State of Alberta
Digital Infrastructure Report

V2.0

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Revision History

Date	Revised By	Version	Revisions
Oct 10, 2014	Cybera	0.9	Development of the first draft
Oct 20, 2014	Cybera	1.0	Revisions to all sections. Additions of the Executive Summary, Introduction and Data section.
Oct 31, 2014	Cybera	1.1	Revisions to all sections.
Sept 13, 2016	Cybera	2.0	Updated network section & acknowledgements. Updated hyperlinks and citations.

Executive Summary

Governments worldwide are investing in digital infrastructure as the foundation for innovation, economic growth and market diversification. This infrastructure is critical for creating new industries, and reinventing traditional industries. Understanding the current landscape of digital infrastructure in the province has the potential to create a strong strategic foundation for government to harness innovations in science and technology, and drive new market diversification in Alberta.

In 2014, Alberta's not-for-profit advanced technology agency, Cybera, began building an outline of the information and communication technology (ICT) infrastructure currently in place, highlighting what is needed to perform advanced research and foster innovation in the province. This **State of Alberta Digital Infrastructure Report** provides a detailed review of Alberta's current network connectivity, data centre resources, high-performance and cloud computing resources, cybersecurity awareness and protection measures, data management policies and procedures, and key personnel. It presents an overview of opportunities for investing in Alberta's digital infrastructure in a way that responds to multiple immediate needs, capitalizes on the efficiencies created by shared infrastructure, and lays the foundation for future research and innovation.

This State of Alberta Digital Infrastructure Report is intended to be a constantly evolving review on digital infrastructure in the province. It is Cybera's intent that this document will continue to evolve as feedback from partner organizations and external stakeholders is received and incorporated. Cybera will continue to collaborate with invested stakeholders and key contacts to gather the full scope of information in an iterative and coordinated approach.

Readers of this report should bear in mind that while Cybera is the province's expert technical agency, we do not have ***all*** the answers and as such rely heavily on our colleagues within our member institutions. Although many have had a chance to comment on this draft, many more have not. As such, the facts and figures reported here may change as more of our colleagues have a chance to read and comment on the material. If readers are making critical decisions based on data in this report, we encourage them to contact the authors to ensure the very latest information is available.

In effort to facilitate and present a summary of the findings, each section is presented "**At a Glance"** as part of this executive summary. Each "At a Glance" presents a section overview, a review of current landscape numbers at the time of this draft, and future recommendations for consideration. For a detailed review of all recommendations see the corresponding section.

1. Networking — At a Glance
2. Data Centres — At a Glance
3. Computing — At a Glance
4. Cybersecurity — At a Glance
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Networking – At a Glance

Over the next 5-10 years, Alberta will continue to see an increased demand for bandwidth as users adopt more cloud services and move to mobile platforms. Alberta houses two high-speed public fibre networks: the research and education network, CyberaNet, and the province-wide fibre optic network, the Alberta SuperNet, which are available to a select portion of the population. Commercially, there are several telecommunications providers in the province, but their reach and bandwidth capabilities vary. Many residents in rural areas struggle to obtain internet connections at a cost and speed comparable to the province's urban centres.

By the Numbers...

- Expected annual growth rate of Canadian internet traffic between 2015-2020: 22% (2.7x today's traffic)[1]
- Percentage of low income households in Canada with internet access at home (as of 2013): 59.7%[2]
- Current number of Albertans without access to internet at speeds of at least 5 Mbps download and 1 Mbps upload: 80,000
- Average Canadian download / upload speeds in 2015: 18.6 Mbps down / 7.3 Mbps up[3]
- Average rural Canadian speeds in 2015: 14.8 Mbps down / 6 Mbps up
- Average Alberta speeds in 2015: 13.5 Mbps down / 5 Mbps up
- Percentage of Albertans over the age of 18 who own a mobile device: 80%
- Expected annual growth rate of Canadian mobile data traffic between 2015-2020: 42% (6x today's traffic)
- Expected annual growth rate of Canadian IP video traffic between 2015-2020: 20% (3x today's traffic)

Recommendations for Improving Networking

Short-term (1-3 years)

- Develop a provincial broadband strategy
- Set a provincial target of 25 Mbps symmetric internet bandwidth
- Establish a community to aggregate and facilitate rural broadband solutions
- Ensure the new Alberta SuperNet agreements (due in 2018) allow Alberta to play a leadership role in broadband

Long-term (3-10 years)

- Develop a provincial plan to leverage federal funds and initiatives to expand broadband access into rural Alberta

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[1] Cisco, VNI Complete Forecast Highlights Tool, 2016.
[2] CRTC. Communications Monitoring Report, Table 2.0.8. Accessed 2 May 2016.
[3] CIRA. Canada's Internet Performance: National, Provincial, and Municipal Analysis. April 2016.

- Set a provincial target of 100 Mbps symmetric internet bandwidth
- Work with municipalities to open their fibre assets to public institutions and community based not-for-profit ISPs

Data Centres – At a Glance

Data centres host most of the physical components of modern computing, including the networking, hosting and storage infrastructure.

For this section, Cybera focused on the research and innovation-focused data centres and, to that end, interviewed the IT infrastructure managers at five post-secondary institutions: the University of Alberta, University of Calgary, University of Lethbridge, Mount Royal University and NAIT. Although Cybera did not gather information for all 26 post-secondary institutions in Alberta, from the sampling of information gathered, it is confident that the availability of space and resources at the Universities of Calgary and Alberta compose the majority of the data centre capacity in the academic sector in the province. From Cybera's perspective, the academic data centres are currently more cost effective for research and innovation, and should continue to be fostered for these sectors going forward.

By the Numbers…

- Number of commercial data centres currently identified by Cybera in Alberta: 17
- Total combined capacity of public data centres at Universities of Alberta and Calgary: ~5.5 MW
- Current available capacity at Universities of Alberta and Calgary ~1.5 MW (more could be made available if old equipment is decommissioned and if renovations are done to expand existing centres).

Recommendations to Improve Data Centre Capacity

Short-term (1-3 years)

- Convene an Alberta team of experts to determine the short and medium term needs for computing infrastructure investment, and analyse the data centre capacity required to support this.
- Support the expansion of the Shared Data Centre Initiative to other K-12 and post-secondary institutions (beyond the Universities of Alberta and Calgary).
- Develop a joint plan between the provincial government and post-secondary institutions for hosting infrastructure for the expected Canada Foundation for Innovation cyberinfrastructure program.

Long-term (3-10 years)

- Develop and build secure and trusted facilities to house information for the research and health communities.
- Create new data centre facilities that are energy efficient and make use of renewable power sources.

Computing – At a Glance

Computing resources and uses by Alberta's research and innovation community includes high-performance computing resources (which offers large amounts of 'compute power', i.e. some combination of CPU cycles, memory and storage), and cloud computing (commodity infrastructure that is available on demand, usually for those doing work requiring less compute power).

For this section, Cybera focused primarily on publicly funded resources, as it is difficult to determine the variety and form of usage within the private sector providers. Cybera is unaware of any non-commercial HPC resources specifically provisioned for innovators. Cybera also looked at the current state of shared services (whereby multiple organizations share the use or expertise of their HPC or cloud resources, to reduce costs while increasing efficiencies).

By the Numbers…

High-Performance Computing

- Four major HPC systems at the Universities of Calgary and Alberta provide 17,360 cores and 0.5 PB of short and medium term storage
- Last major investment in Alberta HPC resources: $22 million (awarded in 2006)
- Compute Canada core hours used by Albertans between Oct. 2013 - Oct. 2014: 1.7 billion

Cloud Computing

- Number of Canadian commercial cloud providers: 13
- Number of Canadian public clouds for researchers and start-ups: 2

Shared Services

- Costs saving by BC institutions through shared services in 2013/2014: over $9.2 million
- Number of Alberta post-secondary institutions piloting shared services: 4
- Number of Alberta education organizations investigating shared services: 6+

Recommendations for Improving Computing Efficiencies

Short-term (1-3 years)

- Commit to and continue to invest in rapid-access cloud resources for researchers and entrepreneurs.
- Provide an ongoing capital refresh to sustain HPC investments and resources required for the research community.
- Expand support for shared service infrastructure and mechanisms (such as investing in shared data centres, or implementing processes for using Federated ID).

Long-term (3-10 years)

- Develop a coordinated digital strategy for providing multiple computing resources that are accessible and scalable for all public sector users.

Cybersecurity – At a Glance

Each year, cybersecurity threats expand and become increasingly pervasive, particularly as more devices connect to the internet and international research collaborations grow. Cybersecurity is also challenging in regards to policies, innovation, and functional operations. As technology is constantly changing, so are the security threats and the responses required.

This section looks at the most commonly encountered standards and resources available in the public sector in Alberta. Input was sought from security professionals in educational organizations, the private sector, and provincial government.

By the Numbers…

- Almost 50% of all global vulnerabilities observed in 2013 are at least two years old (suggesting that basic security practices are not being implemented)
- The Ministry of Service Alberta provides the information and security management directives for all Government of Alberta departments
- The Corporate Information Security Office safeguards the Government of Alberta's IT systems and publishes the Government of Alberta IT Security Framework (to be implemented by shared Security Officers from each ministry)
- Alberta Education provides K-12 divisions with a Technology Services Self-Evaluation Guide, which focuses on: IT Governance, IT Service Management and Information Security (but does not advise on addressing or maintaining these areas)
- The Canadian University Council of Chief Information Officers' special interest group on security represents a valuable resource for sharing of best-practices in post-secondary institutions
- Smaller public institutions struggle more to adapt cybersecurity best practices due to a lack of resources and expertise

Recommendations to Improve Cybersecurity

Short-term (1-3 years)

- Create freely-available, actionable guidance for smaller organizations to approach their cybersecurity in a step-by-step manner.
- Provide opportunities for knowledge sharing between public organizations in order to avoid duplication of effort and fully leverage existing expertise.
- Expand the role of the Government of Alberta CISO and the ministerial security officers to support smaller IT teams in the province.

Long-term (3-10 years)

- Develop a single, province-wide security review process for all public sector organizations that emphasizes risk tolerance and security priorities.

Data Management – At a Glance

With the importance (and complexity) of big data for global economic growth, it is important to not only have the equipment for hosting and categorizing this data, but also the understanding and processes to ensure this data is accurately and securely being processed.

For this section, Cybera focused primarily on public data portals and regulations, including government data discovery points. As well as an overview of these portals and their best practices, this section also highlights the international movement towards Open Data and Open Government.

By the numbers…

- Amount of data humans create daily: 2.5 quintillion(10^18) bytes (90% of the data in the world today was created in the last two years alone)
- Amount of data expected to be stored around the world by 2020: 35 zettabytes (10^21)
- Canadian public organizations who are investigating best practices for data management, access and preservation: Tri-Council Plus (Canada's research funding agencies), Genome Canada, CANARIE, Research Data Canada, Compute Canada, Canadian Association of Research Libraries
- The global Open Data Charter was adopted by all G8 nations in 2013, including Canada, with commitments to take additional actions by the end of 2015
- The Government of Alberta set up the Open Information and Open Data Policy, to increase transparency and accountability, to be implemented 2013-2015
- Government initiatives to increase open data access include the Alberta Open Data Portal, GeoDiscover, the Spatial Data Warehouse and the Alberta Environmental Monitoring, Evaluation and Reporting Agency
- Municipalities in Alberta that have undertaken open data initiatives: 7 (Banff, Calgary, Edmonton, Grand Prairie, Medicine Hat, Red Deer and Strathcona)

Recommendations for Improving Data Management

- The province should establish a working group with other provinces to review and harmonize provincial regulations regarding data residency, with an emphasis on the use of Trusted Data Repositories.
- Require that a data management plan be in place for any data acquired with provincial funds, and mandate that all appropriate data be made open.
- Develop and implement a plan to put the necessary expertise in place to support researchers and government sectors in developing data management plans.

- Encourage municipalities to make their data open using an agreed-upon, standardized method.

Skilled ICT Workers – At a Glance

Having sufficient highly qualified and skilled personnel (HQSP)—including strong ICT workers—in Alberta is necessary to compete in the global market. This section looked at publicly available ICT job statistics to gain a full understanding of the employment availabilities and needs. It also gathered ICT education enrolment and graduation numbers from nine post-secondary institutions. Records show that, while Alberta continues to turn out knowledgeable and internationally sought-after IT talent, their numbers are few, and insufficient to meet the future needs of the province's growing economy.

By the Numbers…

- Number of ICT professionals in Alberta as of 2013: 75,000
- Number of knowledge-based workers Alberta should have achieved by 2010, according to the 1998 ICT action plan: 140,000
- Percentage of Alberta ICT workers who are immigrants: 37%
- Projected shortage for certain ICT roles in Alberta between 2015-2021: +400%
- ICT salaries in Alberta compared to the national average: between 4.9% - 24.5% higher
- Alberta's ranking out of nine surveyed North American jurisdictions for ICT development investing: 9th
- Number of ICT-specific university graduates in Alberta between 2008-2013: 1,459
- Number of programs supporting HQSP in ICT that are available in Alberta: 9

Recommendations for Increasing the Number of HQSP

Short-term (1-3 years)

- Develop a joint plan between the provincial government, industry and post-secondary institutions to increase the number of students enrolling in - and completing - ICT diploma and degree programs.
- Develop a plan to attract and retain more ICT workers and students from abroad (e.g. through tax credits and targeted foreign marketing).
- Expand existing applied research and ICT-based internship programs (such as Mitacs Accelerate Program or iCore) at the graduate and post-doctorate levels.
- Assess the current programs for developing highly qualified skilled personnel, and assess if new programs are needed

Long-term (3-10 years)

- Support industry, post-secondary and technical training institutions to work together to develop programs that are flexible to companies' and ICT professionals needs, and adaptable to changing technologies - such as more co-op and internship programs.
- Support educational programs that encourage more K-12 students to take science, technology, engineering and mathematics (STEM) courses.

- Provide a provincial infrastructure system that supports high-end research and innovation, to attract more skilled personnel and ICT businesses to Alberta.

Introduction

One of Cybera's core mandates is to monitor and document the changing landscape of Alberta's digital infrastructure used for research, innovation and the economic benefit of the province. In this State of Alberta Digital Infrastructure Report, Cybera is setting the benchmark for future digital utilization in the province. Within the next ten years, the majority of digital infrastructure solutions will need significant investments. Success will require an organizational shift in the way this infrastructure is planned for, built, operated, used, and maintained. Digital infrastructure needs to be flexible and adaptable to meet the needs of future generations and disruptive technologies.

High-speed connectivity and access to bandwidth remain the largest barriers to digital advancement in the province. Connectivity is key to making computational resources available. The research and education network fills this need for academic users, but the commercial internet is the backbone for everyone else. This is a major weakness in Alberta, where problems exist with access and affordability. Market forces will not address this for all users, so regulation is needed to ensure equitable, non-prejudicial access.

Once Alberta's issues with connectivity have been resolved, our use of computing resources become location independent. The key then is to address computing needs in the most efficient way possible to ensure that Alberta's researchers, educators and innovators have the tools needed to be competitive. In our discussion of the differing needs of researchers, innovators, entrepreneurs and others, we have identified common synergies. A coherent policy—covering both procurement and shared services—will significantly improve procurement and operational efficiency while providing a flexible growth path.

Alberta will need more skilled ICT workers to manage and build our high-tech infrastructure, including researchers and innovators to use that infrastructure and enhance the economy. Unfortunately, most of the ICT skills training currently carried out in the province follows historical education practices of theory and textbooks, which does not match the fast-changing world of technology. This makes it difficult to retain students in these programs, and those who make it through to graduation are already out-of-date in their knowledge. We need curricula that is flexible and adaptable.

If we look back to Alberta 30-40 years ago, the only people who needed computing resources were university researchers. But as computers became cheaper and digital literacy improved, a wider range of users began to demand these resources. Over time, this will extend to the youngest members of our society. Alberta needs to prepare for the day, not far off, when K-12 students have the same computing needs as post-secondary institutions do today. This will ensure we have a sustainable stake in the global knowledge economy.

Networking in Alberta

Overview

This chapter on the state of network infrastructure in Alberta draws on publicly available information and input from a range of stakeholders in the Canadian and provincial internet community. It will review publicly and privately funded network infrastructure, the availability of a range of broadband services, innovations in broadband delivery technologies, and the changing regulatory landscape.

Background

Broadband internet is the high-speed and high-capacity transmission of internet data over a network (e.g. fibre optic cables).[4] The global internet is comprised of many independent but interconnected networks. Consumers connect to local or regional ISPs through access networks (called the 'first or last mile') that can be wireline (fibre optic or copper cables) or wireless (satellite or tower-based). Fibre-to-the-home or premise supports the highest internet bandwidth speeds (> 1 Gbps), as shown in Figure 1. Consumers purchase internet access from regional Internet Service Providers (ISPs), who in turn acquire internet access from larger upstream ISPs (e.g. a Tier 1 network).

Connections from a local access network to the global internet take place via a middle mile network. In the context of rural communities, the "middle mile" is the connection to a larger metropolitan centre. The Alberta SuperNet is one example of middle mile infrastructure. Backhaul networks then connect the middle mile to a major internet exchange or the core portion of a provider's network. Middle mile and backhaul connections are almost always fibre-based, due to the large bandwidth requirements these connections must support.

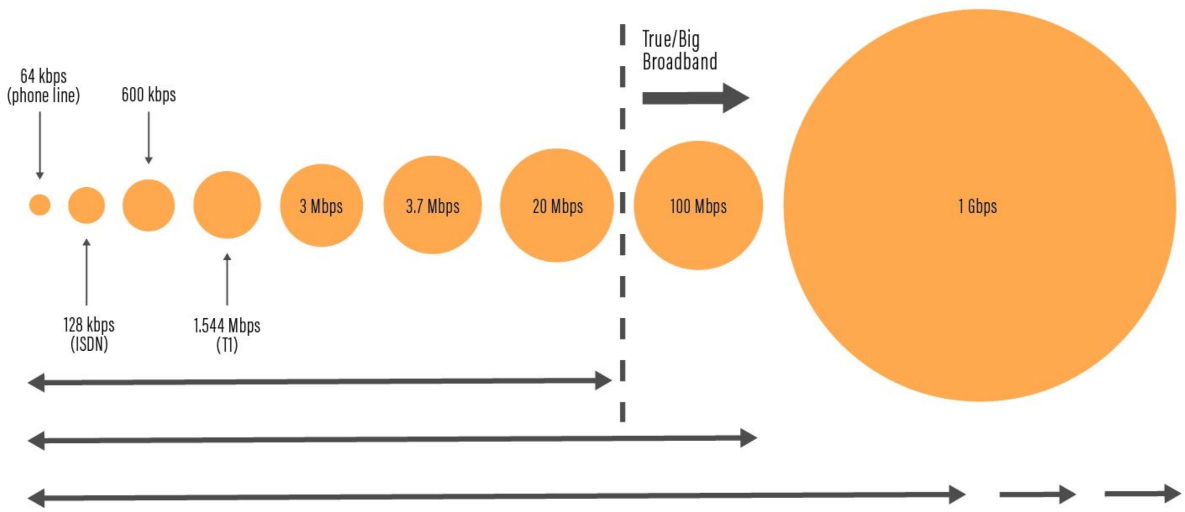
The physical network infrastructure can provide broadband services according to a number of access models, based on who controls the various network layers:

- Physical Infrastructure Layer — ducts, pipes, and fibre optics
- Network Provider Layer — active equipment such as routers and switches
- Service Provider Layer — internet services

Depending on whether one or more organizations control the above layers, different access models are used to deliver broadband services, leading to either infrastructure- or services-based competition. Infrastructure-based competition means each service provider has to own and operate all layers of the network. In order to enter this market, a new service provider has to build its own network infrastructure. In services-based competition, service providers leverage common physical infrastructure in order to deliver broadband services. This is predicated on open access networks that provide fair and non-discriminatory access

[4] Wikipedia. Broadband article. Accessed 19 June 2016.

to the underlying layer(s) for all service providers. This access would either be at the network provider or physical infrastructure layer (Figure 2).



(Adapted from [Broadband Communities Magazine](#) [5])

Figure 1. Carrying Capacities of Broadband Access Solutions

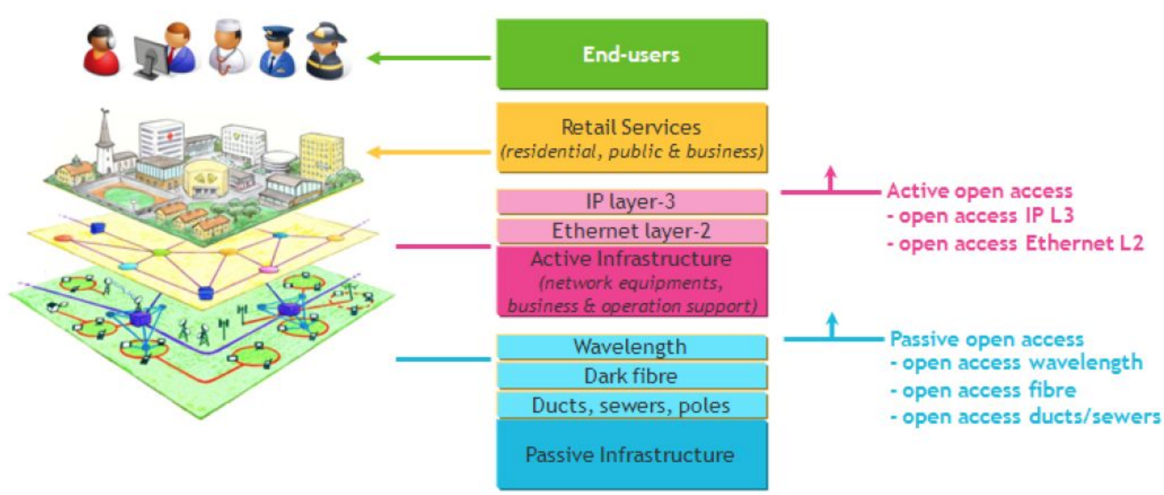


Figure 2. Network layers and types of open access networks. *Source: Fibre to the Home Council* [6]

While download speeds are the most commonly cited attribute reflecting broadband quality, access to symmetric bandwidth is becoming increasingly important. Symmetric bandwidth means the upload speed is as fast as the download speed. Currently in Alberta, symmetric bandwidth is not the norm, as most commercial internet packages provide upload:download

[5] Broadband Communities Magazine. The FTTH Primer. Accessed 27 July 2016.
[6] Fibre to the Home Council Europe. FTTH Handbook - Edition 7. Feb. 16, 2016.

ratios ranging between 1:30 and 1:5. In order to participate in the digital economy and take advantage of the growing number of cloud services available, it is expected that creating and uploading content to the internet will take on a larger role. This in turn will put greater demand on improving access to higher upload speeds.

Current Landscape: Broadband Availability in Alberta

In 2013, the Government of Alberta announced that 98% of Albertans had access to download speeds of at least 1.5 megabits per second (Mbps). This was partly due to the $5.1 million of provincial funding for the Central Alberta Satellite Solution and Final Mile Rural Connectivity Initiative.[7] [8] In 2015, the Canadian Radio-television and Telecommunications Commission (CRTC) reported that this accessible speed had grown, with 98% of Alberta households having access to download speeds in excess of 5.0 Mbps[9] (see Table 1) and a penetration rate of 81%.[10] On average, the national speeds were reported to be 18.6 Mbps download and 7.3 Mbps upload in 2015.[11] Alberta was reported to have lower speeds than the national average, with speeds of 13.5 Mbps download and 5.0 Mbps upload.

Table 1. Broadband Availability in Alberta by Download Speed, 2014 per CRTC Communications Monitoring Report 2015

Download Speed (Megabits per second)	Availability (Percentage of Households)
1.5 - 4.9	**99**
5.0 - 9.9	**98**
5.0-9.9 with LTE	**99**
10.0-15.9	**86**
16.0-24.9	**85**
25 +	**81**

Source: Prepared by Cybera using data from 2015 CRTC Communications Monitoring Report. These figures exclude satellite technologies.

In April 2014, the Government of Canada released the *Digital Canada 150* national digital economy strategy. As part of this strategy, $305 million of the *Connecting Canadians* program was earmarked to address gaps in the delivery of high-speed internet (at speeds of

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[7] Government of Alberta. Alberta leads in access to high speed internet, 6 December 2013. Accessed 1 June 2016.
[8] Service Alberta. How It Works. Accessed 1 June 2016.
[9] CRTC. Communications Monitoring Report, Table 5.3.13, p. 210. Accessed 4 July 2016.
[10] CRTC. Communications Monitoring Report, Figure 5.3.14, p. 207. Accessed 4 July 2016.
[11] CIRA. Canada's Internet Performance: National, Provincial, and Municipal Analysis. April 2016. Accessed 20 July 2016.

at least 5 Mbps) to rural and remote communities across the country.[12] Of this funding, $50 million was designated for Nunavuk and Nunavik,[13] leaving $255 million for the remainder of Canada. To date, Alberta has received $3.6 million of the *Connecting Canadians* funding (split between IWantWireless.ca and Arrow Technology Group Ltd) to expand services to a target subscriber base of 6,000 households.[14]

The *Connecting Canadians* initiative also created a national broadband coverage map[15] (see Figures 3 & 4), with input from ISPs, to identify the areas of Canada that have underserved (< 5 Mbps download speed) or unserved broadband needs. The CRTC released a similar map (see Figures 5 and 6) in April 2016. It depicts the availability of broadband internet access service at or above the CRTC's target speeds of 5 Mbps download and 1 Mbps upload within hexagonal service areas of 25 square kilometres.

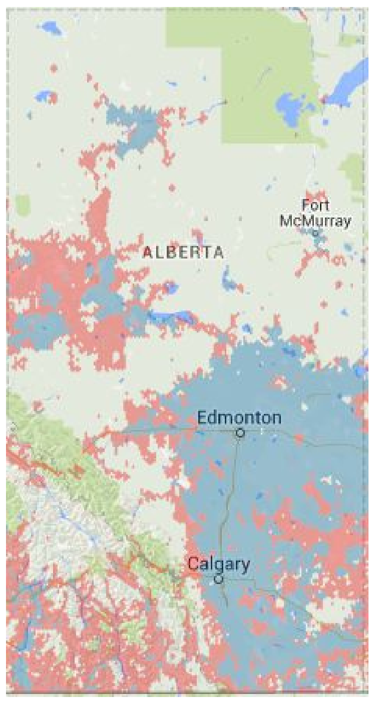

Figure 3. Connecting Canadians Broadband Internet Coverage Map of Alberta. *Source: Industry Canada*[16]

[12] Industry Canada. About Connecting Canadians, 26 June 2016. Accessed 1 June 2016.
[13] Industry Canada. Digital Canada 150 - Northern Component, 20 May 2015. Accessed 4 July 2016.
[14] Government of Canada News. Connecting Canadians, 8 April 2016. Accessed 29 May 2016.
[15] Industry Canada. Digital Canada 150: Connecting Canadians - Could your area benefit? 18 November, 2014. Accessed 1 June 2016.
[16] Industry Canada. Digital Canada 150: Connecting Canadians - Could your area benefit? 18 November, 2014. Accessed 1 June 2016.

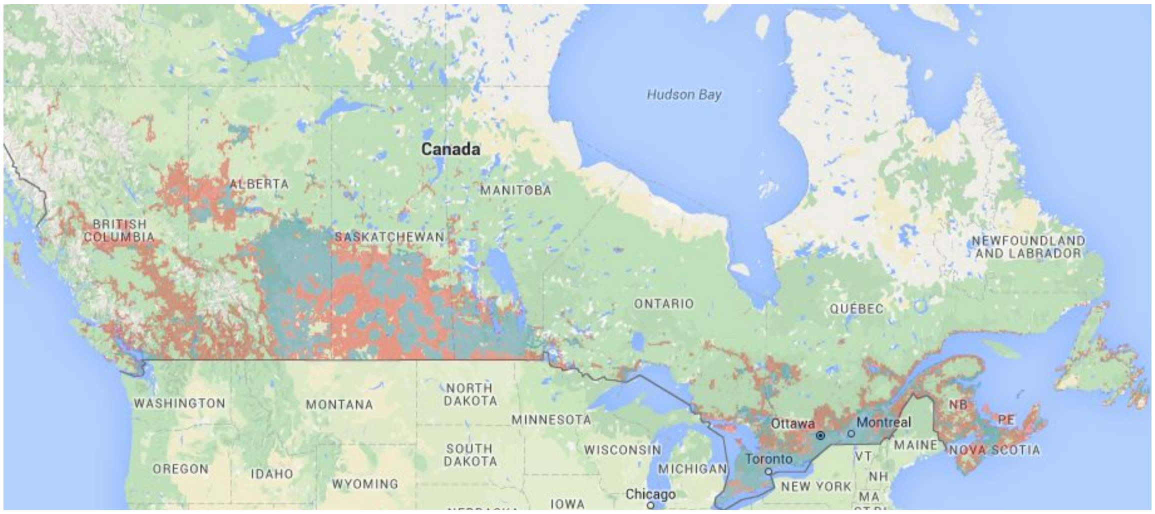

Figure 4. Connecting Canadians Broadband Internet Service Coverage Map of Canada *Source: Industry Canada*[17] *Blue areas indicate regions where internet download speeds of   5 Mbps are available and red areas indicate where speeds of <5 Mbps are available. Further raw data is available on the [Industry Canada website.](#)*

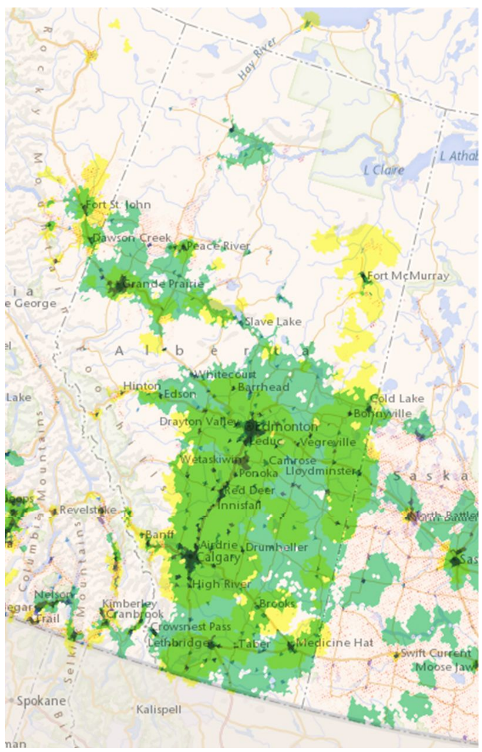

Figure 5. CRTC Broadband Internet Service Coverage in Alberta. *Source: CRTC* [18]

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[17] Industry Canada. [Digital Canada 150: Connecting Canadians - Could your area benefit?](#) 18 November, 2014. Accessed 1 June 2016.

[18] CRTC. [Broadband Internet Service Coverage in Canada](#), 20 April 2016. Accessed 6 June 2016.

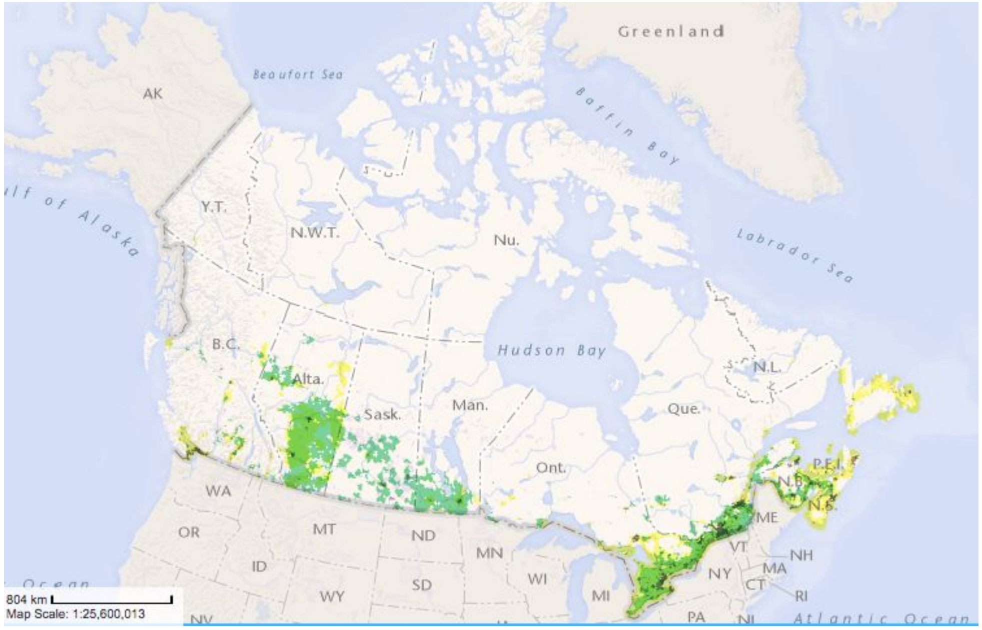

Figure 6. CRTC Broadband Internet Service Coverage in Canada. ***Source: CRTC*** [19] *Coloured areas indicate availability of internet download/upload speeds of 5/1 Mbps. Green represents fixed wireless access and yellow represents LTE access. Note that there is some overlap in this coverage. An interactive map with various layers is available on the CRTC website.*

Within the CRTC map, a hexagon is classified as served if at least one household in the 25 square kilometre area has access to internet service at speeds of at least 5 Mbps download and 1 Mbps upload. In the course of our conversations with stakeholders, this mapping methodology received criticism from some fixed wireless ISPs, as it can lead to an overrepresentation of broadband coverage in Alberta. Similar critiques were put on public record at the CRTC's April 2016 *Review of basic telecommunications services* hearing.[20] The CRTC also notes that "Internet speeds at or above the CRTC's targets may not be achievable throughout the entire LTE coverage area."[21]

Cybera has further heard from fixed wireless ISPs (whose services cover the largest areas of the maps) that download/upload speeds of ≥ 5/1 Mbps may not be available to all subscribers at all times. Fixed wireless access can be complicated by weather, the distance of the subscriber to a tower, and congestion on the wireless access portion of the network, particularly during peak internet usage periods. Please refer to the Fixed Wireless Access/Wireless Internet Service Providers section of this chapter for more information on wireless access networks in Alberta.

Using the estimate that 98% of the province's population is covered, this leaves 2% — 80,000 Albertans — without access to internet at speeds of at least 5 Mbps download and 1

[19] CRTC. Broadband Internet Service Coverage in Canada, 20 April 2016. Accessed 6 June 2016.
[20] CRTC. Transcript, Hearing, April 11 2016, line 1681. Accessed 2 June 2016.
[21] CRTC. Broadband Internet Service Coverage in Canada, 20 April 2016. Accessed 6 June 2016.

Mbps upload. All access rates discussed above do not take into consideration the affordability of broadband service.

Current Landscape

Alberta SuperNet

Vision and History

The Alberta SuperNet is a fibre optic network of cables and wireless access towers that connect public institutions across the province — schools, hospitals, colleges, universities, libraries, and municipal offices [22] — to a broadband network. The goal of the SuperNet is to provide high-speed networking and internet access to these public institutions to enable efficient and ubiquitous delivery of business and social services.

The SuperNet is designed to cover Alberta's large geographical area (661,000 km^2)[23] and to serve both the urban and rural populations.

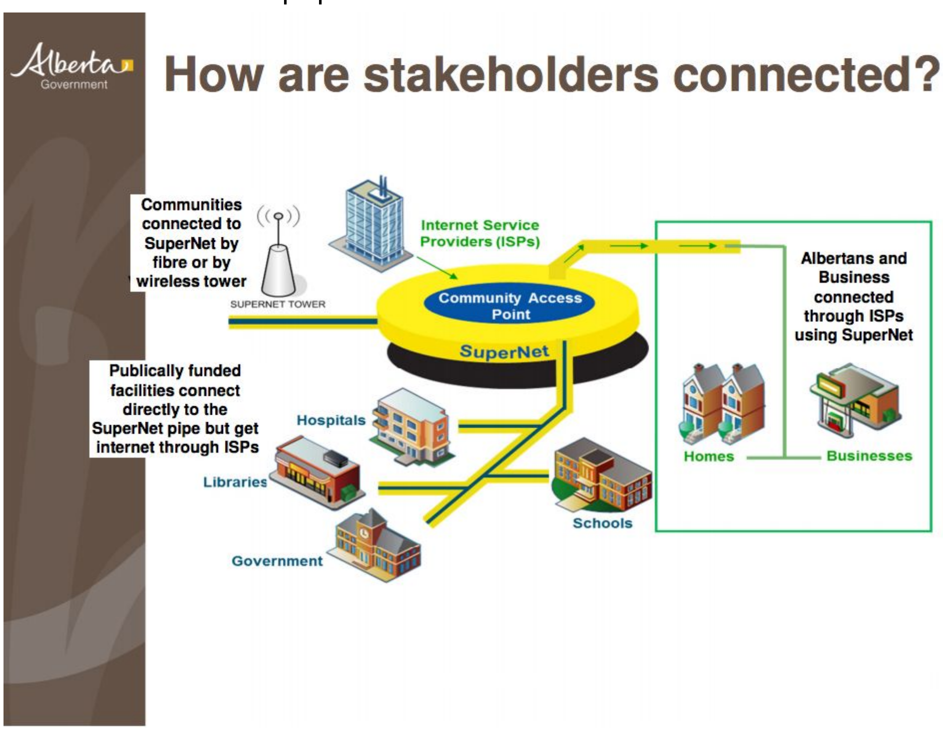

Figure 7. SuperNet - How are stakeholders connected? *Source: June 8, 2016 Service Alberta IM Aware presentation* [24]

[22] Service Alberta. The Network (Technical Information). Accessed 3 June 2016.
[23] Service Alberta. Alberta SuperNet. Accessed 2 May 2016.
[24] Service Alberta. IM Aware presentation - Alberta SuperNet, p. 4, 8 June 2016. Accessed 5 July 2016.

The SuperNet was a $295 million strategic infrastructure investment by the Government of Alberta ($193 million) and Bell Canada ($102 million). Construction was completed in 2005.[25] Final costs, including subsequent extensions, were approximately $330 million.[26] At the time of completion, the SuperNet was the first jurisdiction-wide fibre optic network in North America.

The SuperNet is governed by Service Alberta, a ministry of the Government of Alberta. The operations and management of the SuperNet were contracted to Axia SuperNet Ltd (a wholly owned subsidiary of Axia NetMedia Corporation) on the Extended Area Network (EAN), and to Bell Canada on the Base Area Network (BAN).

The SuperNet consists of over 15,000 km of fibre and 1,930 km of microwave connectivity, comprised of Axia and Bell owned fibre and network assets combined with licensed assets from the Government of Alberta.[27] The initial agreement spanned 2005-2015, and was extended from its initial 10-year term for an additional three-year period until June 30, 2018.[28]

At the time of the awarding of the initial SuperNet contract, Axia was a Calgary-based company with limited experience in telecommunications.[29] It has since expanded operations into France, the United States, and today operates almost 30,000 km of fibre.[30] In March 2016, Axia Netmedia Corporation received an acquisition offer of $272 million by the Swiss firm Partners Group and the deal was finalized on July 29, 2016.[31, 32]

The June 2018 expiry of the SuperNet operating contract is providing government with an opportunity to review the approach for SuperNet and look at possible ways for it to help enable improved rural internet services, while enhancing the delivery of online government services to Albertans. On February 16, 2016, Service Alberta issued a Pre-Qualification Request (PQR), to identify potential service providers, to review business and technical

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[25] Government of Alberta. News Release: New Alberta SuperNet agreements will better serve Albertan, 11 July 2005. Accessed 29 May 2016.
[26] Middleton, C. and Given, J. (2010) Open Access Broadband Networks in Alberta, Singapore, Australia and New Zealand. The 38th Research Conference on Communication, Information and Internet Policy, 1 October 2010. Accessed 29 July 2016.
[27] Axia NetMedia. Axia NetMedia Corporation Management's Discussion & Analysis for the three months ended March 31, 2016, 10 May 2016, p.3. Accessed 10 June 2016.
[28] Axia NetMedia via Newswire.ca. Continuity of Services Assured for Axia's Alberta Customers. Accessed 2 June 2016.
[29] Mitchell, David. Broadband at the Margins: Challenges to SuperNet deployment in rural & remote Albertan communities, University of Calgary, 2004, p.5. Accessed 2 June 2016.
[30] Axia. Who is Axia? Accessed 2 June 2016.
[31] Axia NetMedia Corporation via Newswire.ca. Partners Group Agrees to Acquire Axia for $4.25 per Share in Going Private Transaction. 9 March 2016. Accessed 28 April 2016.
[32] Edmonton Journal. Axia NetMedia and Partners Group complete going private transaction. July 29, 2016. Accessed July 29, 2016.

requirements, and to gather current information on industry trends.[33] Service Alberta also issued a concurrent Request for Proposal (RFP) for a procurement fairness monitor.[34] In May 2016, telecommunications operators Axia, Bell, Telus, and Zayo were prequalified to participate through the PQR process.[35] Service Alberta are also acting as an advocate to the federal government with regards to the internet needs of rural Albertans, and advocating for access to federal broadband funding.

SuperNet Operating Model

The Alberta SuperNet is a backhaul network (or 'middle-mile') that connects on one end to local access networks ('first-' or 'last-mile' connections) and on the other end to separate networks that connect to the internet. It consists of base area (BAN) and extended area (EAN) fibre networks, as well as an extended area wireless network (EAWN). The BAN connects 27 larger urban centres, while the EAN and EAWN reach 402 smaller rural communities (see Figure 8 and Appendices: A1. Networking – SuperNet BAN, and A2. EAN and EAWN communities). The BAN and EAN are supported by Meet-Me-Facilities (MMF) and Points of Presence (PoP), respectively, in each of the communities, to allow interconnection to other networks (e.g. access networks). The EAWN is specifically used to connect remote communities to the SuperNet. Overall, the SuperNet connects over 4,700 provincial (government, learning, health, library) and municipal facilities.[36]

The Government of Alberta set a universal fee structure across the province for monthly flat-rate services, irrespective of a subscriber's physical location. This model contradicts conventional private sector telecommunications billing practices, where rates tend to be lowest in urban centres and highest in rural communities.

The SuperNet does not directly serve residential subscribers. It is intended to provide affordable wholesale fibre access to local ISPs. The ISPs can then provide last-mile connectivity and internet service to residents of SuperNet communities. For a partial list of ISPs providing services through the Alberta SuperNet, please see Appendix A3.

Public sector organizations that utilize Axia's Next Generation Network (NGN) services include Government of Alberta ministries, schools, health facilities, libraries and municipalities.[37] School districts receive subsidies for each site of $800 per month that may

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[33] Service Alberta. Procurement Services. Pre-Qualification Request (PQR) For Provincial Broadband Services PQR 288-PA-PBS, Reference number: AB-2016-01170, 16 February 2016.
[34] Alberta Purchasing Connection. Provincial Broadband Services (PBS) Fairness Monitor - Reference AB-2016-01085, 11 February 2016.
[35] Alberta Purchasing Connection. Opportunity Notice: Provincial Broadband Services, Awarded Vendors, 5 May 2016.
[36] Axia SuperNet Ltd. What is the Alberta SuperNet? Accessed 28 May 2016.
[37] Axia NetMedia Corporation Management's Discussion & Analysis For the three and six months ended June 30, 2014 and 2013 (published 8 August 2014).

only be spent on connecting to the Alberta SuperNet to help offset costs.[38] Pricing for NGN services were revised in September 2015 for all ministries and effective until June 30, 2018. Previous to that, only Alberta Education had been able to utilize updated pricing. These packages provide bandwidth services across all government ministries, with the goal of delivering “dramatically higher bandwidth rates at a significantly lower cost per megabit.” [39] Of note, the cost of connecting First Nations schools to the SuperNet is covered by the Federal Government through the department of Indigenous and Northern Affairs.[40]

Figure 8. Map of the Alberta SuperNet showing the Base Area and Extended Area Fibre Networks and the Extended Wireless Area [41]

[38] Alberta School Boards Association. Education Funding. Accessed July 29, 2016.
[39] Axia. E-mail communication: Service Alberta and Axia announce newly available suite of SuperNet services for all government ministries, 18 September 2015.
[40] Alberta Education. Learning and Technology Policy Framework, 2013. Accessed 27 July 2016.
[41] Service Alberta. SuperNet Map. Accessed 10 May, 2016.

Table 2. SuperNet Services for Government Ministries [42]

<table>
<tr><th colspan="2">SuperNet NGN Service</th></tr>
<tr><td>Base package of 100 Mbps:
$898/month
90 Mbps Basic
5 Mbps Interactive
5 Mbps Real Time
Includes up to 10 Layer 2 or Layer 3 VPNs with additional VPNs available upon request at no additional cost.</td><td>Additional Megabits available in increments of 1 Mbps
Basic - $0.75/Mbps
Standard - $2.50/Mbps
Interactive - $4.00/Mbps
Real Time - $11.00/Mbps</td></tr>
<tr><th colspan="2">SuperNet Line Rate Service</th></tr>
<tr><td>100 Mbps Line Rate Service:
$798/month

1,000 Mbps Line Rate Service:
$1098/month
Includes up to 10 Layer 2 or Layer 3 VPNs with additional VPNs available upon request at no additional cost.
Up to 4 physical 1 Gbps Ethernet Ports.</td><td>For customers with large bandwidth requirements, but don’t need multiple classes of service.
Service can be leveraged by customers with a sophisticated network and IT team, who would like more control over their network.</td></tr>
<tr><th colspan="2">SuperNet 10 Gbps Service</th></tr>
<tr><td>10 Gbps Service:
$5,098/month
Includes up to 10 Layer 2 or Layer 3 VPNs with additional VPNs available upon request.
Includes 1 Physical 10 Gbps Ethernet Port.</td><td>For customers with very large bandwidth requirements, but don’t need multiple classes of service.
Service can be leveraged by customers with a sophisticated network and IT team, who would like more control over their network.</td></tr>
</table>

CyberaNet

CyberaNet is Alberta’s publicly-funded, high-speed research and education (R&E) network. CyberaNet, which is operated by Cybera, connects the province’s education and entrepreneurial institutions to provincial, national and international R&E networks, and to the

[42] Axia. E-mail communication: Service Alberta and Axia announce newly available suite of SuperNet services for all government ministries, 18 September 2015.

internet (Figure 9). Created in 1993, CyberaNet serves post-secondary institutions (PSIs), K-12 schools, government agencies, not-for-profit organizations and high-tech incubators. (The company operated as WURCNet between 1993-1999, and Netera between 1999-2007). The Government of Alberta supports CyberaNet as a strategic investment in provincial innovation through operational funding from the Ministry of Economic Development and Trade.

CyberaNet consists of CANARIE's national R&E network and leased fibre optic infrastructure services — through which logical network connections are configured to reach the Alberta SuperNet and municipal fibre networks in Calgary, Edmonton and Lethbridge. As well as operating the province's R&E network, Cybera offers an Internet Buying Group and Peering service to its members. For the Internet Buying Group, Cybera aggregates members' internet traffic and purchases bulk internet from contracted ISPs on their behalf, thereby obtaining lower cost bandwidth. In order to utilize this service, members must be connected to CyberaNet either through the SuperNet or via another network provider.

For Peering, Cybera leverages direct connections to the Calgary, Seattle, Toronto and New York Internet Exchanges to provide a transit exchange service with major internet content providers such as Google, YouTube and Facebook, thereby reducing overall bandwidth usage.

As of June 2016, CyberaNet is connected to 17 post-secondary institutions, 44 K-12 school districts, 9 government or non-profit members, and 2 enterprise members, representing 55% and 93% of all K-12 and PSI Alberta students, respectively. (For a current list of Cybera members, see http://www.cybera.ca/membership/current-members/).

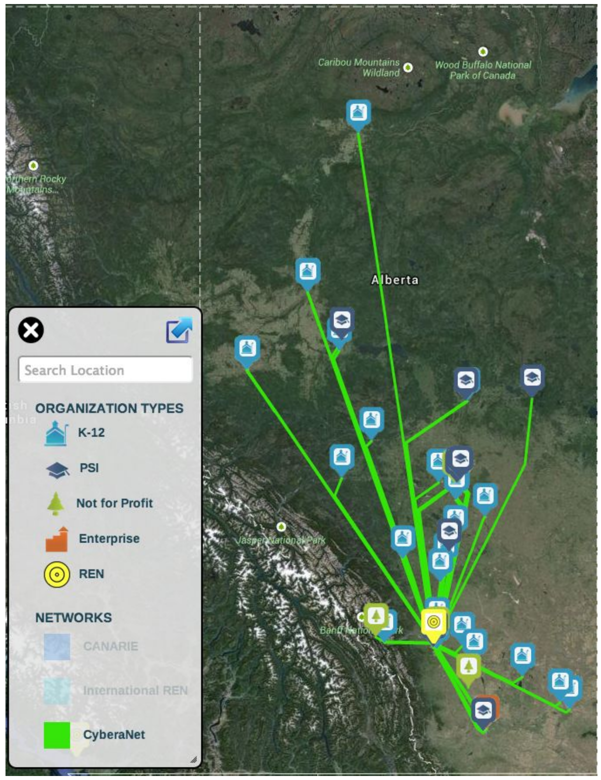

Figure 9. Network map of CyberaNet. *(The network lines are representative and do not reflect the actual path of the network connections)* [43]

Large ISPs

Access to broadband internet in urban jurisdictions in Alberta is primarily provided by large telecommunications and cable companies.

In Alberta, the largest ISPs are Shaw Communications and Telus Corporation, both of which offer residential and business internet services. As of July 2016, Shaw offers business and residential packages of up to 150 Mbps download and 15 Mbps upload speeds for $132.95/month and $135.00/month, respectively.[44, 45] Telus offers slightly higher bandwidth packages: up to 150 Mbps download and 30 Mbps upload for $120/month for residential services. Each of the residential plans have data caps, ranging from 65-1,000 GB/month, depending on the package. Shaw's Business Internet 150 plan[46] offers unlimited data and Telus offers business packages that do not have a data cap, starting at $85/month.[47] Additionally, business services provided by Shaw[48] and Telus[49] offer plans that provide up to

[43] Cybera. Network Map. Accessed 2 June 2016.
[44] Shaw. Business Internet. Accessed 20 July 2016.
[45] Shaw. WideOpen Internet 150. Accessed 20 July 2016.
[46] Shaw. Business Internet. Accessed 20 July 2016.
[47] Telus. Business Fibre Internet Plans. Accessed 9 June 2016.
[48] Shaw. Shaw Internet Solutions - Fibre Gateway. Accessed 29 July 2016.
[49] Telus. Business Internet. Accessed 29 July 2016.

10 Gbps symmetric upload and download speeds (and beyond). These networks are also leveraged by third party providers such as iTel, who provide internet services utilizing the underlying fibre infrastructure.[50]

It is worth noting that commercial providers do not guarantee that a customer will attain the stated maximum connection speed. Most provide an 'up to' speed commitment. Of note, Telus has begun stating a range of speeds that can be expected, although it is not clear whether those are sustained or "up-to" speeds as well.[51]

Municipal / Community Networks

A number of communities have invested in municipally owned infrastructure for broadband delivery both in Alberta and, more broadly, nationally and internationally. The reasons for local investment in a communications network vary, but frequently include economic development, affordability, and improved access to education, healthcare, and social services.

There are multiple community broadband projects either completed or underway in the United States. According to the Institute for Local Self Reliance there are:

- 83 communities with a publicly owned FTTH network reaching most or all of the community.
- 77 communities with a publicly owned cable network reaching most or all of the community.
- Over 185 communities with some publicly owned fiber service available to parts 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 Gbps services.[52]

Several municipal governments and local economic development authorities in Alberta are either actively exploring community broadband options, or undertaking broadband projects, that follow a variety of possible models. For example, the RedNet partnership manages and operates a fibre loop serving the City of Red Deer, Red Deer Library, Red Deer Public Schools, and Red Deer Catholic Schools. As a consortia, they share networking services via the RedNet network. As of June 2016: St. Albert is in the process of procuring services to install fibre for stage 2 of its city fibre optic network;[53] the City of Calgary has made dark fibre

[50] iTel. iTel homepage. Accessed 9 June 2016.
[51] Telus. Telus Internet Plans. Accessed 9 June 2016.
[52] Institute for Local Self Reliance. Community Network Map, October 2015. Accessed 10 June 2016.
[53] Alberta Purchasing Connection. Installation of Fibre Optic - Reference AB-2016-03817. Accessed 6 June 2016.

available for lease[54]; and the Lethbridge Electric Utility has provided dark fibre services to public oriented organizations within the City of Lethbridge.[55]

In early 2016, the Alberta Ministry of Economic Development and Trade, in conjunction with University of Alberta professors Dr. Michael McNally and Dr. Rob McMahon, conducted 8 consultations with Regional Economic Development Authorities (REDA) across the province on the topic of network infrastructure. The goal of the initiative is to produce and make available a “Getting Started - Building a Broadband Consensus” document for communities and the general public by the end of October 2016.[56]

A robust and promising approach to developing municipal broadband projects involves consolidating and organizing efforts into regional alliances of local government representatives. This approach was successfully followed by K-Net, based in Sioux Lookout, Ontario; the Eastern Ontario Regional Network; and the SouthWestern Integrated Fibre Technology network (SWIFT) in Ontario. The Alberta SouthWest Regional Alliance, through its Broadband for Economic Development (B4ED) initiative, focuses on developing a regional strategy to drive development and the application of broadband networks for the purpose of economic and community development. The Alberta Southwest Regional Alliance compiled five business models for community broadband deployment,[57] which were presented to the Van Horne Institute's Digital Futures symposium in March 2016. In addition to the Alberta SouthWest Regional Alliance, a number of other REDAs are in various stages of conducting broadband preparedness assessments. These REDAs have shown an interest in policies that facilitate broadband deployment, such as “dig once” requirements, which entail deploying fibre infrastructure or at least conduit any time a construction project is initiated.

The Van Horne Institute’s biannual Digital Futures symposia on rural broadband regularly feature discussions around: broadband and socioeconomic development; building the business case and models for a networked community; technical considerations around community broadband projects; and the policy and regulatory landscape. These events are well attended by municipal politicians and representatives of regional economic development authorities.

Olds

O-Net is Canada’s first example of a community owned and operated fibre to the premise (FTTP) deployment. It was conceptualized in 2004 by the Technology Committee of the Olds Institute for Community and Regional Development. The Olds Institute, whose aim is to

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[54] City of Calgary. Submission regarding notice no. DGTP-002-2015 Petition to the Governor in Council concerning Telecom Regulatory Policy CRTC 2015-326, 21 December 2015. Accessed 8 June 2016.
[55] Call Me Power. City of Lethbridge Electric Utility, 15 December 2015. Accessed 8 June 2016.
[56] Dr. Michael McNally. E-mail correspondence, 4 July 2016.
[57] Bob Dyrda. Alberta SouthWest Broadband for Economic and Community Development, 8 March 2016. Accessed 13 May 2016.

promote development through relationship building and civic engagement,[58] owns the network infrastructure. O-Net was established separately as an ISP to supply services over the infrastructure. Construction began in 2011.[59] O-Net now operates as a “triple play” service provider, with internet, telephone, and television services available to all residents of Olds.

The Olds example has demonstrated the importance of having a strong showing of local support in order for a community broadband project to be successful. At a 2015 broadband information session with the Calgary Regional Partnership, Mitch Thomson, executive director of the Olds Institute, remarked that, “The Olds Institute has over 150 volunteers and 11 standing committees. [We] have tried to tally what value those volunteers brought to the process. At a $10.00/hour rate, it would reflect millions of dollars of dedicated expertise and effort from volunteers in many corners of our community.” [60]

O-Net offers internet packages at speeds of 50 Mbps, 100 Mbps, and 1 Gbps at $90/month, $100/month, and $125/month, respectively.[61] O-Net also wholesales service to communities interested in developing FTTP networks. O-Net connects to the Calgary Internet Exchange (YYCIX) through fibre leased from Shaw.[62] As a result, O-Net can serve as the ISP over any network that also has a fibre connection to Calgary. At present, O-Net provides service to the village of Waterton in Waterton National Park.[63]

Waterton

Waterton began construction on a fibre network by leveraging funds from a Parks Canada initiative that required Parks Canada offices to have a fibre connection. Telus fibre optic cables run to the entrance of the park and access was extended to near the town by Parks Canada during the construction of the Kootenai Brown Trail.[64] Waterton has procured a fibre connection to Calgary through Telus and utilizes O-Net as its ISP. The Village of Waterton intends to complete residential connections over the next three years (in partnership with a Parks Canada initiative to upgrade water and sewer services).[65]

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[58] Calgary Regional Partnership. Notes of June 17, 2015 CRP Broadband Information Session, 17 June 2015, p.4. Accessed 22 May 2016.
[59] O-Net. About Us. http://o-net.ca/about-us/ Accessed 24 May 2016.
[60] Calgary Regional Partnership. Notes of June 17, 2015 CRP Broadband Information Session, 17 June 2015, p.4. Accessed 22 May 2016.
[61] O-Net. Products. http://o-net.ca/internet/ Accessed 24 May 2016.
[62] Calgary Regional Partnership. Notes of June 17, 2015 CRP Broadband Information Session, 17 June 2015, p.6. Accessed 22 May 2016.
[63] Mountain View Gazette. O-Net could become a nationwide Internet, phone, TV service provider. http://www.mountainviewgazette.ca/article/ONET-could-become-nationwide-20151110 Accessed 24 May 2016.
[64] Pincher Creek Echo. Fibre optic speeds in Waterton, 25 February 2015, p.5.
[65] Calgary Regional Partnership. Notes of June 17, 2015 CRP Broadband Information Session, 17 June 2015 p.2. Accessed 22 May 2016.

Waterton offers a wireless network that covers the town and townsite campground. According to Improvement District chairman, Brian Reeves, wireless internet access is "the number one thing people ask for, no matter whether they're staying in a hotel or in the campground in a motorhome."[66] The project, being spearheaded by the Waterton Park Community Association, aims to eventually connect businesses and residences to the town network.

Parkland

Parkland County has utilized provincial and federal grants to construct a wireless communications network comprised of 20 towers for service providers to collocate on, thereby extending wireless broadband and mobility coverage. Three of the towers are or will be connected with fibre by fall 2016, and the remaining 17 utilize a microwave connection. The towers are designed to serve a full range of rural communications service providers, including: broadband (internet), mobility (cell), public safety (fire, police, ambulance) and enterprise customers.

This model is intended to allow providers who offer different wireless services to residents and businesses to be accommodated on each tower. The County is not a Wireless Internet Service Provider (WISP), but provides infrastructure for the use of WISPs in return for rent (which covers the operating costs of the towers).[67] Parkland is the first county in Canada to pioneer this model. Parkland now faces the challenge of improving network capacity with fibre to each tower and encouraging a competitive service environment for ISPs.[68]

Public WiFi

The availability of public WiFi hotspots has continued to grow in Alberta and worldwide.[69] Consumers now expect WiFi wherever they go, and it is becoming an important service feature not only for ISPs, but for retail service providers as well as public organizations such as the various levels of government. This section will provide an overview of the types of public WiFi available in Alberta.

ISP WiFi Hotspots

The largest provider of WiFi hotspots in Canada (based on the number of access points available) is the Shaw Go WiFi network, with more than 75,000 hotspots across Western Canada.[70] This number has almost doubled since the first version of this report was released

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[66] Pincher Creek Echo. Fibre optic speeds in Waterton, 25 February 2015, p.5.
[67] Parkland County. SMART Parkland Intelligent Community. Accessed 8 July 2016.
[68] Parkland County. Phone conversation with Barb Scully, Connected Communities Coordinator, July 12, 2016.
[69] Australian Communications and Media Authority. Strong signals: Growing use of public Wi-Fi hotspots. November 26, 2014. Accessed 10 June 2016.
[70] Shaw. Shaw Free WiFi. Accessed 26 May 2016.

in October 2014, when Shaw listed 40,000 access points. The full Shaw Go WiFi network is open to Shaw customers and is available for “Guest Access” in select locations.[71] Shaw says that, on average, end users utilize 6 GB of data per month using the Shaw Go WiFi service. Bell also offers WiFi access points across Alberta, with approximately 400 partner retail outlet locations.[72] In June 2015, Telus announced it would make free public WiFi available at more than 8,000 locations throughout British Columbia and Alberta.[73] As of June 2016, a search for Alberta on Telus’s WiFi access point finder reveals approximately 2,100 hotspots, largely concentrated in Calgary and Edmonton.[74]

Municipally driven WiFi Hotspots

In 2015, The Olds Institute directed funds from its social enterprises Mountain View Power and O-NET to the development of a free public WiFi network in the town of Olds. There are currently more than 80 hotspot locations in and around businesses, and another 19 outdoor access points in parks, campgrounds, exhibition grounds, schools and commercial areas within the community.[75] Approximately 11,000 people connect to this network every month, on average. Another 2,600 devices connect monthly to the network that has been developed within the Olds Hospital and Care Centre (patients have access to free WiFi and can receive their O-NET services while in care).[76]

The City of Edmonton is offering a program called Wireless Edmonton that provides free public WiFi in some of the City’s publicly accessible facilities. More than 14,000 devices connect to Edmonton’s “Open City Wi-Fi” every week, utilizing more than 2TB of data traffic. The service routinely accepts over 4,500 concurrent sessions during peak periods.[77]

The City of Calgary has also launched public WiFi access in many of its facilities, such as recreation centres, golf courses, and C-Train stations. The City awarded the contract to provide public WiFi to Shaw Communications, who provide access through the Shaw Go WiFi service. Any user is able to utilize the service and does not need to be a Shaw customer. Out of the 40+ locations offering public WiFi, the City Hall C-Train station is the most popular, with over 36,000 users every month.[78]

Smaller municipalities in Alberta also provide free WiFi. Grande Prairie announced its public WiFi initiative in 2013, and leveraged a Building Canada grant to split the funding of the

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[71] Shaw. Guest Access. Accessed 25 May 2016.
[72] Bell. Bell Wi-Fi locations. Accessed 26 May 2016.
[73] TechVibes. Telus Unveils Free Wifi Across BC, Alberta. 8 June 2015. Accessed 8 June 2016.
[74] Telus. Telus WiFi Finder App. Accessed 8 June 2016.
[75] Olds Institute. E-mail communication with Mitch Thomson, 8 July 2016.
[76] O-NET. Community WiFi Hotspot Map. 22 April 2016. Accessed 20 May 2016.
[77] City of Edmonton. Open City WiFi. Accessed 26 May 2016.
[78] Calgary Transit. We’ve expanded public Wi-Fi to CTrain stations in the downtown corridor. March 2, 2016. 2 March 2016. Accessed 8 June 2016.

deployment over three levels of government. Its WiFi service not only provides internet to the public, but also connects traffic signals in the city to help optimize traffic flow.[79]

On a much smaller scale, the town of Hanna provides WiFi to residents and visitors in and near most municipal buildings, and Vulcan was one of the first counties to provide public WiFi access in its downtown in 2009.[80] [81]

Business Public WiFi

Open access WiFi points are also increasingly being made available through private businesses. Several retail and food chains have partnered with ISPs to provide wireless access in their locations, such as McDonalds' partnership with Bell. The motivation for offering this service includes keeping customers engaged in the business longer, analyzing customer behaviour, and in retail, facilitating comparison shopping in order to induce purchases.[82]

Provincial and National Parks

Parks Canada announced in 2014 that it would begin installing access points at certain visitor centres and campgrounds around the country[83], but in Alberta, none of the federal campgrounds have been connected yet. However, there are several provincial parks that offer WiFi access at their visitor centres, such as Peter Lougheed and Cypress Hills. The complete list is provided on the Alberta Parks website.[84] On weekends during peak tourism periods, Waterton Townsite campground has seen 300 network connected devices, on average. This is the same number of connected users a similarly-sized hotel would see.[85]

Rural

Rural access networks provide connectivity between transport networks and individual premises, enabling service providers to deliver residential and business services. Transport networks are comprised of optical fibre, while most rural and remote access networks often use wireless technologies to reach subscribers. Digital subscriber lines and cable are used where it is available.

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[79] Adam Jackson. Outdoor WiFi on its way to Grande Prairie. Grande Prairie Daily Herald Tribune. March 27, 2013. Accessed 8 June 2016.
[80] Town of Hanna Public Wireless FAQ. Accessed 19 May 2016.
[81] Kevin Rushworth. Wi-Fi access hits downtown Vulcan. Vulcan Advocate. August 3, 2009. Accessed 8 June, 2016.
[82] ICT Pulse. 6 ways your business can benefit from offering free Wi-Fi. August 26, 2011. Accessed 8 June 2016.
[83] CBC. Wi-Fi hotspots coming to Canadian parks. April 29, 2014. Accessed 8 June 2016.
[84] Alberta Parks. Visit our parks. Accessed 8 June 2016.
[85] Calgary Regional Partnership. Notes of June 27, 2015 CRP Broadband Information Session, p.2. Accessed 22 May 2016.

Virtually all premises in rural Alberta are served by at least one wireline or wireless access network, but service levels and quality of service vary greatly.[86] Differences in network operating environments, and in the media and architectures of access networks, account for considerable variation in the performance and cost of service provision. Fixed and mobile wireless are currently the most common solutions for broadband internet access in rural Alberta. Satellite wireless is often used in remote or sparsely populated areas. Several communities and regional economic development authorities are also in the process of exploring or deploying various models of fibre-to-the-premise solutions (see below). Regardless of the access technology, there is widespread agreement that improved rural broadband access is necessary for bridging the digital divide, as well as supporting economic and social growth. A recent study estimates that on average, rural communities experience about 25% worse connectivity compared to their urban counterparts as measured through a number of metrics such as speed, latency, and jitter. For example, rural Canadian download and upload speeds were 14.8 Mbps and 6.0 Mbps, respectively, compared to 19.8 Mbps and 7.7 Mbps in urban communities. [87]

Rural Fibre

Axia Connect (a subsidiary of Axia NetMedia) has begun investing in FTTP networks in small communities. Fibre internet is now available in Vulcan, Nanton and Nobleford. Construction on fibre networks in Barnwell, [88] Stirling, [89] and Pincher Creek [90] was announced in spring 2016. Before investing in a community fibre build, Axia first requires that 30% of homes and businesses in the town register their interest at Axia.com. Axia's fibre plans start at $59/month for 25 Mbps symmetric service on a two year contract. Ontario based VMedia has also partnered with Axia to offer Voice over Internet Protocol (VoIP) telephone service and television packages in Axia's FTTP communities.[91]

TELUS has deployed or is in the process of deploying FTTP networks in 24 regions in Alberta, including 17 communities with a population of less than 10,000, under a similar initiative. Internet, voice and television services will soon be available over fibre in a number of rural communities, as laid out in Telus' map.[92] Advertised internet speeds available in rural fibre communities are the same as in the urban centres.

Please see the *Municipal/Community Networks* section for more information about rural fibre in Olds and Waterton.

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[86] Government of Alberta. Alberta leads in access to high speed internet, 6 December 2013. Accessed 1 June 2016.
[87] CIRA. Canada's Internet Performance: National, Provincial, and Municipal Analysis. April 2016.
[88] Axia. Barnwell to become next fibre optic community, 13 April 2016. Accessed 10 June, 2016.
[89] Axia. Axia announces fibre optic expansion to Stirling, AB, 1 June 2016. Accessed 10 June 2016.
[90] Axia. Axia announces fibre optic expansion to Pincher Creek, AB, 22 June 2016. Accessed 29 July 2016.
[91] Axia. VMedia offers Axia customers a new way of watching TV, 24 May 2016. Accessed 12 June 2016.
[92] Telus. Telus Fibre. Accessed 10 June 2016.

DSL and Cable

As per incumbent telephone company obligations, twisted pair copper connections were deployed by Telus to virtually all residential and business premises in rural Alberta. However, the physical limitations of twisted pair copper loops are such that in rural areas, only dial-up internet connection speeds are possible over this infrastructure. The DSL connections available in urban regions are not widely available to rural customers because DSL performance degrades as the distance from the digital subscriber line access multiplexer (DSLAM) increases, making connectivity in remote sites utilizing copper difficult and expensive. For example, 5 Mbps download speeds on ADSL and ADSL2/2+ technologies are only possible at line distances of less than 4 km from the DSLAM exchange point.[93] Advances in DSL technology, most notably G.fast, can reportedly deliver download speeds of 170 Mbps over a distance of 0.4 km on a single twisted copper pair wire; [94] however, the first commercial deployment of this technology has only recently been announced for Taiwan [95] and the timeline for its availability in Canada is not known.

Shaw is a major provider of wireline coaxial cable connections in rural parts of the province. Broadband internet access over coaxial cable leverages the data over cable service interface specification (DOCSIS) standard. This requires two components: a cable modem termination system, usually located at the head-end of the network, and an end-user cable modem device located at the customer's premise. Modern cable networks often have a hybrid fibre-coaxial cable architecture, where fibre to the curb or cabinet is installed within 1 km of the home and coaxial cable connects the fibre to the customer's home.[96] With DOCSIS 3.0, the maximum download and upload rates are 172 Mbps (for 4 channels) and 123 Mbps (for 4 channels), respectively, over hybrid fibre-coaxial cable. The maximum distance between the cable modem termination system and the end-user cable modem device is 160 km.[97]

In practice, the bandwidth on a DOCSIS network is a shared commodity, where the actual download/upload rates are dependent on the number of concurrent customers actively using a coaxial cable segment. DOCSIS 3.0 is a significant leap over DOCSIS 2.0, as it has improved uplink data rates per channel, and enables aggregation of multiple channels, leading to significant throughput bandwidth improvements. The next-generation DOCSIS 3.1 standard is expected to revolutionize hybrid fibre-coaxial cable connections by providing up to 10 Gbps download and 1 Gbps upload network throughput and significant improvements in latency.[98] Shaw has invested heavily in DOCSIS 3.1 technology and expects to implement

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[93] Increase Your Broadband Speed. Chart of ADSL and ADSL2+ Speed Versus Distance. 25 October 2012. Accessed 12 June 2016.
[94] Network World. DSL reaches speeds of 170 Mbps. 24 March 2015. Accessed 12 June 2016.
[95] Alcatel-Lucent. Alcatel-Lucent and Chunghwa Telecom launch world's first commercial deployment of G.fast ultra-broadband access technology in Taiwan. 14 September 2015. Accessed 12 June 2016.
[96] FTTH Council Europe. FTTH Handbook, 5th edition. P. 6-7.
[97] De Silva, M.M. Cable and Wireless Networks: Theory and Practice. 2016. P. 646-647.
[98] CableLabs. DOCSIS 3.1 Featured Technology. Accessed 20 July 2016.

it in its wireline network by the end of fiscal 2017.[99] For end-users in rural communities that are connected to modern hybrid fibre-coaxial networks and depend on its deployment, DOCSIS 3.1 could provide access to Gigabit internet services.

Mobile Broadband service

The capacity demand and dependence on mobile wireless communications is growing. Mobile or cellular networks are essentially radio communication networks where the last link to the end-user device is wireless. These networks are composed of fixed location transceivers (base stations) that provide wireless coverage over defined land areas known as cells. The signal strength is higher when the cell is closer in distance to the base station.[100] As an end-user moves locations, there should be a seamless hand-off in coverage from one base station to another, ensuring continuous mobile access. In urban or hot-spot areas (e.g. shopping centres, stadiums, airports) where population concentrations tend to be higher, there is typically a higher density of base stations compared to rural areas.[101] This ensures that there is sufficient network capacity to satisfy traffic demands. Mobile broadband service refers to technologies and standards that enable internet access on a portable/mobile device via mobile or cellular networks.

According to the International Telecommunication Union (ITU) — the United Nations' specialized agency for information and communications technologies (ICT) — global mobile broadband penetration (per 100 inhabitants or households) is estimated to have reached 47% in 2015, a mark that represents a 12-fold increase since 2007, with the Americas and Europe leading the way at 78%[102]. The same study indicates that 3G mobile broadband coverage is available to 69% (> 5.1 billion) of the world's population, up from 45% in 2011, of which there is 89% coverage of the world's urban population and only 29% of the rural population. The significant growth in mobile broadband penetration is closely related to the increased availability and coverage of mobile broadband technologies.

In 2014, it was reported that over 19.3 million Canadians subscribed to mobile broadband services, and 93% of households had mobile broadband services available at >5 Mbps download speeds.[103] The extent of the growth, penetration and availability of mobile broadband services can also be seen in Alberta, where 80% of people over the age of 18 now own a mobile device. This represents the highest level of mobile device penetration in the country (see Figure 10).

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[99] Shaw. Shaw Announces Third Quarter and Year-to-Date Results. Accessed 20 July 2016.
[100] Wikipedia. Cellular Network. Accessed 7 July 2016.
[101] Chiaraviglio, L. et al. What is the best spatial distribution to model base station density? A deep dive into two European mobile networks. April 2016.
[102] International Telecommunication Union. ICT Facts & Figures - The World in 2015. Accessed 8 July 2016.
[103] CRTC. Communications Monitoring Report. October 2015. Accessed 13 July 2016.

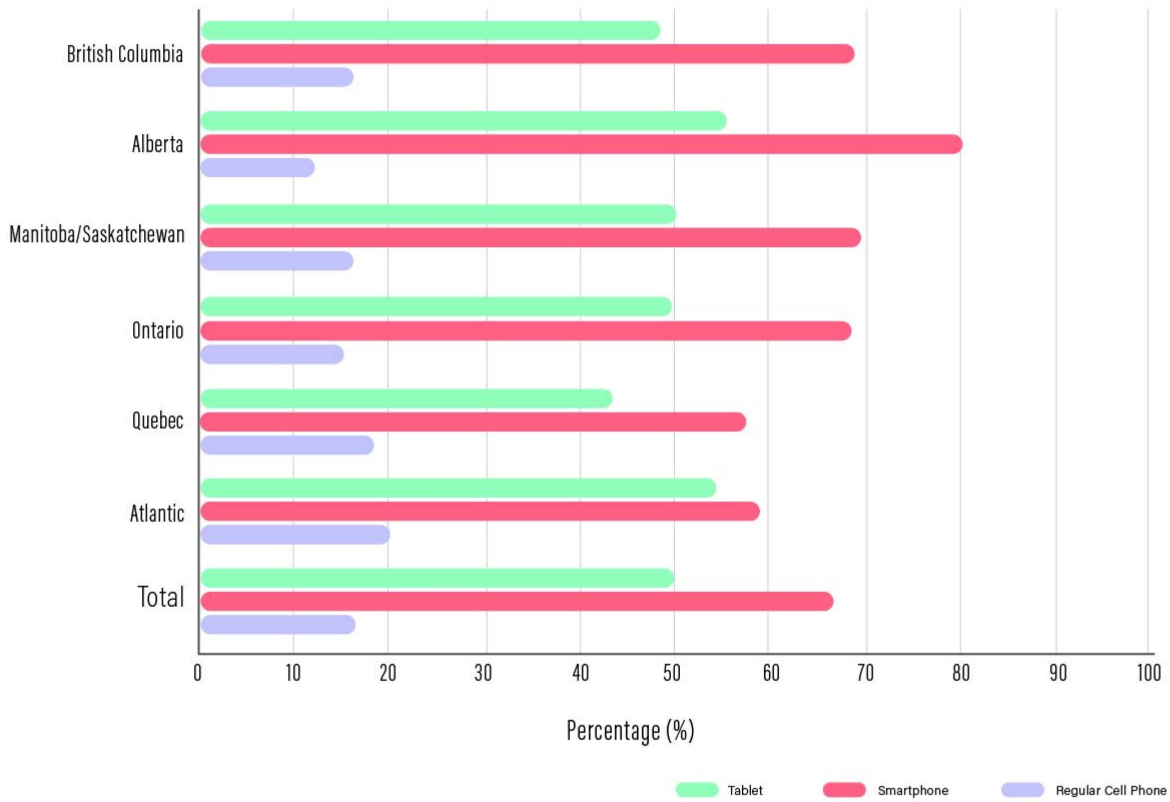

Figure 10. Canadian mobile device penetration, by region. ***Source: CRTC Communications Monitoring Report)*** [104]

Wireless Technologies

The mobile telecommunications standards that enable modern mobile broadband internet access are commonly known as 3G (third generation) and 4G LTE (fourth generation, long-term evolution). These standards are based on various networking technologies and are briefly compared and described in Table 3. The peak download speeds described in Table 3 represent results or tests under ideal conditions, whereas real-world results are significantly lower. For example, average download speeds for 4G LTE networks in Canada have been reported at 18 Mbps.[105] The evolution of each mobile technology generation is driven in part by the need to meet a requirement or gap identified in its predecessor technology. For example, the key differentiator between 4G and 3G is the desire to have faster broadband internet and lower latency.[106] This overall desire to have improved mobile internet user experiences will also likely drive next generation (i.e. 5G) technologies. In order to achieve improvements in speed, latency, coverage and availability, there will need to be significant capital investments in infrastructure that bring mobile services physically closer to an

[104] CRTC. Communications Monitoring Report, figure 5.5.9, October 2015. Accessed 14 July 2016.
[105] OpenSignal. The State of LTE. September 2015.
[106] GSMA Intelligence. Understanding 5G: Perspectives on future technological advancements in mobile. December 2014. Accessed 29 July 2016.

end-user's mobile device. For example, achieving sub-millisecond latency standards on 5G networks would require an increase in the number of base stations per cell area,[107] so that physical distances between users and cells are maintained at less than 1 km.[108] To meet these challenges, an open-access mobile network operator model should be considered, where network infrastructure (e.g. towers and sites) is shared and access is offered affordably, with competition driven by service offerings. In Canada, the CRTC has the power to impose conditions related to tower and site sharing, but it recently ruled that it is currently not in a position to assess whether or not tower-sharing is essential and should be mandated. The CRTC also stated that general wholesale tariffs are also not appropriate at this time.[109]

Table 3. Summary of mobile network generations. Adapted from Abioye, A.D. et al [110]

Technology	**3G**	**4G**	**5G**
Year Introduced	1990	2000	proposed
Standards	CDMA2000, WCDMA	LTE / Advanced, WiMAX	?
Peak Download speeds*[111]	168 Mbps (HSPA+)	300 Mbps (LTE), 3 Gbps (LTE-Advanced)	10 Gbps
Latency (ms)[112]	< 100 ms (HSPA+)	< 100 ms (LTE), < 50 ms (LTE-Advanced)	< 1 ms
Access Technology	WCDMA (HSPA/+)	OFDMA, SC-FDMA	?
Frequency Band	850 / 1900 MHz	700 / 1700 / 1900 / 2100 / 2500 / 2600 MHz	?

* Under ideal conditions.

Fixed Wireless Access/Wireless Internet Service Providers

In rural or remote regions of Alberta where wired cable, DSL, or fibre infrastructure is unavailable, fixed wireless broadband has become a common solution for internet connectivity. Companies operating fixed wireless networks are known as Wireless Internet Service Providers (WISPs) and there are a number of WISP options throughout Alberta (see Appendix A4). While wireless solutions are cost effective and cover a larger geographic area,

[107] Bushan, N. et al. Network densification. The dominant theme for wireless evolution into 5G. IEEE Communications Magazine. February 2014.
[108] GSMA Intelligence. Understanding 5G: Perspectives on future technological advancements in mobile. December 2014. Accessed 29 July 2016.
[109] CRTC. Telecom Regulatory Policy CRTC 2015-177. 5 May 2015.
[110] Abioye, A.D. et al. Comparative Study of 3G and 4G LTE Network. Journal of Advances in Computer Networks. September 2015. Accessed 29 July 2016.
[111] Grigorik, I. High Performance Browser Networking. O'Reilly Media, Inc. 2013. Accessed 29 July 2016.
[112] Grigorik, I. High Performance Browser Networking. O'Reilly Media, Inc. 2013. Accessed 29 July 2016.

concerns about the scalability and robustness of the technology are frequently raised. For example, it is not clear how the technology will be able to accommodate ever growing symmetric bandwidth needs as more devices and services come online.

WISPs in Alberta purchase backhaul bandwidth to public internet via a major ISP that connects to a location in the WISP's service territory — usually Axia, Telus, Bell, or Shaw. From there, the WISP builds additional backhaul connections — either fibre or microwave links — between the public internet connection point and the WISP's towers (See Figure 11). A small dish or antenna that is mounted to the roof of the subscriber's premise is directed at the WISP's nearest access point. This means remote customers can be added to the network without trenching or hanging physical cables or modifying existing infrastructure. Subscribers to a fixed wireless service usually pay an installation fee to cover the cost of installing antenna equipment on their premises.

A WISP may also construct its own towers for signal transmission, or co-locate equipment on existing radio towers or other points of high elevation, such as water towers or grain silos. Co-locating transmission equipment on existing radio towers, however, has proven difficult for WISPs in Alberta. In 2008, during the Advanced Wireless Services (AWS) auction, Industry Canada mandated antenna tower and site sharing.[113] But despite the mandated tower sharing policy, the WISPs that Cybera spoke to reported difficulty and delays with co-locating equipment on incumbents' towers.

[113] Industry Canada. CPC-2-0-17 — Conditions of Licence for Mandatory Roaming and Antenna Tower and Site Sharing and to Prohibit Exclusive Site Arrangements. Accessed 17 May, 2016.

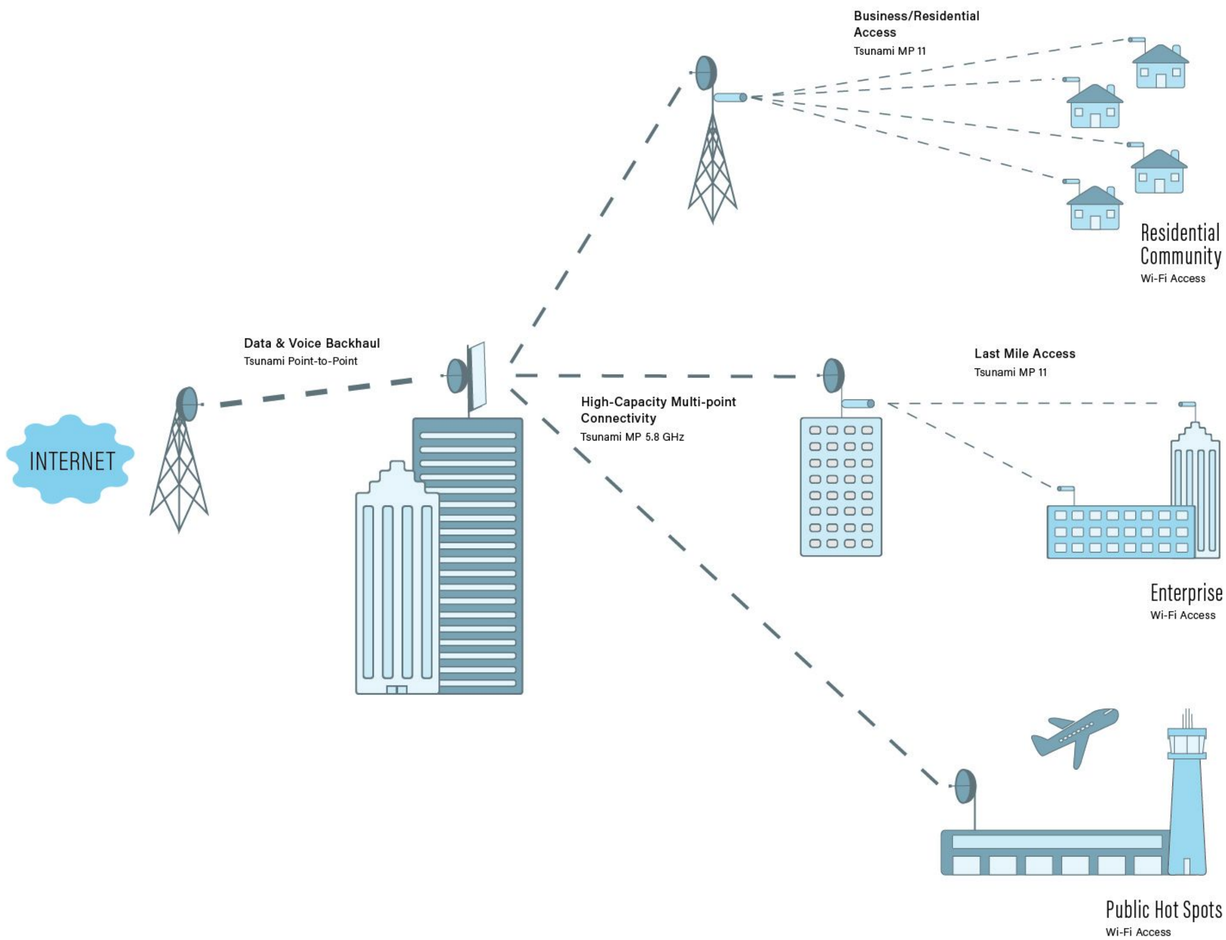

Figure 11. High-level overview of the network architecture for delivery of internet services by WISPs.

Spectrum

Radio frequency spectrum characteristics and their associated policies impact all forms of wireless internet service delivery, including satellite- and WiFi-based technologies. Radio frequency spectrum in Canada is managed by the Ministry of Innovation, Science, and Economic Development (formerly Industry Canada). Spectrum is a finite public resource utilized by various bodies, including commercial private sector entities and their consumers, as well as public sector entities including defence, police, emergency responders, and researchers.

Spectrum is periodically divided into frequency bands, which are allocated for one or more specific uses by international voting decisions at the World Radiocommunication Conference (WRC), which is supported by the International Telecommunications Union (ITU), an agency of the United Nations.

Countries usually adapt global policies developed by the WRC and ITU, and allocate frequency bands on a domestic basis. While the ITU coordinates frequency for different services (broadcasting, mobile, radio, etc.), individual countries determine how those frequencies are subdivided geographically and in terms of channel size. In Canada, these are set out in The Canadian Table of Frequency Allocations (CTFA). Canadian spectrum allocations tend to align with those of the United States, allowing network operators to take advantage of economies of scale achieved by US telecommunications equipment ecosystems specific to each band.

Only a fraction of the complete electromagnetic spectrum can support radio communication, which is why it is important to use the resource as efficiently as possible. As radio communication technology advances, spectrum utilization becomes more efficient. This "spectral efficiency" allows a single block of spectrum to deliver a greater capacity or bits or service more subscribers.

The Spectrum Management System (formerly Spectrum Direct) is a public database that allows users to view data collected and managed by the Canadian Spectrum Program, and search for spectrum used for communications and broadcasting purposes according to geographic area, frequency, licensee name, and other parameters.

Table 4. A curated and summarized list of radio frequency spectrum assigned for broadband technologies

Radio Frequency Bands (MHz)	Intended Usage	Comments
512 - 608, 614 - 698	• Previously for Remote Rural Broadband Systems (RRBS).[114] • Recently, the 600 MHz band has been repurposed for commercial mobile use and digital TV.[115]	• RRBS service providers can continue to operate on a secondary basis (i.e. no-interference, no-protection) for 2 years following the decision to repurpose the 600 MHz band, after which the transition plan will be finalized. • There are 24 RRBS stations in Alberta that will be impacted by the repurposing of this spectrum.[116]

[114] Industry Canada. CPC-2-1-24. 2 August 2011. Accessed 12 June 2016.
[115] Industry Canada. Decision on Repurposing the 600 MHz Band. 3 September 2016. Accessed 13 June 2016.
[116] Industry Canada. Decision on Repurposing the 600 MHz Band. 3 September 2016. Accessed 13 June 2016.

763 - 768, 793 - 798	• Public Safety Broadband Block (PSBB). • For public safety broadband use.	• The 700 MHz band was formerly used for over-the-air television.[117] • This frequency band is favored for delivering next-generation wireless services as it carries well over long distances and is able to penetrate structures well.[118]
Remaining 700 Mhz band	• For mobile broadband service (MBS).	• These spectrum licenses were auctioned off in 2014. • In Alberta, blocks are owned by Rogers, Telus, Vidéotron, and Bell.[119] • In each license area, companies that have access to two or more blocks of 700 MHz — either through auction or spectrum sharing — are required to deploy services to 90% of their existing broadband mobile coverage area within five years, and 97% within seven years of the auction. • In Alberta, this applies to Telus and Rogers by 2021.
2500 - 2690	• For broadband radio services (BRS).	• These spectrum licenses were auctioned off in 2015. • In Alberta, blocks are owned by Telus, Bell, Rogers, and Corridor Communications Inc., Videotron, and Bragg Communications.[120] • This spectrum is best suited for expanding the capacity of mobile systems in urban areas. • Not ideally suited for mobile systems covering expansive rural and remote areas.
902 - 928, 2400 -2483.5, 5150 - 5350, 5470 - 5600, 5650 - 5850, 24050 - 24250	• For wireless broadband services (no spectrum license required).	• License exempt spectrum.[121] • Devices must adhere to specific Radio Standard Specifications. • Services operate under a secondary allocation basis (i.e. no protection and no-interference).

[117] Industry Canada. Policy and Technical Framework. 12 March 2014. Accessed 12 June 2016.
[118] Industry Canada. 700 MHz Spectrum Auction FAQs. 19 February 2014. Accessed 12 June 2016.
[119] Government of Canada. Archived - 700 MHz Spectrum Auction-Process and Results, 19 February 2014. Accessed 12 June 2016.
[120] Industry Canada. 2500 MHz Auction - Final Results, 25 June 2015. Accessed 12 June 2016.
[121] Industry Canada. Radio Spectrum Management Update, April 2015. Accessed 12 June 2016.

3650 - 3700	• For wireless broadband services (spectrum license required).	• Licensing is shared wherein all licensees have equal access to the spectrum.[122] • Currently no annual spectrum licence fees.
3475 - 3650	• For fixed wireless access (spectrum license required).	• Spectrum in some Tier 4 localized service areas has been made available for licensing. • Annual spectrum licence fees apply.[123] • Devices must adhere to specific Radio Standard Specifications.[124][125]
4940 - 4990	• For fixed and mobile services in support of public safety.	• The primary uses of this band are designated for broadband mobile services for public safety, and fixed systems that support these broadband mobile systems.[126]

Remote Rural Broadband Systems (RRBS)

In 2011, a number of frequency bands that were previously used for analogue television (512-608 MHz and 614-698 MHz - TV channels 21 to 51) were re-allocated by Industry Canada to be used for Remote Rural Broadband Systems (RRBS).

Industry Canada considers license applications for RRBS:

> *"...on a case-by-case basis for advanced communications services in remote rural communities on television channels that are unallotted and unassigned to the broadcasting service:*
> - *at sufficient distance from major population centres to avoid causing interference to local broadcasting facilities and their service contours; and*
> - *on the condition that they not constrain the provision of existing and new broadcasting services."*

[122] Industry Canada. CPC-2-1-26. November 2010. Accessed 12 June 2016.
[123] Industry Canada. Notice No. DGRB-008-99. 2011. Accessed 12 June 2016.
[124] Industry Canada. Gazette Notice DGSO-007-14. 3 January 2015. Accessed 12 June 2016.
[125] Industry Canada. SRSP-303.4. December 2008. Accessed 12 June 2016.
[126] Industry Canada. CPC-2-0-19. 1 November 2008. Accessed 12 June 2016.

Licenses are issued for a one year term, and are subject to the spectrum availability within a particular geographic area.[127]

Dr. Gregory Taylor, a spectrum policy researcher and professor at the University of Calgary, is currently studying RRBS adoption across Canada. His early insights suggest that RRBS deployments are highest in Alberta: they occur mainly in sparsely populated areas, and are deployed largely by passionate, self-taught individuals. Some RRBS operators have expressed apprehension about how a future repurposing and potential auction of the 600 MHz band would affect their business, as it could potentially eliminate free use of the unlicensed spectrum. Dr. Taylor expects to publish the findings of his study in the Fall of 2016.

First Nations

Federal Initiatives

The federal government's 2016 budget provides $255 million over two years, starting in 2016–17, to the First Nations Infrastructure Fund. The goal is to support investments in a range of complementary infrastructure projects, including broadband connectivity, "in order to help communities as they develop and grow."[128] In April 2016, the First Mile Connectivity Consortium developed a 'Guide to Federal Funding for Indigenous Broadband in Canada.'

The First Nations Technical Services Advisory Group

The First Nations Technical Services Advisory Group (TSAG) is a not-for-profit First Nations organization that provides technical support and training to First Nations in the Treaty 6,7, and 8 regions. The TSAG Information Technology program delivers IT services, including the First Nations Telehealth Portal, a support desk service for health centres, schools, and family services offices. The Advisory Group owns 51% of Arrow Technology Group, a service provider with a presence in 42 First Nations communities.[129] Arrow Technology Group's top-end business plan includes a 25 GB/month data allowance at a speed of 3.0 Mbps for downloads and 1.5 Mbps for uploads.[130] The company also advertises fibre based solution, but pricing information is not available online.[131] Infinity Solutions serves residential subscribers in the Metis settlements at Buffalo Lake and Elizabeth with download speeds between 2 Mbps and 7 Mbps.[132]

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[127] Industry Canada. CPC-2-1-24 — Licensing Procedure for Remote Rural Broadband Systems (RRBS) Operating in the Band 512-698 MHz (TV channels 21 to 51), section 6.3. Accessed 29 May 2016.
[128] Government of Canada. Budget 2016 - Chapter 3 - A Better Future for Indigenous Peoples, 22 March 2016. Accessed 27 June, 2016.
[129] Arrow Technology Group. Arrow High Speed Internet Locations. Accessed 15 July 2016.
[130] Arrow Technology Group. Business Wireless Broadband Pricing. Accessed 15 July 2016.
[131] Arrow Technology Group. Our Products: Fiber & Wireless Solutions. Accessed 26 July 2016.
[132] Infinity Internet Solutions. Residential Services. Accessed 15 July 2016.

Final Mile Rural Connectivity Initiative

The Final Mile Rural Connectivity Initiative (FMRCI) was a 2014 joint effort between Service Alberta and Alberta Agriculture and Rural Development to increase ISP coverage to SuperNet communities without internet access.[133] This program provided 'last-mile' funding to 27 projects, including eight First Nations communities, enabling unserved rural Alberta communities to connect to the internet via SuperNet.[134] Currently, 43 First Nations and 8 Métis Settlements have SuperNet connectivity within or adjacent to their communities.[135] Of note, the cost of connecting First Nations schools to the SuperNet is covered by the Federal Government through the department of Indigenous and Northern Affairs.[136]

Emergency Communication System

An Emergency Communication System (ECS) is defined as a system that is organized for the primary purpose of supporting one-way and two-way communication of emergency messages between both individuals and groups of individuals.[137]

There are two methods of communicating to devices during an emergency. The first is using infrastructure dependent technologies, such as phones, internet, radio, television, etc.— provided they are still operational. The second is using infrastructure-independent network connections, such as Google's Project Loon (which uses unmanned hot air balloons housing network equipment - see later in this chapter for more details). This offers the potential for networked communication when infrastructure communication is hindered in emergency situations.

Public Emergency Alerts

An emergency notification system refers to a collection of methods that allow the one-way dissemination or broadcast of messages to people during an emergency situation. An important function for such public alerts is the ability to broadcast on more than one forum. Public alerts traditionally make use of radio and television, and most recently have incorporated social media, texting and email.

The increased usage of cellular technology during an emergency has been known to cause communications failures. During the 2005 hurricane Katrina disaster, 70% of the cell towers in affected areas went down for several days. And during the September 11, 2001 attacks in

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[133] Service Alberta. Final Mile Rural Connectivity Initiative. Accessed 19 May 2016.
[134] Alberta Agriculture and Forestry. Final Mile Rural Connectivity Program Approved Projects. 20 March 2015. Accessed 19 May 2016.
[135] Service Alberta. IM Aware presentation- Alberta SuperNet, p. 3, 8 June 2016. Accessed 5 July 2016.
[136] Alberta Education. Supernet. Accessed 10 October 2014.
[137] Wikipedia. Emergency Communication System. Accessed July 12, 2016

the USA, many emergency calls could not go through because the towers could not handle the added traffic. During these and other disasters, where traditional emergency communication systems have been destroyed, amateur radio has played a large role in helping to facilitate communications.

In Alberta, as a result of the July 31, 1987 tornado that struck Edmonton and the surrounding area, the government developed an Emergency Public Warning System (EPWS) in 1992. The EPWS was the first rapid warning system of its kind to use media outlets to broadcast critical life-saving information directly to the public.

In October 2011, the EPWS was upgraded and renamed the Alberta Emergency Alert (AEA) to address the changes in technology, as radio and television moved from analogue to digital. Alerts are disseminated through various media outlets including television, radio, and social media. In 2014, an app was created for both iOS and Android devices to help with the dissemination of information to the public.[138]

First Responder Communication Systems

Traditionally, first responders operate in silos, with each department responsible for running their own networks. Therefore, interoperability during emergencies is essential.

On July 1, 2016, the Alberta First Responder Radio Communications System (AFRRCS) was fully activated. This is a province-wide APCO Project 25 (P25) trunked two-way radio network for first responders in municipal, provincial and First Nations agencies. The AFRRCS system will also carry all the radio traffic of the various government agencies that currently use wireless/radio communications, such as Environment, Sustainable Resource Development, Alberta Sheriffs, Alberta Health Services, as well as the Royal Canadian Mounted Police (RCMP).

The system is a mix of 700 MHz (digital trunking system), and, in some areas such as mountainous terrains and similar regions, a “VHF overlay” involving non-trunked-conventional- P25 VHF-hi (136-174) frequencies. The system, which cost $438 million,[139] will assist in a fully coordinated joint response among first responders from different agencies, and will also reduce the cost of radio system infrastructure. Participation in AFRRCS by first responder agencies is voluntary and will cost an additional $17 million yearly[140] in upkeep and rental cost for the towers. Municipalities and their agencies (and

[138] Alberta Government. Alberta Emergency Alert History. Accessed July 5, 2016.
[139] Alberta Government. New first responder radio system launching July 1 will better protect Albertans, June 23, 2016. Accessed July 5, 2016.
[140] CBC. New radio system that played ‘lifesaving role’ in Fort McMurray launched across Alberta, June 24, 2016. Accessed July 5, 2016.

wireless providers) have access to the towers for free, but will have to pay for the radios and equipment needed to access the network.[141]

Internet Exchange Points

In Alberta there are currently two Internet Exchange Points (IXPs): the YYCIX in Calgary and the YEGIX in Edmonton. These IXPs allow networks to interconnect directly, rather than through one or more (international) third party networks.[142] The advantages of a direct interconnection are primarily related to cost, latency, bandwidth, and network resiliency.

The YYCIX was introduced in 2013 and has 24 peers, transferring 270.65 Mbps, on average (Figure 12). The YEGIX was created in 2015 and currently only has two open connections, with six more scheduled to connect.

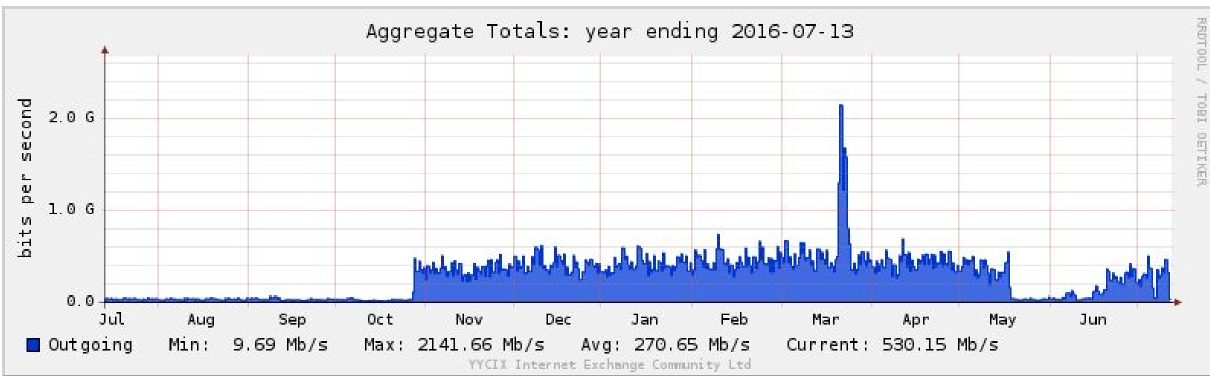

Figure 12. Aggregate total traffic of YYCIX in the year ending 13 July 2016 [143]

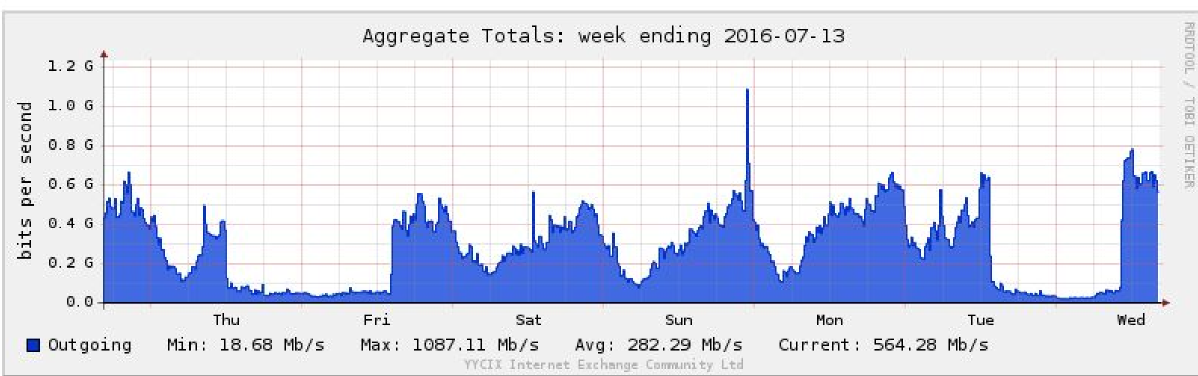

Figure 13. Aggregate total traffic of YYCIX in the week ending 13 July 2016 [144]

[141] CBC. New radio system that played 'lifesaving role' in Fort McMurray launched across Alberta, June 24, 2016. Accessed July 5, 2016.
[142] Wikipedia. Internet Exchange Point article. Accessed 17 May 2016.
[143] YYCIX. Graphs, 13 July 2016. Accessed 13 July 2016.
[144] YYCIX. Graphs, 13 July 2016. Accessed 13 July 2016.

As a result of the internet exchanges in Calgary and Edmonton, Tier 1 ISP Hurricane Electric now peers in both IXs. Hurricane Electric advertises transit fees starting at $0.32 USD/Mbps/month[145] (before transport and data centre fees). It is of note that while Hurricane Electric's internet is advertised on a per Mbps fee, it is only available for purchase in increments of 1,000 Mbps.

A connection to a local IXP may allow regional ISPs to transfer data without limit or cost, vastly improving the connection speed between customers of two adjacent ISPs. A direct interconnection also avoids the need for data to travel through other cities or continents in order to move from one network to another, thus reducing latency and keeping local traffic local (Figure 14).

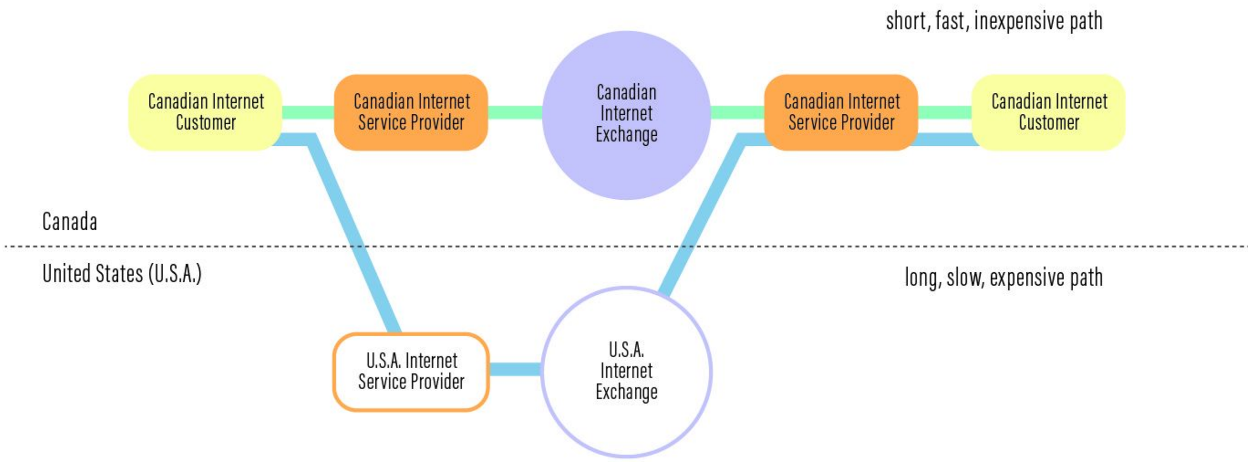

Figure 14. The network paths to connect two Canadian internet customers through a Canadian IX (green) and an American IX (red)[146]

According to Packet Clearing House, "a strong domestic Internet exchange point is the first and most critical component of a cyberwarfare defense" [147] because countries without an Internet Exchange are heavily dependent upon international data circuits for their domestic connectivity. In the case of the 2007 cyberattacks on Estonia, denial-of-service attacks were halted at the country's internet exchange and had minimal impact on domestic internet traffic.

The Canadian Internet Registration Authority considers Internet Exchanges to be an essential component of internet infrastructure, and promotes Internet Exchange development across the country. CIRA encourages government IT departments to facilitate Internet Exchange

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[145] Hurricane Electric. Internet Services. Accessed 12 June 2016.
[146] Woodock, B. and Edelman, B. Towards Efficiencies in Canadian Internet Traffic Exchange, 2012. Packet Clearing House for the Canadian Internet Registration Authority. Accessed 14 June 2016.
[147] Stapleton-Gray, R. and Woodcock, B (Packet Clearing House). ACM Queue. National Internet Defense—Small States on the Skirmish Line - Attacks in Estonia and Georgia highlight key vulnerabilities in national Internet infrastructure, 19 January 2011. Accessed 29 July 2016.

development and improve the Canadian internet landscape by working closely with Internet Exchanges. The benefits of peering for governments include network resiliency. If a government's internet service provider is taken offline by a denial of service attack, the government can lose connectivity to the whole of its citizenry. However, if the government's internet service provider peers at Internet Exchange Points, then its services remain available to its citizens by virtue of the connections to other internet service providers in that Internet Exchange.

Low earth orbit satellites (LEOS)

The global market for broadband internet services in physically isolated rural and remote communities is estimated to be in excess of 100 million households[148], of which over 18,000 [149] are in Canada. To reach this large potential market share, key technology and telecommunications industry leaders have begun examining new opportunities to provide broadband internet connectivity via satellites.

Background

Communications satellites that provide internet services can be deployed in one of three orbit ranges above the earth's surface, as measured from the equator, and in one of three satellite spectrum bands C(4-8 GHz)-, Ku(12-18 GHz)- and Ka(26.5-40 GHz)-band[150] (Figure 15).

Broadband services via satellite can be categorized into two main groups: through a direct-to-home model and through a community aggregator model. In fixed or static satellite services the satellite stays in the same position relative to the earth station(s) and/or antenna(s) that are linked to that satellite.[151] The community aggregator access model is not currently employed in Alberta. This is partly due to the impact of the Government of Alberta's Final Mile Rural Connectivity Initiative (FMRCI), which included the 2013 Central Alberta Satellite Initiative. This initiative focused on direct-to-home broadband internet and made funding available to contribute to one-time satellite installation fees via Xplornet.[152]

[148] CRTC. Transcript Hearing, May 9, 2016, line 15417. Accessed 18 May, 2016.
[149] CRTC. Transcript Hearing, May 9, 2016, line 15298. Accessed 18 May, 2016.
[150] CRTC. Satellite Inquiry Report (2014). Accessed 18 May 2016.
[151] CRTC. Satellite Inquiry Report (2014). Accessed 18 May 2016.
[152] Service Alberta. Final Mile Rural Connectivity Initiative (n.d.). Accessed 18 May 2016.

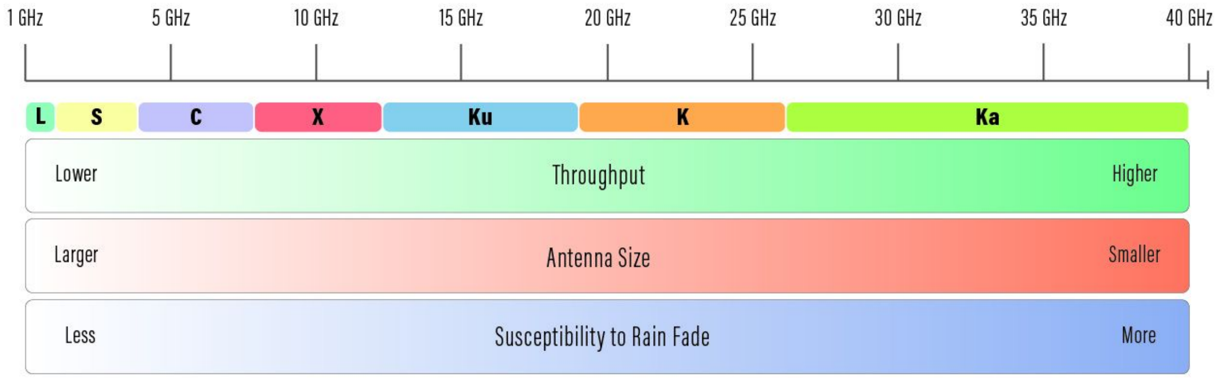


Figure 15. A Comparison of frequency bands and their corresponding characteristics [153]

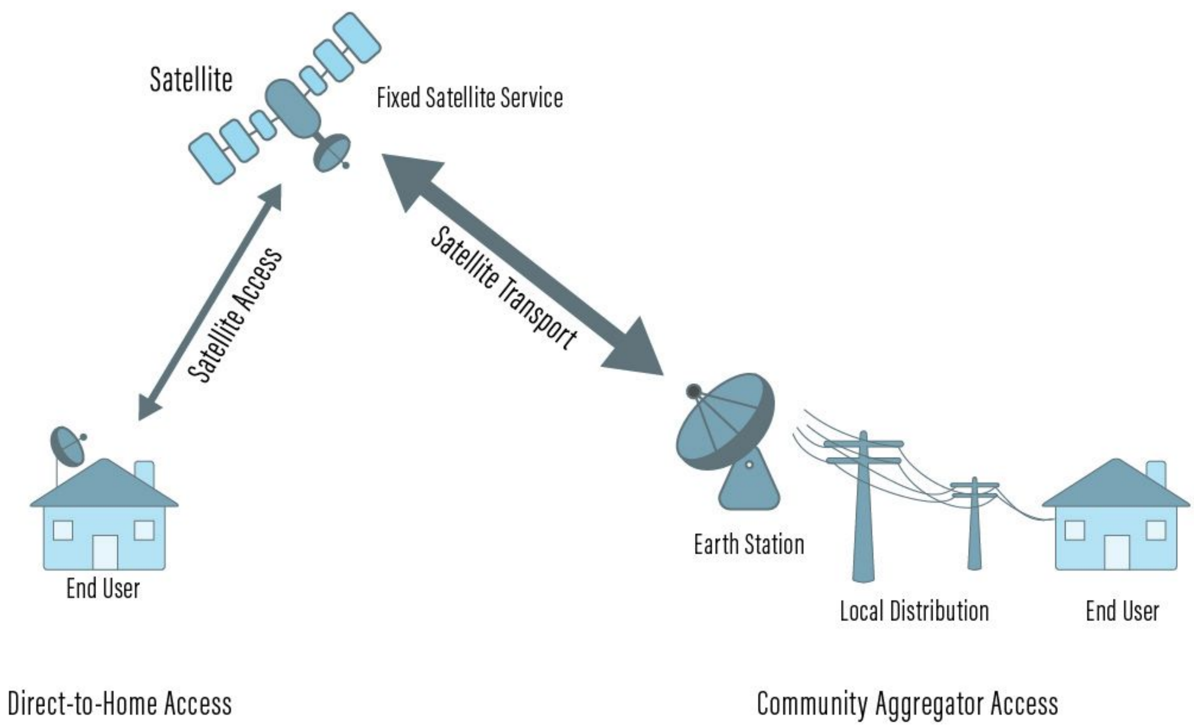


Figure 16. The figure shows how static and non-static satellite services are used to provide telecommunications services to end-users: 1) through a direct-to-home model, in which satellite access is provided directly to end-users, and 2) through a community aggregator model, in which satellite transport provides a link between a satellite and an earth station, and local access is subsequently provided to end-users.

Geostationary or geosynchronous (GSO) orbit satellites

[153] Skyware Technologies. Ka vs Ku - An Unbiased Review. Accessed May 31, 2016.

Geostationary or geosynchronous (GSO) orbit satellites are positioned > ~35,000 km above the surface of the Earth, as measured from the equator. These include the Anik series of satellites launched by Telesat.[154] Currently, GSO communications satellites provide the majority of satellite internet services to Canadian users through communications service providers such as XplorNet. The GSO satellites typically provide long-term coverage over a large area by moving at the same angular velocity as the rotation of the Earth, with limited orbital decay. The costs associated with sending a satellite into GSO are high (> $100 million, e.g. ViaSat-2 Ka-band satellite system costs estimated at $625 million[155]) and take into account build, launch, insurance and ground infrastructure.

In general, GSO satellite launches have a smaller payload capacity and require more propellant (leading to more mass) to reach orbit, which leads to higher costs per satellite, per launch compared to lower Earth orbit destinations. GSO satellites are typically large (> 1,000 kg in mass e.g. ViaSat-2 is 6,400 kg)[156], have long (planned) life spans (e.g. > 10 years) and, for communications purposes, carry technologies that enable large coverage areas and bandwidth (ViaSat-2 estimated at 350 Gbps[157]). This enables satellite-based internet providers to serve a large number of consumers at higher bandwidth with a single satellite. Of note, due to their orbit, data transmission times from GSO satellites will experience a path latency in excess of ~230 milliseconds. Although data packets are being transmitted at the same rate, because they are transmitted over time, longer latency delays lead to a distribution of network data over time, and can impact webpage load times.

Medium Earth orbit (MEO) satellites

Medium Earth orbit (MEO) satellites are deployed between ~2,000 and 35,000 km above the surface of the Earth, as measured from the equator. Individual MEO satellites are not stationary (with visibility between two to eight hours a day) and have a smaller coverage area per satellite than a GSO satellite.[158] In MEO and lower orbits, satellites need to have overlapping coverage areas to ensure visibility and service coverage. However, due to their close proximity to Earth, the latency delay associated with data transmission is significantly shorter (up to 17.5 times shorter) compared with GSO satellites, leading to improved performance for internet communications.

O3b Networks was founded to provide affordable and high-quality internet connectivity across emerging markets utilizing MEO satellite technology, and has been providing services since 2014. O3b operates a constellation of 12 medium-sized (~700 kg mass)[159] high

[154] Telesat. Our Fleet (2016). Accessed 18 May 2016.
[155] Peter B. de Selding. ViaSat-2's 'First of its Kind' Design Will Enable Broad Geographic Reach. Space News. 17 May 2013. Accessed 10 June 2016.
[156] Gunter Krebs. ViaSat2. Gunter's Space Page. 17 April 2016. Accessed 10 June 2016.
[157] Space News. ViaSat-2's 'First of its Kind' Design Will Enable Broad Geographic Reach, 17 May 2013. Accessed 10 June, 2016.
[158] No Jitter. Satellite Internet Looking Attractive, 27 March 2015. Accessed 17 April 2016.
[159] Gunter Krebs. O3b 1, …, 12. Gunter's Space Page. Accessed 10 June 2016.

throughput satellites in MEO (~8,000 km from Earth) that cost an estimated $1.5 billion to build, launch and operate (~ $125 million per satellite). Each has a planned life time of 12 years.[160, 161] The current optimal coverage zone (inclination) for service is between +/- 45 degrees of the equator, but O3b has plans to launch an additional eight satellites by 2019. These will be positioned to extend the company's coverage to polar orbits (> +/- 60 degrees).[162] The O3b satellite constellation operates in Ka-Band mode, with a reported bandwidth of up to 1.6 Gbps per spot beam, 700 km beam coverage diameter, and a total bandwidth of 126 Gbps available per 12 satellite constellations.[163] O3b Networks has data to show it can achieve round trip times in the range of 150 milliseconds, resulting in webpage load times that are up to 4x faster than GSO satellite based internet services.[164]

Low Earth orbit (LEO) satellites

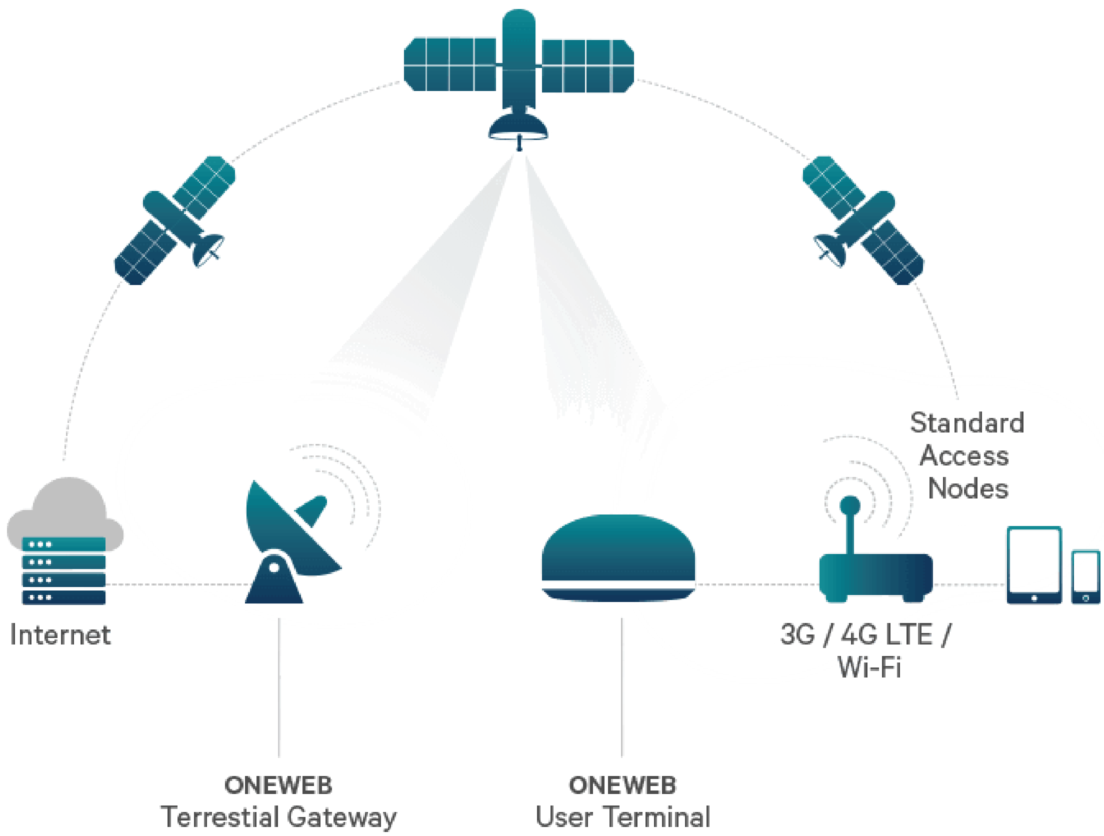
Low Earth orbit (LEO) satellites are deployed between ~400 and 2,000 km above the surface of the Earth. At this altitude, LEO satellites deployed for broadband communications purposes experience a significant advantage with respect to round-trip (~3 milliseconds) and inter-satellite latency, compared to MEO and GSO satellites. The primary disadvantages of being deployed in LEO include experiencing some atmospheric drag leading to loss of orbit, and shorter life spans of the satellites (e.g. the planned life time for the Oneweb microsatellite is 7 years)[165]. Also, due to their high apparent angular velocity, LEO satellites have a smaller "dwell" time (in which the object is visible to one part of the Earth). In order to overcome these challenges, satellite operators are required to use a constellation of satellites (with multiple orbits that differ with respect to location and time) to provide global coverage and visibility.

Despite the significant latency advantages of LEO, there are currently no commercial LEO satellite operators providing broadband communication services to consumers. Factors such as the number of satellites required to provide continuous coverage over a defined area, and the costs of satellite build, launch and replacement, have been historically prohibitive to the successful deployment of LEO satellites for commercial internet services.[166] Recently, there has been renewed interest in this technology fueled by rapidly growing global internet connectivity demands and advances in satellite technology (e.g. smaller size and mass, antennae technology, and configurable radio-frequency payload systems) and practices (i.e. mass production) that have significantly reduced satellite production costs. As well, the demonstration by Space Exploration Technologies (also known as SpaceX) of a recovery of a

[160] O3b Networks. Technology. Accessed 18 May 2016.
[161] Peter B. de Selding. O3b Execs Press Business Case for Bigger Constellation. Space News. 23 October 2012. Accessed 10 June 2016.
[162] Peter B. de Selding. SES takes control of O3b, citing synergies between GEO, MEO constellations. Space News. 29 April 2016. Accessed 18 May 2016.
[163] O3b Networks. Technology. Accessed 18 May 2016.
[164] O3b Networks. What is Network Latency and Why Latency Matters. Accessed 18 May 2016.
[165] Gunter Krebs. OneWeb 1,...,900. Gunter's Space Page. Accessed 10 June 2016.
[166] Gunter Krebs. BATSAT (Teledesic T1). Gunter's Space Page, 17 April 2016. Accessed 10 June, 2016.

first stage (SpaceX Falcon 9) rocket, [167] along with advances in multiple small satellite launchers, will lead to significant satellite launch cost savings.

Three companies have emerged as having significant interest in bringing LEO satellite based commercial internet services to market: OneWeb LLC, LeoSat and SpaceX. OneWeb LLC has plans to launch a satellite constellation of 648 LEO (1,200 km from Earth) Ku-Band microsatellites (< 150 kg) starting in late 2017, along with 250 spare satellites. The target price to produce each satellite is less than $500,000. [168] OneWeb has established partnerships with Airbus (satellite production), MacDonald, Dettwiler and Associates (satellite antenna subsystem production), Virgin Galactic (deployment launches), Arianespace (Soyuz deployment launches) and Qualcomm (chip / electronics technology) to develop this technology. OneWeb is designed to provide up to 50 Mbps of effective bandwidth,[169] a path latency below 30 milliseconds, and end-to-end latency below 50 milliseconds, which is similar to terrestrial fibre, DSL or cable modem service latencies[170] (Figure 17).



[167] Peter B. de Selding. SpaceX's reusable Falcon 9: What are the real cost savings for customers? Space News. 25 April 2016. Accessed 18 May 2016.
[168] Peter B. de Selding. Competition To Build OneWeb Constellation Draws 2 U.S., 3 European Companies. Space News. 19 March 2015. Accessed 18 May, 2016.
[169] Mark Holmes. Greg Wyler Talks OneWeb. Satellite Today. 9 March 2015. Accessed 18 May, 2016.
[170] CRTC. Transcript, Hearing April 25, 2016. Line 15296. Accessed 18 May 2016.

Figure 17. OneWeb LLC satellite technology communications overview. Terrestrial networks will provision internet to OneWeb terrestrial gateways, which will relay data to LEOS, and onwards to user terminals. From the user terminal, consumers will be able to access the internet through direct connection or via 3G, 4G LTE or Wi-Fi technologies.[171]

By 2018 or 2019, LeoSat LLC hopes to launch between 78 and 108 high-throughput Ka-band satellites into LEO (1,400 km from Earth) for global internet and data transfer services. Each satellite will have a bandwidth of 20 Gbps and an end-to-end latency time of less than 140 milliseconds.[172] [173] LeoSat is partnering with Thales Alenia Space for the LEO constellation, which will provide high-speed, low-latency and highly secure communications and bandwidth for business operations in the telecom backhaul, oil & gas exploration, and maritime and international business markets.[174]

SpaceX also intends to launch a large constellation of small satellites for the purpose of providing a low-latency, high-capacity internet service with global coverage. It plans to launch ~4,000 satellites (300-400 kg) into LEO, and intends to begin testing its broadband antenna communications platform (primary payload) in late 2016 when it launches two identical Ku-Band demonstration satellites (MicroSat-1a and -1b) into a 625 km orbit.[175] This will be the first of six-to-eight planned demonstration satellites that will inform the final LEO constellation design.

There is significant interest and potential to provide affordable and reliable internet service to remote and rural communities via satellite technologies. In Alberta, the SuperNet could play a key role in providing internet service providers wholesale access to middle-mile infrastructure to link upstream internet sources with terrestrial-based satellite gateways. Similarly, throughout the rest of Canada, affordable wholesale access to long-range backhaul fibre networks fed by satellite technologies will be critical to providing economical high-speed broadband services to consumers in rural and remote communities.

High altitude regional wireless networks

High Altitude Platforms (HAPs) for wireless communication include vehicles such as balloons, drones, or blimps that are placed in the stratosphere to improve internet connectivity. These vehicles operate in the stratosphere at 17-22 km above ground, which is approximately twice the cruising altitude of airplanes. They contain equipment that is used to receive internet connectivity from a ground station and relay that on to more remote areas.

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[171] Qualcomm. OneWeb Global Communications Network. Accessed 18 May, 2016.
[172] Leosat. Interview with Mark Rigolle, 16 September 2015. Accessed 10 June, 2016.
[173] Space News. Why Leosat's leaving Internet for the masses to Oneweb, 10 March 2015. Accessed 18 May, 2016.
[174] Leosat. Interview with Cliff Anders, 9 September 2015. Accessed 18 May 2016.
[175] Federal Communications Commission [U.S.]. SpaceX Purpose of Equipment. Accessed 18 May 2016.

Airborne transmission vehicles are easier to deploy than towers or fibre infrastructure, in particular in underdeveloped or remote regions, or in areas of conflict.

There are a number of companies that are investigating HAPs for wireless communication, the most prominent being Facebook and Alphabet. Other companies, such as Capanina, are using HAP for supervisory control and data acquisition (SCADA) communication, while Lockheed Martin is investigating HAP for military applications. Because Facebook and Alphabet have the most mature implementations of HAP for wireless communication, their initiatives will be described in more detail.

Alphabet – Project Loon

Project Loon uses balloons to receive and propagate wireless signals. The balloon carries solar panels for energy generation, and measures about 15 metres in diameter. Its location is controlled by manipulating the balloon's altitude, which places it in different air streams that take it to the intended target location.[176] This navigation method is accurate enough to navigate the balloon to within 500 m of its intended target – an important factor in providing reliable internet connectivity.[177] The balloons are not stationary and typically will circle the globe along an east-west path.

Since the project's inception in 2012, Alphabet has been able to extend the balloon's airborne time considerably from little more than a week to 150-180 days.[178] The balloons work in concert to provide uniform coverage on the ground, with each balloon covering a circular area that is roughly 80 km in diameter.[179] As one balloon navigates out of reach of a given ground station, another moves in to take over. The balloons are capable of communicating with each other, with one balloon providing the uplink and relaying the signal to the other balloons (Figure 18). Alphabet reported that it was able to transmit at bandwidths of up to 500 Mbps between balloons that were 100 km apart.

[176] Alphabet. How Loon Flies. Accessed 13 June 2016.
[177] Tom Simonite. Project Loon. MIT Technology Review. Accessed 13 June 2016.
[178] The Guardian. Project Loon: Google balloon that beams down internet reaches Sri Lanka. February 16, 2016. Accessed 13 June 2016.
[179] Leon Kelion. Facebook's laser drones v Google's net-beaming balloons. BBC News. November 11, 2015. Accessed 13 June 2016.

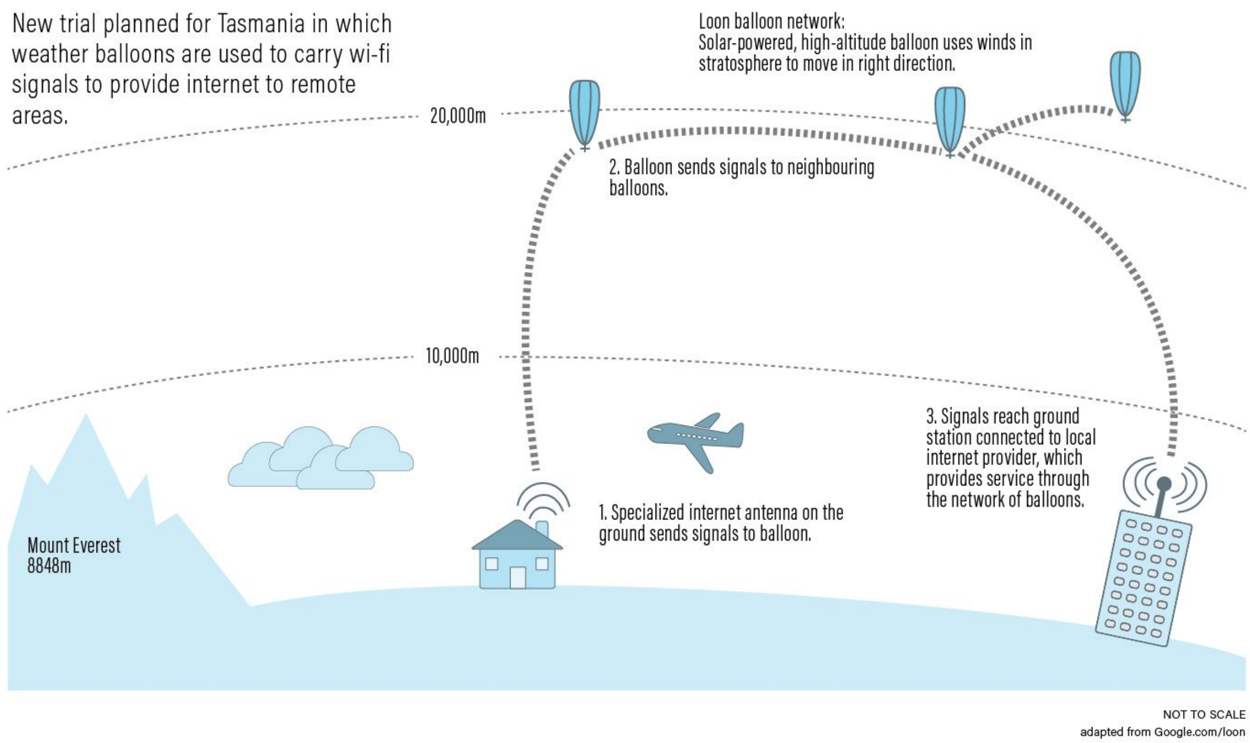

Figure 18. Schematic overview of Project Loon architecture

Alphabet has conducted a number of pilot Loon projects, beginning with New Zealand in 2013[180] and most recently in Sri Lanka and Indonesia[181]. The balloons utilize LTE technology, and Alphabet works with incumbent carriers to rent access to the Loon infrastructure. This could allow ISPs to provide better service in otherwise unreachable locations, and means Alphabet does not have to compete with incumbents and invest in expensive spectrum licenses in the jurisdictions it operates. Its technology is expected to be cost-effective for ISPs, with an estimated cost of operation of hundreds of dollars a day to serve thousands of users.

Drones

Alphabet purchased drone manufacturer Titan in 2014, but little is known about the project's progress to-date. Most recently, Alphabet has been experimenting with millimetre wave technology at Spaceport America under a project called SkyBender.[182] The millimetre wave technology is being tested using custom transceivers on the drones. It could have the ability

[180] Alphabet. Where Loon is going. Accessed 13 June 2016.
[181] The Guardian. Project Loon: Google balloon that beams down internet reaches Sri Lanka. February 16, 2016. Accessed 13 June 2016.
[182] Mark Harris. Project Skybender: Google's secretive 5G internet drone tests revealed. The Guardian. January 29, 2016. Accessed 13 June 2016.

to transmit up to 40 times more bandwidth than 4G technologies. Alphabet has permission from the Federal Communications Commission to run tests until July 2016.

More is known about Facebook's drone project, Aquila, which is being tested as a HAP for wireless bandwidth delivery in underserved rural communities. Miniature versions of the drones were first test flown in the UK in March 2016 and on June 28, 2016, Facebook flew a first test flight of its full-sized drones[183, 184]. The drones have a wingspan of about 42 metres – larger than a Boeing 737 – but only weigh ~400kg.[185] The Aquila drones are solar powered and will have the ability to stay airborne for three-to-six months. Unlike balloons, the drones' location can be precisely controlled, allowing them to circle over a specific underserved region of interest.

The drones will be designed to receive and relay bandwidth via lasers, which will be capable of transmitting up to tens or even hundreds of Gbps. This is considerably higher than the capacity of the radiofrequency communication technology employed by Alphabet's balloons.[186] Facebook has not yet conducted any pilot projects with the Aquila drones, but it is expected that ISPs would also rent access to these drones, preventing the need to compete with local incumbent carriers. Drones face considerable regulatory hurdles, as rules on the utilization of drones in the stratosphere are poorly defined.[187] Using balloons for HAP may have an added advantage in that regard, as there is a special exemption for balloons in international airspace legislation.

While progress is being made in the area of HAPs, there is still a long wait before they can be utilized. Both Alphabet and Facebook's technologies are still about two years away from commercially utilizing balloons or drones for wireless network delivery.

Changes in the policy and regulatory landscape

Federal funding earmarked for rural broadband

In its 2016 budget, the Government of Canada committed $500 million over five years to "extend and enhance broadband service in rural and remote communities." [188] Further details on program parameters will be announced in the coming months.

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[183] Samuel Gibbs. Facebook successfully tests laser drones in UK skies. The Guardian. March 27, 2015. Accessed 13 June 2016.
[184] Daniel Terdiman. Facebook Completes First Test Flight of Its Gian Internet Drone. Fastcompany. July 21, 2016. Accessed 28 July 2016.
[185] Samuel Gibbs. Facebook successfully tests laser drones in UK skies. The Guardian. March 27, 2015. Accessed 13 June 2016.
[186] Leon Kelion. Facebook's laser drones v Google's net-beaming balloons. BBC News. November 11, 2015. Accessed 13 June 2016.
[187] Tom Simonite. Alphabet and Facebook's stratospheric internet plans get tangled in high-altitude red tape. MIT Technology Review. March 26, 2016. Accessed 13 June 2016.
[188] Government of Canada. Budget 2016 - Chapter 2 - Growth for the Middle Class, 22 March 2016. Accessed 27 June 2016.

The federal government's 2016 budget also provides $255 million over two years, starting in 2016–17, to the First Nations Infrastructure Fund. It will be used to support investments in a range of complementary infrastructure projects, including broadband connectivity, "in order to help communities as they develop and grow." [189]

CRTC Review of Basic Telecommunications Services (Telecom Notice of Consultation (CRTC 2015-134)

In April 2016, the Canadian Radio-television and Telecommunications Commission (CRTC) concluded the hearing portion of their "Review of basic telecommunications services." Academics, public interest groups, individuals, municipalities, and telecom companies appeared before the commission to comment on the feasibility of including high speed internet as a "basic telecommunications service," or whether broadband internet is a basic service, akin to landline telephone services, to which all Canadians require access.

The hearing centred around three major questions: Is broadband an essential service? What essential activities are Canadians taking part in online, and what service level is required to support those? And how do we pay for it? The CRTC is expected to release a decision in the coming year.

CRTC Review of wholesale wireline services and associated policies (Telecom Regulatory Policy CRTC 2015-326)

CRTC decision 2015-326 mandates that large incumbent carriers provide disaggregated wholesale access to their fibre networks for access and transport facilities. Large DSL and cable providers have been required to share their copper and coaxial cable networks through wholesale and Third Party ISP Access (TPIA) arrangements since the 1990s. Incumbents will now be required to do the same with fibre optic access networks. Bell Canada appealed the decision with the federal cabinet,[190] but the petition was rejected by the Minister responsible for Innovation, Science, and Economic Development.[191]

The decision will be implemented provincially beginning with Ontario and Quebec. As per paragraph 152 of the decision, when a competitor requests disaggregated wholesale high speed access from the incumbent in Alberta, the new rule can be triggered here.

> *First, since the demand for wholesale HSA services is currently focused within certain geographic markets, disaggregated wholesale HSA services should be implemented in phases, starting with Ontario and Quebec. Other phases targeting the*

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[189] Government of Canada. Budget 2016 - Chapter 3 - A Better Future for Indigenous Peoples, 22 March 2016. Accessed 27 June, 2016.
[190] CBC. Bell appeals CRTC ruling forcing company to sell fibre internet access to small ISPs, 7 December 2015. Accessed 27 July 2016.
[191] CBC. Cheaper internet may be coming after cabinet rejects Bell appeal, 11 May 2016. Accessed 27July 2016.

implementation of disaggregated HSA services in other geographic markets will be identified at a later stage. Implementation of the disaggregated wholesale HSA service in the designated geographic markets will be triggered by competitor requests for the service at specific central office and head-end locations. Incumbent carriers are to consult with their wholesale HSA service customers to identify the specific central office and head-end locations where a disaggregated wholesale HSA service will be in demand. [192]

CRTC Examination of differential pricing practices related to Internet data plans (CRTC 2016-192)

In May 2016, the CRTC initiated a "proceeding to examine the policy issues surrounding the use of differential pricing practices by Canadian internet service providers related to the provision of internet data plans."[193] The proceeding stemmed from applications by several parties concerning Videotron's practice of offering an unlimited music service to its mobile wireless customers. In this example, the music service is a zero-rated service, which means that the music service does not count toward a plan's data-cap, whereas any other traffic does apply. So far, interventions by interested parties have addressed net neutrality and differential pricing practices in the form of zero-rating, sponsored data pricing mechanisms, and data caps.

Differential pricing by internet service providers is a growing global practice, and regulators in other jurisdictions have examined or are currently examining this issue. It is the aim of the CRTC to generate "a clear and transparent regulatory policy regarding differential pricing practices for internet data plans"[194] as a result of this proceeding. The hearing will take place in October 2016.

Industry Canada & Tower Siting

In 2008, during the Advanced Wireless Services (AWS) auction, Industry Canada mandated antenna tower and site sharing.[195] Tower and site sharing will become increasingly important as the provision of wireless access networks grows, particularly in rural Alberta.

In 2013, the Canadian Wireless Telecommunications Association and the Federation of Canadian Municipalities launched a joint Antenna System Siting Protocol Template — a tool for municipalities to use to develop antenna siting protocols or improve existing ones. Industry Canada also offers advice for local governments in creating processes in its Guide to Assist Land-use Authorities in Developing Antenna Siting Protocols.

[192] CRTC. Telecom Regulatory Policy 2015-326, para. 152, 22 July 2015. Accessed 27 July 2016.
[193] CRTC. Telecom Notice of Consultation CRTC 2016-192, 18 May 2016. Accessed 8 July 2016.
[194] CRTC. Telecom Notice of Consultation CRTC 2016-192, 18 May 2016. Accessed 8 July 2016.
[195] Industry Canada. CPC-2-0-17 — Conditions of Licence for Mandatory Roaming and Antenna Tower and Site Sharing and to Prohibit Exclusive Site Arrangements. Accessed 17 May, 2016.

Other infrastructure owners

Fibre and opportunities to coordinate connectivity may exist in the following transportation and infrastructure corridors in Alberta:

Electricity transmission towers
Transmission tower fibre optics, or optical ground wire (OPGW), is located at the topmost position between high-voltage power transmission structures that are distributed throughout Alberta. This wire is positioned to take advantage of an electric utility's transmission right-of-way to transport large amounts of data. It generally serves two main purposes:

1. Protect electrical infrastructure by grounding lightning strikes and fault currents; and
2. Carry optical signals for the protection and management of the transmission line.

The data capacity of the OPGW in almost all cases greatly exceeds the needs of the Transmission Facility Operators, leaving room for others to make use of the utility as a high-speed fibre connection.

Municipal fibre
Municipal communications networks exist in some jurisdictions for the purpose of public safety communications, asset management, public transit system communications, dark fibre leases, and broadband internet service provision.

Canadian Pacific Railway and Canadian National Railway
Fibre optic cables traverse existing rail rights-of-way. Rail lines are well suited for housing fibre backbones because the corridors and associated rights of way are owned by a single entity.

Petroleum and natural gas pipelines
Modern pipelines may employ fibre-optic monitoring systems along the length of the pipeline corridor. Like rail lines, pipeline corridors are well suited to homing fibre backbones as the long range rights-of-way are already negotiated.

Community & Volunteer Initiatives
In the UK, several rural communities have championed broadband initiatives by leveraging support from volunteers, landowners, farmers, private investors and government funding sources. These projects include Tove Valley Broadband, Broadband for the Rural North Ltd. (B4RN) and Fibre for Rural Nottinghamshire (F4RN). The initiatives are dependent on wayleave agreements between the broadband organization and farmer/landowner to enable work to be carried out on privately owned land (including access approval for network

installation, maintenance and repair). Volunteers from the community help with the administration of the project, recruitment of landowners, and even the physical labour involved (including digging trenches and laying duct work on the properties). Investor funding for the projects is raised by selling shares in the company (e.g. B4RN, F4RN) to the public. Shares are also offered as compensation to landowners.[196]

This innovative use of community and funding resources has considerably reduced the cost of fibre deployments in these rural areas. For example, B4RN was able to complete its network for a total of £2.7 million through a mixture of purchased shares (£1.4 M), loans (£1.3 M) and volunteer effort. This represents savings of £800,000 compared to the estimated commercial cost to deploy the fibre network. A similar strategy of leveraging local volunteer capacity and farmer / landowner involvement could be considered for rural Alberta to reduce the costs of deploying rural broadband networks.

IPv6

An Internet Protocol (IP) is a communications protocol system that identifies and locates computers or devices on networks, and routes traffic across the internet. According to Vint Cerf, founder of Transfer Control Protocol/Internet Protocol (TCP/IP) and current Chief Internet Evangelist at Google, Pv4 (Internet Protocol version 4) became the underlying protocol for the global internet when it was first designed in 1973. However, the founders of the internet did not anticipate the explosion of the internet. IPv4 address space allocation — similar to telephone numbers — is sufficient for only 4.3 billion termination points in the internet. Its store of 32-bit addresses was never intended to facilitate the formation of the global commercial internet as it exists today.

As a result of the expansion of the global internet, and increase in connected computers and devices, the IPv4 address "free pool" for the American Registry of Internet Numbers (ARIN — which administers number resource allocation in Canada, the United States, and parts of the Caribbean), was completely depleted by September 2015. (See Figure 19.) The remaining four Regional Internet Registries (RIR) are also nearing depletion of IPv4 number resources. This has resulted in an IPv4 address transfer market, where organizations with an excess of IPv4 resources can either return them to the RIR, or sell them to another organization that qualifies for resources under an RIR policy. When ISPs run out of viable IPv4 addresses, an ISP may not be able to give individual subscribers their own IPv4 address. Instead, to conserve resources, they may opt to put customers behind Carrier Grade Network Address Translation (CGN, NAT).

Engineers began to recognize IPv4 depletion would become a problem in 1998, and began developing the next generation protocol, IPv6. IPv6, which supports 340,000,000,000,000,000,000,000,000,000,000,000,000 or 340 trillion trillion trillion

[196] B4RN. Broadband for Rural North Ltd. Accessed 20 July 2016.

addresses, was developed and formally adopted by the Internet Engineering Task Force in 1998. IPv6 is comprised of unique 128-bit address as opposed to 32-bit addresses, and therefore features an exponentially larger pool of addresses to accommodate exponential growth of connected computers.

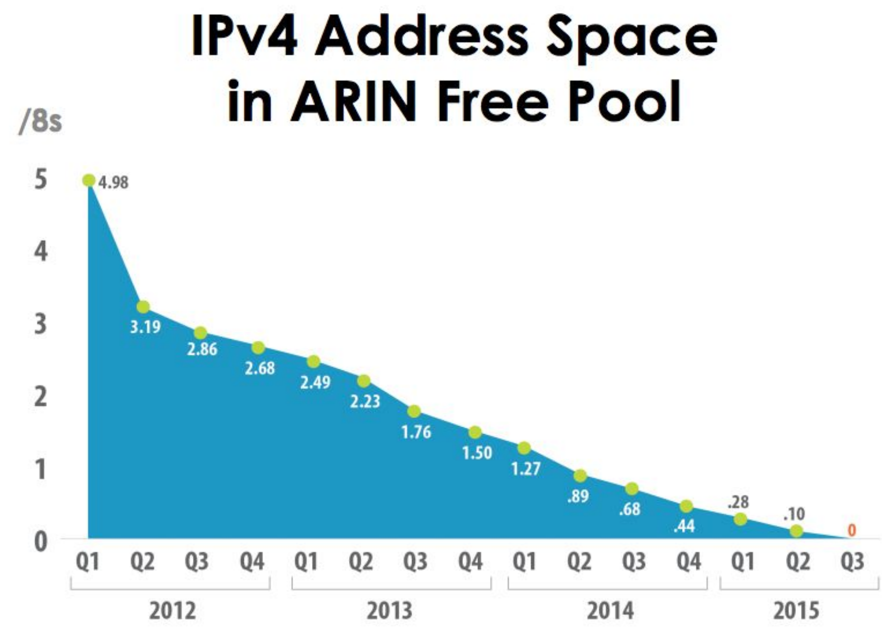

Figure 19. IPv4 Depletion in the ARIN Region[197]

While IPv6 has existed as a protocol for almost 20 years, uptake has been slow until the recent exhaustion of the IPv4 free pool. Because the majority of the internet continues to be accessible via IPv4 only, IPv6 must coexist concurrently, or side by side, with the fully functional IPv4 public internet. This “dual stack” architecture will continue to be necessary into the foreseeable future, until such a time that IPv6 becomes the default standard. “Tunneling” is a method which allows IPv4 and IPv6 to coexist. When two systems on the edge of a network support IPv6, but the routers on the public internet between them do not, IPv6 packets can be put inside IPv4 packets, and “tunneled.” Additionally, IPv6 packets can be translated into IPv4 packets utilizing NAT64 — a Network Address Translation technique.

Without the expansion of IPv6, and eventual replacement of IPv4, diffusion of the internet — including expansion of the Internet of Things (IoT), the “industrial internet” and sensor networks — will be limited by the resource and network management constraints of IPv4. The sheer quantity of devices projected to come online cannot be supported by IPv4. The future of internet connected devices and sensor networks relies on the transition to IPv6.

[197] ARIN. ARIN on the Road in Edmonton presentation, IPv4 Depletion Recap, p. 60, 3 May 2016. Accessed 13 July 2016.

Google collects and publishes statistics on IPv6 adoption rates based on the percentage of users accessing Google with an IPv6 connection. According to its statistics, Canada has adopted IPv6 at a rate of 8.95%, whereas the United States has adopted IPv6 at a rate of 28.96%.[198] CIRA reports different numbers at only 2.4% IPv6 adoption in Canada and even less at 2.06% in Alberta[199].

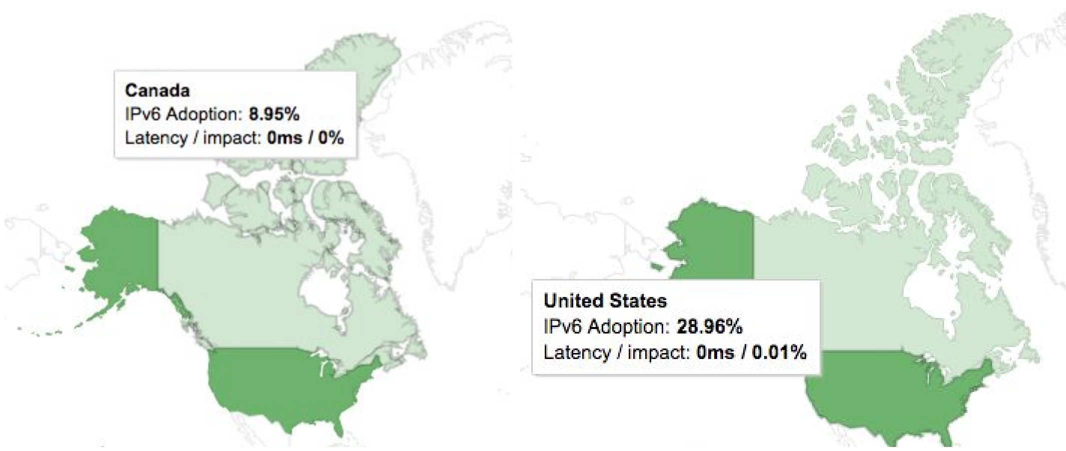

Figure 20. IPv6 Adoption in Canada and the United States based on accessing Google via an IPv6 connection (as of 13 July 2016) [200]

According to Google's statistics, IPv6 adoption has increased rapidly in recent years. This can likely be attributed to the exhaustion of IPv4 resources, leading to the increased immediacy of a full transition to the new protocol.

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[198] Google. IPv6 Statistics, North America. Accessed 13 July 2016.
[199] CIRA. Canada's Internet Performance: National, Provincial, and Municipal Analysis. April 2016.
[200] Google. IPv6 Adoption Statistics. Accessed 13 July 2016.

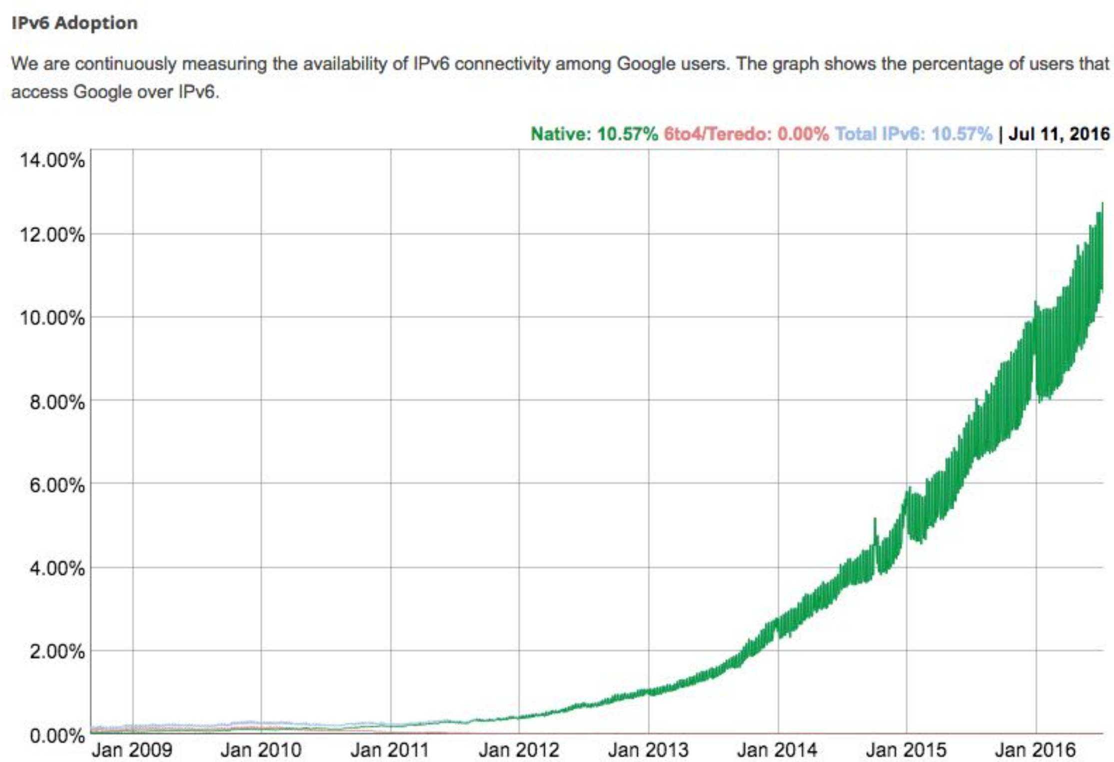

Figure 21. Global IPv6 Adoption over time based on accessing Google via an IPv6 connection (as of 13 July 2016) [201]

The American Registry for Internet Numbers shows similar statistics for uptake based on member ISP requests for IPv6 resources (Figure 22).

[201] Google. IPv6 Adoption Statistics. Accessed 13 July 2016.

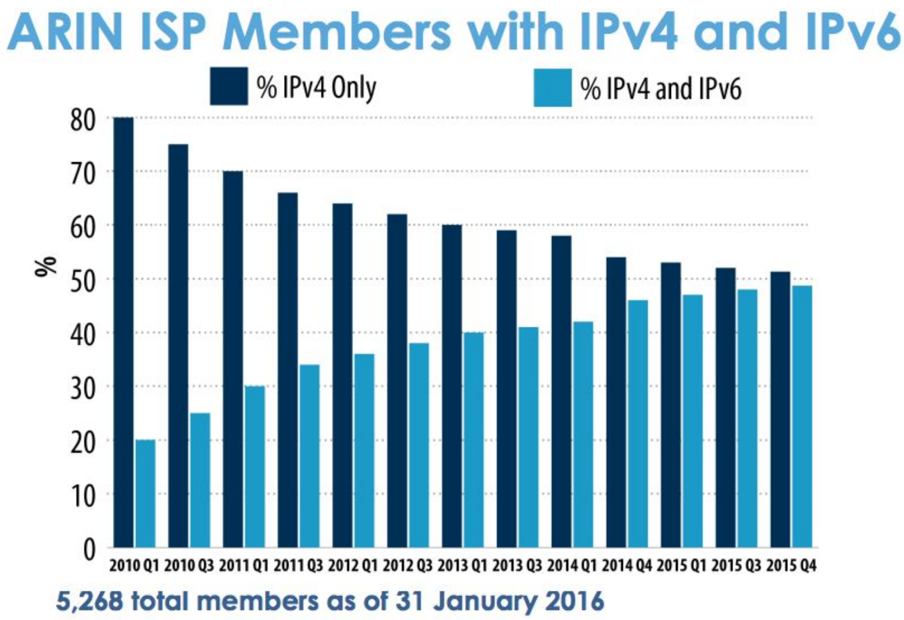

Figure 22. ARIN ISP Members with IPv4 and IPv6 2010-2016 [202]

The Internet Society measures and reports elements of IPv6 deployment on the global internet via the World IPv6 Launch website. Of the 255 networks participating in World IPv6 Launch, Telus ranked 12th in the world in terms of overall IPv6 traffic volume, with 45.92% IPv6 deployment. Rogers Communications (which comprises a significant portion of the mobile wireless market in Alberta) ranked 36th, with 7% IPv6 deployment on its network.[203]

Governments have the opportunity to play an important role in promoting IPv6 expansion and awareness. First, governments can implement IPv6 in their internal network operations and product cycles. Second, they can coordinate with industry to provide incentives for IPv6 adoption. Third, governments can make IPv6 functionality a condition of any network infrastructure related procurement. There are free resources available for IPv6 training available through ARIN's IPv6 wiki, and consultants working in the area of IPv6 offer workshops and seminars to assist network policy makers and operators with the transition.

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[202] ARIN. ARIN on the Road in Edmonton presentation, IPv6 Adoption, p. 183, 3 May 2016. Accessed 13 July 2016.

[203] Internet Society. World IPv6 Launch Measurements. Accessed 13 July 2016.

Future Needs and Opportunities

In some countries, access to the internet is now considered a basic human right,[204] and the UN has recognized the internet as an enabler of human rights (such as freedom of opinion and expression).[205] Multiple studies[206,207] show that broadband has a positive effect on a nation's GDP and household income, as it increases personal productivity and allows for more flexible working and learning opportunities. Making more high-speed broadband available across rural Alberta will open new employment possibilities and revitalize traditional industries with new technologies, such as virtual tourism.

In Canada, internet traffic is expected to grow 2.7 times between 2015-2020 (a compound annual growth rate of 22%),[208] and the number of connected devices will grow to three times the human population. This increase will require more bandwidth.

Short-term recommendations (1-3 years)

- ***Alberta needs a provincial broadband strategy.*** A comprehensive framework linking all connectivity technologies and opportunities across the province.
- ***As per Cybera's submissions to the CRTC, the province should set a target of making available 25 Mbps symmetric internet bandwidth for all citizens.***[209]
- ***Alberta needs coordinated leadership for the development of rural broadband solutions.*** A *community of communities* should be created to act as an aggregator and facilitator of resources from diverse sectors to determine their options for broadband adoption.
- ***The new Alberta SuperNet agreements (due in 2018) must have the necessary vision, flexibility, and sustainability for Alberta to play a leadership role in broadband.***
- ***Government and industry need to further develop and promote Internet Exchange Points (IXPs) as part of a provincial broadband strategy.*** Calgary and Edmonton need to grow their IXPs in order to improve internet resiliency, minimize long range data transport costs, and increase competition within the carrier market.
- ***There should be regulatory oversight for the practice of oversubscription and delivery of advertised download and upload speeds.*** In particular, ISP's should be

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[204] United Nations. Report of the Special Rapporteur on the promotion and protection of the right to freedom of opinion and expression, p. 18, 16 May 2011. Accessed 27 July 2016.
[205] United Nations. The promotion, protection and enjoyment of human rights on the Internet. 27 June 2016.
[206] Danish Energy Association (2010) The socio-economic value of digital infrastructures. Copenhagen Economics.
[207] Ericsson, Arthur D. Little, and Chalmers University of Technology (2013) Socioeconomic effects of Broadband Speed.
[208] Cisco, VNI Complete Forecast Highlights Tool, 2016.
[209] Cybera. CRTC Review: Cybera's Submitted Response on Future of Broadband. 14 July 2015. Accessed 29 July 2016.

required to provide consumers with guaranteed minimum speeds (see Cybera's recommendation to CRTC.[210])

- ***Government should monitor developments and opportunities to leverage new technologies (including DSL and cable protocol improvements, and LEO satellite and high-altitude wireless network deployments) in the province.***

Long-term recommendations (3-10 years)

- ***The province should develop a plan to leverage federal funds and initiatives to expand broadband access into rural Alberta.***
- ***The province should set a target of 100 Mbps symmetric internet bandwidth for all citizens*** to place Alberta among the top 20 countries for average internet access speeds.
- ***Municipalities should consider opening their fibre assets to public institutions and community based not-for-profit ISPs.*** This should not preclude the use of municipal fibre by commercial carriers on commercial terms.
- ***Government regulations should require all trenching of public land to include the installation of conduits that can carry public access fibre.*** This will greatly reduce the cost of building out infrastructure for future expansion.
- ***Antenna tower and site sharing should be encouraged and facilitated by rural municipalities and land-use authorities in a way that supports the deployment of fixed area wireless.***
- ***Continue investment in CyberaNet, the provincial R&E network, with a target of > 100 Gbps capacity in the next five years.***

[210] Cybera. The Future of Broadband Internet Access in Canada. 24 January 2014. Accessed 29 July 2016.

Data Centres and Hosting Facilities

Overview

Data centres are vital tools for the operation of digital infrastructure as they host most of the physical components, including networking and storage equipment. In Alberta, Cybera identified at least 17 commercial data centres, and several not-for-profit data centres, particularly within the Universities of Alberta and Calgary. As well, a number of post-secondary institutions have engaged in a Shared Data Centre initiative, which will benefit all post-secondary institutions in the province by providing access to extensive and secure storage, backup and computing resources.

However, as the research and enterprise needs of the province continue to grow, additional capacity at the data centres will be required. This will require better utilization of existing resources, and the building of new resources. There is also an excellent opportunity for the Government of Alberta to team with post-secondary institutions to access national digital infrastructure funding, and make Alberta a digital research leader in the country.

Background

Data Centre Standards

There are three main standards that data centres in Alberta follow: Uptime Institute, SSAE16, and ISO.

1. **Uptime Institute**

Uptime Institute's four tiers provide a method for objectively comparing one data centre to another, and provide guidance on the design topology for delivering availability to meet the data centre and users' needs. These tiers provide detailed architecture, security, electrical, mechanical, and network recommendations, and evaluate data centres based on their ability to perform maintenance and withstand fault. The tiers are as based on the TIA-942:Data Center Standard, which was implemented in 2005[211].

Table 5. Uptime Institute Tiers

Tiers	Availability	Design Topology
Tier 1: Basic	99.671%	Non-redundant capacity components (single uplink

[211] Gite, Vivek. nixCraft. Explain: Tier 1/Tier 2/Tier3/Tier 4 Data Center. 7 June 2008. Accessed 13 September 2016.

		and servers)
Tier 2: Redundant Components	99.741%	Tier 1 + Redundant capacity components
Tier 3: Concurrently Maintainable	99.982%	Tier 1 + Tier 2 + Dual-powered equipments and multiple uplinks
Tier 4: Fault Tolerant	99.995%	Tier 1 + Tier 2 + Tier 3 + all components are fully fault-tolerant including uplinks, storage, chillers, HVAC systems, servers etc. Everything is dual-powered

2. SSAE16

SSAE16 (Statements on Standards for Attestation Engagements No. 16) is used for reporting on controls (for more information please see the Cybersecurity section).

3. ISO Certification: Security and Environmental Management

<u>Security</u>

ISO 27001 specifies the requirements for establishing, implementing, operating, monitoring, reviewing, maintaining and improving a documented information security management system. This standard ultimately ensures best practice for security controls to protect information assets (more information on this can be found in the Cybersecurity section).

<u>Environmental Management</u>

ISO 14001 addresses environmental management. This standard provides tools for companies to identify and control their environmental impact and constantly improve their environmental performance.

Data Centre Costs

In its 2013 report, Compute Canada reviewed existing data centres located at universities in Canada and determined the most significant capital and operating expenses for running a research data centre facility.

Through the creation of the report, Compute Canada developed a model to help estimate and compare the total cost of ownership of a data centre. This model can be used to evaluate the use of existing and potential new data centres in the research and innovation sector. The model does not include the infrastructure required to develop Tier 3 or 4 data centres, given the additional costs and the limited benefit for an academic or research data centre.

The following section has been copied from the Compute Canada report[212]. It demonstrates the most significant capital and ongoing costs associated with research data centres located at an institution. Megawatts (MW) are used as the benchmark to describe data centre capacity, since power (electricity) access and costs are the determining factor when operating a data centre[213].

Table 6. Typical Capital Hosting Facility Costs for One Megawatt of Computing Equipment

Capital Expenditure (Amortization Period)	**Total Cost ($000s)**	**CC Total Cost ($000s)**
1. Space (50 years)	$353	-
2. Main power feed (25 years)	$600	$600
3. Generators (25 years)	$1,500	-
4. Cooling (20 years)	$1,045	$1,045
5. UPS (25% of load – 10 years)	$313	$313
6. Power Distribution (10 years)	$125	$125
7. Racks and Other	$205	$205
Total and Capital Costs	**$4,141**	**$2,288**

The costs presented in the above table are based on the expected cost for a data centre in British Columbia. Similar analysis can be done for a facility that is developed anywhere in Canada. Although the cost of components will vary by region, it is not expected to vary significantly (ie: a generator will cost the same in BC as in Ontario, within a certain margin). The estimated life (capital amortization period) of each component is also provided in Table 6.

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[212] The information replicated from the Compute Canada report was done so with the permission of the organization. The report was circulated within the Member community, but is not public as it includes confidential, and now outdated information about various Compute Canada sites. However, the information and conclusions included in this report are still accurate.
[213] Miller, Rich. Data Center Knowledge. Data Center Leasing: It's All About the Megawatts. 11 November 2009. Accessed 13 September 2016.

Table 7. Typical Annual Hosting Facility Costs for One Megawatt of Computing Equipment

Expenditure	**Total Cost ‘000 ($)**
Annual Operating Costs	
1. Maintenance Costs: For each component annual maintenance costs were derived as a percentage of initial capital costs	$153
2. Infrastructure personnel costs: Security, janitorial, accounting, administration personnel, but not CC HQP support staff.	$100
3. Electrical energy costs: @ 10 cents/kWhr and a PUE of 1.2	$1,052
Subtotal Annual Operating Costs	***$1,304***
Annualized Capital Costs (see Table 6 for total cost by item)	$359
Total Annual Hosting Facility Costs	**$1,662**

Regardless of who pays, the true cost of hosting one MW of computing equipment is on the order of $1,662,000 per year, including amortizing invested capital and $1,304,000 in annual direct operating costs (such as electricity, ancillary equipment maintenance and on-site non-Compute Canada personnel).

Table 8 decomposes the five Compute Canada-determined relevant infrastructure components, plus electricity and personnel, to assess which ones are most significant. This table excludes items that Compute Canada does not need nor typically pays for.

Table 8. Breakdown of Hosting Facility Cost Components

Component	**Capital Cost (%)**	**Annual Cost (%)**
Main Power Feed	26%	4%
Cooling	46%	10%
UPS	14%	4%
Power Distribution	5%	1%
Racks and Other	9%	3%

Electrical Energy	N/A	71%
Infrastructure personnel	N/A	7%
Total Percent	100%	100%
Total Cost	**$2,288,000**	**$1,482,000**

While no two data centres are alike (hence why the capital and annual costs differ), the above table does suggest which costs are more/less significant. From a capital cost perspective, cooling and the main power feed account for approximately three quarters of the total cost. Although costs in any specific hosting facility will vary it is believed that the relative proportions will not. Hence, attention should therefore focus on electrical costs, cooling, and the main power feed when determining which sites offer the lowest cost opportunities.

Current Landscape

Private Sector Data Centres

Alberta has a significant amount of capacity and capability available within its commercial data centres. At the time of writing this report, Cybera identified 17 commercial data centres (See Appendix 5: Data Centre - Industry) located in the province. The most significant commercial providers were Q9 and Rogers Data Centres. The use of these facilities, particularly the Tier 3 and 4 data centres, are dominated by commercial users. On average, the difference in the cost between a Tier 2 and Tier 3 data centre is 50%.[214] This section provides an overview of the public information available about commercial data centres in the province, however the focus of this report is on the academic data centres. These not-for-profit facilities are traditionally more cost-effective and amenable (at least to date) for the research and innovation sector.

Not-For-Profit Data Centres

Cybera gathered information from post-secondary institutions, municipalities and the provincial government on their not-for-profit data centre use. Reasonably detailed information was provided by the University of Alberta, University of Calgary, NAIT and Mount Royal University.

[We intend, wherever possible, to obtain detailed information from all post-secondary institutions to understand the full scope of facilities within the province. It will take some time to get this data but this section will be updated as it becomes available. Cybera also reached

[214] Avelar, Victor. American Power Conversion. Specifying Data Center Criticality/Tier Levels, White Paper #122. 2007. Accessed 13 September 2016.

out to select municipalities and the Province to include information about the broader scope and data centre information, but we did not receive any information back in time for this draft.]

From the information gathered, Cybera can conclude that the most significant data centre capacity in the province rests within the Universities of Alberta and Calgary — with approximately 5.5 MW of combined power capacity. In comparison, NAIT and Mount Royal have a combined capacity of less than 0.5 MW of capacity. At the time of writing this report, the combined spare capacity at the Universities of Calgary and Alberta was 1.5MW, the majority located at the University of Alberta. It is important to note that this available capacity is subject to change as additional projects are developed and brought online, and as resources are consolidated and decommissioned. Although Cybera did not gather information for all 26 Post Secondary Institutions in Alberta, from the sampling of information gathered, Cybera is confident that the availability of space and resources at the Universities of Calgary and Alberta compose the majority of the data centre capacity in the academic sector in the province.

The University of Alberta operates three major data centres at their institution. Two of the facilities are located on the north campus in the General Services Building (GSB) and the Edmonton Clinic Health Academy (ECHA); the third is located downtown at Enterprise Square (ESQ). The University of Calgary operates four major data centres at their institution. Three of the facilities are located on the main campus and the third is at Foothills. The following table provides some basic information about these data centres, additional details can be found in Appendix 6: Data Centre - Not-for-Profit.

Table 9: Basic data center information from the UofC and UofA

	Power (MW)	**Power Usage Effectiveness (PUE)**	**Generator**
GSB (UoA)	1.0 (could expand up to 4.0)	1.6	Yes - Partial
ECHA (UoA)	1.0	Unknown	No
ESQ (UoA)	1.0	1.6	Yes - Partial
PDC (UoC)	1.0	1.5 (estimate)	Yes
RDC (UoC)	> 0.5	2.0 (estimate)	Yes - Partial
CCIT (UoC)	0.4	1.3 (estimate)	No
HRIC (UoC)	0.45	1.5 (estimate)	Yes

Although neither the University of Calgary nor the University of Alberta data centres has had a formal security audit or certification, they have a variety of security measures in place to ensure that the resources and information housed within their facilities are secured. Both universities have a variety of physical security measures in place, including access policies, swipe access cards and video cameras. They also have consolidated monitoring of environmental, mechanical, electrical and fire/water detection systems. As well, all buildings have campus or building security teams that monitor the facilities. The University of Calgary houses Patient Identifiable Data (PID) at two of its sites, and has the necessary infrastructure and security measures in place to meet the requirements to house that data.

The Alberta Shared Data Centre initiative is providing an innovative approach to developing cost effective solutions for other post-secondary institutions within Alberta. This initiative will leverage unused data centre capacity within the Universities of Calgary and Alberta to support smaller institutions' data centre needs, creating cost savings as well as disaster recovery opportunities.

Future Needs and Opportunities

Determining the future needs and opportunities for data centres within the province is very much dependent upon how Alberta's entire digital infrastructure is developed. There is little benefit to funding a large data centre if there are no corresponding investments into data management and storage in that centre. Similarly, investments into computing hardware need similar investments in data centres to house them.

It is expected that, within the next 5-10 years, additional capacity will be required to host the growing digital infrastructure required to support Alberta's research and innovation sector.

Short-term recommendations (1-3 years)

- ***An Alberta team of experts should be created to determine the short and medium term needs for computing infrastructure investment, and analyse the data centre capacity required to support this.*** This could include leveraging existing data centre capacity at the Universities of Alberta and Calgary, with plans to build additional public data centres, as well as leveraging the capacity at existing private sector data centres (when cost effective).
- ***The province should support the development of the Shared Data Centre Initiative****.* This will enable the sharing of expertise, facilities and best practices across a broad range of institutions. It will also help predict future capacity needs by providing an example of an effective, geographically distributed, data centre tuned for the provision of shared services.
- ***As new data centres are developed, additional capital investment should be made to develop energy efficient data centres.*** Since the most significant cost for

data centre operations is electricity, there can be significant savings by reducing energy consumption.

- ***The government of Alberta should support a joint plan for hosting infrastructure for the expected Canada Foundation for Innovation (CFI) Cyber-infrastructure program.*** This would give Alberta a significant opportunity to be a national leader in computing infrastructure. At the time of writing this document, Compute Canada had just released its plans for selecting the sites for this expected program. The Universities of Calgary and Alberta are developing a joint plan in response to the call.

Long-term recommendations (3-10 years)

- ***Build one or two trusted facilities within government or the University of Alberta and University of Calgary campuses to house sensitive information.*** This would provide a valuable service for both the research and health communities. Although there is some capacity to host personal identifiable data (PID) in existing facilities, there is a growing demand for this information within the province.
- ***Create requirements for new data centre facilities that make use of renewable power sources.***

Gaps

- Waiting on additional stakeholder feedback.

Computing

Overview

Computing needs in the province can be broken down into two broad categories: High Performance Computing (HPC) and Cloud computing. HPC is used by researchers requiring large amounts of computing resources (‘compute power’: i.e. some combination of CPU cycles, memory and storage). These demands could require specialized hardware and software, or more commodity type systems in which large amounts of resources are utilized simultaneously. Cloud computing resources are defined as commodity infrastructure that is available on demand and is user-friendly. Cloud is typically used by people requiring smaller amounts of resources, and can occasionally also serve the needs of users who require HPC or large amounts of resources. The underlying hardware that creates a cloud resource is the same as that which is acquired for *non-specialized* HPC usage. It is only the software and the mode in which the infrastructure is allocated that makes it different.

The figure below summarizes the vast computational power required by HPC users, while demonstrating that the majority of users can utilize a much smaller amount of compute power. The generally accepted ratio of users on the head-end vs the long tail is 5% vs 95%.

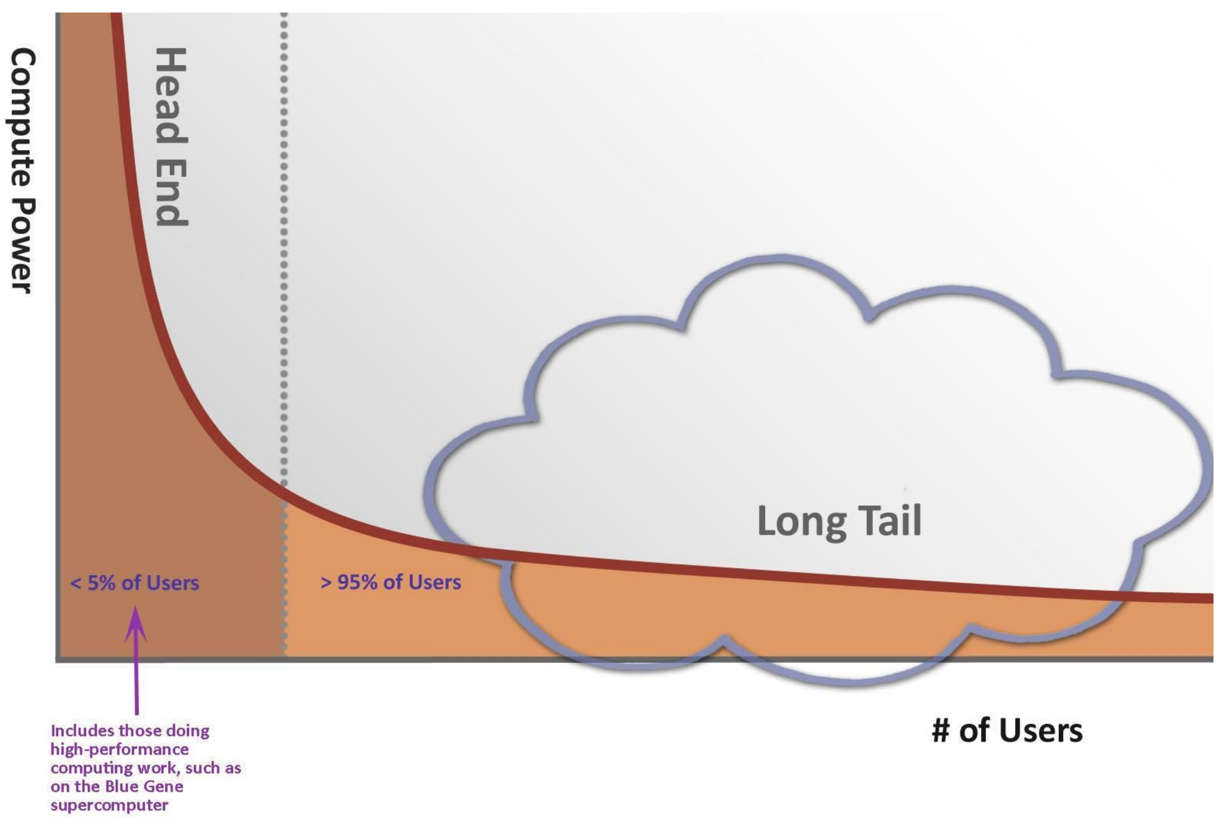


Figure 23. Long-tail graph depicting computational power required by HPC users

The demand for computing resources for Research, Education & Innovation fits into a Long Tail, or power law graph, with the number of users along the x-axis and the scale of required computing resources along the y-axis. A relatively small percentage of researchers do their work at the head-end, but their hunger for computing resources is almost limitless. This is where HPC is needed, and head-end researchers will work and compete to get access to the limited HPC resources available.

It is important to note that head-end researchers *must* have special computational resources to do their work (i.e. without them they cannot function). Long-tail researchers and entrepreneurs do not require HPC, but instead require basic computing resources to help get the job done. These users are not generally competing for and acquiring access to high-performance computing resources, nor would they have the expertise to use HPC if it was available to them. Percentage-wise, the long tail represents the majority of researchers and innovators. The detailed uses of these researchers will vary dramatically and are difficult to predict, but they all share the feature of only requiring relatively small amounts of computing resources.

> *In the head-end, researchers have sparse and limited access to the shared resources they need, meaning they must use shared HPC resources as quickly and efficiently as possible. In the long tail, researchers have immediate and frictionless access to computing resources, freeing up their time and creating new investigative avenues for them.*

Although for simplicity we distinguish between head-end resources as HPC, and long tail resources as "cloud", it is important to note that cloud computing can also be used as HPC resources by some researchers. In general, many HPC providers have, or plan to have, large clouds available as part of their suite of HPC resources, as well as various other specialized types of HPC computing equipment. Conversely, specialized HPC resources are not typically suitable for commodity computing by the less demanding users in the long tail.

While it is possible to total the amount spent by various levels of government on highly visible, and sometimes costly, head-end computing resources, this is not true for the long tail. Because there are so many projects being supported with no overall coordination, the total is unknown. It is, however, reasonable to hypothesise that the spending on the long tail may equal or exceed that of the head-end, without achieving the commensurate benefits from economies of scale described later in this section.

This section will talk about the availability of HPC and Cloud resources for the research and innovation/private sectors in Alberta.

Background: High Performance Computing

Within Alberta it is difficult to gather information about private sector HPC use and resources. Cybera is aware of significant usage in this area by a variety of sectors (particularly oil & gas), but these resources are independently owned and information is not readily available. As such, all of the information presented in the HPC section focuses on the resources that have been publicly funded and are available primarily for the research sector. However, some of these resources are also available for the innovation community through partnerships with the research community. Cybera is not aware of any non-commercial HPC resources specifically provisioned for innovators.

Current Landscape: High Performance Computing

Compute Canada / WestGrid

The majority of data centre and HPC capacity for the research and academic sectors resides at the Universities of Alberta and Calgary. These HPC resources are owned by the Universities, and are managed by Compute Canada through its regional division, WestGrid.

All Compute Canada resources are available for use by any Canadian researcher, regardless of where they are located. As such, researchers from Alberta commonly use resources located outside of the province, while researchers from outside of Alberta utilize resources located at the Universities of Alberta and Calgary. This sharing model provides an efficient and cost-effective way to maximize the benefit of these resources. As long as sufficient network bandwidth for the movement of data is available through Cybera, CANARIE and its partner organizations, there is no reason to duplicate expensive special purpose hardware. Data residency considerations may apply in some cases, such as health, but it is often cheaper to resolve inter-provincial regulations than to buy redundant systems.

The last major installation of HPC resources in Alberta was through the National Platforms Fund awarded in 2006, with the infrastructure installed from 2010-2012. This award was for more than $150 million, which included a $60 million investment from CFI matched by the provinces and vendors through in-kind contributions. Within Alberta, the total investment was $22 million — with a $6.75 million contribution from CFI, a $6.75 million contribution from the Province of Alberta, a $600,000 investment from the institutions and an $8 million in-kind investment from vendors.

There are four major HPC systems (see table 10) located in Alberta, providing 17,360 cores and 0.5 PB of short and medium term storage. The full network of Compute Canada resources (which Alberta researchers have access to) includes almost 200,000 cores and 20 PB of storage.

Table 10: Major HPC Systems in Alberta

Name	# Cores	Memory	Storage	Capabilities
Parallel (UoC)	7,056 & 180 GPUs	13.8 TB	160 TB (shared with Lattice)	Cluster with fast interconnect, GPUs/Visualization
Hungabee (UoA)	2,048	16 TB Shared across all nodes	53 TB + 356 TB shared with Jasper	Shared memory
Jasper (UoA)	4,160	8.1 TB	356 TB (shared with Hungabee)	Cluster with fast interconnect
Lattice (UoC)	4,096	6 TB	160 TB (shared with Parallel)	Cluster with fast interconnect

The majority of HPC in the province is funded by CFI in partnership with the Province through matching contributions. The appendix (Data Centre - Not-for-Profit) lists all of the known HPC infrastructure in the province. Most of these systems are smaller clusters that were purchased by individual researchers or a small number of researchers. Since Compute Canada was created in 2006, CFI has pushed researchers to utilize Compute Canada resources, greatly reducing the number of individually owned institutional HPC resources which are available to the research community. The list provided in the appendix is not a complete list, but does illustrate that the majority of HPC capacity in the province is provided through the Compute Canada network.

Compute Canada allocates the majority of its resources (typically 70-80%) through an annual Resource Allocation Call. A small portion is also available to researchers who only require a small amount of resources or don't fit within the Resource Allocation Committee call. In the last Resource Allocation Committee round, 44 of the 280 resource allocations went to Alberta faculty members. Between October 2013 - October 2014, Alberta researchers used a total of 1.7 billion core hours, with an estimated cost within the Compute Canada environment of $7.4 million. The estimate to purchase the equivalent computational power from commercial providers is $18.5 million. [215]

High Performance Computing Usage

High performance computing resources are utilized by a diverse number of researchers in a wide variety of disciplines including humanities, social sciences, engineering, science, business and medicine. Alberta has renowned researchers creating new discovery and innovation through the use of these computational resources. Almost 600 users within

[215] This is calculated by Compute Canada annually based on averaging the cost of purchasing roughly equivalent cloud resources from a few vendors.

Alberta have leveraged Compute Canada HPC resources over the past year. In the past decade, 25 researchers received Alberta Innovates grants to leverage HPC resources through Compute Canada.

Examples of the various disciplines and researchers that rely on this infrastructure within Alberta include:

Chemistry, Biochemistry and Biophysics: Access to substantial HPC resources is critical to international competitiveness in these fields. Understanding the behaviour of molecules through complex simulations pushes the limits of high performance computation. Example researchers: Peter Tieleman (University of Calgary). Dennis Salahub (University of Calgary), Sergei Noskov (University of Calgary), Paul Hayes (University of Lethbridge) and Stacey Wetmore (University of Lethbridge).

Bioinformatics and Medicine: These represent two of the fastest growing sectors in usage of HPC resources. There are challenging requirements in these sectors around privacy of personal health information, data movement and pace of technological change. Researchers have been making tremendous breakthroughs using Compute Canada resources. Example researchers: Lorne Tyrrell (University of Alberta), Jack Tuszynski (University of Alberta), Michael Houghton (University of Alberta), Jason DeKoning (University of Calgary) and Gang Wong (University of Alberta).

Subatomic Physics and Astronomy: In these fields, both experimental and theoretical work rely critically on HPC. The experimental side of subatomic physics and astronomy help to define both “Big Science” and “Big Data”. Experimental research in these areas is typically performed by large international collaborations with significant computational and data storage needs. Example researchers: Darren Grant (University of Alberta), Roger Moore (University of Alberta), Erik Rosolowsky (University of Alberta) and Eric Donovan (University of Calgary).

Engineering, Computer and Information Sciences: These disciplines employ HPC to solve problems ranging from improving aircraft design to artificial intelligence. HPC resources are also critical for reservoir modelling. Example researchers: Michael Bowling (University of Alberta), Duane Szafron (University of Alberta), Zhangxing (John) Chen and Craig Johansen (University of Calgary).

Sustainability & Operations

There is no contribution to the ongoing operations of Compute Canada’s systems from the province. The ongoing operations of Compute Canada infrastructure currently costs around $2.3 million annually, including electricity (23% of budget) and personnel (72% of budget). Alberta’s post-secondary institutions currently employ 9.5 staff to support Compute Canada equipment, and 2.5 staff to support "central" WestGrid functions. Over 65% of these expenses are borne by the institutions, with the remainder funded by CFI through the Major Science Initiatives.

The full-time equivalent staff that support WestGrid are highly qualified personnel, most with Masters or PhD-level education. A small portion of these individuals support the clusters, but the majority provide advanced support to assist HPC users. The non-CFI clusters are also operated and maintained by the institution, with all but a small portion of the expenses covered by the institutions.

Background: Cloud Resources

Cloud resources can be sourced in several different ways. Similar to HPC resources, the physical location of the equipment is largely irrelevant as long as there are sufficient network resources for connection. This means that Alberta innovators and researchers can choose between commercial and publicly funded resources in the manner best suited to their needs.

It is essential to ensure that these groups can access cloud resources to effectively collaborate, scale from prototype to commercial volume, and use the range of computing power to accelerate and enable their work. The character of their usage is quite different from the HPC users, but no less key to their success.

When mentioning cloud resources, this report is specifically referring to Infrastructure as a Service (IaaS). Types of resources available in a long tail cloud include compute, memory, and storage. It is important to realize that there are practical limitations to how much of each type of resource can be made available on-demand to long tail researchers. The particular resource mix required by a long tail researcher at any given time will vary dramatically, and the overall requirements of long tail users will cover the whole spectrum of possible combinations of compute, memory and storage.

It is therefore important to plan long tail cloud resources to be flexible enough to cover a broad range of use cases. As an example, one long tail user may require modest amounts of computing resources and memory but significant amounts of storage, as in the case of users who record and store video footage for their research. Another user may need little storage and compute, but may require significant amounts of memory to perform analyses of data. Some users may need to seek additional resources from other sources, such as a shared HPC facility or data store.

Current Landscape: Cloud Resources

Although Cybera recommends making an Alberta cloud (singular) available for long tail researchers and innovators, it is important to realize that, in the long-term, long tail resources will be fungible and researchers need not (in fact, in general *should not*) care if they are using a local cloud resource or many clouds spread out across the country or world. For example, researchers and innovators already make widespread use of commercial resources such as Amazon Web Services (AWS), Microsoft Azure, RackSpace, and Google Compute Engine. JANET (in the UK) has negotiated contracts with major commercial cloud providers on a national basis to allow local researchers to seamlessly access and use these resources at a set rate. In Europe, Australia and North America, new research clouds are also springing up frequently, and will continue to do so at local, regional, and national levels. This section describes some of these existing cloud resources.

Table 11: Cloud Resources of RAC and DAIR

	RAC	DAIR	WestGrid
Cores (vCPU)[216]	8,960	12,288	TBD
Physical Cores (CPU)	280	384	1,218
Memory (TB RAM)	5	4.5	16.5
Storage (TB)	Object: 12 Block: 109	Object: 48 Block: 24	300

Rapid Access Cloud (RAC)

The Rapid Access Cloud provides free cloud computing resources for up to one year to Alberta-based academics, researchers, not-for-profits and small to medium sized organizations. It is intended to:

- Reduce the time it takes for small and medium-sized enterprises to prototype, test and validate new ideas and bring products to market.
- Help researchers compete more effectively.
- Provide a staging ground for businesses to learn about running services in the cloud before moving to a commercial platform

The RAC is operated by Cybera and run on an OpenStack environment. It is housed in the Universities of Alberta and Calgary's Shared Data Centre. Today, there are over a 120 active users of the RAC cloud and 57 completed projects. These include groups that are prototyping games or video development platforms, as well as creating social media analysis tools or time-saving apps. User groups include education (K-12, post-secondary), not-for-profit organizations, and government. As examples, two use cases for RAC include:

Sound Card in the Cloud: A researcher at the University of Alberta used the RAC to set up a soundcard in the cloud. One problem for a DJ is the transport of computers to a venue and

[216] RAC and DAIR use a x16 overcommit ratio and x2 hyper threading. Compute Canada uses x2 hyper threading, but the overcommit ratio is still being tested and determined. The system will likely have different policies for different cores ranging from a 1:1 to 1:10 ratio.

the following setup of the computers used in playing and rendering music. The more computers involved, the longer the setup and teardown of a performance. To solve this he developed a prototype in the RAC simulating the effect of multiple computers. Instead of interacting with multiple physical computers, the researchers could generate different sounds simply by moving the cursors around. Those sounds then streamed to the user's device - like a tablet or even a smartphone, which is connected to speakers to output the sound. He recently presented his research done on the RAC at a conference in London, England.

SAIT Applied Research Lab: SAIT's applied research lab works with entrepreneurs to help them develop applications. One such entrepreneur is Paylab. Paylab developed a smartphone enabled payment system for vending machines that will allow you to use your cellphone to pay. The RAC provided them with a quick prototyping and development environment.

Digital Accelerator for Infrastructure and Research (DAIR)

DAIR is a CANARIE project that leverages Canada's investment in CANARIE and the research and education network to provide Canada's high-tech entrepreneurs access to free cloud-based compute and storage resources to help them accelerate the pace of product development and gain a competitive edge in the global market. DAIR provides entrepreneurs with free, high-performance, made-in-Canada cloud resources for product development, testing and demonstration.

Cybera operates the OpenStack cloud infrastructure and equipment is managed by Compute Canada at the University of Alberta and the University of Sherbrooke. There are currently 229 active users and 67 users who have completed their one-year tenancy in DAIR. Two example use cases for DAIR are:

Kiribatu Labs: Kiribatu Labs was developing a risk management technology and software for the insurance sector. They were developing formulas that calculate what claims clients will make, based on the data they supply which involves a lot of number crunching and computing resources. They needed a solid computing infrastructure to run simulations on to develop their product. They utilized DAIR to run faster and more simulations and more test scenarios than what they could do on their own servers. This resource allowed them to get to market with their products faster.

Gnowit: Gnowit is an information monitoring solution. They needed to be able to manage and sift through vast amounts of data sourced from the web. To conduct ongoing product development and testing, Gnowit needed to either purchase a room full of servers, or use a commercial cloud offering. Both of these solutions would have cost money, and as a startup they were very sensitive to incurring cost. DAIR enabled them to experiment with the cloud infrastructure for a fraction of the cost (and at a much lower risk profile) than if they had used one of the commercial offerings. Without readily available cloud resources, Gnowit may never have had the incentive to consider a cloud-based solution which would have limited their growth significantly.

WestGrid/Compute Canada & Institutional Resources

The University of Calgary has acquired some additional cores and are using these with the HP Labs cluster at the University of Calgary to provide an OpenStack cloud for a number of University of Calgary users. In addition, Compute Canada has recently deployed two OpenStack cloud instances in Victoria and Sherbrooke, offering more than 2,432 cores.

Commercial Cloud Resources

There are 13 commercial Canadian cloud service providers that currently have computing infrastructure located in Alberta. However, there are numerous Canadian cloud service providers located across Canada (e.g. IBM, RackForce). In general, most companies do not appear to make their pricing readily available, only a listing of benefits of cloud computing and the services that they offer. At the time of writing, the costs of cloud services located in Alberta appear to be higher than those located outside the province. For example, a small Virtual Machine at Blackbridge Networks costs $78/month CDN. The same computing resources at Amazon Web Services (AWS) cost $38.07/month USD. Comparable resources at IBM (located across Canada) cost $40.20/month. For more details please see Appendix 7: Computing Services - Industry.

Background: Shared Services

Shared Services is a term used to describe for consolidation of business operations and services used by multiple organizations to reduce costs and increase efficiencies. These operations can include educational technologies such as a learning management systems, or collaborative services such as shared procurement of hardware and software licences.

With shrinking budgets, it is essential for institutions to identify opportunities for long term cost savings. Shared services offers a way to consolidate resources and stretch budgets. In the 2013/2014 fiscal year in British Columbia, it is estimated that shared IT services helped post-secondary institutions reduce and avoid increased IT costs of over $9.2 million[217].

But shared services is more than just cost savings; it is also a mechanism for creating closer collaborations, and sharing resources and knowledge.

In Alberta, there are numerous initiatives that are currently being piloted or in the initial stage of development. This report will focus on shared services in the post-secondary, K-12 and

[217] BCNET. BCNET Continues to Build Value through Collaboration. 15 May 2014. Accessed 13 September 2016.

municipal sectors. There are number of organizations and stakeholders in the education space who are interested in shared service solutions, including:

Alberta Association in Higher Education for Information Technology
The Alberta Association in Higher Education for Information Technology (AAHEIT) is a consortium of colleges, universities and technical institutes in Alberta. AAHEIT initiates and manages IT contracts and projects for the benefit of its members while fostering collaboration among higher education institutions.

Campus Alberta
Campus Alberta was formed in 2002 to to formalize and encourage collaboration between the province's 26 publicly funded post-secondary institutions.

Alberta Advanced Education
Alberta Advanced Education is the government ministry responsible for overseeing post-secondary education.

Advisory Committee on Education Technology Alberta
The Advisory Committee on Education Technology (ACET) is an advisory group that reports to the Senior Academic Officers and Vice-Presidents Academic at Alberta's post-secondary institutions. The committee recommends and facilitates the development and implementation of educational technology.

Alberta Education
Alberta Education is the government department responsible for overseeing K-12 education.

Alberta Technology Leaders in Education
Alberta Technology Leaders in Education (ATLE) was formed to support the work of K-12 jurisdiction technology leaders in Alberta. The group works as a mechanism to connect these technology leaders with educators to determine the best way to implement emerging technologies in Alberta schools through forums, conferences and events.

Current Landscape: Shared Services

Post-Secondary

The need for shared IT infrastructure, applications, knowledge, processes and documentation is growing rapidly in the post-secondary sector. Smaller institutions are facing computing demands that are accelerating at a significantly faster rate than the resources to meet them. This is resulting in a lowering of both the functionality and quality of services across the sector, and increasing pressure on IT departments to find solutions.

There are a number of shared service initiatives currently in production or in the development phase in Alberta to address this issue. These include:

Learning Management Cloud

The Learning Management Cloud (LMC) initiative began in June of 2012. It is an institution-led project involving the University of Alberta, NAIT, NorQuest College, and Cybera. This initiative provides a cloud-based infrastructure to host the learning management system Moodle, and offers 24/7 infrastructure support. In addition to sharing infrastructure resources and support personnel, the LMC has encouraged a closer working relationship between the collaborating institutions. For smaller institutions, such as NorQuest College, who are normally limited in their IT resources, this partnership has provided real benefits. NorQuest has been able to leverage the expertise and resources of the larger partners to offer a fast and efficient learning management system to students.

Adobe Connect

The Adobe Connect pilot between NAIT and Bow Valley College will test how federated identity (ID) management works on a shared service and to see how easy it is to implement. The plan is for NAIT to host Adobe Connect for both institutions. This project is currently slated to begin in January 2015, after the service level and policy agreements have been established.

Shared Services Framework

The Shared Services Framework comes from the work being done by the AAHEIT Shared Services Working Group, which was formed in March 2014 and consists of over 11 Alberta PSIs. The shared services framework (Figure 24) would establish the model governing how and what shared services are adopted and delivered. This proposal is currently under development and review by IAE.

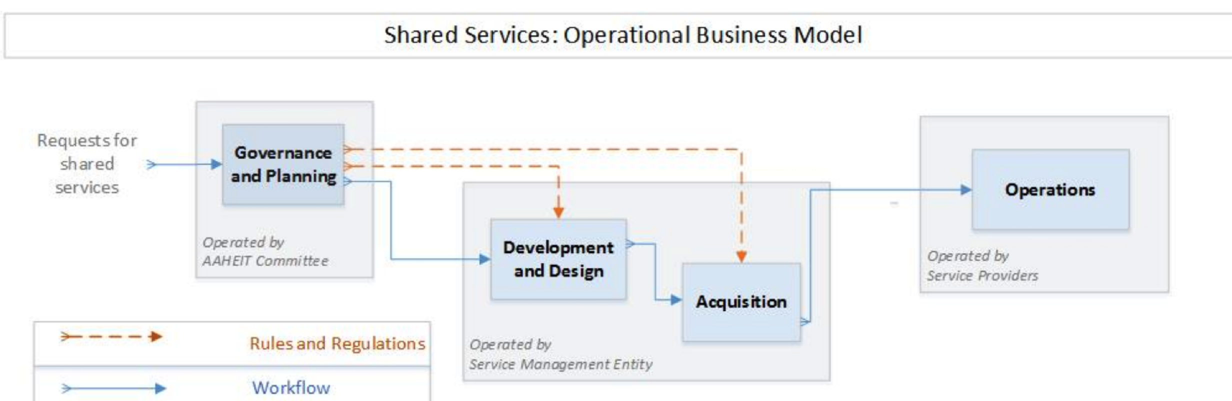


Figure 24. Shared Services Framework

K-12

As indicated above, smaller institutions often find they are falling behind because they do not have the resources to keep up with the technology. This is even more significant in the K-12 school districts, where budgets and resources are significantly less than than what PSIs have. Unless school districts form collectives, it is hard to receive volume discounts. The

K-12 divisions are eager to leverage shared services, but are unable to afford the computing resources or personnel to develop these solutions on their own. The goal of this initiative is to have K-12s work with PSIs to leverage existing shared services.

Future Needs & Opportunities

Alberta has a timely opportunity to build an integrated system that effectively and efficiently addresses the needs of both the research and innovation communities. Cloud resources and cloud-based services need to be part of the basic infrastructure that all researchers can depend on to do their work. The high speed network will ensure that collaboration using these resources will be simple and seamless across departments, institutions, and innovation. Addressing these needs will require:

Short-term recommendations (1-3 years)

- ***The Government of Alberta should provide an ongoing capital refresh to sustain HPC investments and resources required for the research community.*** This can be matched with CFI funds. In the coming months it is expected that CFI's Cyberinfrastructure Initiative program will provide at least $50M, a large portion of which is expected to be allocated for a Compute Canada refresh.
- ***The province should commit to build a long tail cloud at scale for research and innovation, and make the resources in that cloud freely and readily available to long tail researchers.*** Access to such resources should be considered as fundamental and necessary as access to the high-speed Provincial and National Research & Innovation networks. Alberta's head start with the RAC puts it in a unique position to lead the country toward a Canadian research, education and innovation cloud.
- ***Continue efforts to pilot and expand shared service projects to demonstrate their viability to members.***

Long-term recommendations (3-10 years)

- ***Couple both the design and funding of the Alberta Cloud system with the critical need to refresh the HPC infrastructure required by the research community within the province.*** The economic benefits of unleashing the pent-up potential in the long tail, in collaboration with the continued support of traditional HPC resources, will result in a renaissance in research and innovation across a broad spectrum of disciplines over the next 5-10 years.
- ***Develop a coordinated overall digital strategy to provide resources to HPC and cloud users in the research and innovation space.*** Many of the same considerations of scale and accessibility apply to both user groups.

- ***Expand support for infrastructure and mechanisms to make shared services easier to adopt.*** This could include establishing a shared procurement service or simplifying Federated ID implementation.

Gaps

- Waiting on additional stakeholder feedback.
- Cybera intends to survey Alberta Education, CBE and a few other jurisdictions to gather information about shared services challenges and concerns
- Cybera intends to contact municipalities to get an overview of current service requirements and identify some of the challenges and concerns for computing and shared services

Cybersecurity

Overview

Each year, cybersecurity threats continue to expand and become more pervasive. Security agencies around the globe report the number of security incidents, such as DDoS, malware, and botnet attacks, are growing as the world becomes increasingly connected and additional devices come online. As international collaborations become more widespread, combined with an increased focus on new workplace computing policies such as Bring Your Own Device, the security perimeter for organizations is becoming far reaching and dynamic. The consequences of falling behind can be severe. For example, recent network breaches at over 100 educational institutions, including the University of British Columbia, McMaster University, and other institutions, led to the release of 120,000 records.[218]

Cybersecurity is also a challenge to policies, innovation, and functional operations. As technology is constantly changing, so are the security threats and the responses required. While threats adapt dynamically over time, legislation and policy continue to be manually adapted and are at risk of always being a step behind. This has consequences on innovation, as it may prevent new technologies or functions from being adopted.

This section will provide an overview of some of the most commonly adopted standards and resources available in the public sector in Alberta. Because cybersecurity is a global, interjurisdictional topic, the discussion here is not exclusive to Alberta. Cybera has consulted security experts to get the widest scope of information possible, and will continue to shape this section as more information is received.

Finally, this section highlights the international movement towards Open Data and Open Government, which attempts to reconcile transparency and openness with the need to protect privacy.

Background

Description of standards

A large number of standards are available that cover different aspects of cybersecurity and play different roles. For example, comprehensive standards exist that set controls and best practices, while others provide specific requirements for a set of services, such as the processing of card payment data.

Attestation versus certification

[218] ZDNet. Ghost shell university hack: By the numbers. Accessed Oct 30, 2014.

For each of the standards provided, it is important to distinguish between attestation and certification. Attestation ensures that an organization meets its policies and procedures, but it provides no indication as to whether the standards are valid for the intended outcome. Certification results from an audit that evaluates whether a prescriptive standard has been met. Therefore, certification is objective and independent of a service organization's internal standards.
Some of the most common standards are identified and described below.

- ISO 27001
    - ISO 27001 is a comprehensive certification standard for Information Security Management Systems (ISMS). The standard provides requirements for operating an ISMS, including planning, supporting, and reviewing the system's performance.
- ISO 27002
    - ISO 27002 provides 114 controls for operating an ISMS. This standard specifies best practices and is not a certification standard as is the case for ISO 27001. These two standards are frequently adopted together.
- SSAE16
    - SSAE 16 stands for Statement on Standards for Attestation Engagement No. 16, which reports on the controls in place for a service organization. This is an attestation standards that requires an independent auditor's report, a description of the system, and control activities in place.

Current Landscape

Common Threats and Issues

Figure 8 represents highlights from a 2014 report on global security from the NTT security group, as well as a 2014 Symantec Internet Security Threat Report[219],[220]. They show the growing and diverse number of attacks worldwide, and illustrate the increased importance cybersecurity plays. At the same time, the types of vulnerabilities, and the fact that at most 50% observed in 2013 are at least two years' old, indicate that basic security practices are frequently not implemented, which would help mitigate some of the most common threats, such as effective system patch management.

[219] NTT Group. Global Threat Intelligence Report. 2014. Accessed 13 September 2016.
[220] Symantec Corporation. Internet Security Threat Report 2014. April 2014. Accessed 13 September 2016.

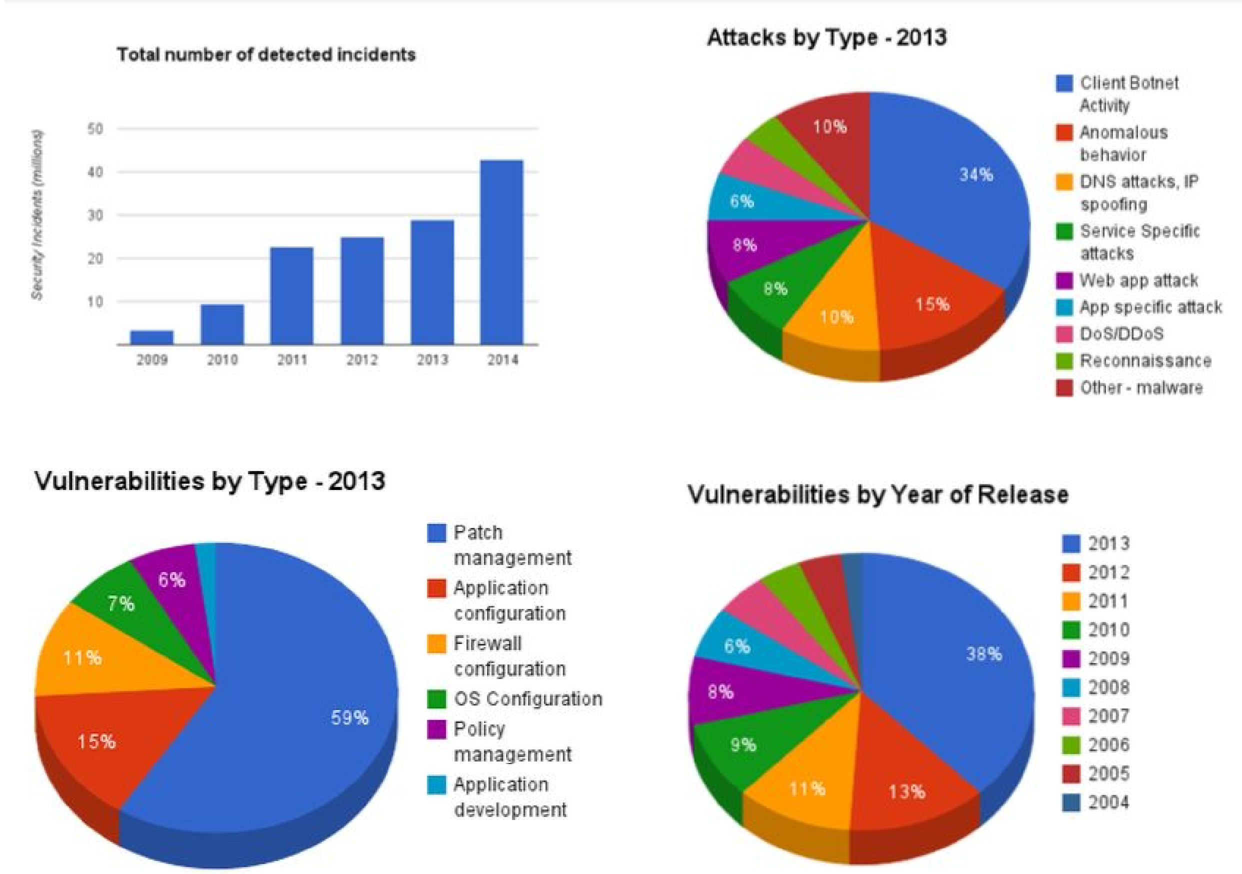


Figure 25. Threats and types of attacks observed from 2004-2013

Risk Tolerance

A major challenge for organizations is trying to find the right balance between security and maintaining flexible operations. To take an extreme example, one way to secure an organization from any internet-based risks is to completely sever all internal connections to the internet. With very few exceptions, such an approach would render the organization completely incapable of functioning. On the other hand, security is not optional, so it is important to at least have a few principles in mind (from Dan Boneh, a Security and Cryptography professor at Stanford University):

1. *Never* design your own security mechanisms and *never* implement your own crypto. It is guaranteed to be vulnerable.
2. Make sure that your systems are “crypto agile”: in other words, if vulnerabilities are discovered in a crypto algorithm, you need to be able to react quickly and get patched versions into production. The recent Heartbleed and Shellshock vulnerabilities are good examples of this: despite the fact that the software had vulnerabilities, patches were made available very quickly after the vulnerabilities were discovered and could be applied throughout the enterprise.

Cybersecurity in Alberta

Within the Government of Alberta, the ministry of Service Alberta is responsible for providing information and security management directives. The Corporate Information Security Office (CISO) is responsible for safeguarding the Government of Alberta's IT systems and provides documentation for the improvement of IT security. CISO published the Government of Alberta IT Security Framework, which provides tools for the implementation of security standards.[221] It provides resources such as an e-learning course covering important security informations, guidelines on disaster recovery, and management directives based on the ISO 27002 standard for the management of IT security. Best practices from ISO 27002 cover management systems, including networking, compute, and hosting facilities, and include guidance for ensuring compliance with standards. Each ministry employs dedicated or shared Security Officers to help ensure cybersecurity standards are implemented in accordance with the standards and guidelines prescribed by Service Alberta.

Cybersecurity at public educational institutions, such as at post-secondary institutions and K-12 school districts, represents a challenge. Personal devices are becoming more and more pervasive and most organizations are expected to accommodate a Bring Your Own Device (BYOD) work scenario. The risk this brings is clear, considering that 42% of all malware events in 2013 took place in open access environments such as at universities[222].

Given the size disparity among post-secondary institutions and K-12 school districts, and the corresponding differences in resource availability, the capacity to address cybersecurity questions varies greatly. To help alleviate this in the K-12 sector, Alberta Education provides school districts with a Technology Services Self-Evaluation Guide, which is intended to help guide jurisdictional leaders in three areas:

- IT Governance
- IT Service Management
- Information Security

The self-assessment guide does not provide specific instructions on how to address each of these components, but is intended to standardize each jurisdiction's assessment, to facilitate future collaboration for addressing any gaps identified. It is compatible with major standards and practices, such as Risk IT, ISO 27001, and ISO 27002.

Post-secondary institutions across the country engage in share knowledge and best practices through the Canadian University Council of Chief Information Officers' (CUCCIO) special interest group on security. However, this information is only available to CUCCIO members, who, in Alberta, include the Universities of Alberta, Calgary, and Lethbridge, as well as Mount Royal University and Athabasca University. A similar special interest group

[221] Service Alberta - IT security framework. Accessed Oct. 19, 2014.
[222] NTT Group. Global Threat Intelligence Report. 2014. Accessed 13 September 2016.

exists under the Alberta Association in Higher Education for IT (AAHEIT), but it has not been active in the last twelve months.

Larger post-secondary institutions have a broader pool of resources and expertise at their disposal to ensure security measures are in place. For example, the University of Alberta has established security practices for all existing services as well as for newly introduced ones, which must undergo privacy and security reviews and represent a collaboration between multiple departments. At smaller institutions, the privacy and security roles are often merged, and a single staff may be required to perform a number of these functions.

The auditor general's office annually reviews security practices at post-secondary institutions. The scope of this review varies from year to year, but it generally covers all aspects of cybersecurity based on COBIT and ISO 27001 standards. The auditor general makes recommendations to the post-secondary based on this audit.

Resources

There are a number of security resources available through expert agencies, the federal and provincial governments, and other public groups. These resources cover high-level frameworks, such as those from the Office of the Information and Privacy Commissioner, as well as more specific guidance, such as the Top 20 Critical Security Controls. Further, through learning tools such as Massive Open Online Courses, there are various educational resources available online. (Please see Appendix 9: Cybersecurity - Resources for a full list of resources on implementing security processes.)

Future Needs and Opportunities

While the cybersecurity landscape is not only constantly evolving, it is also becoming increasingly integral to our daily lives. This was recognized in 2013, as President Obama issued Executive Order 13636: *Improving Critical Infrastructure Cybersecurity* and gave rise to a NIST framework to help accomplish the defined objectives. The US framework outlines a method of evaluating an organization's current security program, which is a critical step in the customization of a security approach to an organization's priorities and risk tolerance.

Short-term recommendations (1-3 years)

- ***The Government of Alberta should create freely-available, actionable guidance for smaller organizations to approach their cybersecurity in a step-by-step manner.*** The Council on Cybersecurity[223] and the Canadian and Australian governments (see Cybersecurity - Resources in the Appendix), have already recognized the effectiveness of this approach and released lists of steps to take.

[223] Council on Cybersecurity. Critical Security Controls. Accessed Oct. 19, 2014.

These controls should be a living document that is updated regularly, and leverage input from a vast community of “risk assessment” experts.

- ***Provide opportunities for knowledge sharing between public organizations in order to support avoid duplication of effort and fully leverage existing expertise.*** Educause provides an example of leadership and effective information sharing through the Higher Education Information Security Council’s Information Security Guide, which provides a centralized guide for security practices.
- ***Expand the role of the Government of Alberta CISO and the ministerial security officers to support smaller IT teams in the province.*** As more schools move towards shared services, the more effective a skilled central security team would be at providing the cybersecurity skillset needed to operate appropriate security.

Long-term recommendations (3-10 years)

- ***Develop a single, province-wide security review process for all public sector organization that focuses on risk-based and process maturity.*** Certification does not always equal security. Instead, a customized and prioritized plan for organizations to devote resources to the most appropriate sectors and focus on cybersecurity priorities, in-line with their organizational goals is needed (see Figure 26 below)[224].

Figure 26. Using risk-based prioritization for organizational security planning

Gaps

- Waiting on additional stakeholder feedback.

[224] Cyber Solutions Handbook - Making Sense of Standards and Frameworks. Booz Allen Hamilton. 2014.

Data Management

Overview

While changes in computing power over time are affecting how people live and work, the vast expansion of available data is expected to have the biggest impact on society. Sensor technology has become inexpensive, meaning these devices are everywhere, constantly feeding people information about everyone and everything. Humans now create 2.5 quintillion bytes of data every day — in fact, 90% of the data in the world today was created in the last two years alone. By 2020, it is expected there will be 35 zettabytes of data stored around the world.[225] Understanding and being able to make use of this information is important for Alberta to remain competitive in the global community.

Data is not useful without context.
It is necessary to be able to gather data and put it into context, to know what came before, what is happening nearby and what dependencies there may be. Given this context, the data becomes information.

Information is not useful without analysis.
Through analytics, we uncover trends and gain insights into the future, and come to understand the mechanisms that give rise to the behaviour of systems, from the small to the large. Through analytics, information becomes knowledge.

Knowledge is not useful without action.
Wise choices can only be made when decisions are based on data, rather than on unsupported beliefs. These wise choices enable a healthy economy and high quality of life, with all the attendant benefits in terms of job creation, attraction of talent and attraction of capital.

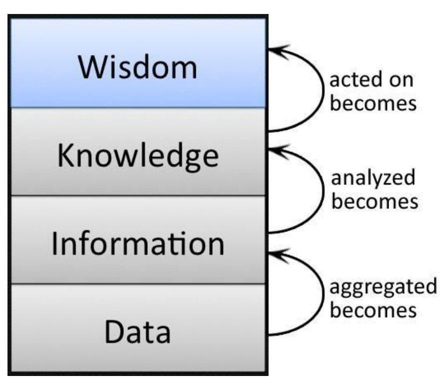


Figure 27. Choices based on Data

[225] IBM. Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data, p.5. 2012. Accessed 13 September 2016.

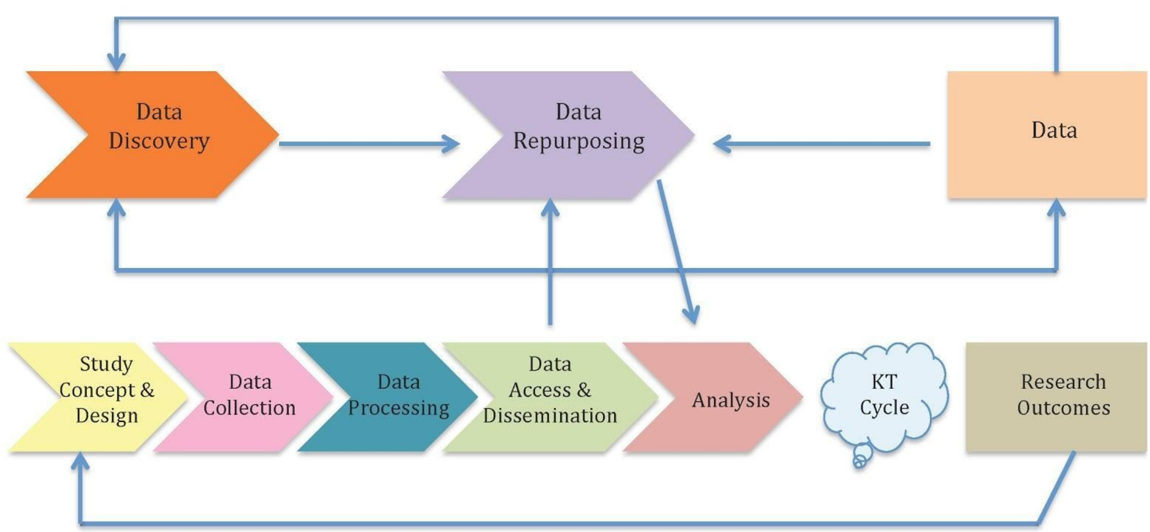
Alberta's digital infrastructure is essential in enabling this progression from data gathering to a robust economy.

Background

The world is becoming increasingly digital, with multiple devices per individual becoming the norm rather than the outlier. Data is being collected from a diverse array of sources, and advances in connectedness and technology have created the possibility and expectation that information is readily accessible. Governments, who create, house, and own vast amounts of data are now in a position to share information more effectively with each other as well as the public.

Ensuring data is available, can be used, re-used and is preserved for long term benefit is referred to as data management. These steps and actions are often described in the data management lifecycle. There are a number of varying descriptions of this lifecycle, but all attempt to conceptualize that data management includes a variety of steps including planning, collecting, processing, preserving and discovering data.

Figure 28 below titled the Research Lifecycle, outlined by C. Humphrey from the University of Alberta, describes the data management lifecycle inside the research process.



Research Lifecycle (the KT Cycle refers to a separate lifecycle for knowledge transfer)
Source: C. Humphrey, E-Science and the Lifecycle of Research, 2006.

Figure 28. Research Lifecycle

The principles outlined in the diagram can apply to data management in government, industry and any function which generates data.

It is important to remember that making data available and accessible for uses other than what was originally intended and ensuring it is properly preserved takes time and resources. The economic, societal and potential research and innovation benefits are significant, but given this extra time, data is often siloed and only effectively available and accessible for its original purpose.

To help combat this challenge the TC3+ launched a consultation on Digital Scholarship and is considering including a requirement that ensures data funded by public money is properly managed. More information on the TC3+ Digital Scholarship and a variety of initiatives that are underway to support this policy framework will be described below.

> *It is not only scientists that use data, the public and industry has learned to do so with significant steps forward in discovery and innovation. Alberta faces this challenge in particular with regard to its rich resource base. In the absence of data, advocacy groups make up their own, leading to mistrust and confusion with all its attendant impact on our ability to market our products.*

Through implementation and execution of a comprehensive data management policy, incorporated within the scope of a broader digital strategy, Alberta has an opportunity to dispel many of the myths and confusion associated with its natural resources. A legislative framework has already been established through the Alberta environmental monitoring and reporting agency (AEMERA) (http://aemera.org) to capture and make environmental data available.

By linking this important data intensive environmental initiative to Alberta's digital strategy, the province can establish itself as a leader in openness of environmental data and openness of government.

> *Many governments are trying to establish open data policies but the advantage Alberta has is that the world cares, and cares deeply, about its environmental da.*

Current Landscape

TC3+ & Digital Scholarship

Tri-council plus or TC3+ refers to Canada's research funding agencies[226]. TC3+ in collaboration with Genome Canada joined forces to develop a consultation paper titled: *Capitalizing on Big Data: Toward a Policy Framework for Advancing Digital Scholarship in Canada*[227]. The document and consultation process was launched in 2013. It outlines a plan for aligning the TC3+ policies on the management of data obtained through projects developed with agency funds.

The plan outlined three main areas for consideration:

1. Establishing a Culture of Stewardship - the development of a policy requiring researchers to submit data management plans with future funding applications and awards to ensure the effective management of data developed with agency funds.
2. Coordination of Stakeholder Engagement - working with stakeholders in the space to ensure ongoing consultation and coordination of resources and efforts related to data management.
3. Developing Capacity and Future Funding Parameters - developing a coordinated plan with the various stakeholders. This includes reviewing the funding parameters for national-scale digital infrastructure and the balance of roles and responsibilities among national, provincial and institutional stakeholders.

From this consultation there are expected changes in the way that research grants are awarded in the coming years. This will include a policy requiring a data management plan for all research grants. A data management plan must outline all steps of the data management lifecycle and indicate the plans associated with handling the data in a coordinated effort. If long term preservation is outlined then the steps to ensure that this data is not only preserved (archived), but remains accessible, must be outlined.

Research Data Canada & Canadian Academic Libraries

Research Data Canada (RDC) is the national organization responsible for coordinating the efforts within Canada to address the challenges and issues surrounding the access and preservation of data arising from Canadian research. CANARIE is currently funding Research Data Canada and working closely with the staff and Steering Committee to develop the most effective path forward to ensure an effective and sustainable organization that supports research data initiatives within Canada.

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[226] Includes: the Social Sciences and Humanities Research Council (SSHRC), the Natural Sciences and Engineering Research Council (NSERC), the Canadian Institutes of Health Research (CIHR) and the Canada Foundation for Innovation (CFI)

[227] SSHRC-CRSH. Capitalizing on Big Data: Toward a Policy Framework for Advancing Digital Scholarship in Canada - Consultation Document. 16 October 2013. Accessed 13 September 2016.

Research Data Canada has involvement from a number of key organizations in the country including: the granting agencies, service providers such as CANARIE and Compute Canada, government labs, researchers and libraries.

University Libraries are very active in RDC and represent an important stakeholder community. Academic libraries employ some of the leading experts in research data management (RDM) in Canada, particularly in the area of digital preservation and curation. Libraries maintain local services that support research data management and participate internationally in the development of standards internationally. They are also developing collaborative services around RDM which will enable cost efficiencies and national coverage. In March 2014, the Canadian Association of Research Library (CARL) initiated Project ARC[228]. The project has two key goals: to implement a centre of expertise for the management of research data in Canada that will support researchers across the country; and to pilot a national preservation service for research data that will evolve and expand over time. The latter activity is being done in collaboration with Compute Canada, CANARIE, and key domain repositories under the coordination of Research Data Canada.

Open Data

National and International Open Data Charters

The value of Open Data and Open Government initiatives are being increasingly recognized. At the 2013 G8 summit in Northern Ireland, the Open Data Charter was adopted by G8 nations, including Canada, with commitments to take additional actions by the end of 2015.

Under the Charter, Canada has agreed to three commitments, including:

1. Develop a country-specific Action Plan
2. Release high value datasets in 14 key areas
3. Contribute to a G8 metadata mapping exercise

The first commitment in that list has been completed. Canada's Action Plan[229] is available and outlines further steps and plans to complete the additional commitments.

Government of Alberta Open Information and Open Data Policy

The Government of Alberta has set up an Open Information and Open Data Policy[230] to assist in meeting its goal of greater transparency and accountability. The policy provides a framework for establishing responsibilities, processes, and tools to efficiently move this program forward. Inspired by the Open Data Charter adopted at the G8 summit, the policy has three guiding principles:

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[228] Canadian Association of Research Libraries. Annual Report. 2014. Accessed 13 September 2016.
[229] Open Data Canada. G8 Open Data Charter - Canada's Action Plan. Accessed 24 October 2014.
[230] Government of Alberta. Government of Alberta Open Information and Open Data Policy. Accessed 24 October 2014.

1. Open by Design
    a. Integrate Open Data and Open Government as a part of the government's culture and improve access to data to meet citizens' needs.
2. Innovation from Quality Data
    a. Utilize technology to release quality data in a timely fashion, which will allow users to derive value and innovate utilizing these datasets.
3. Improved Governance
    a. Enable public participation by engaging informed citizens.
    b. Improve government services through insights gained from open data.

To move this policy forward, the Government of Alberta established an Action Plan spanning 2013-2015, which will improve daily interaction and engagement with citizens. The Action Plan outlines three areas of focus for the implementation of the Alberta Open Government policy:

- Enabling change
    - Within the government, ensure Open Government becomes part of the culture and norm.
    - Set up governance, strategic vision for more transparency and accountability.
- Informing Albertans
    - Establish a routine disclosure program and open information portal.
    - Promote innovative use of government data by transforming and building new solutions utilizing government data.
- Better conversations
    - Allow Albertans to participate and collaborate with the government by integrating new methods for communicating between government and its citizens.

University of Alberta Initiatives

The University of Alberta has several activities underway to support effective data management within the academic community. The University's Research Data Management Website (http://library.ualberta.ca/researchdata/) provides detailed information for researchers on organizing, sharing and storing their data. From this site, users can deposit their data using the University's Dataverse deployment, which is a tool for publishing, citing, analyzing and preserving research data. The University has also installed DMPOnline to help researchers on campus and across the country develop data management plans. It also hosts an annual Research Data Management Week every spring to update the research community on best practices, new tools, and campus services.

Alberta Government Initiatives

The Government of Alberta also has a number of data initiatives underway, a few of which are highlighted below. These activities are broad in scope and offer the potential for significant impact on the province.

Alberta Open Data Portal

As part of the Open Information and Open Data Policy referenced above, the Government of Alberta has set up the Alberta Open Data Portal. The portal provides a central location to search and download data collected from all government ministries. As of October 31, 2014, there are 404 data sets across 19 categories in this Portal.

Industry & Initiatives

Industry / Environment groups that offer open data:

- Spatial Data Warehouse: http://www.spatialdatawarehouse.ca/
- AltaLIS: http://www.altalis.com/
- Joint Oil Sands Monitoring Platform: http://jointoilsandsmonitoring.ca/
- Blackbridge Geomatics: http://blackbridge.com/geomatics/
- GeoDiscover Alberta: https://geodiscover.alberta.ca/
- Wood Buffalo Environmental Association: http://www.wbea.org/

Municipalities

According to the Government of Canada, there are seven municipalities in Alberta that have open data policies and interfaces available for anyone to search: Banff, Calgary, Edmonton, Grand Prairie, Medicine Hat, Red Deer and Strathcona.[231] Edmonton is leading the way in Alberta (and Canada) in terms of the scope of its open data municipal initiatives. In addition to the City of Edmonton website that offers accessible and downloadable data, users can also access the Citizen Dashboard, which provides information related to transportation, livability, the environment, urban form, the economy and finances, and how the city is doing compared to the targets for each.

Future Needs and Opportunities

Short-term recommendations (1-3 years)

- ***The province should establish a working group with other provinces to review and harmonize provincial regulations regarding data residency, with an emphasis on the use of Trusted Data Repositories.*** The goal should be to allow pooling of data—including health data—and knowledge around the efficient use of infrastructure.

[231] Government of Canada. Open Government Across Canada. Accessed 24 October 2014.

- ***Require that a data management plan be in place for any data acquired with provincial funds, and mandate that all appropriate data be made open.*** All data management plans should be made public by the funding agency at time of grant even if the data itself, for privacy reasons, cannot be.
- ***Develop and implement a plan to put the necessary expertise in place*** to support researchers and government sectors in developing data management plans, and ensuring their data is effectively open and available.
- ***Encourage municipalities to make their data open using an agreed-upon, standardized method*** (ie: Socrata or Open Government Data Initiative) to simplify the integration of data across jurisdictions.

Gaps

- Waiting on additional stakeholder feedback.
- Will add information on GoA initiatives:
  - Innovation and Advanced Education Economic Dashboard
  - AEMERA
  - GeoDiscover
  - Provincial Health Data Warehouse
- Section on data privacy will be added

People

Overview

Highly qualified and skilled personnel (HQSP) are people whose education and/or skills are critical to the economy. Having sufficient HQSP—including strong ICT workers—in Alberta is necessary to compete in the global market, and build a healthy and diversified innovation economy. The province continues to turn out knowledgeable and internationally sought-after IT talent, but their numbers are few, and insufficient to meet the future needs of the growing economy. This will become even more apparent as the software and electronics-based industry (including apps and sensor development) continues to expand.

The section will:

1) Provide an inventory of the skilled personnel currently working on Alberta's cyberinfrastructure, and assess their relevance in the global IT space;
2) Provide an inventory of IT-related education programs and assess their ability to provide the HQSPs required for Alberta's growing economy; and provide an inventory of advanced research programs contributing to HQSP development.

Background

Over the past two decades, skills shortages have become more predominant in the province. The energy economy and demand for new ICT workers is growing faster than the existing availability of these workers. This, coupled with an aging population, is creating a diminishing pool of HQSP to draw upon.

Current State of HQSP Landscape

In 2013, the professional, scientific and technical services industry in Alberta had the largest increase in employment, accounting for 32.1% of all employment gains in the province[232]. Since 2011, the number of ICT professionals in Alberta has grown by 81% to 75,000. Of these, 59% (44,000) work in Calgary, 33% (25,000) are in Edmonton, and another 5% (4,000) work in the rest of the province.

The make-up of Alberta's ICT workers are largely male and disproportionately foreign-born: 37% are immigrants — a trend that is reflected across the country[233].

[232] Government of Alberta. Annual Alberta Labour Market Review. Accessed 24 October 2014.
[233] Information and Communication Technology Council. Digital Economy Annual Review 2014. Accessed 13 September 2016.

Table 12: Sample of Current Alberta ICT Employment Numbers by Occupation Fields*.

Occupation	Number Employed in 2013
Information Systems Analysts and Consultants	15,600
Computer Programmers and Interactive Media Developers	13,200
User Support Technicians	9,300
Electronic Service Technicians (Household and Business Equipment)	6,400
Electrical and Electronics Engineers	6,600
Computer Network Technicians	6,200
Computer and Information Systems Managers	5,200
Graphic Designers and Illustrators	5,000
Software Engineers and Designers	4,700
Electrical and Electronics Engineering Technologists and Technicians	4,000
Database Analysts and Data Administrators	3,300
Telecommunications Installation and Repair Workers	2,300
Library and Archive Technicians and Assistants	1,900

**Source: Alberta's Short-Term Employment Forecast 2014 - 2016, Government of Alberta*
[*NB: For future update: Expand table to show all ICT employment numbers.*]

Current Projection for Skilled Shortages

More trained technical workers are still needed in the province. A 2012 State of the Industry survey of organizations in Alberta's ICT sector found that 65% of ICT leaders see challenges in meeting staff requirements due to limited qualified candidates and/or high asking salaries.[234]

This survey matched the findings of a cloud computing focus group study that Cybera held in March 2013 among 21 representatives from Alberta's post-secondary and entrepreneurial / business incubator communities[235]. Respondents noted that "finding skilled labour, or

[234] Alberta ICT Magazine. April 2012. Accessed 24 October 2014.
[235] Cybera. Cloud Computing Training in Alberta. Accessed 13 September 2016.

qualified IT trainers, is an ongoing issue, and the knowledge and experience of those who have been hired to IT departments seems to vary greatly.” Initial feedback on this report in October 2014 also noted that organizations like Cisco struggle to find people skilled in network architecture.

A 2010 study[236] on Alberta's Occupational Demand from 2011-2021 predicts increasing shortages in nearly all ICT roles. For roles such as managers in engineering, architecture, science and information systems; Computer and information systems managers; and Electronic Service Technicians (Household and Business Equipment), the projected shortage will increase by upwards of 400% between 2015-2021 (see Appendix 10: People - HQSP Projected Staff Shortages). These occupation shortages will be seen in every major sector in Alberta: Environment, Energy, Oil and Gas, Health Sciences and Technology, AICML, BioSciences, as well the emerging sectors of nanotechnology, biotechnology, microelectronics, and apps / software development.

Emerging Market Case Study: Apps Development

An estimated 64,100 jobs have been created in Canada to-date for the development and distribution of apps. Of these, 6,600 are in Alberta. The total apps-related employment in Canada is estimated to reach 110,000 by 2019.

According to the Information and Communications Technology Council:

> *“The potential magnitude of revenue, the size and competitiveness of the provincial economy, and capabilities and capacity of its workforce are major considerations for apps enterprises in choosing a province in which to locate. The pool of required skills and potential employees available is the biggest draw among apps enterprises, as over half of the surveyed enterprises maintain that this is of particular value to them. A third of the surveyed enterprises cite various provincial government support programs as one of the reasons for selecting their base.”*
>
> *“ICTC's consultation with apps enterprises suggests that nearly half of apps employers experience difficulty filling these positions. To combat this, many are forced to hire people who may lack some of the skills required and provide training opportunities to upgrade their skills. While up-skilling the workforce and updating their skills is a good practice in the fleeting world of modern technology, it does put further financial pressure on employers in Canada's apps economy.”*[237]

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[236] Government of Alberta. Alberta's Occupational Demand and Supply Outlook 2011-2021. Accessed 13 September 2016.
[237] Information and Communications Technology Council. The Appification of Everything, Canada's Apps Economy Value Chain. 2014. Accessed 13 September 2016.

Relevance in the Global IT Space

Alberta's highly qualified and skilled personnel are world-class. A 2011 ICT industry survey ranked Canadian computing very highly: "Canadian PSIs earn an 'A' for the quality of the programmers, software engineers and electrical engineers they produce, and a B+ for computer engineers."[238] The average ICT salary in Alberta is also between 4.9% to 24.5% higher than the national average.[239]

Unfortunately, there is simply not enough ICT workers to meet Alberta's growing needs, and this is affecting how the province competes at a global level. The Centre for the Study of Living Standards (CSLS) estimates that the average ICT investment per worker in Canada is only 60 percent of that in the United States[240]. The results are even worse for Alberta. A 2010 paper on Alberta's global competitiveness, prepared for the Government of Alberta by PriceWaterhouseCoopers, found that Alberta ranked last out of nine jurisdictions in Canada and the USA when it came to investing in ICT development.[241] This correlates to the CSLS estimates of ICT investment by industry. While most business sectors increased their investment in ICT between 1996-2006, the mining, oil and gas extraction sectors showed huge declines in investment (-16.7%). This is causing Alberta, and Canada as a whole, to slip further behind other countries and jurisdictions when when it comes to GDP growth and R&E development.

Inventory of IT-related Education Programs

Alberta's post-secondary education system is central to the development of highly qualified and skilled personnel (HQSP) in the province. In Canada, there are some indications of a shrinking talent base due to decreasing university enrolment in the areas of computer and information sciences, applied mathematics and computer software engineering.

In 1998, it was recommended that Alberta double, at a minimum, the output of ICT-skilled knowledge workers through post-secondary education[242], including graduates in the computing, communications, mathematics, physics, and engineering fields. The 1998 goal was to reach 140,000 knowledge-based workers in Alberta by 2010. Understanding if and how these goals were achieved is difficult.

Tracking or measuring HQSP across the province is often done using the following metrics:

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238 Nordicity. Labour Supply/Demand Dynamics of Canada's Information and Communications Technology (ICT) Sector, March 2012, Nordicity, p. 23. Accessed 13 September 2016.

239 Information and Communications Technology Council. Digital Economy Annual Review. 2014. Accessed 13 September 2016.

240 Centre for the Study of Living Standards. Can the Canada-U.S. ICT Investment Gap be a Measurement Issue? May 2013, p. 23. Accessed 13 September 2016.

241 Government of Alberta. Alberta Finance and Enterprise: Alberta's Competitiveness – A Primer for Discussion, June, 2010. Accessed 24 October 2014.

242 Alberta Science and Research Authority. Information and Communications Technology - A strategy for Alberta, 1998. Accessed 13 September 2016.

1. Measuring the number of program graduates
2. Number of graduates employed following degree completion
3. Number of applied researchers, doctorates or post-doctorates working in advanced research
4. Number of programs supporting HQSP

Number of ICT Program Graduates or Program Completers

Over six years (2008 to 2013), there were 1,459 graduates (Table 13) in Alberta in the fields of information technology, computer systems networking and telecommunications, networks and systems administration and management programs.

Table 13. Number of FLE Program Completers from certificate, diploma, and degree programs*

Program Description	2008-09	2009-10	2010-11	2011-12	2012-13
Information technology	163	142	154	147	165
Computer systems networking and telecommunications	17	10	30	35	37
Network and system administration/administrator	56	78	50	48	38
System, networking and LAN/WAN management/manager	44	36	57	85	67
Total Completers	**280**	**266**	**291**	**315**	**307**

**Please note*: The table will be expanded in the future to include more ICT programs, such as engineering, geomatics, U of C Computing Science, and others

Table 13 data was gathered from nine post-secondary institutions: Athabasca University, Lakeland College, Medicine Hat College, Mount Royal University, Northern Alberta Institute of Technology (NAIT), Northern Lakes College, Red Deer College, Southern Alberta Institute of Technology (SAIT), University of Alberta (see Appendix 11: People - HQSP Post-Secondary ICT Programs).

Number of Applied Researchers, Doctorates or Post-doctorates Working in Advanced ICT Research

A large number of HQSP are trained outside of formal programs, either through on-the-job training or through their research team. Individuals on research teams (students, research associates, PhDs, etc) are trained on specific domain expertise and the utilization of digital infrastructure in their work.

It is difficult to quantify the number of researchers trained, as their expertise will depend upon the research program and work being done. However, it is known that, within Alberta, there are almost 200 faculty groups utilizing resources through Compute Canada from Oct. 2013 - Oct. 2014. These groups have, on average, a minimum of six individuals working on the project. This means that right now there at least 1,200 individuals in Alberta have a unique skill set related to the utilization of digital infrastructure inside a given domain.

In addition, many of these individuals are learning advanced analytical skills. It is worth noting:

- This estimate does not include the large number of researchers who are utilizing digital infrastructure in the province outside of the Compute Canada framework.
- It does not take into consideration the number of individuals learning these skills inside the workforce.
- It does not factor other curricula at institutions that include teaching students digital infrastructure skills within a specific domain (such as engineering and other science fields)

Number of Programs Supporting HQSP in ICT

*Please note, this is list is not inclusive and it expected to grow with additional research and input.

1. Mitacs (https://www.mitacs.ca/en) - The mission of Mitacs is to build partnerships between academia, industry, and the world – to create a more innovative Canada. (Of the 3,266 Mitacs-funded projects in Canada in 2013(??), only 205 or 6% were in Alberta. This is not reflective of the fact that Alberta's population is 12% of the country's total)
2. BESTT Internship Program (http://www.ab-bestt.ca/) - In collaboration with Athabasca University, industry, government, and educational institutions, the BESTT program assists highly qualified personnel who are looking for careers in Science, Engineering, or Technology fields.
3. Alberta Innovates Bio Solutions (http://bio.albertainnovates.ca/)
4. Alberta Innovates Technology Futures (http://www.albertatechfutures.ca/)
5. Alberta Innovates Energy and Environment Solutions (http://www.ai-ees.ca/)
6. Alberta Innovates Health Solutions (http://www.ahfmr.ab.ca/)
7. Innovates Centre of Research Excellence (iCORE) (http://www.albertatechfutures.ca/AcademicProgramsiCORE.aspx)
8. Western Economic Diversification (http://www.wd.gc.ca/)
9. TECTERRA (http://www.tecterra.com/)

Future Needs and Opportunities

The ultimate outcome of increasing highly qualified and skilled personnel (HQSP) in Alberta will be increasing business innovation. The Canadian Chamber of Commerce lists skills shortages as the number one barrier holding back Canadian competitiveness. The Chamber recommends that "governments and businesses work together cooperatively and aggressively to address this ubiquitous issue".

Given the significant role that digital infrastructure must play in the future of Alberta's economy, the development of HQSP in ICT must be a joint effort between industry, government and academia. Addressing the future shortage of skilled personnel will require:

Short-term recommendations (1-3 years)

- ***Develop a joint plan between the provincial government, industry and PSIs to increase the number of students enrolling in - and completing - ICT diploma and degree programs****.* These programs should focus on: computer and information management, information systems analysis, electronics, and computer engineering.
- ***Government and PSIs should develop a plan to attract and retain more ICT workers and students from abroad.***
- ***Post-secondary institutions should expand and better leverage existing applied research and ICT-based internship programs.*** This includes programs such as the Mitacs Accelerate Program or iCore offered at the graduate and post-doctorate levels.
- ***The province should assess current programs for developing highly qualified skilled personnel, and assess if new programs are needed*****.**

Long-term recommendations (3-10 years)

- ***Industry, PSIs and technical training institutions should develop a joint plan to create programs that are flexible to companies' and ICT professionals needs****.* These include programs that are adaptable to changing technologies include more co-op and internship opportunities.
- ***The province should support educational programs that encourage more K-12 students to take science, technology, engineering and mathematics (STEM) courses.***
- ***The province should provide a provincial infrastructure system that supports high-end research and innovation, to attract more skilled personnel and ICT businesses to Alberta.***

Gaps

- Waiting on additional stakeholder feedback.
- Additional data on number of FLE Program Completers from certificate, diploma, and degree programs is needed, including information on more ICT programs, such as engineering, geomatics, U of C Computing Science, and others
- Additional data is needed on the number of graduates employed following degree

completion in ICT

Conclusion

To grow the economy, we must invest more strategically in digital infrastructure. The goal of Cybera's State of Alberta Digital Infrastructure Report is to provide key stakeholders with a comprehensive portrait of the current ICT landscape in Alberta. Based on the insights received, Cybera suggests both short-term (1-3 year) and longer-term (3-10 year) recommendations for guiding and building Alberta's future digital infrastructure. These are presented in detail at the end of each section.

Across all sections, there is an opportunity for Alberta to build a coordinated approach and framework on growing digital infrastructure in the province. We all share the responsibility in this effort if we hope to see a knowledge-based economy supported by a comprehensive and sustainable digital infrastructure system. The information presented in Cybera's State of Alberta Infrastructure Report provides a starting point. Strong leadership is required by all sectors to build and move forward with a clear and organized digital infrastructure agenda.

Appendix 1: Networking - SuperNet BAN Communities

List of the 27 Alberta SuperNet Base Area Network (BAN) communities. According to the Government of Canada Digital 150 Broadband Internet Map[243] all these communities have access to Internet download speeds of ≥ 5 Mbps.

SuperNet BAN Communities	Connection Type
Airdrie	Fibre Optic
Bonnyville	Fibre Optic
Brooks	Fibre Optic
Calgary	Fibre Optic
Camrose	Fibre Optic
Cold Lake	Fibre Optic
Drumheller	Fibre Optic
Edmonton	Fibre Optic
Fort McMurray	Fibre Optic
Grande Prairie	Fibre Optic
High River	Fibre Optic
Lacombe	Fibre Optic
Leduc	Fibre Optic
Lethbridge	Fibre Optic
Lloydminster	Fibre Optic
Medicine Hat	Fibre Optic
Red Deer	Fibre Optic
Sherwood Park	Fibre Optic
Spruce Grove	Fibre Optic
St. Albert	Fibre Optic
Stony Plain	Fibre Optic
Strathmore	Fibre Optic
Vegreville	Fibre Optic
Vermilion	Fibre Optic
Wainwright	Fibre Optic
Wetaskiwin	Fibre Optic
Whitecourt	Fibre Optic

[243] Industry Canada. Digital Canada 150 Broadband Internet Map. Accessed 18 October 2014.

Appendix 2. Networking - SuperNet EAN and EAWN Communities

List of the 402 Alberta SuperNet Extended Area (EAN) and Extended Wireless Area Network (EAWN) communities[244]

SuperNet EAN and EAWN Communities	Connection Type	SuperNet EAN and EAWN Communities	Connection Type
Acadia Valley	Fibre Optic	Jasper	Fibre Optic
Acme	Fibre Optic	Jenner	Wireless
Alberta Beach	Fibre Optic	John D'Or Prairie	Wireless
Alder Flats	Fibre Optic	Joussard	Fibre Optic
Alexander I.R. 134 (special areas 2, 3, 4)	Fibre Optic	Kathyrn	Fibre Optic
Alix	Fibre Optic	Keephills	Fibre Optic
Alliance	Fibre Optic	Keg River	Fibre Optic
Altario	Wireless	Kehewin I.R. 123	Fibre Optic
Amisk	Fibre Optic	Kikino	Wireless
Andrew	Fibre Optic	Killam	Fibre Optic
Anzac	Fibre Optic	Kingman	Fibre Optic
Ardmore	Fibre Optic	Kinuso	Fibre Optic
Ardrossan	Fibre Optic	Kitscoty	Fibre Optic
Arrowwood	Fibre Optic	La Crete	Fibre Optic
Ashmont	Fibre Optic	La Glace	Wireless
Athabasca	Fibre Optic	Lac La Biche	Fibre Optic
Atikameg	Fibre Optic	Lafond	Fibre Optic
Banff	Fibre Optic	Lake Louise	Fibre Optic
Barnwell	Fibre Optic	Lamont	Fibre Optic
Barons	Fibre Optic	Lancaster Park	Fibre Optic
Barrhead	Fibre Optic	Langdon	Fibre Optic
Bashaw	Fibre Optic	Legal	Fibre Optic
Bassano	Fibre Optic	Leslieville	Fibre Optic
Bawlf	Fibre Optic	Lindale	Fibre Optic
Bear Canyon	Wireless	Linden	Fibre Optic
Bearspaw	Fibre Optic	Little Buffalo	Fibre Optic
Beaumont	Fibre Optic	Lomond	Fibre Optic
Beaver Lake	Fibre Optic	Longview	Fibre Optic

244 Industry Canada. Comments received on Telecom Decision CRTC 2008-01, 19 September 2008. Accessed 13 June 2016.

Beaverlodge	Fibre Optic	Loon Lake	Fibre Optic
Beiseker	Fibre Optic	Lougheed	Fibre Optic
Bellevue	Fibre Optic	Lundbreck	Fibre Optic
Bena Ito	Fibre Optic	Magrath	Fibre Optic
Bentley	Fibre Optic	Mallaig	Fibre Optic
Berwyn	Fibre Optic	Ma-Me-0 Beach	Fibre Optic
Bezanson	Fibre Optic	Manning	Fibre Optic
Big Valley	Fibre Optic	Mannville	Fibre Optic
Bind loss	Fibre Optic	Manyberries	Fibre Optic
Black Diamond	Fibre Optic	Marwayne	Fibre Optic
Blackfalds	Fibre Optic	Mayerthorpe	Fibre Optic
Blackie	Fibre Optic	Mclennan	Fibre Optic
Blairmore	Fibre Optic	Meander River	Fibre Optic
Blood I.R. 148	Fibre Optic	Mecca Glen	Fibre Optic
Blue Ridge	Fibre Optic	Medley	Fibre Optic
Bluffton	Fibre Optic	Milk River	Fibre Optic
Bodo	Wireless	Millarville	Fibre Optic
Bon Accord	Fibre Optic	Millet	Fibre Optic
Bonanza	Fibre Optic	Milo	Fibre Optic
Botha	Fibre Optic	Mirror	Fibre Optic
Bow Island	Fibre Optic	Monarch	Fibre Optic
Bowden	Fibre Optic	Morinville	Fibre Optic
Boyle	Fibre Optic	Morley	Fibre Optic
Bragg Creek	Fibre Optic	Morrin	Fibre Optic
Brant	Fibre Optic	Mountain View	Fibre Optic
Breton	Fibre Optic	Mundare	Fibre Optic
Brocket	Fibre Optic	Myrnam	Fibre Optic
Brownfield	Wireless	Namao	Fibre Optic
Brownvale	Fibre Optic	Nampa	Fibre Optic
Bruce	Fibre Optic	Nanton	Fibre Optic
Bruderheim	Fibre Optic	Neerlandia	Wireless
Buck Lake	Fibre Optic	New Brigden	Wireless
Buffalo Head Prairie	Fibre Optic	New Norway	Fibre Optic
Buffalo Lake	Fibre Optic	New Sarepta	Fibre Optic
Burdett	Fibre Optic	Newbrook	Fibre Optic
Busby	Fibre Optic	Nisku	Fibre Optic
Byemoor	Wireless	Niton Junction	Fibre Optic
Cadogan	Fibre Optic	Nobleford	Fibre Optic
Cadotte Lake	Fibre Optic	Nordegg	Wireless

Calling Lake	Wireless	O'Chiese I.R. 203	Wireless
Calmar	Fibre Optic	Okotoks	Fibre Optic
Canmore	Fibre Optic	Olds	Fibre Optic
Carbon	Fibre Optic	Onoway	Fibre Optic
Cardston	Fibre Optic	Oyen	Fibre Optic
Carmangay	Fibre Optic	Paddle Prairie	Fibre Optic
Caroline	Fibre Optic	Paradise Valley	Fibre Optic
Carse land	Fibre Optic	Peace River	Fibre Optic
Carstairs	Fibre Optic	Peavine	Wireless
Casian	Fibre Optic	Peerless Lake	Fibre Optic
Castor	Fibre Optic	Peers	Fibre Optic
Cayley	Fibre Optic	Pen hold	Fibre Optic
Cereal	Fibre Optic	Picture Butte	Fibre Optic
Gessford	Fibre Optic	Pincher Creek	Fibre Optic
Champion	Fibre Optic	Pipestone	Fibre Optic
Chard	Fibre Optic	Plamondon	Fibre Optic
Chateh	Fibre Optic	Ponoka	Fibre Optic
Chauvin	Fibre Optic	Provost	Fibre Optic
Chestermere	Fibre Optic	Radway	Fibre Optic
Chipewyan Lake	Wireless	Rainbow Lake	Fibre Optic
Chipman	Fibre Optic	Rainier	Fibre Optic
Clandonald	Fibre Optic	Ralston	Fibre Optic
Claresholm	Fibre Optic	Raymond	Fibre Optic
Cleardale	Wireless	Red Deer	Fibre Optic
Clive	Fibre Optic	Red Earth Creek	Fibre Optic
Clyde	Fibre Optic	Redcliff	Fibre Optic
Coaldale	Fibre Optic	Rich Valley	Wireless
Coalhurst	Fibre Optic	Rimbey	Fibre Optic
Cochrane	Fibre Optic	Riviere Qui Barre	Fibre Optic
Cold Lake I.R. 149	Fibre Optic	Rochester	Fibre Optic
Coleman	Fibre Optic	Rocky Lane	Fibre Optic
College Heights	Fibre Optic	Rocky Mountain House	Fibre Optic
Condor	Fibre Optic	Rockyford	Fibre Optic
Conklin	Fibre Optic	Rolling Hills	Fibre Optic
Conrich	Fibre Optic	Rosalind	Fibre Optic
Consort	Fibre Optic	Rosemary	Fibre Optic
Coronation	Fibre Optic	Round Hill	Fibre Optic
Coutts	Fibre Optic	Rumsey	Fibre Optic
Cremona	Fibre Optic	Rycroft	Fibre Optic

Crestomere	Fibre Optic	Ryley	Fibre Optic
Crooked Creek	Fibre Optic	Saddle Lake	Fibre Optic
Crossfield	Fibre Optic	Sandy Lake	Wireless
Crowsnest Pass	Fibre Optic	Sangudo	Fibre Optic
Czar	Fibre Optic	Schuler	Fibre Optic
Dapp	Fibre Optic	Seba Beach	Fibre Optic
Darwell	Fibre Optic	Sedgewick	Fibre Optic
Daysland	Fibre Optic	Seven Persons	Fibre Optic
Delburne	Wireless	Sexsmith	Fibre Optic
Delia	Fibre Optic	Shaughnessy	Fibre Optic
Derwent	Fibre Optic	Siksika	Fibre Optic
Devon	Fibre Optic	Silver Valley	Wireless
Dewberry	Fibre Optic	Slave Lake	Fibre Optic
Didsbury	Fibre Optic	Smith	Wireless
Dixonville	Fibre Optic	Smoky Lake	Fibre Optic
Donalda	Fibre Optic	South Cooking Lake	Fibre Optic
Donnelly	Fibre Optic	Spirit River	Fibre Optic
Drayton Valley	Fibre Optic	Springbank	Fibre Optic
Driftpile	Fibre Optic	Spruce View	Fibre Optic
Duchess	Fibre Optic	Sputinow	Fibre Optic
Duffield	Fibre Optic	St. Isidore	Fibre Optic
Dunmore	Fibre Optic	St. Paul	Fibre Optic
Dunstable	Wireless	Stand Off	Fibre Optic
Eaglesham	Fibre Optic	Standard	Fibre Optic
East Prairie Metis Settlement	Fibre Optic	Stavely	Fibre Optic
Eckville	Fibre Optic	Stettler	Fibre Optic
Edberg	Fibre Optic	Stirling	Fibre Optic
Eden Valley I.R. 216	Fibre Optic	Strome	Fibre Optic
Edgerton	Fibre Optic	Sturgeon Lake I.R. 154	Fibre Optic
Edson	Fibre optic	Sunchild I.R. 202	Wireless
Elizabeth Metis Settlement	Fibre Optic	Sundre	Fibre Optic
Elk Point	Fibre Optic	Sunset House	Fibre Optic
Elmworth	Wireless	Swan Hills	Fibre Optic
Elnora	Fibre Optic	Sylvan Lake	Fibre Optic
Empress	Fibre Optic	Taber	Fibre Optic
Enchant	Fibre Optic	Tall Cree I.R. 173	Wireless
Enoch	Fibre Optic	Tall Cree I.R. 173A	Wireless
Entwistle	Fibre Optic	Teepee Creek	Fibre Optic
Erskine	Fibre Optic	Thorhild	Fibre Optic

Evansburg	Fibre Optic	Thorsby	Fibre Optic
Exshaw	Fibre Optic	Three Hills	Fibre Optic
Fairview	Fibre Optic	Tilley	Fibre Optic
Falher	Fibre Optic	Tofield	Fibre Optic
Falun	Fibre Optic	Tomahawk	Fibre Optic
Faust	Fibre Optic	Trochu	Fibre Optic
Fawcett	Fibre Optic	Trout Lake	Fibre Optic
Flatbush	Fibre Optic	Tsuu Tina Sarcee	Fibre Optic
Foremost	Fibre optic	Tulliby Lake	Fibre Optic
Forestburg	Fibre Optic	Turner Valley	Fibre Optic
Fort Assiniboine	Fibre optic	Two Hills	Fibre Optic
Fort Chipewyan	Wireless	Uncas	Fibre Optic
Fort Mackay	Fibre Optic	Valhalla	Wireless
Fort Macleod	Fibre Optic	Valhalla Centre	Wireless
Fort Saskatchewan	Fibre optic	Valleyview	Fibre Optic
Fort Vermilion	Fibre Optic	Vauxhall	Fibre Optic
Fox Creek	Fibre Optic	Veteran	Fibre Optic
Fox Lake	Wireless	Viking	Fibre Optic
Frog Lake	Fibre Optic	Vilna	Fibre Optic
Gadsby	Fibre Optic	Vimy	Fibre Optic
Galahad	Fibre Optic	Vulcan	Fibre Optic
Garden Creek	Wireless	Wabamun	Fibre Optic
Gem	Wireless	Wabasca Desmarais	Fibre Optic
Gibbons	Fibre Optic	Wandering River	Wireless
Gift Lake	Fibre Optic	Wanham	Fibre Optic
Gleichen	Fibre Optic	Warburg	Fibre Optic
Glendon	Fibre Optic	Warner	Fibre Optic
Glenevis	Fibre Optic	Waskatenau	Fibre Optic
Glenwood	Fibre Optic	Water Valley	Fibre Optic
Goodfish Lake	Fibre Optic	Wembley	Fibre Optic
Grand Centre	Fibre Optic	Westerose	Fibre Optic
Grande Cache	Fibre Optic	Westlock	Fibre Optic
Granum	Fibre Optic	Whitelaw	Fibre Optic
Grassland	Fibre Optic	Wildwood	Fibre Optic
Grassy Lake	Fibre Optic	Willingdon	Fibre Optic
Gregoire Lake I.R. 176	Fibre Optic	Winfield	Fibre Optic
Grimshaw	Fibre Optic	Woking	Fibre Optic
Grouard	Fibre Optic	Worsley	Wireless
Grouard Mission	Fibre Optic	Wrentham	Fibre Optic

Grovedale	Wireless	Youngstown	Fibre Optic
Gwynne	Fibre Optic	Zama City	Wireless
Halkirk	Fibre Optic		
Hanna	Fibre Optic		
Hardisty	Fibre Optic		
Hay Lakes	Fibre Optic		
Hays	Fibre Optic		
Heart Lake	Fibre Optic		
Heinsburg	Fibre Optic		
Heisler	Fibre Optic		
High Level	Fibre Optic		
High Prairie	Fibre Optic		
Hill Spring	Fibre Optic		
Hines Creek	Fibre Optic		
Hinton	Fibre Optic		
Hobbema	Fibre Optic		
Holden	Fibre Optic		
Horse Lake I.R. 1528	Fibre Optic		
Hughenden	Fibre Optic		
Hussar	Fibre Optic		
Hythe	Fibre Optic		
Indus	Fibre Optic		
Innisfail	Fibre Optic		
Innisfree	Fibre Optic		
Irma	Fibre Optic		
Iron River	Fibre Optic		
Iron Springs	Fibre Optic		
Irricana	Fibre Optic		
Irvine	Fibre Optic		
Islay	Fibre Optic		
Janvier	Fibre Optic		
Jarvie	Fibre Optic		

Appendix 3. Networking - Retail Service Providers providing services through the Alberta SuperNet

A list of retail service providers that connect consumers to the Alberta SuperNet using wireless or wireline services. Please note, this is only a partial list provided by Axia SuperNet Limited.[245]

360 Business Solutions	Optic-Lynx
3C Information Solutions Inc	Pathcom Wireless Inc
Aaxess Satellite Communications Inc.	Persona Communications Inc.
Abnorth.com	PetroBand Networks Inc.
Alberta Communication Cable Services Inc	Platinum Communications Corporation (Xplornet)
Arrow Technology Group	Prairiewireless
Binary Solutions Ltd.	Rainbow Lake Cable TV
CampTek	Rigstar Communications Inc.
Care Radio Broadcasting Association	Serbernet
Communications Cold Lake	Slave Lake Communications Ltd.
Comtech (Telecom Solutions) Ltd	Tera-byte Dot Com Inc
Corridor Communications, Inc	The Rural Link Inc.
DataDrill Communications Inc	Tough Country Communications Ltd.
Davinci Broadband Inc	True Solutions
DigitalWeb Internet Services	Westcan Wireless
Galaxy Broadband Communications Inc	Wiband Communications Corp
Harewaves Wireless	Wispernet.ca
Hybrid Wireless Inc.	*Wolfpaw Services Inc*
I Want Wireless. Ca Ltd.	Xplornet
Iristel Inc.	
KBS Cable	
MCSNet	
Milk River Cable Club	
NETAGO	
NEXXCOM Technologies Ltd.	
Noralta Technologies Inc.	
Northwestel Cable Inc	
O-NET	

245 Axia SuperNet Ltd. List of Service Providers. Accessed 29 July 2016.

Appendix 4. Networking - Wireless Internet Service Providers in Alberta

Please note that this list represents a best effort search for available providers and may not be exhaustive.

Name	***Head office***	***Source***	***Service territory map or list, where available***
		North	
CCI Wireless	*Calgary*	*cciwireless.ca*	*Map*
I Want Wireless	*Debolt*	*iwantwireless.ca*	*List*
Slave Lake Communications	*Slave Lake*	*slavelakecommunication.com/*	*List*
First Broadband	*Grand Prairie*	*firstbroadband.ca*	*Map*
GPNetworks	*Grand Prairie*	*gpnetworks.ca*	*List*
Wild Rose Internet	*Calgary*	*wildroseinternet.ca*	*Map*
		Central	
NETAGO	*Hanna*	*netago.ca*	
CCI Wireless	*Calgary*	*cciwireless.ca*	*Map*
Clearwave	*Edmonton*	*clearwave.ca*	*Map*
MCSNet	*St. Paul*	*mcsnet.ca*	*Map*
Airsurfer	*Edmonton*	*airsurfer.ca*	*Map*
Arrow Technology Group	*Edmonton*	*sis.net*	*List*
Broadband Surfer	*Spruce Grove*	*canadasurfs.ca*	*Map*
TeraByte Wireless	*Edmonton*	*tbwifi.ca*	*Map*
Harewaves	*Eckville*	*harewaves.net*	*Map*
TeraGo (business	*Calgary*	*terago.ca*	*n/a*

services only)			
Wild Rose Internet	*Calgary*	*wildroseinternet.ca*	*Map*
South			
CCI Wireless	*Calgary*	*cciwireless.ca*	*Map*
Tough Country Communications	*Pincher Creek*	*toughcountryinternet .ca*	*Map*
Wild Rose Internet	*Calgary*	*wildroseinternet.ca*	*Map*
Satellite			
Xplornet		*www.xplornet.com*	*Coverage*

Non-residential

Rigstar Communications	*Calgary*	*rigstar.ca*	*Energy, mining, financial services, healthcare, construction, remote camps, public & private sector*
TeraGo	*Calgary*	*terago.ca*	*n/a*
WiBand	*Calgary/Edmonton*	*wiband.com*	*n/a*

Appendix 5: Data Centre - Industry

Name	Location (City)	Location Details	Sq Footage Total	Total Power to facility (MW)	Availability/Redundancy (Power redundancy, network redundancy)	Generator (blank if no, capacity in KW if yes)	Cooling Total Capacity	Cooling Types (Chilled, water, etc)	Network capacity to Data Centre	Fire control	Certifications ad Compliance	Costing Information
Q9	Calgary	n/a	250,000 (100,000 operational as of Apr 2013)	15 MW	Power redundancy.	Yes	Not available	Air handling	High availibility bandwidth, Cross connections, Inter-data centre connectivity, Remote connectivity,	Dry-pipe, pre-action sprinkler systems, Clean agent fire suppression systems	SSAE 16	Upon request
DataHive	Calgary	n/a	Not available	Not available	N+1	Diesel generator up to 72 hours	Not available	Not available	High availibility bandwidth, Cross connections, Inter-data centre connectivity, Remote connectivity, Carrier neutral including Shaw, Supernet, Hurricane Electric	An advanced fire-suppression system is in place	Not available	Half Rack: $980/month $400 setup 200GB Transfer
Blackbridge	Lethbridge	n/a	12,000 (phase 1) / 38,000 phase 2	Phase 1: 2.5MW Phase 2: 5MW	N+1	1.5 MW	1 MW (phase 1)	Clycol, air cooled and dry coolers	10GB redundant core network Redundant, diverse fibre connections Carrier neutral facility, access to Telus, Bell, Shaw, and other major carriers	Waterless, 3M Novec 1230 clean agent, mutli-zone with Vesda	Tier 3	Upon request
Rogers	Calgary	Calgary DC_1 Calgary DC_2	Not available	Not available	N+1	UPS, 24 hours high capacity backup diesel generators	Not available	N+1 cooling redundency	Multi diverse carrier and fibre paths multi-homed, extensive peering Tier 1 transit providers 99.999% reliability for private WAN	FM-200 gas (without water), 2-stage pre-action dry pipe sprinkler	SSAE 16 Type II PCI DSS, ISAE 3402 Type II, and CSAE 3416 Type I	Upon request
Rogers	Airdrie	Calgary DC_3	over 10,000 SqFt	9 MW	N+1	UPS, 24 hours high capacity backup diesel generators	Not available	N+1 cooling redundency	Multi diverse carrier and fibre paths multi-homed, extensive peering Tier 1 transit providers 99.999% reliability for private WAN	FM-200 gas (without water), 2-stage pre-action dry pipe sprinkler	Undergoing Tier 3 certification process SSAE 16 Type II PCI DSS, ISAE 3402 Type II, and CSAE 3416 Type I	Upon request
Rogers	Edmonton	Edmonton DC_2	40,000	Not available	N+1	UPS, 24 hours high capacity backup diesel generators	Not available	N+1 cooling redundency Redundant computer-controlled compressors	Multiple fibre providers - independent diverse fibre entrances, redundant switch gear Multi-homed Network with peering and Tier 1 Transit	FM-200 gas (without water), 2-stage pre-action dry pipe sprinkler	Persuring Tier 3 certification SSAE 16 Type II PCI DSS, ISAE 3402 Type II, and CSAE 3416 Type II	Upon request
Rogers	Edmonton	Edmonton DC_1	12000	15kW per rack	N+1	duty-rated generators. Multiple UPS N+1 and 2N distribution options	Not available	New Liebert DSE Precision cooling system (free air)	Multiple fibre providers - independent diverse fibre entrances, redundant switch gear Multi-homed Network with peering and Tier 1 Transit	FM-200 Gas Fire Suppression Multi-stage pre-action dry pipe sprinkler	SSAE 16 SOC1 Type2 CSAE 3416 Type 2 ISAE 3402 Type 2 AT101 SOC2 Type 1 PCI DSS	Upon request
KTI Data Center	Edmonton Markham, ON	n/a	Over 20,000	Not available	N+1	UPS 1.4 MW diesel generator with up to 4 MW standby	Not available	Not available	Muliple carrier backbone	Vesda Fire Alarm system, and Sapphire Fire Suppression System for Fire protection	Not available	Upon request

Name	Location (City)	Location Details	Sq Footage Total	Total Power to facility (MW)	Availability/Redundancy (Power redundancy, network redundancy)	Generator (blank if no, capacity in KW if yes)	Cooling Total Capacity	Cooling Types (Chilled, water, etc)	Network capacity to Data Centre	Fire control	Certifications ad Compliance	Costing Information
Q9	Calgary	n/a	250,000 (100,000 operational as of Apr 2013)	15 MW	Power redundancy.	Yes	Not available	Air handling	High availibility bandwidth, Cross connections, Inter-data centre connectivity, Remote connectivity,	Dry-pipe, pre-action sprinkler systems, Clean agent fire suppression systems	SSAE 16	Upon request
4web.ca	Edmonton	n/a				UPS	Not available	Not available	10Mbps, 100Mbps or 1000Mbps fibre connectivity Multi-homed fibre backbone 99.9% uptime gurantee	Not available	Not available	Upon request
Axia	Calgary	n/a	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Upon request
The Internet Centre	Edmonton	South side of Edmonton	Not available	Not available	Not available	Not available	Not available	Not available	gigabit BGP peered n	Not available	Not available	Dedicated co-lo starts at $1400/month $200 set-up
Wolf Paw	Edmonton	Edmonton - Financial Core	Not available	Not available	Not available	dedicated natural gas generator, site wide UPS	Not available	Leibert A/C with remote monitoring	Carrier neutral	Clean Agent extinguishers	Not available	Upon request
Wolf Paw	Calgary	Calgary - Away from downtown core	Not available	Not available	Not available	dedicated deisel generator, site wide UPS. A/B redundant avilable.	Not available	Leibert A/C with remote monitoring	Carrier neutral	Dual pre-action dry pipe.	Not available	Upon request
Webfire	Edmonton	n/a	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	Not available	10U = $50/month
IBM	Edmonton	Acheson	15,000 (expandable to 30K)	1 (expandable to 2.5MW)	N+1 for all critical infrastructure components (IBM Reliability Level 3 design)	Not available	Not available	Free cooling with water side conomizer	Dual incoming network and utility feeds provided to the site Network links from Bell, Telus and Allstream	Multi-stage, pre-action, automated fire protection VESDA smoke detection Water - only in the area where the sprinkler head is activated	LEED	Upon request
Mercator	Calgary	Downtown	3,000	Not available	Not available	Diesel generator UPS maximum of two hours of battery backup with parallel battery banks to provide redundancy	Not available	No info other than: dual HVAC units with dual compressors work to keep our Data Center at a controlled temperature of 22 oC or 71.6 oF and a relative humidity of 30%	BGP4 routing scalable bandwidth from 10Mbps to 100Mbps	Zonal fire detection nd supression gas-based fire supression	Not available	Full rack (w/1x15) = $1500/month (1yr) Setup = $600
NIRIX	Edmonton	n/a	25,000	Not available	Dual power grid on separate conduits	Not available	Not available	Not available	Not available	Not available	SSAE 16, ISAE 3402, CSAE 3416 and PCI DSS compliant,	Upon request

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Appendix 6: Data Centre - Not-for-Profit

Name	Location Details	Sq Footage Total	Available/unused sq footage'	Total Power to facility (MW)	Total unused power	Generator	Cooling Types	PUE	Network capacity to Data Centre	Availability/Redundancy (Power & network)	Fire control	Security (physical and any device/network security in place)	Co-location possible? Model and available to who?	Colocation Costing Information (if applicable)
NAIT	Main campus, E building, room E01	1,100	None	0.25 MW	0.1 MW	500KVA dedicated generator supporting power and cooling	Free air wtih compressor backup Capacity exactly matches poer capacity	1.6-2.0	Commercial: 1GB Supernet: 60Mb To be connected: CyberNet: 10GB	Single utility feed to DC, upstream campus switching has two utility feeds, 250KVA UPS, with dedicated UPS on the transfer switch.	VESA smoke, Vortex nitrogen agent on first stage, pre-action water on secon	Card access for physical entry, CCTV monitoring at entrance	No	n/a
Mount Royal University	Main Campus room E235G	1,860	640	0.16 MW	0.1 MW	160KW capacity	Water cooling	no data	Shaw: 30Mb Telus: 300Mb To be connected: CyberaNet: 10Gb	2(N+1) Power: 2 entrance 112KVA transformers, 2 x 80KVA N+1 UPS Network: 2 independent ISP load balanced via BGP	- Sapphire Clean Agent Fire Suppression - Vesda air sampling system. - 4 Stage system from alert to release of fire suppression agent.	- Anyone requesting access must fill out a Data Centre Access form - Card Swipe and Proximity Card Access only for those granted Level 1 and 2 access. - Physical Key issued only to MRU Infrastructure Team, MRU Security and Physical Resources.	No	n/a
University of Calgary	Professional Development Centre	Not available	Not available	1 MW	Not available	Yes	More than sufficient	0.5		UPS: 500kVA	Not available	Access policies, swipe access and cameras.	Not available	Not available
University of Calgary	Research Data Centre	Not available	Not available	> 0.5 MW	Not available	Yes - Partial	Sufficient	2		UPS: 2 x 160 kVA	Not available	Access policies, swipe access and cameras.	Not available	Not available
University of Calgary	Calgary Centre of Innovative Technology	Not available	Not available	0.4 MW	Not available	No	More than sufficient	1.3		UPS: 80kVA	Not available	Access policies, swipe access and cameras.	Not available	Not available
University of Calgary	Health Reseach Innovation Centre	Not available	Not available	0.45 MW	Not available	Yes	Chilled water	1.5		UPS: 225kVA	Not available	Access policies, swipe access and cameras.	Not available	Not available
University of Alberta	General Services Building (GSB) - North Campus, Edmonton	8,000	2,000	1 MW Dual 3 MVA transformers in the building could provide up to 4 MW to the data centre with in-building upgrades.	0.5 MW. With in-building electrical upgrades this could be expanded up to 4 MW.	500 KW	Chilled water Free air	1.7	Telus: 10GB with 2GB provisioned Shaw: 10GB (moving to 10Gb with 2GB provision) CyberaNet: 10GB Supernet: 1GB	N+1 utility feeds N+1 building transformers	None	Network Security: Intrusion Prevention Systems, Firewalls, Log management/analysis tools, dedicated network and IT security teams Physical: Access policy, swipe access, cameras, 24x7 staff in building, consolidated monitoring of environmental, mechanical, electrical, and fire/water detection systems, 24x7 campus peace officers	Yes	Researchers and related groups/institutions
University of Alberta	Edmonton Clinic Health Academy (ECHA) - North Campus, Edmonton	2,500	1,200	1 MW	0.5 MW	None	Chilled water Free air	not available	included in above	N+1 utility feeds N+1 building transformers	Inert gas - Novak 1230	Network Security: Intrusion Prevention Systems, Firewalls, Log management/analysis tools, dedicated network and IT security teams Physical: Access policy, swipe access, cameras, consolidated monitoring of environmental, mechanical, electrical, and fire/water detection systems, 24x7 campus peace officers	Yes	Researchers and related groups/institutions
University of Alberta	Enterprise Square (ESQ) - Downtown, Edmonton	2,000 expandable to 3,000	1,000	1 MW	0.5 MW	100 KW	Chilled water supported by free air	1.6	included in above	1 utility feeds 1 building transformers	Inert gas - Novak 1230	Same as above	Yes	Researchers and related groups/institutions

Appendix 7: Computing Services - Industry

Name	Location	Managed	Backup	Storage	IaaS	Price	What you get	AWS Pricing	IBM
F12 networks	Calgary, Edmonton, Red Deer	No	Not clear	Not clear	Yes	Upon request	Not clear		
Blackbridge	Lethbridge	No	Yes	Yes	Yes	78.00/month	1 Core 2 GB RAM 100 GB Storage	38.07 on-demand price 22.47 with 3-year contact	40.20/month
NIRIX	Edmonton	No	yes	No	yes	Upon request	Not clear		
Q9 Networks	Calgary	yes	No	No	No	Upon request	Not clear		
Rogers	Edmonton, Calgary	yes	yes	No	yes	Upon request	Not clear		
Bell	Customer equipment hosted in AB.	yes	yes	No	yes	Upon request	Not clear		
teliPhone	Calgary	No	yes	yes	yes	Upon request	Not clear		
DataHive	Calgary	No	No	No	yes	$180/setup $271/month	1 Core 2 GB RAM 100 GB Storage	38.07 on-demand price 22.47 with 3-year contact	40.20/month
KTI	Presence in Alberta but not clear on whether equipment is hosted in Aberta	No	yes	No	yes	Upon request	Not clear		
Mercator	Calgary	yes	No	No	No	Upon request	Not clear		
Alentus	Edmonton Columbus, Ohio	Yes	No	No	No	Upon request	Not clear		
4web.ca	Edmonon	No	Yes	No	No	Upon request	Not clear		
OnX	Office in Calgary & Edmonton but not clear on whether equipment is hosted in Alberta	Yes	Yes	Yes	Yes	Upon request	Not clear		

Appendix 8: Computing Services - Not-for-Profit

								Compute Information					Storage Info				
Owner	Principal Investigator	Location	System Name	Type	Year purchased (if system)	Funder(s)	Vendor	Number of cores	Chip speed (GHz) & Type	Memory per node (GB)	Interconnect (IB or GigE)	Software stack/allocation	Disk Size (TB)	Tape Size (TB)	System purpose / Access	Cost (if applicable)	Filesystem
NAIT	n/a	Edmonton	n/a	n/a	n/a	NAIT	HP, Dell, Cisco	344	1,171	6,700		A mix	500	n/a	Internal use	n/a	n/a
UCalgary	WestGrid	Calgary	Breezy	Large Memory		CFI, Prov AB	Appro	384	2.4 / AMD	256	IB	Batch/Moab			Any Canadian Researcher (CC access policy) / research computing / interdisciplinary	Free for research	IBRIX
UAlberta	WestGrid	Edmonton	Hungabee	Shared Memory		CFI, Prov AB	SGI	2048	2048 Intel E7 Xeon	16384	IB	Batch/Moab	50 TB short term / 355 medium term	n/a	As above, but by special request only	Free for research	NFS
UAlberta	WestGrid	Edmonton	Jasper	Cluster with fast interconnect		CFI, Prov AB	SGI	4160		16-24 / 40 Gbit/sec	IB (1:1 and 2:1)	Batch/Moab	356 TB (shared with all nodes)		As above (no special request)	Free for research	Lustre
UAlberta	WestGrid	Calgary	Lattice	Storage, Cluster with fast interconnect		CFI, Prov AB	HP	4096	2.27	12	IB (2:1 blocking)	Batch/Moab			As above	Free for research	IBRIX
UCalgary	WestGrid	Calgary	Parallel	Storage, Cluster with fast interconnect, visualization		CFI, Prov AB	HP	6336 / 60 12 core nodes with GPU	2.54, NVidia Telsa M2070s	5.5	IB (2:1)	Batch/Moab			As above	Free for research	IBRIX
UCalgary		Calgary	Terminus									OpenStack/Cloud					
UCalgary		Calgary	Tieleman Cluster														
UCalgary		Calgary	Kusalik Cluster														
ULeth		Calgary	Wetmore cluster														
UCalgary		Calgary	John Chen Cluster														
UCalgary		Calgary	DeKoning cluster														
UCalgary		Hosting services	http://www.ucalgary.ca/it/hostingrates														
		Edmonton	CWRC														
UAlberta		Hosting services	http://ist.ualberta.ca/ts/hosting														
Cybera		Calgary/Edmonton	Rapid Access Cloud		Mix	Cybera	Dell	560		4.5		OpenStack/Cloud	Object: 12 Block: 109	n/a	Researcher, SME	Free	Various
Cybera		Edmonton	DAIR		2011	CANARIE	Dell	768		4.5		OpenStack/Cloud	Object: 48 Block: 24	n/a	SME	Free tier, additional reasourse available upon request	Various
Ualberta		Edmonton	CPB	LAMP			VM					LAMP			Researcher		Ubuntu
Ualberta		Edmonton	jaguar				VM								Researcher		RedHat
Ualberta		Edmonton	Thor	EQS Statistical Analysis			VM					EQS Statistical Analysis			Researcher		Ubuntu
Ualberta		Edmonton	Wellwiki	LAMP			VM					LAMP			Researcher		RedHat
Ualberta		Edmonton	Wiserpath	GIS			VM					GIS			Researcher		Ubuntu
Ualberta		Edmonton	Wiserpath-dev2	GIS			VM					GIS			Researcher		RedHat
Ualberta		Edmonton	E101	LAMP			VM					LAMP			Researcher		Ubuntu
Ualberta		Edmonton	anther	Web server			Physical	Dual Xeon E5520	2.27	8		Web Services - Apache			Researcher		
Ualberta		Edmonton	coyote	Qnap			VM					Qnap			Researcher		Debian
Ualberta		Edmonton	dw-gw1	HA Cluster - Web Servers			Physical	Dual Core AMD Opteron 2210		4		Web Services - Apache			Researcher		Cent OS
Ualberta		Edmonton	dw-gw2	HA Cluster - Web Servers			Physical	Dual Core AMD Opteron 2210		4		Web Services - Apache			Researcher		Cent OS
Ualberta		Edmonton	dw-proxmox-fs1	NFS Shares and ISCSI Shares			Physical	2z Intel 5160 Xeons		8		NFS Shares and ISCSI Shares			Researcher		Cent OS
Ualberta		Edmonton	dw-proxmox-node1	Web Server			Physical	2x Intel Xeon X5355		32		Web Services - Apache			Researcher		Debian
Ualberta		Edmonton	dw-proxmox-node2	Web Server			Physical	2x AMD Opteron 6128		64		Web Services - Apache			Researcher		Debian
Ualberta		Edmonton	optimus	Samba File Server			VM	Common KVM Processor		1		Samba File Server			Researcher		Cent OS
Ualberta		Edmonton	srv002088	Database (MySQL) & Apache			VM					Database (MySQL) & Apache			Researcher		Cent OS
Ualberta		Edmonton	wks80920	Legacy Research Application			VM					Legacy Research Application			Researcher		RedHat
Ualberta		Edmonton	boreal-birds	LAMP			VM					LAMP			Researcher		Debian
Ualberta		Edmonton	sperling-V0seq	MySQL & Apache			VM	1 Core		1		MySQL & Apache			Researcher		Debian
Ualberta		Edmonton	cookelab	Site Redirector			Physical	Intel i7 950	3	12		Site Redirector			Researcher		Debian
Ualberta		Edmonton	snipper	Genomics Server			Physical	Xeon E5650	2.67	48		Genomics Server			Researcher		Cent OS
Ualberta		Edmonton	fermenter	Fermenter Application			VM	Xeon E5650	2.67	0.5		Fermenter Application			Researcher		Debian
Ualberta		Edmonton	moose	MySQL Server for iPhone App Data Collection			VM	1 Core		1		MySQL Server for iPhone App Data Collection			Researcher		Debian
Ualberta		Edmonton	boutin	Web Server			Physical	Intel Xeon	3	8		Web Server			Researcher		Debian
Ualberta		Edmonton	carpel	Various Applications			Physical	Intel Xeon E5520	2.27	16		Various Applications			Researcher		Debian
Ualberta		Edmonton	dendro	Various Applications			Physical	Xeon E5506	2.13	16		Various Applications			Researcher		Debian
Ualberta		Edmonton	euc	Various Applications			Physical	Intel Xeon E5506	2.13	16		Various Applications			Researcher		Debian
Ualberta		Edmonton	fabid	Various Applications			Physical	Intel Xeon E5506	2.13	16		Various Applications			Researcher		Debian
Ualberta		Edmonton	glume	Various Applications			Physical	Intel Xeon E5506	2.13	16		Various Applications			Researcher		Debian
Ualberta		Edmonton	hilum	Various Applications			Physical	Intel i7-3820	3.6	64		Various Applications			Researcher		Debian
Ualberta		Edmonton	biofiler	File Storage, Apache, Database Backup			VM	1 Core		1		File Storage, Apache, Database Backup			Researcher		OpenFiler
Ualberta		Edmonton	iolaus	Web/MySQL, Pearl Code, Blastall			VM	Intel Xeon E5540	2.53	4		Web/MySQL, Pearl Code, Blastall			Researcher		Debian
Ualberta		Edmonton	hydra-1	Head node of Hydra Cluster (Bioformatics Cluster)			Physical					Head node of Hydra Cluster (Bioformatics Cluster)			Researcher		Debian
Ualberta		Edmonton	bioinfor1	Bioformatics Cluster			Physical	AMD Opteron 6128		16		Qiime			Researcher		Debian
Ualberta		Edmonton	bioinfor2	Bioformatics Cluster			Physical	AMD Opteron 6128		16		Qiime			Researcher		Debian
Ualberta		Edmonton	bioinfor3	Bioformatics Cluster			Physical	AMD Opteron 6128		16		Qiime			Researcher		Debian
Ualberta		Edmonton	bioinfor4	Bioformatics Cluster			Physical	AMD Opteron 6128		16		Various mounted binaries			Researcher		Debian
Ualberta		Edmonton	bioinfor5	Bioformatics Cluster			Physical	AMD Opteron 6128		16		Various mounted binaries			Researcher		Debian

									Compute Information				Storage Info				
Owner	Principal Investigator	Location	System Name	Type	Year purchased (if system)	Funder(s)	Vendor	Number of cores	Chip speed (GHz) & Type	Memory per node (GB)	Interconnect (IB or GigE)	Software stack/allocation	Disk Size (TB)	Tape Size (TB)	System purpose / Access	Cost (if applicable)	Filesystem
Ualberta		Edmonton	bioinfor6	NFS file server			Physical	AMD Opteron 6128		16		NFS Shares, Qiime			Researcher		Debian
Ualberta		Edmonton	bioinfor7	Web Services			Physical	AMD Opteron 6128		24		Web/MySQL			Researcher		Debian
Ualberta		Edmonton	hydra	Headnode for former Bioinformatics Cluster			Physical	AMD Opteron 6128		32		MySQL/Postgres DB Apache, Mira, Mothur, Paup4,RAxML, ClonalFrame,Hmmerbuild (MPI) Pysam,Samtools,Cufflinks, Qiime(1-4(usearch),6(usearch, usearch61)) Mr Bayes,Mgra,Bowtie,amos,R NEWBLER,BLASTALL, PHYML,PhyloBayes MUSCLE,SPAdes,BWA,tophat,bcftools			Researcher		Debian
Ualberta		Edmonton	boreal	SQL Server			VM					SQL			Researcher		NTFS
Ualberta		Edmonton	bs-gamon	File Services			Physical	Xeon E31320	3.2	32		File Services			Researcher		NTFS
Ualberta		Edmonton	chacka	Licence server for Biotools			VM	1 Core		0.5		License Server			Researcher		NTFS
Ualberta		Edmonton	dali-vpc2	Windows Applications for Mac Lab			VM	1 Core				Windows Applications for Mac Lab			Researcher		NTFS
Ualberta		Edmonton	vinebrooks-srv	Windows File Server Lab			Physical	Opteron 4226	2.7	32		File Server			Researcher		NTFS
Ualberta		Edmonton	abmi-dell	ABMI VM Farm			Physical	Xeon(R) CPU E5-2620		48		vmware			Researcher		
Ualberta		Edmonton	abmi-sharepoint	Sharepoint Server			VM	Xeon(R) CPU E5-2620		16		Sharepoint			Researcher		NTFS
Ualberta		Edmonton	abmi-dc	Domain Controller			VM	Xeon(R) CPU E5-2620		2		Domain Controller			Researcher		NTFS
Ualberta		Edmonton	abmi-fs	ABMI File Services, Researcher Storage			VM	Xeon(R) CPU E5-2620		4		File Services, Researcher Storage			Researcher		NTFS
Ualberta		Edmonton	abmi-server2	ABMI Research Server			Physical	Core 2 Duo	2.66	4		Research Server			Researcher		NTFS
Ualberta		Edmonton	abmi-server	ABMI Research Server			Physical	Xeon 3070	2.66	4		Research Server			Researcher		NTFS
Ualberta		Edmonton	abmi-wp	ABMI Wordpress Server			VM	Xeon E5 2620	2	4		WordPress			Researcher		NTFS
Ualberta		Edmonton	abmi-mysql	ABMI SQL Server			VM	Xeon E5 2620	2	8		MS-SQL			Researcher		NTFS
Ualberta		Edmonton	barryslava	Stata			VM	8 vCPU		24		Stata	0.23		Researcher		NTFS
Ualberta		Edmonton	boskovic	Accumap GIS			VM	2 vCPU		4		Accumap GIS	0.14		Researcher		NTFS
Ualberta		Edmonton	ceo	Database			VM	2 vCPU		4		SQL	0.21		Researcher		NTFS
Ualberta		Edmonton	coldfusion	Coldfusion			VM	2 vCPU		8		Coldfusion, IIS	0.02		Researcher		NTFS
Ualberta		Edmonton	dkw	Statistical analysis			VM	4 vCPU		8		SAS	22.4		Researcher		NTFS
Ualberta		Edmonton	fuji1	Statistical analysis			VM	2 vCPU		4		SAS	3.22		Researcher		NTFS
Ualberta		Edmonton	fusion	Webscraping research			VM	2 vCPU		4		Fusion	0.14		Researcher		NTFS
Ualberta		Edmonton	ji	Statistical analysis			VM	2 vCPU		4		SPSS, SAS	0.06		Researcher		NTFS
Ualberta		Edmonton	khughes-nvivo	Nvivo			VM	2 vCPU		4		Nvivo	0.09		Researcher		NTFS
Ualberta		Edmonton	liu	Statistical analysis			VM	2 vCPU		4		Stata, SAS	0.16		Researcher		NTFS
Ualberta		Edmonton	matlab	Matlab			VM	8 vCPU		12		Matlab	0.18		Researcher		NTFS
Ualberta		Edmonton	monterosa	Stata			VM	8 vCPU		32		Stata	0.16		Researcher		NTFS
Ualberta		Edmonton	mtcolumbia	CPLEX, AMPL			VM	4 vCPU		12		CPLEX, AMPL	1.5		Researcher		NTFS
Ualberta		Edmonton	ninjaturtles	Research			VM	8 vCPU		8			0.33		Researcher		NTFS
Ualberta		Edmonton	odin	AOIS dept research server			VM	4 vCPU		8		EQS, Shazam, Matlab, R, SAS, Mathematica, ArcGIS, Weka	0.34		Researcher		NTFS
Ualberta		Edmonton	res	Future replacement of coldfusion server			VM	4 vCPU		8		Coldfusion	0.09		Researcher		NTFS
Ualberta		Edmonton	stata11	Stata			VM	2 vCPU		4		Stata	0.19		Researcher		NTFS
Ualberta		Edmonton	yuma	SAS			VM	2 vCPU		6		SAS	1		Researcher		NTFS
Ualberta		Edmonton	aragon	File Share/Matlab			Physical					File Share/Matlab			Researcher		
Ualberta		Edmonton	assyria	File Server			Physical					File Server			Researcher		Tru64
Ualberta		Edmonton	chola	Research Server			Physical					Research Server			Researcher		linux
Ualberta		Edmonton	hittite	Research Server			Physical					Research Server			Researcher		linux
Ualberta		Edmonton	inca	Research Server			Physical					Research Server			Researcher		linux
Ualberta		Edmonton	knossos	Research Server			Physical					Research Server			Researcher		linux
Ualberta		Edmonton	parthia	Research Server			Physical					Research Server			Researcher		Tru64
Ualberta		Edmonton	sumeria	Research Server			Physical					Research Server			Researcher		Tru64
Ualberta		Edmonton	biovpn	VPN			Physical					VPN			Researcher		
Ualberta		Edmonton	moresby	MathBio Server			Physical					MathBio Server			Researcher		
Ualberta		Edmonton	deneb	MathBio Server			Physical					MathBio Server			Researcher		
Ualberta		Edmonton	gilford	MathBio Server			Physical					MathBio Server			Researcher		
Ualberta		Edmonton	pd-idrac-ceswp-01				Physical								Researcher		Ubuntu
Ualberta		Edmonton	pd-idrac-ceswp-02				Physical								Researcher		Ubuntu
Ualberta		Edmonton	pd-idrac-ceswp-03				Physical								Researcher		Ubuntu
Ualberta		Edmonton	pd-idrac-ceswp-04				Physical								Researcher		Ubuntu
Ualberta		Edmonton	pd-idrac-ceswp-05				Physical								Researcher		Ubuntu
Ualberta		Edmonton	pd-srv-black-01				Physical								Researcher		Ubuntu
Ualberta		Edmonton	pd-srv-blue-01				Physical								Researcher		CentOS 6

Owner	Principal Investigator	Location	System Name	Type	Year purchased (if system)	Funder(s)	Vendor	Number of cores	Compute Information Chip speed (GHz) & Type	Memory per node (GB)	Interconnect (IB or GigE)	Software stack/allocation	Storage Info Disk Size (TB)	Tape Size (TB)	System purpose / Access	Cost (if applicable)	Filesystem
Ualberta		Edmonton	pd-srv-ceswp-01				Physical								Researcher		Ubuntu
Ualberta		Edmonton	pd-srv-ceswp-06				Physical								Researcher		Ubuntu
Ualberta		Edmonton	pd-srv-ch-01	Research server. File server. Licensing server.			Physical					Research server. File server. Licensing server. For Mirko's group.			Researcher		Debian
Ualberta		Edmonton	pd-srv-clc-01	GMT/Torque - Patching and updates at users request. System regular updates			Physical					GMT/Torque - Patching and updates at users request. System regular updates			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-clc-02	GMT/Torque - Patching and updates at users request. System regular updates			Physical					GMT/Torque - Patching and updates at users request. System regular updates			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-cssdp-01				Physical								Researcher		Ubuntu
Ualberta		Edmonton	pd-srv-gs-001				Physical								Researcher		
Ualberta		Edmonton	pd-srv-gs-01				Physical								Researcher		Red Hat Ent 6.x
Ualberta		Edmonton	pd-srv-isset-01				Physical								Researcher		CentOS 6
Ualberta		Edmonton	pd-srv-jgu-01	Computational.			Physical					Computational.			Researcher		Scientific Linux 6.3
Ualberta		Edmonton	pd-srv-magneto-01				Physical								Researcher		CentOS 6
Ualberta		Edmonton	pd-srv-mb-01	computation machine			Physical					computation machine			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-ms-01	Computational/Storage/Scratch space.			Physical					Computational/Storage /Scratch space.			Researcher		Ubuntu Server 12.04
Ualberta		Edmonton	pd-srv-msa-01	Head Node for cluster. Computational cluster.			Physical					Head Node for cluster. Computational cluster.			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-msa-02	Computational Cluster.			Physical					Computational Cluster.			Researcher		
Ualberta		Edmonton	pd-srv-msa-03	Computational Cluster.			Physical					Computational Cluster.			Researcher		
Ualberta		Edmonton	pd-srv-mvdb-01	Research server. File server. Licensing server.			Physical					Research server. File server. Licensing server. For Mirko's group.			Researcher		Ubuntu Server 11
Ualberta		Edmonton	pd-srv-ni-01				Physical								Researcher		Debian
Ualberta		Edmonton	pd-srv-ni-03				Physical								Researcher		Debian
Ualberta		Edmonton	pd-srv-ni-04				Physical								Researcher		Debian
Ualberta		Edmonton	pd-srv-ni-05				Physical								Researcher		Debian
Ualberta		Edmonton	pd-srv-ni-08				Physical								Researcher		Debian
Ualberta		Edmonton	pd-srv-ofs-01	File Server.			Physical					File Server.			Researcher		Oracle Linux
Ualberta		Edmonton	pd-srv-vf-01	Runs Matlab, Mathimatica.			Physical					Runs Matlab, Mathimatica.			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-wr-01	Computational Server. They compile code etc. Adrian does not know whats running on it.			Physical					Computational Server. They compile code etc. Adrian does not know whats running on it.			Researcher		Scientific Linux 5
Ualberta		Edmonton	pd-srv-cpp-01	Gateway for everybody to connect to the thuner grid. Connects to a NIS server.			VM					Gateway for everybody to connect to the thuner grid. Connects to a NIS server.			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-er-01	Web Server			VM					Web Server			Researcher		Ubuntu 64-bit
Ualberta		Edmonton	pd-srv-fs-01	Test file server for Linux. Kerberos for Linux			VM					Test file server for Linux. Kerberos for Linux			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-geo-01	File portal, not set up yet.			VM					File portal, not set up yet.			Researcher		
Ualberta		Edmonton	pd-srv-idl-01				VM								Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-rm-01	Runs Vu			VM					Runs Vu			Researcher		Open SUSE Linux Enterprise 11 (64-bit)
Ualberta		Edmonton	pd-srv-web-01	Patching - Wordpress			VM					Patching - Wordpress			Researcher		Open SUSE Linux Enterprise 11 (64-bit)
Ualberta		Edmonton	pd-srv-web-02	webserver			VM					webserver			Researcher		Open SUSE Linux Enterprise 11 (64-bit)
Ualberta		Edmonton	pd-srv-web-03	webserver			VM					webserver			Researcher		Ubuntu Linux (64-bit)
Ualberta		Edmonton	pd-srv-web-04	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-05	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-06	webserver			VM					webserver			Researcher		Open SUSE Linux Enterprise 11 (64-bit)
Ualberta		Edmonton	pd-srv-web-07	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-08	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-09	webserver			VM					webserver			Researcher		Open SUSE Linux Enterprise 11 (64-bit)
Ualberta		Edmonton	pd-srv-web-10	webserver			VM					webserver			Researcher		Red Hat Enterprise Linux 6 (32-bit)
Ualberta		Edmonton	pd-srv-web-11	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-12	webserver			VM					webserver			Researcher		Scientific Linux 6

Owner	Principal Investigator	Location	System Name	Type	Year purchased (if system)	Funder(s)	Vendor	Number of cores	Compute Information Chip speed (GHz) & Type	Memory per node (GB)	Interconnect (IB or GigE)	Software stack/allocation	Storage Info Disk Size (TB)	Tape Size (TB)	System purpose / Access	Cost (if applicable)	Filesystem
Ualberta		Edmonton	pd-srv-web-13	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-14	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-15	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-16	webserver			VM					webserver			Researcher		Ubuntu Linux (32-bit)
Ualberta		Edmonton	pd-srv-web-17	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-18	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-19	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-20	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-21	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-22	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-23	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-moodle-02	Used for developing apis as needed			VM					Used for developing apis as needed			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-24	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-25	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-26	webserver			VM					webserver			Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-web-27				VM								Researcher		Scientific Linux 6
Ualberta		Edmonton	pd-srv-moodle-01	Backup via Veeam			VM					Backup via Veeam			Researcher		
Ualberta		Edmonton	gedco	Omni 3D software for Geophysics			VM					Omni 3D Software			Researcher		NTFS
Ualberta		Edmonton	filemaker	Filemaker			VM					Filemaker			Researcher		NTFS
Ualberta		Edmonton	filemaker2	Filemaker			VM					Filemaker			Researcher		NTFS
Ualberta		Edmonton	bruce	Research lab			Physical					Xserve G5			Researcher		OS X
Ualberta		Edmonton	carl	Research lab			Physical					AFS, FileMaker, OpenVPN, ssh, httpd			Researcher		OS X
Ualberta		Edmonton	cmigrid	Statistical Server			Physical					VNC, Matlab, RStudio			Researcher		CentOS
Ualberta		Edmonton	eeggrid	Statistical Server			Physical					VNC, Matlab, RStudio			Researcher		CentOS
Ualberta		Edmonton	alcatraz	Backup Server			Physical					VNC			Researcher		Ubuntu
Ualberta		Edmonton	arabinose	Rocks			Physical	Quad Xeon 5160 @ 3Ghz (dual core)	3	2x 1TB		rocks			Researcher		CentOS
Ualberta		Edmonton	cucumber	Rocks			Physical	Quad Xeon 5160 @ 3Ghz (dual core)	3	2x 1TB		rocks			Researcher		Ubuntu
Ualberta		Edmonton	thistle	Rocks			Physical	Quad Xeon 5160 @ 3Ghz (dual core)	3	2x 1TB		rocks			Researcher		CentOS
Ualberta		Edmonton	jo	Research Server			Physical	2x Intel Xeon E5-2667 6C/12T 2.9Ghz	2.9	384		GAMESS, Amber, TeraChem, gaussian, ganglia, and apache			Researcher		RedHat
Ualberta		Edmonton	nucleus	Samba			Physical	2.6 GHz AMD Athlon(tm) 64 X2 Dual Core Processor 5000+	2.6	2		Samba			Researcher		FreeBSD
Ualberta		Edmonton	chem-derda	Group script for the Web			VM					apache, mysql, and php			Researcher		Debian
Ualberta		Edmonton	researchweb	WordPress sites			VM	2.33 GHz Intel(R) Xeon(R) CPU 5148	2.33	2		wordpress, apache, mysql, and php			Researcher		Ubuntu
Ualberta		Edmonton	chem-cairo	Group shares - worktime server			VM	1 Core		2					Researcher		NTFS
Ualberta		Edmonton	chem-derda-file	Group shares			VM			2					Researcher		NTFS
Ualberta		Edmonton	chem-klassen	Group shares			VM			2					Researcher		NTFS

Appendix 9: Cybersecurity - Resources

Implementing Security Processes

- OIPC - Office of the Information and Privacy Commissioner
  - Provides information needed for use of the provincial Freedom of Information and Privacy (FOIP) Act, the Personal Information Protection Act (PIPA), and the Health Information Act (HIA), among others.
- Government of Alberta Corporate Information Security Office (CISO)
  - Responsible for safeguarding the provincial governments IT systems. It provides information for implementing IT security through things such as the GoA IT Security Framework.
- Alberta Education School Technology Services
  - The School Technology Services program provides resources for governing and handling of IT assets.
- University of Alberta and Calgary Information Technologies policies
  - University of Alberta
  - University of Calgary
- Cyber Incident Management Framework for Canada
  - The Canadian CyberIncident Management Framework was set up to provide a guiding document for coordinating an integrated response by all levels of government, critical infrastructure owners, as well as the public sector.
- Canadian Cyber Incident Response Centre (CCIRC)
  - The Cyber Incident Response Centre is the federal coordination centre for preparing for and responding to cyber incidents. It provides advice in regards to cybersecurity matters and a forum for communication and information sharing for Canada's critical infrastructure sectors. This includes a Top 4 Strategies to mitigate cyber attacks.
- Critical Security Controls - Top 20
  - The Top 20 are a prioritized, actionable set of continuously updated controls that help organizations implement fundamental security measures.

Educational Resources

- Massive Open Online Courses:
  - Designing and Executing Information Security Strategies, University of Washington, offered free online through Coursera.
  - Cryptography and Security Course (CS155), Stanford University.
  - Cybersecurity: A specialization on Coursera, University of Maryland, College Park, offered online through Coursera. This is a series of four online security courses (Usable Security, Software Security, Cryptography, Hardware Security) and a capstone project, leading to a Cybersecurity Specialization certificate.
  - Information Security and Risk Management in Context, University of Washington, offered free online through Coursera.

- Interview with Dan Boneh, Professor, Stanford University.
- Interview with Reed Hundt on Security and Openness. Hundt was the Chairman of the FCC from 1993-1997 and has some fascinating and powerful insights into how to strike the right balance between security and privacy/openness.

Appendix 10: People - HQSP Projected Staff Shortages

Occupation	2015	2016	2017	2018	2019	2020	2021	% Increase 2015 - 2021
Managers in engineering, architecture, science and information systems	107	159	236	323	417	519	632	*590*
Office equipment operators	291	434	470	517	577	647	734	*252*
Computer and information systems professionals	567	867	952	1091	1236	1435	1666	*293*
Technical occupations in computer and information systems	361	411	459	571	701	899	1132	*313*
Electrical trades and telecommunications occupations	848	932	1008	1114	1228	1362	1514	*178*
Computer and information systems managers	50	93	131	158	246	280	325	*650*
Electrical and electronics engineers	106	124	127	141	147	156	184	*174*
Information systems analysts and consultants	343	568	642	730	824	998	1156	*337*
Database analysts and data administrators	35	40	42	45	52	54	62	*177*
Software engineers and designers	104	116	124	135	135	146	159	*152*
Computer programmers and interactive media developers	149	182	185	209	252	264	297	*199*
Web designers and developers	34	58	58	71	71	71	91	*268*
Electrical and Electronics	57	76	94	115	138	170	185	*324*

Engineering Technologists and Technicians								
Electronic Service Technicians (Household and Business Equipment)	92	113	130	178	233	285	366	*398*
Computer network technicians	277	322	366	466	582	761	946	*342*
User support technicians	80	84	87	110	123	140	184	*230*
Library and Archive Technicians and Assistants	148	167	182	200	219	240	266	*180*
Graphic designers and illustrators	112	137	161	206	249	311	405	*362*
Telecommunications Installation and Repair Workers	36	52	55	58	73	80	106	*294*

** Alberta's Occupational Demand and Supply Outlook 2011-2021, Government of Alberta*

Appendix 11: People - HQSP Post-secondary ICT Programs

Institution Name	Program Name	Program Credential	Specialization Name	Program Description
Athabasca University	Post-Baccalaureate Certificate	Certificate	Data Analytics	Information technology
Athabasca University	Master of Science	Degree	Information Systems	Information technology
Lakeland College	Networking Technology Diploma	Diploma	Networking Technology Diploma	Computer systems networking and telecommunications
Lethbridge College	Computer Information Technology Diploma	Diploma	Computer Information Technology Diploma	Information technology
Lethbridge College	Computer Network Technician	Certificate	Computer Network Technician	Computer systems networking and telecommunications
Medicine Hat College	Information Technology Certificate	Certificate	Information Technology Certificate	Information technology
Medicine Hat College	Information Technology Diploma	Diploma	General	Information technology
Medicine Hat College	Information Technology Diploma	Diploma	Technology Support	Network and system administration/administrator
Medicine Hat College	Information Technology Diploma Co-op	Diploma	Technology Support	Network and system administration/administrator
Mount Royal University	Bachelor of Computer Information	Degree	Bachelor of Computer Information	Information technology

	Systems		Systems	
Northern Alberta Institute of Technology	Bachelor of Applied Information Systems Technology	Degree	Information Systems	Information technology
Northern Alberta Institute of Technology	Computer Network Administrator	Certificate	Computer Network Administrator	Network and system administration/administrator
Northern Alberta Institute of Technology	Bachelor of Applied Information Systems Technology	Degree	Network Management	System, networking and LAN/WAN management/manager
Northern Lakes College	Information Technology Analyst	Certificate	Information Technology Analyst	Information technology
Northern Lakes College	Information Technology Analyst Diploma	Diploma	Information Technology Analyst Diploma	Information technology
Red Deer College	Computer Information Systems	Diploma	Computer Information Systems	Information technology
Southern Alberta Institute of Technology	Network Technician	Certificate	Network Technician	Computer systems networking and telecommunications
Southern Alberta Institute of Technology	Information Technology	Diploma	Network Systems	System, networking and LAN/WAN management/manager
University of Alberta	Master of Science	Degree	Internetworking	System, networking and LAN/WAN management/manager

Appendix 12: People - Resources

- Alberta’s Aging Labour Force and Skill Shortage: http://work.alberta.ca/documents/alberta-aging-labour-force-and-skill-shortages.pdf
- Alberta’s Top 50 Occupations by Vacancy Rates: http://work.alberta.ca/documents/top-fifty-occupations-in-alberta-by-vacancy.pdf
- Alberta’s monthly vacancy rates by industry: http://work.alberta.ca/labour/skill-shortages-in-alberta.html
- Alberta’s Short-Term Employment Forecast 2014-2016: http://work.alberta.ca/documents/short-term-employment-forecast.pdf
- Mitacs: https://www.mitacs.ca/en
- The Canadian Chamber of Commerce: http://www.chamber.ca/ - The Top 10 Barriers to Competitiveness 2014
- Annual Alberta Labour Market Review, 2013
- Digital Economy Annual Review, Information and Communications Technology Council, 2014
- Alberta ICT Magazine, April 2012
- Cybera Focus Group Study
- The Appification of Everything, Canada’s Apps Economy Value Chain, The Information and Communications Technology Council (ICTC), 2014
- The Issue – The Importance of Canada’s Domestic and Global ICT Labour Force, August 2014, Information Technology Association of Canada
- Alberta Finance and Enterprise: Alberta’s Competitiveness – A Primer for Discussion, June, 2010)
- OECD Skills Outlook 2013: First Results From the Survey of Adult Skills
- Information and Communications Technology - A strategy for Alberta, 1998

About Cybera

Cybera is a not-for-profit agency responsible for accelerating technology adoption in Alberta. At the core of its operations is CyberaNet, a publicly funded high-bandwidth network dedicated to support discovery. Working with partners in the public and private sectors, Cybera is also leading 'above the network' projects in Alberta to pilot emerging technologies that support the province's economic growth. Cybera provides member organizations with unbiased, highly skilled expertise on high-tech products, processes or services, and access to shared IT services. Cybera's operations are enabled by a strategic investment from Alberta Innovation and Advanced Education.

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