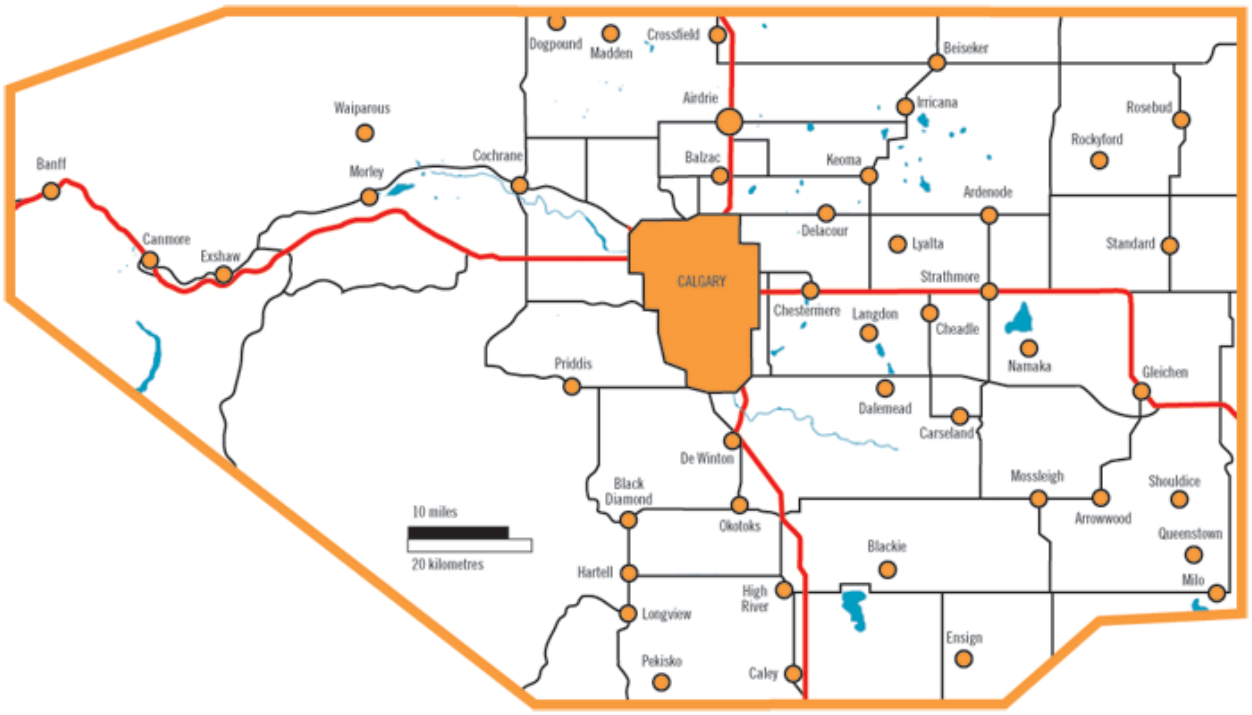
Enhanced broadband infrastructure comes under the second bullet in focus area 4.

10.3 Bow Valley College Regional Stewardship Program

As Calgary and the region's one and only comprehensive community college, under the Alberta Governments Regional Stewardship program, Bow Valley College (BVC) has been assigned responsibility for rural and First Nations post-secondary education across essentially the same footprint as the CRP. BVC serves 1.3 million residents in the Calgary Region - from High River to Cremona and from Lake Louise to Cluny. In the region, BVC operates community campuses in eight centres:

Airdrie	Calgary	Chestermere/	High River
Banff	Canmore	Strathmore	Okotoks

[80] Alberta Agriculture and Rural Development; *Rural Economic Development Action Plan – An Economic pathway for rural Alberta*; Government of Alberta; 2015.



From Canmore to Strathmore, BVC's Regional Stewardship program partners with local employers and community organizations to offer a range of locally-delivered services. The demand-driven/market-pull approach adopted by the BVC is both unique and successful – offered classes tend to fill up quickly.

Enhanced broadband both to its community campuses and throughout the region is critical for the ongoing success and growth of the program, to say nothing of the student benefits that will ensue.

10.4 Alberta Economic Framework

Released in June, 2014, the Alberta Economic Framework sets out create a *framework within which all those whose work impacts economic development might be inspired to work together as one team, with one vision*. [81] Four focus areas are laid out:

- Expand Alberta's presence and role in the global marketplace
- Solidify Alberta as a world centre for resource- based and resource-related industries
- Foster clusters that offer high growth potential to broaden Alberta's economic base
- Inspire entrepreneurs to innovate, commercialize and expand businesses across the province

As a meta-technology, ICT-related technologies impact all aspects of the economy and from that perspective capable ICT infrastructure will fundamentally underpin success in each focus area.

[81] Alberta Innovation and Advanced Education; *Building on Alberta's Strengths*; Government of Alberta; 2014-06.

11 Why Not Go Wireless?

11.1 Context

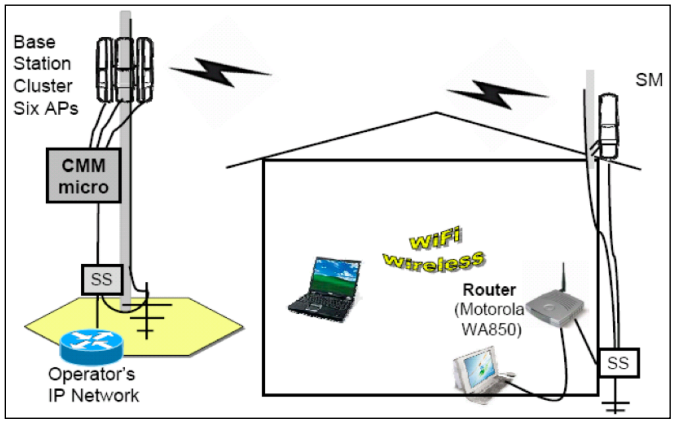
Given both the expense and complexity of deploying a fibre network, the question of 'why bother' comes up. After all, with wireless bandwidths constantly improving, surely the fibre will become irrelevant. The easy answer is that wireless Internet networks on any scale do not exist, only wireless Internet access does. That is, while wireless links are often used to connect your smart phone, iPad, or premise to the network, the underlying network that the devices connect to is fully wired. Over the past few years, TELUS has regularly announced billions of dollars in fibre network enhancements to it network in Alberta. Except for its more recent announcement to fibre Edmonton, virtually the entire amounts were earmarked for fibre to its mobility-towers – fibre required to increase the 'wireless' access capacity available to mobile devices. A corollary might be that from David Clark at MIT, i.e., *'the future of wireless'*, is wired.

Given buried fibre deployment costs typically account for some 70% of required capital, wireless access does have a role to play, particularly in more rural areas. But there are trade-offs. First, though, note that wireless access systems come in four flavours:

- Point-to-point wireless links
- Mobility / cellular networks offered by TELUS/Bell and Rogers.
- Point-to-multi-point (PMP) wireless networks typified by the offerings of XplorNet, CCI, and others.
- Wi-Fi Networks such as those deployed in the homes, offices, many commercial establishments, and throughout some municipal areas

Point-to-point (PTP) wireless networks connect two locations together using aligned dedicated high gain antennas. Current systems will do 1 Gb/s bi-directionally. Reliability is affected by weather and distances are typically limited to under 20 km/link.

Mobility networks need no explanation. Coverage by the major providers is extensive, but typically confined to urban/community centres and transportation corridors. Bandwidths are improving (2G, 3G, 4G, and LTE), but as data services get expensive when streaming audio and video media, they tend to be impractical for most home environments.

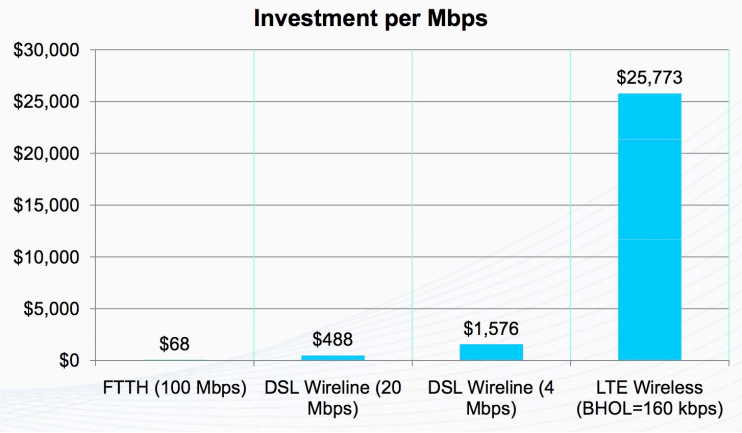


Widely deployed in rural areas, PMP wireless access networks provide services off a typically tower mounted centrally located access point (AP) to client subscriber modules (SMs) installed at client premises. Bandwidth from the AP is shared amongst those using the same AP. Moving from an omnidirectional antenna to a cluster of more directional antennas, like that shown in the diagram (courtesy of Vitel), effectively multiplies the available bandwidth by the number of sector antennas deployed. In the diagram, CMM refers to the cluster management module or controller and the SS units are surge suppressors needed to obviate impact from lightning strikes. Data signals within the home are wirelessly distributed via an indoor Wi-Fi system.

Available bandwidth and quality of service (QoS) in PMP systems depends on the radio equipment and frequencies selected, design considerations such as range of the SM from the AP, and operational

practices of the operator. Advantages include low capital outlay, short deployment intervals, and range. A single AP might serve clients up to 10 km away. Disadvantages include limited shared bandwidth, limited scalability, and the need for specialized SMs, which may need to be mounted on towers erected at the client site. While operators can elect to operate at lower frequencies to increase coverage areas, lower frequencies support less bandwidth.

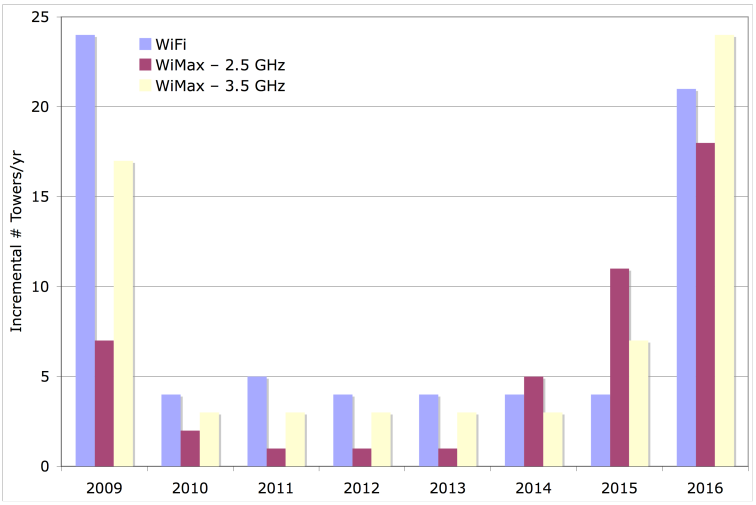
To some extent piggy-backing on the advances in mobility networks, fixed LTE equipment has increased aggregate bit rates off PMP APs to 100 Mb/s per sector antenna, and up to 12 sectors with a coverage range of some 25km is possible. As 100 Mb/s is aggregate, the capacity is typically split into downstream/upstream bandwidths depending on usage patterns. Splits of 75/25 are typical. To extend coverage to truly rural areas, PTP wireless links are used to relay signals back to the AP that are connected to network. Providing fibre to a tower can significantly improve available bandwidths available on each subtending AP.



Wi-Fi networks are, in essence, small, localized PMP systems in which the SMs are replaced by the user devices directly. Largely designed for work in-place situations, wi-fi access provides a convenient extension of a premises' wired connectivity connection. Unlike their indoor counterparts, outdoor units used to provide community-wide services are environmentally hardened to withstand cold temperatures and moisture, output ten times the power, and can be meshed or linked together to provide their own backhaul connections to perhaps the one unit that is 'hard-wired' to a backbone network such as the SuperNet. The issue with larger scale deployments, though, is the 'meshing penalty', i.e., the more access points required to relay signals, the less bandwidth that is available for connecting devices. Bandwidths typically decrease by half with each additional AP that is added to the mesh.

11.2 Trade-offs

Though wireless systems can be deployed quickly and, relative to burying fibre, much less expensively, they are more operationally intensive and, when normalized to bandwidth offered, are significantly more expensive.



As mentioned in Subsec. 5.1.2, a sample design for a 200 mi^2 rural area in Chamberlain, S.D., Vantage Point Consulting found that whereas the least expensive wireless deployment came in at $370 per Mb/s per client, fibre came in at US$7 – and fibre scales but wireless does not.[61] In this comparison, the wireless network was designed to support 4 Mb/s per client whereas the fibre network could support 1 Gb/s.

As illustrated in the chart from a Taylor Warwick study a few years ago, scaling wireless systems eventually requires significant increases in a providers' tower density. The associated costs place a fairly hard limit on the overall bit rates that can be

delivered. Based on this, potential solutions should be compared on a total cost of ownership basis over, say a ten year period during which the proposed networks are scaled to meeting all projected bandwidth requirements. On this basis, in many cases, the fibre solution will turn out to be the least expensive.

12 Why Not Just Leave Broadband to the Incumbents?

12.1 Historically

Based on historically limited electronics functionality (indeed, electronics did not even exist during the advent of telecom systems), two very different service-specific network infrastructures were developed and deployed:

- ***Telephony Network:*** A twisted pair copper-based centrally circuit switched (dedicated physical circuits) narrow-band (64 kb/s) symmetric (two-way) network to support POTS (plain old telephone services). Because dedicated circuits are established between every two parties that wish to talk, all voice data travels unencumbered between the two parties on each call.
- ***Cable Television Network:*** A coaxial cable-based non-switched (every endpoint receives the same signal) or shared wide-band (initially ~300 MHz) signal consisting of many television channels. In this case, it was the end-user device (TV) that selected the desired channel.

Given the expense of deploying their single-purpose networks, the telecom and cable incumbents were each granted monopoly status so that their network investments could be recouped over long amortization periods. In return, and to ensure they did not abuse the privilege, all services offered off the networks were regulated by the CRTC. With service revenues regulated, the incumbents sought to control their network costs by maintaining tight control over all services utilizing their networks' resources. As a result, incumbents became vertically integrated across their network and service operations.

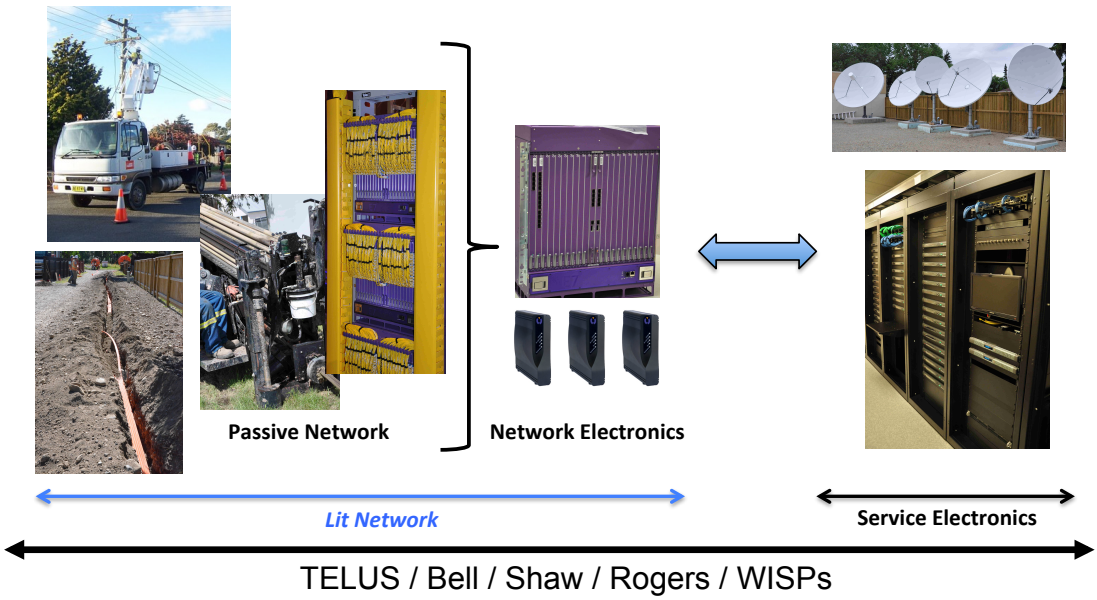
12.2 Vertical Integration

The delivery of telecommunication services requires the three functional components illustrated in the next figure. On the left, is the passive network piece comprising the connectivity infrastructure. It consists of all the ducts, copper, fibre, hand-holes, and coaxial cabling required to connect sites together. Once the network electronics are added, information signals and data can be exchanged between communicating sites – and the network becomes functional. The service electronics depicted on the right, provide the Internet, television, and telephone services that businesses and consumers pay for. The service rates charged are high enough to cover the costs of the underlying network.

The unabated progress in integrated electronics over the past 52 years has led, based on Moore's Law, to the 34.4 billion-fold improvement in capabilities that has powered the development of the digital age. The ramifications are everywhere – from the convergence of media to the development of personal computers and the proliferation of devices of all sorts – Future Shop did not exist in 1964.

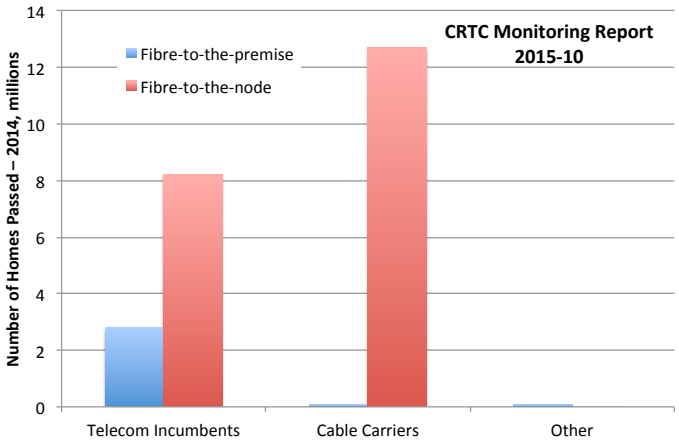
Over time, network support to enable digital communication between many of these new devices – from point-of-sale terminals, access to time-shared computers, and so on – became necessary and the carriers began to meet these needs by enabling access to a novel academically-based data network called the Internet. As demand for Internet grew, telephony networks were adapted to support wider-band signals and two-way and switching (routing) capabilities were added to cable networks. Adaptations on both networks had their limitations, however, and as the number of services requiring support proliferated, it became impractical to either deploy a dedicated network to support each service or to even provide dedicated circuits for each service on a single network. The answer lay in the

development of a single shared bi-directional routed digital broadband network infrastructure capable of transporting all current and reasonably envisioned services. The most capable of these required access to an underlying fibre optic network.



12.3 The Upgrade Issue

As the business case for incumbent carriers to upgrade their copper or coaxial cable networks to fibre is based on only the incremental revenue the upgrades would enable, the incumbents only elect to upgrade when other factors such reduced maintenance expenses or competitive considerations come in to play. Otherwise, only incremental improvements, such going fibre to the neighbourhood, are deployed. As coaxial cable will intrinsically support higher bit rates than copper, the cable companies are even less inclined to deploy fibre access than the telecom players.



12.4 The Googin Paradox

In helping facilitate the development of this all-purpose network and the Internet, the incumbent's inadvertently opened Pandora's Box. You see, with sufficiently sophisticated end-user devices, Internet enabled a complete bypass, albeit very poorly at first, of the incumbent service sets – with Internet you could do voice-over-IP and Skype, YouTube and Netflix. With sufficiently unencumbered access, you no longer need the incumbent's services.

The Internet broke the age-old service/network linkage and thereby disrupted incumbent control of their networks and directly threatened their revenue streams. Adding fibre simply made everything worse – and led to Googin's Perfect Network Paradox:

The better the network, the lower the profit. 'Telecom is either a valuable monopoly or a valueless commodity.' – R. Googin

In the limit, this logic suggests that a theoretically perfect all-optical network – offering infinite bandwidth, reliability, low latency and protocol neutrality – while greatly enriching society, would bankrupt any network provider 'foolish' enough to deploy it; i.e., with open high bandwidth transparent networks, services can be developed and deployed with no telecom incumbent involvement outside of Internet services – and therefore reduced revenue streams.

The incumbents' then, face an interesting conundrum:

- **Don't deploy** the 'perfect' network because you can't profit from it and may go bankrupt in the process – at a minimum your share price will drop.
- **Do deploy** the 'perfect' network, but restrict it such that you can maintain control and profit from it: i.e., maintain network control, ration bandwidth, and lobby against net neutrality.

If the incumbents owned the road/highway system, this would be paramount to installing toll gates and enforcing usage charges based on deep inspection of each vehicle's content (value).

The predicable result, then, is that instead of the open, symmetric, high bandwidth (100+ Mb/s) networks required to stimulate/catalyze innovation and economic development in Alberta (and increasingly available elsewhere), we have asymmetric low bandwidth (typically < 10 Mb/s downstream) gated (closed, controlled) networks, optimized for content delivery (i.e., video broadcast) and the maintenance of the incumbent operators' historical business models. In the transportation industry, this is paramount to the automotive manufacturers owning the roads their cars drive on. To develop and sell a new car, you'd have to deploy your road network first. Moving from low asymmetric to high symmetric bit rates enables a new service paradigm and a plethora of new service possibilities

12.5 Beating the Paradox

In summary, the stall in fibre deployment is fundamentally an agency issue – a conflict between corporate stakeholders and the interests of the communities they serve, investor ROI vs regional economic development. The issue has been recognized around the world and a variety of approaches in varying stages of deployment are in currently in play. The challenge, then, is to collectively customize what's worked elsewhere and create a 'Made in Canada' solution that benefits us all.

The good news is that the agency issue is an offshoot of the traditional business model in which services and the networks on which they run are tightly coupled. The better news, is that if you change the business model – the issue disappears. The best news is that, as has been empirically proven in Europe, the solution is structural separation between the network (passive + network electronics) and the services that run over it; i.e.: you run the network as a utility and enable full competition at the service level just as the power grid is provisioned on a utility basis that enables full competition amongst the appliance providers. To work, the network must be operated on an open nondiscriminatory basis that enables full services competition on a level playing field.

Needless to say, the incumbents prefer the current vertically integrated facilities-based competition model as it effectively limits services-based competition and preserves their defacto monopoly; i.e., to compete in services, a would-be competitor has to build a network first. With structural separation and services-based competition sharing a utility fibre network, any smart teenager with a server in his (her) basement can develop services that can be run over the utility network infrastructure.

From both competitive and innovation perspectives, the results of services-based competition are striking:

- In the 60 000 home community of Västerås, Sweden this approach yielded true broadband (fibre) infrastructure with 30 service providers offering 110 different services and take-rates are over 50%
- In Alberta, there are two wireline competitors and only a handful of service options.

With services-based competition, communities seeking to deploy fibre as a utility are not competing with private enterprise, they are facilitating it.

12.6 Infrastructure

Given the incremental nature of the business case incumbents face to upgrade their networks, the conflict between their shareholder interests and those of the communities they serve, and their desire to maintain facilities-based model, precious few communities are likely to see fibre access deployed by the incumbents any time soon. On the other hand, given the many positive off-balance sheet benefits enabled by fibre and access to long term infrastructure financing, communities are well positioned to deploy fibre on a utility basis – and can thereby enable fibre services at rates simply unavailable to the incumbent providers.

Consider a rural example. At two farms per mile and $30/m deployment cost, a $1 M fibre build would pass 50 farms with little left over for the drop and electronics. Whereas a private operator financing this would require payback in five years, a community could finance the build over 20 or 30 years. The difference is significant. Whereas a five year payback at 5% requires payments of $18,871/month, over a 20 year term from the Alberta Capital Finance Authority, a 2.766% loan requires payments of only $5,430/month. In the utility infrastructure game, private industry cannot compete with communities.

12.7 Private Sector Players

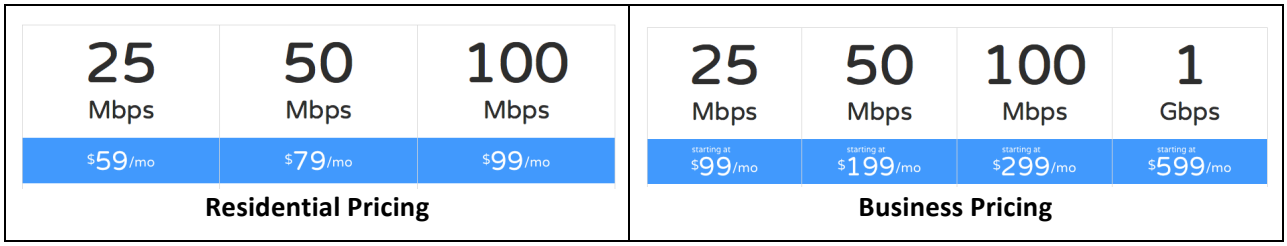
12.7.1 Axia

In return for access to a Town's rights-of-way, Axia is offering to deploy fibre infrastructure throughout the town and provide residential and business Internet connectivity at rates up to 100 and 1000 Mb/s, respectively, should 30% of the addressable premises in the community show interest in these services. Offers are contingent on due diligence by Axia and Axia may or may not agree to 'fibre' any individual community.

While merits of an essentially hassle-free and free, FTTP infrastructure are self-evident, the offer is neither without cost nor risk. All revenues from the network would accrue to Axia's shareholders and once deployed, Axia would have monopoly control over critical civic infrastructure. No infrastructure would be deployed into the surrounding MD or county and the network would not be open in the traditional sense of the term.

To date, Axia has deployed fibre in Barnwell, Nobleford, Nanton, and Vulcan. Axia has also announced FTTP services for Magrath, Pincher Creek, Raymond, and Stirling. Communities such as Black Diamond and Turner Valley in the Calgary region have opted to delay decisions relative to Axia until a regional study (the CRP study in their case) has been completed.

Service pricing on a two year contract appears below.



12.7.2 Bell Canada

Bell Canada has recently shown renewed interest in providing broadband services in Alberta.

12.7.3 CCI Wireless

Though currently solely a wireless ISP, CCI is looking to develop 50/50 PPP arrangements to deploy fibre in communities such as Caroline.

12.7.4 Shaw

Shaw wholesales has been very aggressive/competitive with respect to providing backhaul services throughout the province.

12.7.5 TELUS

TELUS' approved a fibre access strategy in 2013. It is based on three pillars:

- Community-centric: to ensure accessibility, ubiquity and homogeneity from an operational perspective. Their objective is to include more than 90% of the homes and businesses in each community.
- Coordinated deployment: to leverage scale economies.
- Innovation across all aspects of customer engagement and business operations.

The strategy is focused on enabling small cell wireless deployment together with enhanced consumer, business, and health services.

Under this program, TELUS has, since 2014, spent $430M deploying fibre to 107,000 premises in smaller Alberta communities.[82] TELUS plans to spend another $1.2 billion by year-end 2019.

Last year, TELUS undertook a review of new greenfield investments. During this process, investment was scaled back less than 10%. Going forward, TELUS has made the decision to fund new developments working jointly with developers and builders in both commercial and residential developments.

TELUS fibre in the selected communities is deployed at no cost to the municipality. Home and property owners are under no obligation to obtain services when granting permission for TELUS to place the fibre drop directly to their premises. While Axia does offer symmetric 1 Gb/s business and 100 Mb/s residential services together with an option for other service providers to lease fibre access lines, as yet, TELUS has not yet seen a market need for these services. On the other hand, the CRTC will require TELUS to provide wholesale access to their fibre on some yet to be determined basis, whereas Axia will not be so encumbered.

[82] Mawji, Zainul; *Expanding Broadband Networks*; 2016-09-12. Though marked confidential, this slide was provided for this document.

Our investments in Alberta

TELUS Fibre Investments since 2014 = 107,000 premises

Community	Premises	Community	Premises
Blackfalds	3.1k	Peace River	3.3k
Bonnyville	1.3k	Ponoka	0.9k
Calgary	33.3k	St. Paul	2.7k
Coaldale	2.8k	Stettler	2.6k
Didsbury	1.7k	Taber	3.6k
Drumheller	2.9k	Vegreville	3.1k
Edmonton	17.5k	Wainwright	3.3k
Edson	3.4k	Westlock	2.0k
Hinton	5.0k	Wetaskiwin	5.3k
Innisfail	3.2k	Misc Communities	13k

Since 2014, we have invested $430m in fibre in Alberta and plan another $1.2b by YE 2019

Challenges

- AB build costs ~3x BC builds due to Direct Buried infrastructure
- Weather leads to short build season
- Economic downturn increases investment risk profile
- Limited comparative revenue streams

Between 2000 and 2019, TELUS will have invested $46b in Alberta

TELUS | Broadband Networks | © 2016 TELUS Communications Company Confidential I 2

13 Next Steps

As mentioned early on, this CRP project has been broken into two parts – (1) Landscape Issues, (2) Municipal and Regional Opportunities. As this document is Part 1 of 2 and focuses on the landscape Issues and context, the next step will be to complete Part 2.

14 Conclusions

- Economic development is not a zero-sum game in which the winning community takes all. Together, the CRP members and non-members can raise the 'tide' throughout the region so that all can benefit.
- The municipalities, municipal districts, and counties can accomplish more together than separately.
- Scalable broadband connectivity is critical civic utility infrastructure and should be treated as such. In the US, 25 of the 48 states reporting have a broadband office.
- Federally, the CRTC universal service options are inhibited by the facilities-based framework under which they operate. Moving to a services-based framework in which the required underlying fibre infrastructure is provided on an open basis as a fourth utility over which all providers can compete on services would enable ubiquitous deployment and help eliminate the existing digital divide. Under this model, private providers would get access to infrastructure superior to that which they themselves could afford to deploy and could then re-direct the capital saved to innovate and compete on services.
- As municipalities and regions can fund fibre infrastructure over 20+ year periods, they can provide the infrastructure much less expensively than can a private interest firm intent on recouping its capital in, say, five years. Monthly payments by a community on a $1M infrastructure loan over 20 years at 2.602% from the Alberta Capital Finance Authority

(ACFA) are $5,349 versus the $18,417/month payments required of a private firm paying 4% on the same amount over a five year term.

- Both federally and provincially, funding and debt limit policies need to be updated to help enable municipalities to deploy the required infrastructure.
- As the required infrastructure upgrades represent a once in a century opportunity, it is worth getting this right.

15 Acronyms

ABF	air blown fibre
ACFA	Alberta Capital Finance Authority
ADSL	asymmetric DSL
AESO	Alberta Electrical System Operator
API	application programming interface
AUC	Alberta Utilities Commission
BAN	base area network
BCG	Boston Consulting Group
BVC	Bow Valley College
CAD$	Canadian dollars
CAGR	cumulative annual growth rate
CRP	Calgary Regional Partnership
CRTC	Canadian Radio-television and Telecommunications Commission
DARPA	Defense Advanced Research Projects Agency (US)
DIY	do-it-yourself
DOCSIS	data over cable systems interface standard
DSL	digital subscriber line
ERaCha	Edge of Radial Change
FDH	fibre distribution hub
FTTH/FTTP	fibre to the home/premise
GB	gigabyte, where 1 B = 8 bits (b)
Gb/s	gigabits (10^9 bits) per second (1000 Mb/s)
GDP	gross domestic product
G.fast	G.970x standard fast access to subscriber terminals
GLHLM	GoA, Learning, Health, Library, and Municipality
GoA	Government of Alberta
GPON	gigabit passive optical network
HD	high definition
HDD	horizontal directional drilling
Hz	Hertz (cycles/second)
ICF	Intelligent Community Forum
ICT	information and communications technology
IoE	Internet of Everything

IaaS	infrastructure as a service
ILSR	Institute for Local Self-Reliance
IRU	indefeasible right-of-use
ISP	Internet service provider
IT	information technology
λ	wavelength
LED	light-emitting diode
LEOS	low earth orbit satellite
LTE	long-term evolution
M	mega, million ($10^{6)}$
Mb/s	megabits (10^6 bits) per second
µm	micron, micro-meter; 10^{-6}m
M2M	machine-to-machine
NAP	network access point
NPV	net present value
OCCN	Olds' Connected Community Network
OECD	Organization for Economic Co-operation and Development
OICRD	Olds Institute for Community & Regional Development
ONT	optical network unit
OPGW	optical ground wire
OSP	outside plant
OSLI	Oil Sands Leadership Initiative
QAM	quadrature amplitude modulation
PaaS	platform as a service
PMP	point-to-multipoint
PPP	public-private partnerships
PTP	point-to-point
REDA	regional economic development alliance
RMWB	Rural Municipality of Wood Buffalo
SaaS	software as a service
SD	standard definition (television)
TB	Terabyte where 1 TB = 10^{12} B or 1000 GB
TCCi	The Creative Coast Initiative
TV	television
UHD	ultra-high definition (television – 4k)
US	United States (of America)
VDSL	very high bit-rate DSL
WISP	wireless ISP
XaaS	X as a service, where X can be I (Infrastructure), P (Platform), or S (Software)
yr	year