Digital Technology Adoption in Northern and Remote Indigenous Communities in Canada

Appendix 1: Literature Review and References

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Digital Technology Adoption in Remote and Northern Indigenous Communities in Canada

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Abstract:

This paper is the most comprehensive review and analysis to date of the adoption and use of digital technologies in remote and northern Indigenous communities in Canada. It is based primarily on a literature review, supplemented by personal communications with key informants and the authors' knowledge from extensive research and practical experience in the topic area. We begin by developing a "whole community" approach to understanding how remote Indigenous communities adopt digital technologies for community, social and economic needs. To extend technology adoption models that focus on "individual" and "household" metrics, we use a community informatics analysis: technology is adopted within a broad ecology of community support that makes it possible for these tools and the information they transmit to be available for community members. The whole community approach guided our review and analysis. The literature highlights the role of digital technologies in community organizations and services as well as the community intermediary organizations that support the development and sustainability of digital technologies and networks in Indigenous communities.

The interactions that take place using digital technologies in remote and northern Indigenous communities are central to everyday lives. Our review includes the current understanding of levels of digital technology adoption, how the communities are using digital technologies, and policies and programs to support digital technology adoption in Indigenous communities. Our conclusion highlights the main challenges to digital technology adoption in these unique remote and northern environments.

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1 Introduction

The term "Indigenous communities in Canada" refers to First Nations, Inuit and Métis communities. There is no pan-Canadian Indigenous reality or situation. According to Indigenous and Northern Affairs Canada, there are 618 First Nation communities in all the provinces and two northern territories (NWT and YT), representing more than 50 nations or cultural groups and 50 Indigenous languages. Inuit peoples live in 53 communities across the northern regions of Canada in Inuit Nunangat (which means "the place where Inuit live"). Inuit Nunangat is comprised of four regions: Inuvialuit (NWT and YT), Nunavut, Nunavik (Quebec) and Nunatsiavut (Labrador).

Most Indigenous communities in Canada are small, remote and rural. It is worth noting that from the perspective of southern Canada, remote and northern Indigenous communities exist on the outer edge of Canadian society, but for the Indigenous people, these communities are the centre of their world (Brady & Dyson, 2015). Indigenous communities are often concentrated within a small geographic footprint to support local infrastructure development such as water, wastewater, electricity, roads and telecommunications. Public services including education, health, justice, and governance facilities are usually surrounded by the housing units within relatively tight clusters of buildings. While these settlements are practical for development purposes, there are ongoing challenges such as housing shortages, high cost of transportation, food costs, maintenance and operation of all the facilities (Anaya, 2014). Most Indigenous communities require unique programs and services to properly operate, maintain, sustain, and upgrade the infrastructure required to support the residents.

Before digital technologies became available, Indigenous communities were keen adopters of analogue communications, including radio and telephony (Chouinard, 1983; Hudson, 1990, 1984, 1977a, 1977b; Rupert, 1983; Valaskakis, 1992, 1986). By the mid-1980s, remote First Nation communities in Northern Ontario were building local cable plants and receiving public satellite television broadcasts from Wawatay,

TVOntario, and the Canadian Broadcasting Corporation, and the Inuit Broadcasting Corporation was creating and transmitting culturally-relevant content in the North; 10 years later, this expanded to commercial satellite television and the multi-channel universe (Fiser, Clement and Walmark, 2005). By the mid-1990s, there were also more than 60 newspapers and almost 50 radio stations run by Indigenous organizations across Canada, many of which eventually created an online presence. In 1999, the Aboriginal Peoples Television Network (APTN) was launched (Roth, 2005).

Indigenous community members have always expressed their enthusiasm and desire to adopt digital technologies, beginning in the early days when the technologies and their possibilities were just being introduced (Fraser, 2007; Keewaytinook Okimakanak Research Institute, 2005). Today in northern and remote Indigenous communities across Canada, thousands of community members are accessing and using digital technologies in their homes, the homes of friends and family members, community schools, and other community spaces. Those working in the community health centres, local government offices, schools, public works buildings, the airports, water treatment centres, and other community services and buildings are using digital technologies in many different ways to do their work and communicate with other community members and people further away. Community members are using a range of devices from smartphones to tablets, notebooks and videoconferencing units. The infrastructure supporting the digital technology adoption may be arriving to the community by fibre, coax cable, microwave or satellite. The use of the technologies and infrastructure is likely supported by a regional Indigenous community intermediary staffed with technology experts who have learned many tricks over the years to keep all this infrastructure and digital communications operating smoothly.

Considerable diversity exists among the Indigenous communities discussed in this paper. Although many share common strengths and challenges, each is unique. This point is particularly important for digital technology adoption. Unlike in cities across Canada, where access to broadband infrastructure is generally similar, in remote and northern communities each may have a different level, mode and cost of broadband infrastructure. The reliability of the digital services may vary considerably among communities. The challenges and solutions are different. To give just one example, in the Arctic the challenges for broadband vary considerably in different regions. In the eastern Arctic, there are no roads, an arctic climate, no industrial activities and a low population; in the western Arctic, there is a road infrastructure, a sub-arctic (milder) climate, industrial activities and a higher population. These differences make digital infrastructure solutions different in each region and from community to community (Dumoulin, 2016).

One common challenge faced by all northern and remote Indigenous communities is the high level of poverty and underfunding of basic public services. There are many reasons for this situation (Anaya, 2014; Palmater, 2011). At the same time, as discussed in this paper, digital infrastructure costs are much higher in northern and remote communities than in other regions of the country. The economic situation combined with the high cost of connectivity suggests that that many remote and northern Indigenous communities and community members may be struggling to pay the high costs of using digital technologies. At the same time, Indigenous community members and Indigenous communities have demonstrated that they are eager users of digital technologies and they will adopt them when they are affordable, reliable and meet their needs. To give one example, Facebook is widely used in all Indigenous communities, as discussed in the paper.

This paper is a overview of the adoption and use of digital technologies in northern and remote Indigenous communities in Canada. The topic is important because digital technologies have the potential to bring transformative change to all communities but particularly to communities in remote and northern regions. Digital technologies allow the transfer of information, data, and services much more rapidly than analogue technologies, and many more types of information and services can be transmitted by digital technologies than analogue technologies. The new services, information and data can not only give community members

more choices for beneficial new opportunities but also support them to continue to live traditional lifestyles in a more sustainable, safe, secure and healthy manner.

Given the considerable interest in Canada in how digital technologies can be used for economic, social and community development, there is a surprisingly little known about digital technologies in remote and northern Indigenous communities. Fifteen years ago, researchers were writing about the "digital divide" between Indigenous communities and the rest of Canada and commenting on the lack of research on this topic (Alexander, 2001; Bredin, 2001). Although more research is available today, it has been published and disseminated in a wide range of formats and venues and is not easily accessible. This paper contributes the most comprehensive overview to date of the adoption and use of digital technologies in remote and northern Indigenous communities in Canada. We review and analyze current and recent literature about digital technology adoption in these communities. The core questions considered are:

- What is the best approach to understanding digital technology adoption in remote and northern Indigenous communities?
- What are the different levels of technology adoption in Indigenous communities?
- How are Indigenous communities using digital technologies?
- What are the policies and programs supporting digital technology adoption?
- What supports for digital technology adoption and use are available through Indigenous community intermediary organizations?"
- What are the challenges to digital technology adoption in remote and northern communities?

This comprehensive literature review covers the current understanding of the state of digital technology adoption and use by Indigenous communities in northern and remote communities in Canada. Our review included published and grey literature (reports and other materials that may not be published in traditional venues). Each section and sub-section includes, when available: 1) literature about the three northern territories of Canada; 2) literature about Indigenous communities in the northern and/or remote regions of the provinces and/or other Indigenous communities in the provinces. For the first section of the report, on the whole-community approach, we included international literature, including research from the US, Australia and Europe.

2 A whole-community approach to understanding digital technology adoption in Indigenous communities

Researchers have used numerous methods and approaches to study and understand digital technology adoption. It is instructive that most technology adoption models focus less on the community aspects and more on individual and household adoption. For example, within the well-regarded Technology Acceptance Model (TAM), the most important predictor of technology adoption is that the technology is useful (Davis, 1989; Porter & Donthu, 2006) but the wider social processes are not part of the TAM model. One theory that accounts for the role of the community in digital technology adoption is community informatics (Clement, Gurstein, Longford, Moll & Shade, 2012; Gurstein, 2003). Community informatics theory posits that technology in itself will not support community development if the collective capacity is not available to use the technology effectively. In a community context, Gurstein (2003) defines "effective use" of a technology as the capacity and opportunity to successfully integrate digital technologies to accomplish collaboratively-identified goals.

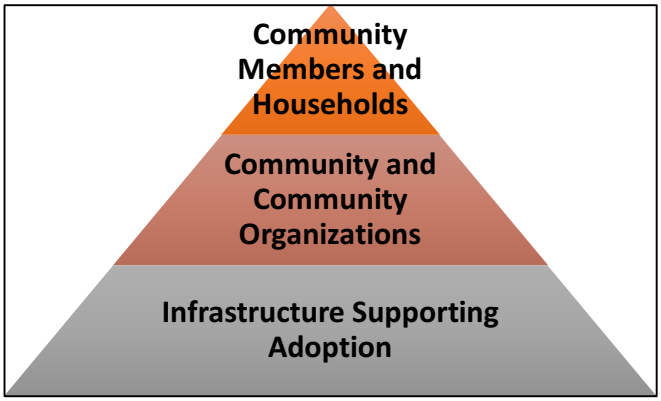
In his criticism of the "digital divide" rhetoric that focuses simply on individual access to the internet, Gurstein points to Clement & Shade (1998) and their "access rainbow," a socio-technical model that accounts for the multiple layers or facets of access. Without considering the socio-technical questions, then "access" simply becomes a matter of: "ensuring opportunities to 'consume' Internet enabled services and

Internet supplied goods or information by passive consumers." However by considering the wider access issues, effective use would include local leadership, coordinated planning and design, and training at all levels to make the technology usable. The community informatics approach has been used to analyze technology adoption and use in rural and remote Indigenous communities in Canada, including many publications reviewed in this paper.

Many authors have highlighted the vital role of the "community" in Indigenous communities in Canada, in particular small remote and northern communities (for example: Alfred, 2005; Mignone, 2009; Moody & Cordua-von Specht, 2005). The concept of social capital is particularly relevant for these communities. Mignone & Henley (2009) have studied the link between digital technologies and social capital in Indigenous communities. Dale & Onyx (2005) among others have highlighted the role of social capital in contributing to Indigenous community well-being and economic development. The literature suggests that there is a link between the use of digital technologies in Indigenous communities, social capital, and community economic development.

Digital technology adoption and effective use of digital technology is a multi-faceted process shaped by many factors, many outside the control of any one individual. Based on the research on digital technologies in remote and northern Indigenous communities, we propose a whole-community analytical approach to understand digital technology adoption. In our approach there are three levels of factors that shape digital technology adoption:

- Community members / household factors (top level)
- Community and community-organization-level factors (middle level)
- Local and transport infrastructure supporting individual and community adoption (base level)



The three levels factors in technology adoption in northern and remote Indigenous communities are illustrated in the diagram below. All three need to be considered in the community-level research proposed for this project.
Adoption by Indigenous community members and their households is the top level. Many factors are involved in a decision by community members and household to adopt a digital technology. Adoption within and by communities is the middle level. The community level includes how digital technologies are adopted by community organizations, and the regional community intermediary organizations that support community adoption. The base level is the infrastructure supporting digital technology adoption. Infrastructure issues such as availability, price, quality of service and/or experience, interoperability, ownership and accessibility are factors in digital technology adoption. Infrastructure also includes the middle mile and backhaul layer that affects bandwidth, price and quality of service.

The Canadian Telecommunications Policy Review Panel report (2016) noted that community networks and other community-based organizations provide both technological and social infrastructures for digital technology access, adoption and use. Community networks also act as important sources of local economic development and innovation. Through training programs, for example, they help ensure that all Canadians, particularly those most at risk of being left behind, have the necessary skills to participate in the networked economy.

As noted in the introduction, many Indigenous communities in Canada - in particular those in remote, northern and rural areas - are characterized by low household income (Anaya, 2014; Palmater, 2011). For this reason, the literature on digital technology adoption in low-income communities is relevant to our review. The latest research from the US on digital inclusion and broadband adoption initiatives in low-income communities supports a whole-community approach (Rhinesmith, 2016). That study advocates a networked community model of meaningful broadband adoption that focuses on the links between digital technology adoption and community activities. The research found that digital inclusion happens within a broader ecology of community support. The support includes connections with local community-based organizations and other local institutions, such as schools, healthcare providers, libraries, local government departments and agencies. For example, many of the digital inclusion organizations in the study had strong relationships with individual schools and local school systems because schools are logical partners in fostering digital inclusion (Rhinesmith, 2016).

Similarly, Dailey, Bryne, Powell, Karaganis & Chung (2010) found that community-based organizations play a central role in low-income communities in the US. They provide access, training, and support services in ways that extend their traditional work. The authors describe the "self-reinforcing characteristics of connectivity and digital exclusion" - in communities with many technology resources, such as many urban centres, digital technology access is increasingly available through a variety of sites, devices, and personal networks and there are many technical supports. In communities with fewer technology resources connectivity is "mediated by much thinner technical and social infrastructures, which are often overstretched and fragile." Recognizing that the two are different environments helps explain how a simple challenge such as a computer breakdown can be dealt with more easily in an urban environment than a remote community that has fewer technical supports.

In her study on the role of community organizations in Europe, O'Donnell (2001) found that community organizations foster digital skills and access by low-income groups in a number of ways. Among other roles, the organizations can build trust in digital technologies by using computer applications that are credible, accessible and affordable and meet the specific needs of people experiencing disadvantage. The whole-community approach to digital technology adoption was also advocated in a study published by the Irish Government's Information Society Commission. That study recommended developing and supporting digital capacity in community organizations as one of the main thrusts of policy and programs to increase the adoption of digital technologies (O'Donnell, McQuillan & Malina, 2003).

In his study on community access centres in Indigenous communities in Australia, Daly (2005) identified elements for their success: active community support for the centre; close involvement by the community with its development and management; having the centre management focused on ways it can contribute to the future of the community, including active involvement in outreach activities; and delivering skills training, especially for youth, aimed at expanding opportunities. Hudson (2012, 2015) points out that library, school and other community public access locations are used extensively by Indigenous residents in remote areas of Alaska. More than 60% of residents in the 2012 study said that they would continue to use public access locations even if they subscribed to broadband service at home. It is worth noting here that the International Telecommunication Union has identified connecting schools as a means to support more widespread adoption of digital technologies in Indigenous communities globally (ITU, n.d).

3 Levels of digital technology adoption in Indigenous communities across Canada

3.1 Community members and households

There is a lack of research on levels of technology adoption in northern and remote Indigenous communities in Canada. Conducting research about technology adoption by community members and households in these locations can be expensive and time-consuming and therefore prohibitive. Online surveys and research are more cost-effective to conduct than telephone or in-person surveys although they still take considerable time and effort (Beaton, Perley, George & O'Donnell, 2016, in press; Gratton & O'Donnell, 2011). The disadvantage of conducting online surveys is that only people who are already online will participate and so the surveys do not generate representative data about the overall level of technology adoption in a community (Beaton & Carpenter, 2015).

The three territorial government statistical institutes have basic relevant data on household internet access, described below. The Inuit region of Nunavik in northern Quebec is also currently collecting information on household spending, including spending on Internet access; that data may be available mid-2016 (Rogers, 2014). To our knowledge there is no information available on why and how Indigenous community members and households in the three territories are adopting digital technologies, aside from some data on Facebook use in Nunavut presented later in this paper.

The Nunavut statistical data is from 2009-10. In that period there were 8,550 dwellings in Nunavut and 59% had internet access. The territory has three regions. The average for the Baffin region was also 59% household access, and the access rates for the 13 communities in that region ranged from 71% in Iqaluit (of 2,260 homes in the community) to 36% in Sanikiluaq (of 190 homes). The average household internet access in the other two regions was 63% in Keewatin and 53% in the Kitikmeot region.

The NWT government collected data on household access to the internet in 2009 and 2014. In 2014, there were 14,730 households in the NWT and 79% had internet access, up from 74% In 2009. There are six regions in the NWT. The average for the Yellowknife region was 90%. The average rate of household internet access for the other regions was: Beaufort Delta region, 70%; Dehcho region 52%; Sahtu region 68%; South Slave region 81%; Tijcho region 50%. Among the communities in the regions, there were huge variations. For example, three communities in different regions had only 35% household access: Detah in the Yellowknife region (down from 36% household access in 2009), Nahanni Butte in the Dehcho region (up from 29% in 2009), and Lutselk'e in the South Slave region (up from 17% in 2009).

We did not find similar statistics on household access to the internet in communities in the Yukon although that territory publishes statistics on household consumer spending. In 2012, 78% of households reported spending on internet access services (Yukon Bureau of Statistics, 2012).

For the provinces, there are no comparable provincial statistics on levels of community member or household access to the internet in northern or remote Indigenous communities. This underlines the earlier point about the challenges of doing this kind of research. We found several studies conducted at the community level that give an indication of digital technology adoption rates: two based on interviews with community members and one based on a household survey.

An analysis in 2009 in First Nation communities in southern British Columbia using the Ktunaxa network (Henley, 2010) found that 77% of community members interviewed had a computer in their home and 71% of community members had an internet connection at home. 2010 research in Fort Severn First Nation found that 43% of participants interviewed had a computer in their home, 85% were weekly internet users,

and the internet was central to daily communication in Fort Severn (Gibson, Kakekaspan, Kakekaspan, O'Donnell, Walmark & Beaton, and the People of Fort Severn First Nation, 2012).

A separate study using the same Fort Severn interview data looked at mobile phone use several months after the introduction of a new community-owned mobile phone service. In the interviews, 45% of respondents owned a cell phone, but only 32% used the cell service in Fort Severn. For 42% of these respondents, the main reason they did not use the service was the perceived or actual cost; another 33% believed they did not need a cell phone (O'Donnell, Kakekaspan, Beaton, Walmark, Mason & Mak, 2011).

In 2011, researchers and community members in Kitigan Zibi First Nation in rural Quebec conducted a study based in part on a paper survey distributed to community households with school-aged children. The survey found that 73% of Kitigan Zibi households with school-age children were accessing the internet from home, and 27% were not connected to the internet; 17% indicated that they had 'no service' in their home. Others were waiting to get connected or trying to get connected, but were having difficulties with this process for a number of reasons, including that respondents were uninterested, their computer was inadequate, or they used the internet at the home of a family member (Lockhart, Tenasco, Whiteduck & O'Donnell, 2013).

Our literature review found references to three online surveys with data about digital technology adoption, two conducted in 2011 and one in 2014, with the same population base: people living in remote First Nation communities of the Sioux Lookout zone, an area of northwestern Ontario that is home to the most remote First Nations in Canada, most of which are fly-in communities. The studies were conducted with the Keewaytinook Okimakanak First Nations council and their telecommunication service KNET.

The 2011 KNET study analyzed for statistical differences among respondents related to education and gender. Interestingly, no significant correlations were found between frequency of online activities and education. Only two slight statistical relationships were found: participants with a higher education (more than high school) were making voice calls on a mobile phone and accessing the internet on a mobile phone more frequently than participants with a high school education or less. This suggests that education is not a significant factor in predicting which community members will use technologies more frequently than others for a broad range of online activities. This finding is interesting given that education is often cited as a key variable in the digital divide. On the contrary, the study suggests that community members across all educational levels are engaging with a range of technologies to meet their daily needs (Walmark, Gibson, Kakekaspan, O'Donnell, 2012)

There were few significant relationships between gender and the frequency of technology use in the 2011 KNET study. However, one was noted: men were more likely than women to be using gaming consoles and watching online videos more frequently. Women were more likely to be using social networking sites more frequently – but the statistical relationship was quite small. Using data from the same survey, Carpenter, Gibson, Kakekaspan and O'Donnell (2013) analyzed the responses of the 231 women completing the survey; women reported their levels of daily digital technology use for: social networking (81%), email (59%), text messaging (32%), playing games (29%) and watching videos (25%). Younger women were more frequent viewers of online video, engaged in more video calls, uploaded more videos, and used the internet for shopping activities. However, what was perhaps most interesting was the fairly moderate to high level of engagement with technologies across the ages.

A separate 2011 survey by Budka (2012) of residents of remote and rural communities in Northwestern Ontario using the KNET network found that daily social networking use was common. The survey question relevant to this discussion was: Where is the computer from which you usually update your MyKnet / Facebook page? The majority of respondents (80.2%) indicated that they did this from home, 7% doing so

at work, 5% from the home of a friend or family member, 3% from school, and 2% from a public access point. These findings confirm the results of an earlier study (Budka, Bell & Fiser, 2009).

3.2 Communities and community-based organizations

The literature review did not find any publications about the levels of use of digital technologies by community-based organizations in the three northern territories. We conducted a basic web search to find the following high-level information on government websites about community access in libraries in the territories: Yukon has 15 public libraries and all have free public internet access. The NWT has 20 public libraries, all providing free computer and internet access. There are 11 public libraries in Nunavut. Information on computer and internet access in the Nunavut libraries was not available on the web however a search on the site of one library at random found a photo of public-access computers in the library. No information was available on the government websites about the use of the libraries by Indigenous community members.

Aside from the CAP program evaluation (Industry Canada, 2009), we could find no literature from Canada analyzing the role of public access centres in Indigenous communities. Several publications in our literature review reference the fact that the remote and northern Indigenous communities in the provinces have public internet access points, for example in Fort Severn First Nation (Gibson, Kakekaspan, Kakekaspan, O'Donnell, Walmark, Beaton & and the People of Fort Severn First Nation, 2012) and Mishkeegogamang First Nation (Gray-McKay, Gibson, O'Donnell & the People of Mishkeegogamang, 2014). Walmark, Gibson, Kakekaspan and O'Donnell (2012) found that participants reported using computers in a variety of locations, and for regular use (daily/weekly) 14% used them at an e-centre or public place. The authors note that even though using computers and the internet at an e-centre or public place is the least popular location, it is highly likely that community members connecting to the internet in these public places have few other options, and so these community internet resources are valuable for ensuring that everyone in the community has connectivity.

A number of publications discussed later in this paper reference the connectivity and digital adoption by community organizations in First Nation communities. The main community organizations adopting digital technologies in First Nations are health centres, schools and band offices. In general, the literature suggests that most if not all schools, health centres and band offices have internet access. However developing and maintaining sustainable technology capacity in these organizations is always an ongoing challenge (Gray-McKay, Gibson, O'Donnell & People of Mishkeegogamang, 2014); Lockhart, Tenasco, Whiteduck & O'Donnell, 2014; McMahon, O'Donnell, Smith, Walmark & Beaton, 2011; O'Donnell, Walmark & Hancock, 2010; Whiteduck, Beaton, Burton & O'Donnell, 2012).

3.3 Infrastructure supporting community adoption

There are many references to the lack of or inadequacy of digital infrastructure to support technology adoption in remote and northern communities. For example, a story by Leask (2015c) about the isolated First Nation community of Natuashish on the northern coast of Labrador, community members have very poor infrastructure. When the Canadian government decided to relocate the community from Davis Inlet to Natuashish in 2002, no one thought to set up digital infrastructure. The network administrator is quoted in the story saying that: "It's a complete bottleneck….the network is completely saturated and far outdated," and for those with one of the few broadband connections it is an "exercise in frustration" to use the Internet. "There's supposedly 1.5 Mb but you'd be lucky to get 10% of that."

Adopting digital technologies obviously relies on the access to infrastructure. Levels of connectivity to Indigenous communities vary considerably across the country and by region. Some Indigenous regional

organizations and communities were able to access funding to develop broadband infrastructure under federal and provincial government programs such as Broadband Canada, Connecting Canadians, Plan Nord, and the First Nations Infrastructure Fund. Many other Indigenous communities did not access these funds. There is currently no literature or reliable source of current data on the level, cost, capacity or reliability of broadband infrastructure to and in Indigenous communities across the country.

In 2001, the report of the National Broadband Task Force (Industry Canada, 2001) stated that a minimum symmetrical speed of 1.5Mbps per individual user, capable of supporting 2-way symmetrical data circuits, was required and that applications such as peer-to-peer file interactions and videoconferencing would increase individual user demand for symmetric bandwidth in the 4Mbps-to-6Mbps range. In 2011, the CRTC raised those minimum requirements and stated that by the end of 2015, all Canadian households should have access to broadband speeds of at least 5 megabits per second (Mbps) for downloads and 1 Mbps for uploads (CRTC, 2011).

Fiser (2010), in collaboration with the First Nations SchoolNet RMOs (organizations described later in this paper), presented the most comprehensive overall analysis to date of First Nation community connectivity. The 2010 analysis mapped Statistics Canada Census Subdivisions (CSDs) with 2009 data from internet service providers. Using this methodology, their research identified that in 2010, 426 First Nation CSDs (49.2%) had no residential broadband/high speed access greater than or equal to 256Kpbs (kilobits per second); 355 First Nation CSDs (41%) had residential broadband access greater than or equal to 256Kbps but less than 1.544 Mbps (megabits per second); and 85 (9.8%) had residential high speed access greater than 1.544Mbps. Note that this data pertained to availability only, did not identify how many households in the CSDs actually subscribed to internet services, and used a measure of broadband (1.5Mbps) that is now outdated.

Organizations that coordinate and manage the community connectivity for northern and remote Indigenous communities (First Nations SchoolNet RMOs) have documented a need for a minimum dedicated 10Mbps connection to the schools in the First Nations. In most cases, a 10Mbps circuit will provide enough bandwidth for shared access to videoconferencing, data transfer, voice services, and basic internet adoption. The 2014 report on broadband needs in the Arctic identified a need for households in the three territories to have a 9Mbps download and 1.5Mbps upload speed. The report states that currently the households in NWT and the Yukon have an average of 2.6 Mbps per household (for microwave and satellite served communities), while Nunavut has an average of 1.5 Mbps per household (satellite only) (Nordicity, 2014). The report also notes that countries such as Finland and the state of Alaska have set ambitious targets of 100Mbps to be reached within five years.

In 2015, the CRTC found "…a clear and persistent access gap exists between northern and southern Canada... roughly 18,000 households in the three territories and the northern regions of the provinces lack access to broadband Internet service at the Commission's target speeds." Regarding affordable digital infrastructure, the CRTC (2015) states that residents in most southern urban centres can choose between four to seven service providers who offer 5 Mbps broadband Internet access service at prices as low as $25 per month (up to a maximum of $72 per month), whereas residents of Whitehorse, Yellowknife, and Iqaluit only have access to one service provider offering 5Mbps service. Residents of Whitehorse and Yellowknife pay no lower than $63 per month, while urban Iqaluit residents are asked to pay $180 per month for 5 Mbps service - a price that would surely be unaffordable for all but the most affluent members of society. According to the CRTC's data, rural residents fare even worse.

Several policy-related reports have been published reviewing the digital infrastructure situation in the three territories. One recent report (Canada's Public Policy Forum, 2014) includes an overview of the infrastructure supporting community adoption in the three territories, summarized as: "Infrastructure and

connectivity challenges are not uniform across, or even within, territories. The Northwest Territories (NWT) has a mixture of land-based (cable) and satellite services. In Yukon, all communities except one are served by cable. But while Whitehorse and Yellowknife have close to service parity with each other (in speed, latency and affordability), more remote communities have significantly poorer connectivity than the capitals. As a result, they also have limited access to e-health and distance education, which has a significant effect on social welfare. Meanwhile, Nunavut communities, including Iqaluit, are entirely satellite-dependent, with limited options for infrastructure development." (pp. 30). Other significant consultancy reports commissioned by northern governments, the Nunavut Broadband Development Corporation and other organizations outline the challenges and solutions to improve the digital infrastructure in the territories (Fiser & Jeffrey, 2013; Imaituk Inc., 2011; LYA, 2012; Nordicity, 2014; Salter Global Consulting, 2011, 2012).

We are aware of only one research project that focuses on cellular (mobile) networks in Indigenous communities, the extensive research conducted on the history and use of the community-owned Keewaytinook Mobile (KMobile) service now operational in more than 20 remote First Nations in northern Ontario (Beaton, Burnard, Linden & O'Donnell, 2015; O'Donnell, Kakekaspan, Beaton, Walmark, Mason & Mak, 2014). In his recent literature review, Pulla (2015) found no research currently relating to mobile learning and Indigenous peoples in Canada. He noted the lack of infrastructure to support mobile learning in Indigenous communities and also highlighted the many opportunities that will be available when the infrastructure is widely available. Using mobile devices on local wifi networks has been documented recently in the remote First Nations in northwestern Ontario (Beaton, Burnard, Linden & O'Donnell, 2015). In his research in Nunavut and Nunavik, Pasch (2015) noted that because of challenges with cellular voice and data networks, the iPod touch has proven to be exceedingly popular in Nunavut and Nunavik, as these systems are able to utilise existing Wi-Fi networks. He observed that other than laptops, Apple iPod Touches and iPad tablets running iOS are among the most popular mobile computing devices currently in use by Inuit in the Canadian North. A recent news story by Leask (2016b) describes a community-managed Wi-Fi network in Central Manitoba that allows residents of the Fisher River Cree Nation to connect to the Internet at speeds similar to people living in Winnipeg, 200 kilometres to the south.

4 How Indigenous communities use digital technologies

People living in remote and northern communities are active agents of change who are transforming their communities through their use of digital technologies and telecommunication services. This section of the paper reviews the literature on how Indigenous communities - particularly in remote and northern regions of the country - are using digital technologies. In general, for the reasons presented earlier in this paper, there is a lack of research on this topic, particularly in Inuit communities. The studies that exist are primarily at the community level. While these studies cannot be generalized to all Indigenous communities they do provide examples of the many ways Indigenous communities have adopted and are using digital technologies to meet their needs.

4.1 Social media for community interconnection and interdependency

The literature reviewed indicates that the most popular use of the internet by community members is social networking. The earliest research on social networking in northern and remote Indigenous communities (Budka, Bell & Fiser, 2009) studied MyKnet.org in First Nations in northern Ontario. The MyKnet.org social networking service was established in 1999 by KNET, the broadband services and support organization discussed earlier. MyKnet.org is available to the approximately 45,000 people living in the region. At its peak there were 30,000 registered users and 25,000 active sites. More than half the 30,000 users were under age 25, signifying that this is primarily a youth-driven online social environment. The network plays an important socio-cultural role by providing a means to build and maintain familial,

friendship, and community relationships. The MyKnet.org service still exists although Facebook is now the most common social media site used today in the KNET-served communities and other Indigenous communities (Molyneaux, O'Donnell, Kakekaspan, Walmark, Budka & Gibson, 2014).

According to their recent submission to the CRTC, the Nunavut Broadband Development Corporation (2015) believes not only that Canada leads the world in Facebook usage but also that Nunavut is not far behind. The NBDC calculated that there are 25,196 inhabitants in Nunavut who are 15 or older and Facebook has at least 15,000 members from Nunavut, 15 and older. This is a penetration rate of 60%, similar to Canada as a whole.

Using an ethnographic methodological strategy, Castleton (2014) analyzed how a group of Inuit college students in Iqaluit use Facebook. He found that Inuit youth are intensive users of Facebook, using it to "communicate with their communities of origin, to maintain friends and family ties across a vast territory, to access cultural topics in Facebook groups, discuss issues, shape their identity, ask questions, access pictures of the land and recall traditions." His research argues that Inuit youth are immersed in a culture of connectivity increasingly mediated by social network sites.
The significance of social media in Indigenous communities is worth noting. Traditionally, Indigenous children were raised as part of interconnected, familial, tribal, band, and community webs of relation with shared responsibilities. These circles of connection were also combined to create wider social and religious communities. Prior to colonialism, values such as respect for all living things, individual responsibility, self-reliance, and proper conduct were taught in traditional practices and through positive role modeling and learning from oral traditions, stories, and games (Klinck et al., 2005).

Based on the 2011 KNET survey of residents in the remote Indigenous communities in northwestern Ontario, Molyneaux, O'Donnell, Kakekaspan, Walmark, Budka and Gibson (2014) analyzed the link between social media and community resilience. Community resilience includes ties to people both inside and outside the community, intergenerational communication, sharing of stories, and family and community connectedness. Their findings strongly suggest that the intense social networking activity in the region is contributing to social capital, strengthening both bonding and bridging networks within and among the communities, and providing an important avenue for sharing information and stories that support the development of culture and the maintenance of cultural preservation. Mignone and Henley (2009) have also studied the link between digital technologies and social capital in Indigenous communities.

4.2 Digital content about Indigenous culture and identity

Professional Indigenous content producers such as radio and television organizations including APTN, the Inuit Broadcasting Corporation, Wawatay News and others, have moved their former analogue operations to digital, allowing community members with digital access to view or hear their programming about Indigenous cultures and in Indigenous languages. Leask (2016) recently reported that in 10 Inuit communities, including Igloolik, Arctic Bay, Pond Inlet, Iqaluit, Arviat, Cambridge Bay, Taloyoak, and Hall Beach, people can now tune in to an IsumaTV channel on their televisions to watch round-the-clock programming in languages such as Inuktitut and Dene. Mindful of the challenges of watching high-bandwidth video on the internet, the IsumaTV system partners with local communities to make the content available. IsumaTV allows people to plug into a locally owned and operated television system and wireless Internet service that hosts thousands of hours of Indigenous content, on a server located in the community. If people stream locally-housed content on-demand, they do it through the community cable TV system or through a local Wi-Fi network that plays videos from the local server, already downloaded from the internet, at no cost to the viewer (Leask, 2016a)

A number of projects and initiatives have been using technology to record, document and preserve Indigenous culture and also to develop digital literacy. These include the Community Insight Project led by the Kitikmeot Heritage Society in Cambridge Bay, Nunavut; the Qaujigiartiit Health Research Centre in Nunavut; the "Dream Lives On" project in northern Manitoba; the "Together at a Distance" project in Nunavut; the film and television skills workshops in Clyde River, Nunavut; the Arctic Bay Traditional Name Placing project in Nunavut; and many others described in a unique publication produced by the Nunavut CAP organization (N-CAP, 2011).

Gearheard (2005) has studied how interactive media can be used to document and communicate Inuit knowledge. She notes that media technology has been not only a threat to local knowledge and language but also a tool to strengthen it. Multimedia technology is being applied in a number of ways. Inuit peoples are using it to preserve and pass on local knowledge and languages, in ways that engage young people and are closely aligned with Indigenous forms of teaching and learning. Her study in Nunavut concludes that multimedia and other technologies should be creatively applied to help local people reach their goals. She believes that multimedia can grow into a key tool for documentation and communication in the North.

Another example of using web and multimedia technologies to share Inuit culture is the IQ Adventure website supported by Canadian Heritage: http://www.inuitq.ca/index_en.html. Alexander, Adamson, Daborn, Houston & Tootoo (2009) believe that "the Inuit have staked their claim in cyberspace" and that their case study of the IQ Adventure Website illustrates how "new media technologies can serve as a means to assert and perhaps, advance, Inuit objectives; socio-economic, linguistic, and cultural knowledge systems; and political philosophy." Alexander (2011) further explains that the website was designed to guide the user to make policy decisions based on Inuit knowledge and worldviews.

George (2015) has highlighted how Indigenous communities are adopting digital technologies for Indigenous language resurgence. Language is closely connected to identity, health, and relations (King, Smith & Gracey, 2009). Uses of digital technologies to support Indigenous languages include an online Oji-Cree dictionary (Beaton, Fiddler & Rowlandson, 2004), a syllabic computer keyboards in Cree and Oji-Cree (Fiser, Clement & Walmark, 2005), audio podcasts for the benefit of Indigenous languages (Phillips, 2009), and videoconferencing to support a multi-community event on Native language resources (O'Donnell, Beaton & McKelvey, 2009).

The presence of healthy role models in a community is extremely important for cultural preservation. Indigenous communities have adopted digital technologies to support Elders. Elders living in a number of Saskatchewan communities (Whiteduck, T., 2010) and in communities in Ontario and Atlantic provinces (O'Donnell, Walmark & Hancock, 2010) have adopted videoconferencing to meet with each other and discuss issues they identify as important. The Elders regularly speak their Native languages in these sessions. In the Atlantic region, there are several examples where the only contact some Elders have with speaking Mi'kmaq is during these videoconferences, because there are no other Native language speakers in their communities (O'Donnell, Walmark & Hancock, 2010). Numerous initiatives across Canada are adopting video to capture the stories and wisdom of Indigenous community Elders. A good example from the Atlantic region is the Dear Elders videos project available for viewing at the following URL: http://dearelders.ca/

According to research by Iseke-Barnes and Danard (2007), representations of Indigenous peoples on the internet and other media are contextualized according to an outsider worldview. This furthers the current practices of erasing and reconstructing Indigenous history, language, culture and tradition and ensures continued silencing of Indigenous voices. The authors highlight the importance for Indigenous peoples to reclaim and resist these representations. Carpenter, Gibson, Kakekaspan and O'Donnell (2013) have analyzed how women in remote and rural Indigenous communities are using digital technologies to preserve

their culture, among other activities online. Perley (2009) notes that with the rise in websites for video sharing and the increase in resources to create and upload videos, there is potential for Indigenous women to adoption this technology to represent issues they cannot normally address through mainstream media. Her critical analysis provides some insight into how Indigenous women are adopting digital technologies to question and challenge mainstream media assumptions and representations of Indigenous women.

Hancock and O'Donnell (2009) explore the potential for new media to provide a means for members of northern and remote Indigenous communities to challenge problematic mainstream representations of Indigenous identity. Online videos made by Indigenous people may provide the means for a social movement that undermines the misrepresentations of Indigenous culture and identities in mainstream Canadian media. On the other hand, Philpot, O'Donnell & Kenny (2013) identify some of the limits of online videos in their study of the reception of these videos by mainstream audiences.

A study of the use of YouTube by Inuit youth and young adults (Wachowich & Scobie, 2010) focused on how they are using the site to post short excerpts from their lives and connect with others (Wachowich & Scobie, 2010). The authors situate the practice as Inuit storytelling. They posit that digital technology allows individual narrators the freedom to bypass established rules and institutions of cultural representation. They believe that the self-produced videos posted online are more "multivalent, dialogical, and provocative expressions of Inuit selfhood" than analogue texts circulating in the past. Their study found that many of the social relationships and communications fostered by this technology are intimate and localized and that "Inuit youth and young adults use video-sharing technology to creatively mediate pasts, presents, and futures in the creation of new social world" (Wachowich & Scobie, 2010).
Pasch (2010) references the history of early media productions by the Inuit Broadcasting Corporation (IBC), comparing the quality of the IBC productions with that of Inuktitut media online. His study asks if the new media can compare with the example of linguistic and cultural preservation set by the visionaries of the early IBC. He challenges prevailing critical approaches to the Inuit as linguistically and culturally vulnerable and views Inuktitut new media content as a model of strength, resilience, and adaptability. Pasch concludes that the creativity of the early IBC productions should set the standard for a new generation of Inuktitut content creators online (Pasch, 2010).

In a later work, Pasch (2015) proposes a preliminary framework for digital 'translation' attempting to localise aspects of Inuit knowledge, culture and IQ (in the sense of Inuit Qaujimajatuqangit) into digital artifacts for new generations of Inuit and non-Inuit learners. He proposes developing Arctic digital industries through convergent cultural media and argues that this is the crucial time to ensure that digitally localised and disseminated voices of the Inuit are available electronically in the widest possible variety of media forms.

Brown and Nicholas (2011) highlight some important considerations for protecting Indigenous heritage and cultural objects when material is digitized. In their comparative study of the situation in Canada and New Zealand, the authors note the limitations of conventional law regarding the protection of Indigenous cultural and intellectual property. Expressions of traditional knowledge and culture in general are not protected by copyrights and patents, a situation exacerbated when that heritage is in digital format.

4.3 Commercial entertainment online

In mainstream society, accessing commercial entertainment online such as games and gaming, and streaming movies and television programs and similar content is one of the most popular uses of the internet; it would stand to reason that this activity would also be popular in remote and northern Indigenous communities. However there is almost no mention of this activity in the literature reviewed. In her study of gambling in Indigenous communities in Quebec, Papineau (2010) states that games are deeply rooted in

Aboriginal cultural traditions however her study makes no reference to the use of online gambling in these communities. Anecdotal evidence suggests that where the bandwidth is available in First Nations, community members use it for Netflix and X-box games. Castleton (2014) quotes an Inuit youth who mentions connecting with Arctic gamers and several others who play games on Facebook. The high cost of connectivity and data caps restrict these high-bandwidth activities in satellite-served communities in Inuit Nunangat (Nunavut Broadcasting Development Corporation, 2015). As previously mentioned, the analysis of the 2011 KNET survey of remote communities in northwestern Ontario found that men were more likely than women to be using gaming consoles (Walmark, Gibson, Kakekaspan, O'Donnell, 2012).

4.4 Indigenous resurgence, self-determination and activism online

The leading Indigenous academic authors working in Canadian universities today all highlight the primary importance of resurgence and self-determination for Indigenous nations and communities (Alfred, 2015; Battiste, 2013; Corntassel, 2012; Coulthard, 2014; Palmater, 2011; Simpson, 2011). At the same time, the new federal government has indicated that it will have a "nation to nation" relationship with Indigenous communities (Smith, 2015). Several publications mention Indigenous self-determination in the context of digital technologies. Fiddler (2008) outlines how the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) is a building block and guideline that Indigenous peoples and their states can use to pursue their collective rights and freedoms using digital technologies. Similarly, an ITU publication makes the link between the UNDRIP, digital technologies and Indigenous self-determination (ITU, n.d.). Article 16 of the UNDRIP, for example, states that, "Indigenous peoples have the right to establish their own media in their own languages and to have access to all forms of non-indigenous media without discrimination" (United Nations General Assembly, 2007). McMahon (2015) makes the argument that Indigenous nations are practicing "digital self-determination" because the widespread use of digital networks for governance, economic development, and the delivery of services are also increasingly used to make decisions that impact the balance of powers among indigenous nations and state governments.

The earliest publication found about Indigenous communities and the internet discussed how they are using them for resurgence and self-determination (O'Donnell & Delgado, 1995). At that point, two decades ago, several Indigenous nations had websites and were using email to communicate with each other and to post information on public websites to keep the public informed of their activities. "Postings appear regularly from, among others: the Carrier Sekani Tribal Council, working to halt Alcan's Kemano 2 project; and the Lubicon Lake Indian Nation, working to stop the Daishowa Corporation's plans to clearcut unceded territories. The Lubicon Nation is also using Internet e-mail to help coordinate a boycott of Daishowa paper products" (O'Donnell & Delgado, 1995).

Two decades later, the use of the internet for social activism and resurgence are much more widespread. Tupper (2014) analyzed how the Idle No More Movement demonstrates young people's commitments to social change and willingness to participate in active forms of dissent. In this way, she argues, the internet fosters "ethically engaged citizenship through greater knowledge and awareness of Indigenous issues in Canada, which necessarily requires an understanding of the historical and contemporary legacies of colonialism."

The Nunavut Broadband Development Corporation (2015) believes the #sealfie campaign in the spring of 2014 is an example of Inuit leveraging social media for activism, in this instance to take on one of mass media's largest celebrities: Ellen Degeneres. Northerners posted pictures of themselves wearing seal skin in response to Degeneres' Oscar #selfie campaign against the sealhunt. The sealfie hashtag briefly trended and got significant media coverage nationally and internationally. NBDC believes that social media is an important tool for accurate self-representation and activism for Inuit, "a very useful tool for preserving and asserting Inuit identity in the 21st century."

Another example of Inuit use of social media for activism is the nascent movement to raise awareness about food insecurity in Nunavut (Nunavut Broadband Development Corporation, 2015). The Feeding my Family Facebook group was created in May 2012. Less than one week later, the group had 2,000 members. After another week membership had doubled to 4,000 and in two weeks had risen to more than 19,000 members. In 2015 there were 24,469 members. The movement received international attention and the Facebook group continues to be an active resource for the movement.

4.5 Technology in education and distance education

Post-secondary distance education is an option in many rural and remote Indigenous communities in Canada. There are many challenges to successful adoption in these communities and also many opportunities for post-secondary institutions to expand their capacity to develop and deliver appropriate content supporting these unique, self-governing environments. A study by Simon, Burton, Lockhart & O'Donnell (2014) in Elsipogtog First Nation in New Brunswick explores the experiences of students with post-secondary distance education, focusing on how different delivery methods offer both opportunities and challenges for community-based students. Post-secondary distance education gives students and their families living in remote and rural regions the option to stay in their communities while they study instead of moving closer to the universities in cities. Steel and Fahy (2011) analyze distance education programs for Indigenous communities in northern Alberta and make recommendations for improvement to better assist students to complete the courses.

In another example of digital technologies supporting distance education, McAuley and Walton (2011) describe the challenges and opportunities learned from the experience of delivering a distance education program - Masters in Education - in Nunavut. A report prepared for Inuit Tapiriit Kanatami (Lees, Burgess & Walton, 2010) noted that technology has the potential to overcome problems of remote location, providing access to a range of professional learning experiences. Virtual and distance learning, guided by Inuit educators, Elders and community members, offers promise with respect to the retention of culture and language. In its report to the CRTC, the Nunavut Broadband Development Corporation (2015) noted that internet access at home and at school is essential for education, and the current state of connectivity at home and at school is putting Nunavut's children at a disadvantage.

Although the use of digital technologies in schools is widespread in many Indigenous communities, it is clearly not the case in all. In the story by Leask (2015c) from Natuashish in Labrador, the community school principal says the lack of connectivity creates challenges. Since the school is not subject to the same bottleneck as residential services it should be fast, but according to the principal, school staff face constant frustration in carrying out basic tasks now done online. For example, attendance is tracked and submitted online, but what would take about ten minutes with a better connection takes him more than an hour each day. The slow connection is also holding teachers back in the classroom because they cannot use tools that need online connectivity. Natuashish students won't be able to learn through any interactive science based websites, because Fewer knows they won't be able to use them so they don't subscribe. An online cloud library service, Tumblebooks, is paid for by the school board but not functional in Natuashish (Leask, 2015c).

A number of publications explain how digital technologies are used in schools with better connectivity. For example, in Kitigan Zibi Anishinabeg First Nation in Quebec, both the community elementary and high schools take an innovative approach to teaching and learning by integrating digital technologies into the classroom (Lockhart, Tenasco, Whiteduck, & O'Donnell, 2014). Educators use email on a daily basis. In the classrooms they and the students use SMART boards, e-Learning programs, various multimedia programs, videos, laptops and iPads. In addition, digital technologies are also used in after-school programs, the

summer educational programs, and the community daycare. Education staff use digital technologies to communicate with parents and the community through email and the community online newsletter. At the same time, there are concerns about the situation of having technology readily available at school and less so at home. This transition from a technology-filled classroom to limited or no computer and internet access at home is a challenge, not only for individual students and their families but also for the community as a whole.

In Fort Severn First Nation in Ontario, the internet is used extensively for school administration (Kakekaspan, O'Donnell, Beaton, Walmark & Gibson, 2014). School administrators use email regularly to connect with the band office and the community education director who is often travelling outside the community. Since most of the pupils are on Facebook some teachers use it to coordinate school events. Teachers use the Web to download educational programs and to conduct research for preparing classes, and senior pupils use it to do research. When the study was conducted in 2011, computers were a scarce resource in the portable classrooms because the computers in the old school had to be destroyed due to mould contamination.

According to Leask (2015b), while the internet connection isn't always perfect, the 200 students at St. Anne's School in remote Conne River, Newfoundland, can access many kinds of technology in the classroom. The school has increased the use of classroom technology as their connectivity has improved, and teachers have embraced new ways of teaching students. At each stage of improvement in internet connectivity, the way teachers connect changes, pushing the boundaries of what they can do with those speeds. "Technology is a great motivator," said one of the teachers, who has seen children who do not like writing and are not confident or interested in the subject, be transformed by using an app called WriteAway.

Potter (2010) and Walmark (2010) describe how the Keewaytinook Internet High School (KiHS) was established and the high support it receives in the communities in which it operates. KiHS is a response to the education challenges faced by young First Nations students and their families living in remote communities. "Best practices" based on the assumption that students must leave their communities to attend high school have contributed to the current crisis in education. Against this backdrop, the KiHS is the first provincially-accredited First Nations digital school in Canada. KiHS is a network of more than a dozen classrooms located in remote First Nations in Ontario's far north connected to each other by a robust broadband network. When students and other learners can engage with training and education in their own communities, they remain connected with their social networks. There are many examples of distance education programs in northern and remote Indigenous communities but few examples of ongoing programs like KiHS that adopt technologies extensively to engage young people in formal education and connecting with young learners in other communities.

The First Nations Education Council (FNEC) in Quebec has developed online educational content and games for children; the material has high cultural value and significance and encourages the students to learn about their culture while they are having fun. The educational materials are available in both official languages on the FNEC website; the games were distributed in DVD format to all Indigenous communities schools in the region and are also available online (Whiteduck, T., 2010).

In another example of digital technologies for community-based learning, Atlantic Canada's First Nation Help Desk supported a project called MMTV (Mi'kmaq/Maliseet TV) News. MMTV was a place for students in Indigenous community schools in the Atlantic to produce, record, edit and broadcast local, national and international stories. The Helpdesk adopted multi-site videoconferencing to broadcast the clips to schools in the region and anchor them to a news desk, emulating a television news broadcast. Using this technology, students learned about group cooperation, journalism, and current events (Milliken, O'Donnell & Gorman, 2009; O'Donnell, Perley, Walmark, Burton, Beaton & Sark, 2009).

Digital technologies adopted to support literacy includes a program to support print-on-demand book services in remote Indigenous communities in northwestern Ontario (Caidi and Walmark, 2006). Digital technologies have also been adopted to support musical development in children (Masum, Brooks and Spence, 2005; Warden, Joe, Wisner & Liman, 2009) and to develop community links to Indigenous community cultural resources in museums (Rowley, Sparrow and Schaepe, 2009).

Remote Indigenous communities face considerable challenges and opportunities related to adult learning and quality education and training programs for local citizens. Beaton and Carpenter (2014) found that the internet has become a valuable resource for informal education in Indigenous communities. Their 2014 study included a survey of member of six remote Indigenous communities in northwestern Ontario. When asked what they do when they want to learn something new, most respondents (83%) indicated that they use social media sites (MyKnet, Facebook, etc.) for this every day. Often (daily or weekly) they search the web (84%) to learn something new, while others go online to ask a friend (66%). Daily or weekly they watch a video to learn how to make something or complete a task (45%). About half (51%) said they share skills or teach others online often (daily or weekly). Daily or weekly activities included sharing news and stories on social media (57%), reading stories about First Nations (51%), searching for information about First Nations and Aboriginal people online or posting announcements about different events (42%).

4.6 Technology for healthcare, telehealth, and health education

Healthcare is another primary use of digital technologies in Indigenous communities. A comprehensive literature review on digital technologies for health and wellness in remote and rural First Nations conducted in 2010 describes the range of technology use from telemedicine to health administration. The authors use a "social determinants of health" perspective to build a broader understanding of the link between digital technologies and health and wellness in remote and rural First Nations (O'Donnell, Molyneaux, Gorman, Milliken, Chong, Gibson, Oakley & Maitland, 2010).

Over the past decade, the adoption of telehealth has increased in Indigenous communities across the country. Telehealth refers to providing health services over a distance using telecommunications networks. There have been many studies published on the clinical adoption of digital technologies in northern and remote Indigenous communities, including for general clinical consultations by videoconference (Bruner, 2009; Carpenter and Rowlandson, 2009; Ward, 2009); telemental health (Brasfield and Clement, 2007; Gibson et al., 2011; Reid, 2008; River Valley Health, 2006); remote speech pathology and audiology (Eriks-Brophy et al., 2008; Polovoy, 2008); tele-opthalmology (Williams, 2010); telehomecare (Coulson and Vermette, 2008); telerehabilitation (Coulson, 2010); and rheumatology services (Jong & Kraishi, 2004).

The most current picture of the adoption of telehealth in Indigenous communities across the country is from the 2013 Telehealth survey (COACH, 2013) based on data collected primarily in 2012. The data show that clinical telehealth in the in the three territories increased from 2010 to 2012. In that year, there were 14 communities served by telehealth in the Yukon, 32 in the NWT and 25 in Nunavut. For First Nations communities in the provinces, there were five in BC, 44 in Alberta, 79 in Saskatchewan and 26 in Ontario. A wide range of clinical services were available in the communities, as well as educational services for community and professional staff. (The 2015 Telehealth report did not include data specific to Indigenous communities; however such data would be available from Health Canada, First Nations and Inuit Health Branch.) The McGill Telehealth Expertise and Coordination Centre publishes data on health-related videoconferencing in Nunavik; the use of videoconferencing for health in Nunavik increased dramatically from 2011 to 2014 (McGill, 2016).

Walmark, Gibson, Kakekaspan, O'Donnell and Beaton (2012) describe one outstanding example of an Indigenous-community operated health service: KO Telemedicine (KOTM). The service operates in the context of significant health inequalities rooted in the lack of opportunity faced by remote regions and health services modeled on Western medical traditions (Gideon, Nicholas, Rowlandson & Woolner, 2009). KOTM began providing remote access service in 2000 and now serves more than two dozen First Nation communities (Williams, 2010). The key to its success is building First Nations ownership and control of both the network and service, and addressing cross-cultural barriers to implementing Western-based clinical service into a First Nation community (Carpenter & Kakepetum-Schultz, 2010). A study in 2011 found positive reviews of the KOTM service by the remote Indigenous community members (McKenzie, Kakekaspan, Gibson, O'Donnell & Kakepetum-Schultz, 2012).

Several publications describe the use of digital technologies for health services in Indigenous communities. Kakekaspan, O'Donnell, Beaton, Walmark and Gibson (2014) documented the situation in Fort Severn First Nation. Health centre workers use technology extensively for health administration, clinical health services, professional development, and community wellness activities. The telehealth visit typically takes place in the health centre, but staff can also bring a mobile videoconference camera to the patient's home when required. The internet has become an essential tool for the health staff. They use email daily for health administration, especially to schedule appointments with patients, and IP (Internet Protocol) telephones. They sometimes use Facebook to contact community members as the social media platform is quickly becoming the best way to reach some people in the community. Health staff use videoconferencing for health administration, with scheduled monthly videoconference meetings with staff in other communities. Videoconferencing is also used extensively for professional development courses and information sessions for health professionals and community members concerning all aspects of health and wellness.

In Kitigan Zibi Anishinabeg First Nation, the community administers their own health services (Whiteduck, Tenasco, O'Donnell, Whiteduck & Lockhart, 2014). These include environmental health and social services; community health nursing; home and community care programs; mental health counseling; substance abuse addictions counseling; medical transportation; and a medical clinic. All of these services and activities have extensive use of digital technologies, notably for online reporting functions essential to daily operations. Health service providers are using mobile phones, computers, email, videoconferencing, and other technologies to facilitate their everyday work. Service providers noted that texting has improved the way co-workers can communicate with one another, making it more efficient. The community nurses and medical transportation drivers communicate with one another and the main centre via mobile phones provided by the community. This is important for the health sector because it increases communication and availability while also ensuring that these service providers are accessible at all times if they need to be reached immediately. Given the limited cell service in some parts of the community, however, being out of range can create challenges for health service delivery using mobile technologies.

Gibson, Coulson, Miles, Kakekakekung, Daniels and O'Donnell (2011) conducted a study of community member perceptions of telemental health in two remote First Nation communities. Telemental health involves technologies such as videoconferencing to deliver mental health services and education, and to connect community members and communities for healing and health. In remote and rural First Nations communities there are often challenges to obtaining mental healthcare in the community and to working with external mental health workers. Telemental health is a service approach and tool that can address some of these challenges and potentially support First Nations communities in their goal of improving mental health and wellbeing. Community members' perspectives on the usefulness and appropriateness of telemental health can greatly influence the level of engagement with the service. The authors also conducted a separate study of mental health workers in Canada who reported experience working with people living in remote and rural First Nations, to explore their perceptions of usefulness and ease of use of telemental health (Gibson, Coulson, Kakepetum-Schultz, O'Donnell, 2011).

Other examples of the adoption of digital technologies for health training and education are mini-courses on health by videoconference for Indigenous communities in British Columbia (Johnson, 2008); a special event with partner Keewaytinook Okimakanak Telemedicine and the VideoCom project on telemental health (Gibson et al., 2011); web-based social work education to Indigenous community members in Quebec (Ives and Aitken, 2008), multiple technologies uses for Indigenous nursing students at the University of Manitoba (Russell, Grecory, Hultin, Care & Courtney, 2005), and continuing medical education by videoconference (Heaton, 2006). A project by the Public Health Agency of Canada, Skills Online, uses internet and web-based modules for the professional development of public health officials in the circumpolar north (Bell & MacDougall, 2013).

Digital technologies are adopted for sharing health information. This includes culturally-sensitive health information on the web (Friedman and Hoffman-Goetz, 2007), a website to address the crisis number of suicides in Indigenous communities (NAHO, 2009), a website for community-based health information (Jarvis-Selinger et al., 2008), online health discussion forums (Donelle & Hoffman-Goetz, 2008) and integrated health website to address diabetes issues (Ho et al., 2006), and videos on health topics, such as FASD and Native Parenting (Whiteduck, T., 2010).

4.7 Digital technologies for Indigenous government and governance

Several publications included in our review discuss how Indigenous communities are adopting digital technologies for governance. McMahon, LaHache and Whiteduck (2015) describe how digital infrastructure and technologies are powerful tools that can support self-government. In this context, the authors document the development of digital data management in the Mohawk community of Kahnawà:ke. Data is the digital information generated by a community, encompassing areas like research, education, finance, health, membership, housing, lands, and resources. As self-determining political entities, each First Nation determines how this data is interpreted and used, supported by tools like data management platforms and information-sharing protocols. The authors show how local practices regarding the collection, use, and sharing of digital data in Kahnawà:ke provides a clear example of Indigenous governance and resurgence.

The use of digital technologies by the communities to deliver public and community services is another example of adoption of digital technologies for governance. Walmark, Gibson, Kakekaspan, O'Donnell & Beaton (2012) describe how the Keewaytinook Okimakanak First Nations leadership and their First Nation council have developed and operate a digital network that supports their delivery of broadband-enabled services to their community members. Another article describes how First Nations are using videoconferencing to create and support First Nations-controlled education and health services (O'Donnell, Johnson, Kakepetum-Schultz, Burton, Whiteduck, Mason, Beaton, McMahon & Gibson, 2013).

Several publications based mention that the Indigenous community government has adopted digital technologies for its administrative functions, for example in Mishkeegogamang First Nation in northern Ontario (Gray-McKay, Gibson, O'Donnell and People of Mishkeegogamang, 2014); Fort Severn First Nation in northern Ontario (Gibson, Kakekaspan, Kakekaspan, O'Donnell, Walmark, Beaton & the People of Fort Severn First Nation, 2012) and in Kitigan Zibi Anishinabeg First Nation in Quebec (Whiteduck, Tenasco, O'Donnell, Whiteduck and Lockhart; 2014).

4.8 Technology for economic development, business and entrepreneurship

Digital technology adoption for economic development, business and entrepreneurship in northern and remote Indigenous communities would seem to be an important topic. Many Indigenous companies are offering web-based services and their websites are easily found online; among many examples are:

Qukiqtaaluk Information Technology Corporation in Iqualuit offering IT retail, services and support; the Membertou Data Centre offering data storage; and KNET Services based in Sioux Lookout offering a range of telecommunications services. However aside from the publications about KNET referenced elsewhere in this paper there is almost no research on technology-related businesses in remote and northern Indigenous communities.

The Nunavut Broadband Development Corporation's 2004 feasibility study references a survey of businesses in Nunavut and how they would use broadband when it becomes available; 109 businesses responded to the survey. The most common proposed uses of the broadband were: communicating directly with clients, research, training and education for staff, accessing government information, and having meetings connecting people in different locations, among many other uses (Nunavut Broadband Development Corporation, 2004).

Indigenous communities building their own local and regional digital networks and services to support community and economic development is the best example of community economic development we found in Quebec (Whiteduck & Beaton, 2014) and Ontario (Beaton & Campbell, 2014; Kakekaspan, O'Donnell, Beaton, Walmark & Gibson, 2014). Local First Nation or individually owned Internet Service Providers are supporting the development and adoption of digital technologies in Indigenous communities across the country. First Nation IT technicians and Online Content Producers are operating their own businesses. Many of these new businesses are located in northern and remote communities. For example, Angus Miles operates his own IT Service Centre out of Sachigo Lake First Nation (see http://66.165.220.194/viewerportal/vmc/player.do?eventContentId=977).

A new publication about the Indigenous owned and operated Keewaytinook Mobile (KMobile) cell phone service describes the development of the service and its successful operation over the first six years of existence (Beaton, Burnard, Linden & O'Donnell, 2015). As explained in an earlier publication, KMobile will contribute to economic development in several ways (O'Donnell, Kakekaspan, Beaton, Walmark, Mason & Mak, 2011). KMobile is a community-owned service, with profits from the service staying in the community. KMobile can support local business and traditional economic development by allowing more timely communications and fewer missed calls. KMobile could also contribute to economic development in Fort Severn through community use of future services and applications that build on the mobile infrastructure.

Beaton, Seibel & Thomas (2014) studied how digital technologies are used to support the social economy in remote First Nations in northwestern Ontario. Out of necessity caused by scarce resources, the social economy in First Nations uses innovative technology solutions to support required services, economic opportunities, and sustainable communities. The authors' analysis of a 2014 online survey provides insights into the nature of the social economy in these unique remote communities and how their use of digital technologies is evolving as their local economy matures.

The Nunavut Broadband Development Corporation (2015) submission to the CRTC calls sell/swap groups on Facebook 'Nunavut's version of the sharing economy.' All but one Nunavut communities have sell/swap groups and in every case membership to these groups greatly exceeds the entire population of the community. Many communities also have auction groups and public service announcement groups. All these groups serve an important role for intra and intercommunity trade. The wide range of postings – anything from fresh baked bannock to a $500,000 house for sale - are evidence of the trust and importance users place in the platform as well as the diversity of the group's membership. Auction sites in particular are important to the traditional economy, helping artists and hunters sell their products or catch to their prime market – other Nunavummiut.

A 2013 report using very limited and possibly inaccurate data failed to show a statistically significant impact between broadband networks and economic development in Indigenous communities; the report noted that this finding should be interpreted with caution (CSLS, 2013).

4.9 Technologies to support land-based activities and environmental sustainability

Although each of the remote and northern Indigenous communities across the country is unique, they all have common sustainable development priorities, primarily securing and ensuring ongoing sustainability of lands and resources (O'Donnell, Beaton & McKelvey, 2008). Beaton & Campbell (2014) and Beaton, Seibel & Thomas (2014) describe how digital networks, technologies and services are sustaining a land-based lifestyle for people living in remote Indigenous communities. To give just one example, the Indigenous community-owned and operated KMobile service referenced earlier supports land-based activities such as hunting, fishing and trapping (Beaton, Burnard, Linden & O'Donnell, 2015).

A common belief among Indigenous peoples in Canada is that the relationship they have with the land shapes the cultural, spiritual, emotional, physical, and social lives of community members and communities (Wilson, 2003). In addition, this balance is maintained through living a life of stewardship and harmony with the earth. Uses of digital technologies to support land-based activities in First Nations include creating three-dimensional and web-based visualizations of landscapes (Lewis & Sheppard, 2006), electronic resources for co-managing lands and resources (Greskiw & Innes, 2008; Lulua & Flannery, 2009), websites and other technologies for training and mentoring community water operators (Gurstein, Beaton & Sherlock, 2009; Stewart, Allan, Nelson, Bohn, Smith & Laboucan-Massimo, 2009), and digital tools to assess archaeological evidence (Jules and Steves, 2008).

Recent projects in Nunavut include Igliniit, a project that combined Inuit knowledge and geomatics engineering to develop a new observation tool for hunters. The four-year project, based in Clyde River, Nunavut, brought Inuit hunters and geomatics engineering students together to design, build, and test a tool to assist hunters in documenting their observations of the environment. The approach of supporting local people in their own activities year-round and outfitting them with a simple but powerful tool to document their environmental observations, proves a promising method in future community-based environmental research and monitoring, with applications as well in land use planning, resource management, hazards mapping, wildlife and harvest studies, and search and rescue operations, according to the authors (Gearheard, Aipellee and O'Keefe, 2010).

Other recent projects using digital technology for land-based activities and mapping include research by Engler, Scassa and Taylor (2013) on digital cartography to record Indigenous knowledge of the land. The authors highlight that given corporate interest in the natural resources of the Arctic, and that digital maps rely heavily upon, and record, oral knowledge in digital format, there are challenging issues of informed consent, intellectual and cultural property, and privacy. Barlindhaug and Corbett (2014) conducted case studies from two Indigenous communities in BC and Norway to explore how land-use traditions and related knowledge constitute a peoples' identity, and how digital technologies can support the ongoing transfer of Indigenous knowledge between geographically dispersed community members, as well as future generations. Bennett and Landz (2014) used participatory photography and other digital technologies to document local observations, working with local Hunter and Trapper Committees and the Inuvialuit Joint Secretariat. Their research indicates that participatory photomapping monitoring programs can significantly improve capacity to detect the impacts of environmental change and contribute to northern planning and decision-making.

Indigenous community members are also using social networking sites such as Facebook to share stories about land-based activities (Castleton, 2014; Molyneaux, O'Donnell, Kakekaspan, Walmark, Budka &

Gibson, 2014). The Nunavut Broadband Development Corporation (2015) reports that the "Inuit hunting stories of the day" Facebook group of Inuit from the circumpolar Arctic brings together people who share a common identity rooted in a connection to the land and traditional hunting and harvesting. The group's founder started the group to provide a space for Inuit to share photos and stories of their hunts, to foster pride among Inuit and to assert an Inuit perspective on traditional harvesting for the world to see.

4.10 Technologies for justice, public safety and emergency communications

The authors are aware of an increase in the adoption and use of videoconferencing for justice services in remote and northern Indigenous communities although little information is available about this. A presentation by the Kativik Regional Government about the costs of an undersea fibre link to the territory (Dumoulin, 2016) estimated that travel for justice services currently costs $2 million annually and that travelling court costs could be reduced by 50% with improved broadband infrastructure.

The telephone infrastructure in Nunavik is aging and currently does not support any digital services or services such as 911 emergency service or voice messaging. The limited number of telephone circuits in the communities has caused public safety issues in the past. The Kativik Regional Government (2016) recently entered into a partnership for a backup emergency telecommunications service for all of Nunavik's 14 Inuit communities. A KRG representative stated that the new service is an independent voice and video communications link between the communities and with the south via the internet. The service is already in use by the Kativik Regional Police Force and community CLSCs during emergency management and response situations. It uses a small amount of bandwidth that is reserved for public safety use.

The research in Kitigan Zibi Anishinabeg First Nation in Quebec (Whiteduck, Tenasco, O'Donnell, Whiteduck & Lockhart (2014) included documenting how the community policing services are using digital technologies. The eight officers that make up the Kitigan Zibi Police force are all long time members of the community. Digital technologies are integrated into their everyday operations since they use it to communicate with one another, other police forces, the community, and the world at large. Advances in mobile technologies have done much to increase their ability to respond to the community. Officers always have their cell phones with them, ready to react quickly to calls. Texting, for its convenience and better security, has taken the place of voice calls. Officers communicate quickly with one another via text messaging. Social networking sites such as Facebook have also had an impact on the services that the Kitigan Zibi Police force delivers.

Regarding emergency communications, Indigenous community members who live a land-based lifestyle often carry the traditional knowledge required to create innovative responses to environmental challenges. Floods, forest fires or other climate change natural disasters affecting remote and northern environments require immediate actions to properly protect people, property and the environment. Earlier in this paper, the point was made that adoption of digital technologies supports the work required to continue land-based activities and culture (Beaton & Campbell, 2014). Local police services and natural resource departments are also employing digital technologies in Indigenous communities to communicate with and support staff during times of crisis.

Little research has been conducted specifically on the use of digital technologies for public safety and emergency communications in remote and northern Indigenous communities, aside from the work on the Keewaytinook Mobile (KMobile) service in northern Ontario. That research found that KMobile is a welcome service addressing critical safety and development requirements facing every remote community (Beaton, Burnard, Linden & O'Donnell, 2014; O'Donnell, Kakekaspan, Beaton, Walmark, Mason & Mak, 2011). The research in Fort Severn First Nation found that, for many residents, the KMobile service ensures a sense of safety and security when traveling for short trips outside the community because in case of

emergencies the cell phone means that help will be available. The range of the KMobile service may become even more of an issue in future as climate change continues to have an impact on the sensitive ecosystem in the area and people travel further from the community for land-based activities.

5 Policies and programs to support technology adoption in Indigenous communities

5.1 Supporting adoption by community members and households

We found no literature about policies or programs specifically designed to support the adoption of digital technologies by community members or households in northern and remote Indigenous communities. We are aware from media releases and community reports that some community-based organizations have developed services and programs to support local community members to increase digital literacy and adopt digital technologies in their homes for example through training, computer repairs and so on; however there is little research about these activities. McMahon, Whiteduck & Timiskaming First Nation (2015) recently conducted a community survey to support Timiskaming First Nation's efforts to improve digital literacy in that community.

One federal regulatory decision not designed specifically to support technology adoption may well aid that objective. The CRTC has a requirement for a must-carry channel in the basic cable television packages: the Indigenous channel APTN. This requirement was included in the new "skinny basic" package offered by the cable companies (Kwong, 2016). Making Indigenous content a requirement for cable subscribers could be considered a support for digital technology adoption in the communities.

5.2 Supporting adoption by communities and community organizations

Over the past several decades several initiatives, strategies, and projects have been implemented to support increased adoption of digital technologies in Indigenous communities. The main federal programs are:

- First Nations SchoolNet program
- Community Access Program
- Computer for Schools Program

The main Indigenous approaches are:

- Developing the First Nations SchoolNet Regional Management Organizations (RMO) into community intermediaries
- The Assembly of First Nations' eCommunity approach

The **First Nations SchoolNet** program is perhaps the best example at a national level of a program to support the adoption of digital technologies in northern and remote Indigenous communities (O'Donnell, Milliken, Chong & Walmark, 2010). From 2002 to 2010, the federal program provided dedicated funding for six First Nations SchoolNet regional management organizations (RMO) across Canada. The program was initiated by Industry Canada in 1996; in late 2006 it was transferred to Indian and Northern Affairs Canada, and the program budgets were reduced in subsequent years. A positive evaluation of the program was published in 2009. The next year dedicated funding for the program was cut and the First Nations SchoolNet activities were funded as part of another INAC funding program, New Paths for Education. Under that program, the RMOs were re-labeled as Regional Technology Organizations (RTOs).

In their 2009 evaluation, INAC (2009) found that the program remains an integral part of Indigenous community education on-reserve. The program has enhanced the educational experience of Indigenous students, provided them with valuable skills and capabilities which have increased their competencies, and improved their outlook on learning as well as their confidence in their futures. The program also provided

students with the option of staying in their communities with their families as they complete their education through distance learning which has positively affected retention and graduation rates while providing access to opportunities similar to students from provincial schools (INAC, 2009). The evaluation also found that the RMO delivery model is both effective and efficient. During the life of the program, the RMOs developed partnerships with both the public and private sector to reduce costs, maximize opportunities and provide economies of scale. Their work has largely supported the success of the program in positively contributing to educational outcomes, cultural education, cultural and linguistic preservation, mitigating isolation and allowing access to other essential services in the schools and the communities (INAC, 2009).

Another successful program to support digital technology adoption in remote and northern communities was the **Community Access Program (CAP).** Initially focused on rural communities, the CAP program was later extended to urban centres; the program was not specific to Indigenous communities. However similar to First Nations SchoolNet, CAP received a positive evaluation by the government (Industry Canada, 2009) and the program was cut by the government soon after the evaluation. CAP was originally established in the early 1990s by Industry Canada and Human Resources Development Canada. CAP sites were places where community members could access computers and the internet in supported, culturally-appropriate settings. Many CAP sites were set up in northern and remote Indigenous communities across the country. Industry Canada also initiated the Community Access Program - Youth Initiative (CAP YI) to allow CAP Sites to apply for funding to hire Youth Interns to train the public in the use of digital technologies. CAP sites in Indigenous communities were instrumental in introducing community members to digital technologies and supporting their use (O'Donnell, Milliken, Chong & Walmark, 2010). After the federal government cut the CAP program in 2010, the government of Nunavut continued funding the sites; however as of writing the situation of CAP in Nunavut is unclear.

The third federally-supported program to support digital technology adoption that benefits some remote and northern Indigenous communities is **Computers for Schools (CFS)**. CFS, launched in 1993, is a national, partnership-based program that makes use of surplus computers from federal departments, provincial-territorial governments and the private sector. Computers are donated to refurbishment centres, where they are refurbished for use by the program's beneficiaries, which include schools, libraries and Canadian not-for-profit learning organizations. The Computers for Schools program received a positive evaluation in 2012 (Industry Canada, 2012). It is unclear to what extent remote Indigenous schools were included in the program evaluation.

Turning to the Indigenous approaches, the one that continues to have an impact on digital technology adoption in remote and northern Indigenous communities is **developing the First Nations SchoolNet RMOs/RTOs into community intermediary organizations**. The RTOs work in their particular regions to advance broadband infrastructure and applications in the Indigenous community schools and communities. The seven organizations that took on the RTO role are: Mi'kmaw Kina'matneway / Atlantic Canada's First Nation Help Desk (Sydney, Nova Scotia); The First Nations Education Council (CEPN-FNEC, Wendake, Quebec); Keewaytinook Okimakanak (KNET, Sioux Lookout, Ontario); Keewatin Tribal Council (Thompson, Manitoba); Keewatin Career Development Corporation (KCDC, La Ronge, Saskatchewan); and the First Nations Education Steering Committee (FNESC, Vancouver, British Columbia) (Whiteduck, T., 2010). The Technical Services Advisory Group (TSAG) for the First Nations across Alberta began delivering SchoolNet support in 2011 in their region.

The "community intermediary" concept describes how community organizations that deliver public services foster adoption of digital technologies in communities through the organizations' own use of digital technologies (McMahon, Gurstein, Beaton, O'Donnell & Whiteduck, 2014). In this context, the Indigenous organizations that took on the RTO role have grown beyond their federal RTO mandate to act as a bridge between Indigenous organizations and various federal and provincial government agencies (McMahon et al.,

2014; Whiteduck & Beaton, 2014). The RTO organizations extended the infrastructure developed under the First Nations SchoolNet program to other applications and uses within communities (Whiteduck, T., 2010). A number of publications describe how the community intermediary organizations are increasing the adoption of broadband technologies in remote and rural Indigenous communities, including: Beaton, Fiddler & Rowlandson, 2004; Carpenter, 2010; Fiser & Clement, 2009; KORI, 2005; FNEC, 2009; McMahon et al., 2013; O'Donnell et al., 2009 and 2010; Ramirez, 2001; Ramirez, Aitkin, Jamieson & Richardson, 2004; Rimirez, Aitkin, Kora & Richardson, 2005; TeleCommons Development Group, 2004; Whiteduck, T., 2010; Whiteduck, Beaton, Burton & O'Donnell, 2012.

The second way that Indigenous organizations are fostering digital technology adoption in communities is through **Indigenous policy development**. By 2009, the Assembly of First Nations (AFN) – the national political organization representing First Nations across Canada – had passed five resolutions at their annual general assemblies recognizing the need for Indigenous communities to have adequate broadband connectivity and access to digital technologies. At a major Indigenous research and policy conference in Ottawa that same year, the AFN outlined a strategy for an equipped First Nation broadband network. They saw the network as part of a broader plan for economic, social and cultural change based on knowledge and information.

The AFN's "e-Community digital technologies model" builds upon a common network model employed by Canadian institutions and corporations and has five themes: First Nation capacity development, connectivity, human resources development, information management, and service delivery and partners (Whiteduck, J., 2010). Beaton & Campbell (2014) have analyzed how the e-Community framework was operationalized in remote Indigenous communities in northwestern Ontario. Another publication (Whiteduck, Tenasco, O'Donnell, Whiteduck & Lockhart, 2014) analyzes how the AFN e-Community framework fits with the adoption of digital technologies in the community of Kitigan Zibi Anishinabeg First Nation in Quebec.

In 2013, the First Nations Innovation research project based at the University of New Brunswick developed two **policies to support digital technology adoption and use in Indigenous communities**: the First Nations Broadband Infrastructure and Operations Policy and the First Nations Data Governance policy. Both policies were developed by the FNI project partners: Keewaytinook Okimakanak, First Nations Education Council and Mi'kmaw Kina'matnewey. The policies are available online at this link: http://firstmile.ca/resources/sharing-resources/.

5.3 Developing the infrastructure to support community, individual and household adoption

In 2001, the National Broadband Task Force was established to propose strategies to increase connectivity for Indigenous and rural Canadians (Industry Canada, 2001). In 2002, the federal government created the pilot program Broadband for Rural and Northern Development (BRAND) to bring broadband to northern and remote areas (Howard, Busch and Sheets, 2010). The 2006 evaluation of the BRAND program noted that a top down approach may be easier to administer however the recommendation was for Industry Canada to maintain a bottom-up approach in any future broadband initiative undertaken by the Department, in order to more fully realize the social and economic benefits of using broadband. The evaluation also recommended that, where broadband initiatives are not the responsibility of Industry Canada, the Department should make efforts to ensure that local needs are taken into consideration, such as creating a local advisory committee to the vendors (Industry Canada, 2006).

At the federal level, the Connecting Aboriginal Canadians policy initiative combined two federal programs – Gathering Strength and Connecting Canadians (CC) – and partnered with government and key national Indigenous organizations to develop the Aboriginal Canada Portal in 2001. It became evident that cultural

consideration is as important as improved technological infrastructure, and that governments need to tailor their support for the different approaches taken by Indigenous people to preserve their diverse cultures (Alexander, 2001).

According to one analysis, the federal CC program overemphasized the technological side and undervalued the human side of the public-private partnerships created to build community-based networks. Fiser & Seibel (2009) compared different community-based networks created to address the digital divide in rural, remote, and underserved urban communities, and also compared the investment paradigm of CC programs to those in the US and other OECD countries. Measuring the results of the CC programs is difficult because there is no long-term tracking of the grassroots organizations that received funding. Fiser and Seibel (2009) concluded that funders need a better policy framework to complement project-based funding so they can make more efficient decisions about how to support broadband infrastructure development in Indigenous communities.

In 2009, federal government infrastructure funding (Broadband Canada) was again made available to increase broadband connectivity in northern and remote regions; many of the Indigenous organizations who had taken on the First Nations SchoolNet RMO role took this opportunity to partner on funding. One example is Keewaytinook Okimakanak's KNET worked with Bell Canada and Nishnawbe Aski Nation to raise $82 million to construct a Bell fibre network connecting 26 rural and remote First Nations in the far northern region of Ontario (Philpot et al., 2014).

A summary of the literature is that the lack of reliable, adequate and affordable digital (broadband) infrastructure is the major restraint and barrier to more rapid adoption of digital technology in northern and remote Indigenous communities; this issue will also be discussed later in the report. Currently some Indigenous communities are slated for infrastructure upgrades and others are working with different partners to identify and implement connectivity solutions.

Many of the details of infrastructure funding and development are not available in public documents. For example, in 2015, Nunavik received $15 million from the federal government under Connecting Canadians and $11.5 million from the Quebec government from Plan Nord. The Kativik Regional Government (KRG) injected an additional $7.5 million from regional development funds, and $4 million from operating budgets. KRG will use the funding to expand their satellite bandwidth capacity to achieve Innovation, Science and Economic Development Canada (ISED) minimum household connectivity levels. At the same time, the KRG continues to plan and advocate for a long-term fibre-optic cable construction project to serve the Inuit communities across northern Quebec. As of February 2016 the contribution agreements were not signed, but this process is ongoing (Personal communication with KRG, 2016).

Whiteduck, Beaton, Burton & O'Donnell (2012) and McMahon, Gurstein, O'Donnell, Beaton & Whiteduck (2014) describe how telecommunication service providers are reluctant, slow or refuse to develop infrastructure in remote and northern regions without significant government investment; consequently it is always very challenging to build the partnerships necessary to develop broadband infrastructure and provide equitable and affordable internet services in many remote and rural regions of the country. Government policy to support broadband in remote and northern Indigenous communities is underdeveloped and uncoordinated among different federal departments and program areas. Too often public funds paid to telecom providers are first used to develop their regional infrastructure resulting in the communities at the "end of the road" remaining underserved or unserved (Philpot, et al., 2014).

According to McMahon, O'Donnell, Smith, Walmark, Beaton and Simmonds (2011), the First Mile approach to telecommunications development can be leveraged to support economic and community development in rural and remote regions that can otherwise lack employment opportunities. Keeping

ownership and control of broadband infrastructure and internet services inside communities helps generate jobs and keep revenues circulating locally. This approach aims to empower members of these communities to build, operate and manage resources such as digital infrastructures and services in ways that best meet their locally-determined needs and aspirations.

A number of other sources have also been advocating for community control and capacity of digital technologies and infrastructure. These include: the final report of the Aboriginal Canada Portal Working Group (2004), with participants from government, national Indigenous organizations and the World Summit on the Information Society (WSIS); a series of forums dedicated to the Indigenous digital divide (Aboriginal Connectivity Portal, 2006); and the Aboriginal Voice project consultations (Jock et al., 2004).

In Quebec, researchers have analyzed the First Mile approach in the Inuit territory of Nunavik (McMahon & Mangiok, 2014) and in First Nations in central, remote and rural regions of the province (Whiteduck & Beaton, 2014). A good example of First Mile in Action is NICSN (Kakekaspan, O'Donnell, Beaton, Walmark & Gibson, 2014; McMahon, 2014). NICSN is the Northern Indigenous Community Satellite Network (http://smart.knet.ca/satellite/), a jointly-managed, inter-provincial partnership between First Nation and Inuit communities in northern Quebec, Ontario and Manitoba. NICSN has demonstrated that a satellite network can be locally and regionally owned, managed, operated and maintained. Indigenous organizations first demonstrated the capacity to manage satellite networks in the 1970s and 1980s, when Wawatay operated a satellite-based radio network on the Communication Technology Satellite (also known as Hermes) and Inuit organizations conducted video conferences and produced television programs carried on the Anik B satellite (Hudson, 1990; Valaskakis, 1992).

In Ontario, researchers have analyzed the First Mile approach in Fort Severn First Nation, the most northern community in that province, on the shore of Hudson Bay (Kakekaspan, O'Donnell, Beaton, Walmark & Gibson, 2014). Also in Ontario, researchers have analyzed how First Mile concepts were used to build the Keewaytinook Mobile (KMobile) cellular service (Beaton, Burnard, Linden & O'Donnell, 2015). The authors found that these remote Indigenous communities are capable of local innovation and can collaborate with intermediary organizations to build digital infrastructures, by bridging the gap between the public and private sectors.

6 Conclusion: challenges to digital technology adoption in Indigenous communities

As stated in the introduction to this paper, the term "Indigenous communities in Canada" refers to First Nations, Inuit and Métis communities. First Nation communities are different from Inuit communities and each community is unique. We have attempted in this paper to avoid generalizations about Indigenous communities' experiences of digital technology adoption. In this concluding section we would like to emphasize the point that some of the challenges highlighted may be more relevant for Inuit communities and others for First Nations.

Indigenous communications organizations have been involved in providing analogue communications facilities and services for their communities for more than 40 years, including two-way radios, community radio stations, radio programming, video and television programming, internet services, cable television, and mobile telephony. Remote and northern Indigenous communities are now adopting digital technologies for many purposes discussed in this paper. Indigenous community members in every region of the country have demonstrated their eagerness and ability to use digital technologies when they are affordable, accessible and meet their needs.

However many challenges restrain the more widespread adoption and effective use of digital technologies in northern and remote Indigenous communities. Indigenous communities want to be part of the solutions to

these challenges. Indigenous communities have taken an active role in advocating for and shaping policy development related to broadband development in their communities (McMahon, Hudson & Fabian, 2014). Recognizing that marginalized groups such as Indigenous communities and residents of remote and rural areas face daunting challenges as they attempt to influence regulatory and policy decision-making, the First Mile Connectivity Consortium supports under-resourced groups to have their voices heard in regulatory proceedings alongside well-resourced corporate interests.

6.1 Challenges for community members and households

As mentioned earlier, many Indigenous communities are low income communities with widespread poverty (Anaya, 2014; Palmater, 2011) and as discussed throughout this paper, the costs of connectivity to northern and remote communities are very high, particularly the costs of exceeding data caps in remote satellite-served communities. The costs of adopting digital technologies will continue to be a restraint or a barrier to technology adoption while this situation exists. In addition, there may be poverty-related issues for individuals and households such as having a bank account or not, and having a credit card or not; we do not know the extent to which overall access to bank services and credit influence the ability to set up home internet services.

Language may be a challenge for some community members and households, especially those more comfortable in Indigenous languages than in Canada's two official languages. It is possible that some community members avoid certain applications or devices because they do not support syllabic scripts (they are not available on Android mobile devices, for example). The target audience for most online content and services is the dominant 'Western' population (Pannekoek, 2001; Pasch, 2015). Language is a strong indicator of this bias; English is the overwhelmingly prevalent language used on the internet, while many scarcely-used and endangered Indigenous languages are virtually non-existent.

As a result, the internet and associated technologies may fuel the disappearance of Indigenous languages even as the communities strive to preserve them. This is an obvious restraint to digital technology adoption in Indigenous households. To deflect the globalizing force of technology, the literature highlights the importance of providing community members with access to localized online resources catered to community-specific needs (Dyson & Hendriks, 2007; Gordon, 2006). This will help to ensure the protection that Indigenous peoples require to maintain ownership and control over their knowledge, language, and culture (Nickerson & Kaufman, 2005).

Furthermore, much of the existing material representing Indigenous peoples on the internet imposes an outsider worldview that misrepresents and objectifies the culture, thereby furthering a colonialist agenda and contradicting the holistic values that Indigenous cultures uphold (Iseke-Barnes et al., 2007; Perley, 2009; Todd, 1996). At the same time, there are many examples of Indigenous organizations and communities using digital technologies to preserve Indigenous languages, as discussed earlier in this review. Pasch (2015) provides an excellent discussion of the "double-edged sword" of technology, including both utopian and dystopian views about bringing cutting-edge digital technologies into Inuit communities.

6.2 Challenges for community organizations and at the community level

Many programs designed to support digital technology adoption in Indigenous communities underemphasize the importance training, skills development and capacity-building within the community. The availability of training, skill development and community capacity building is a key factor determining whether or not the potential of digital technologies in Indigenous communities will be realized (Clement, Gurstein, Longford, Moll, Shade, 2012; Gibson et al., 2011; Peddle, 2012; Simms, O'Donnell and Perley, 2008; Smith, 2008. Whiteduck, J., 2010). Project-based funding formulas favour short-term benefit over

long-term sustainability and the resulting instability creates significant complications for the organizations receiving the funding and their staff (Gibson, O'Donnell & Rideout, 2007).

Pasch (2015) proposes a train-the-trainer model for digital training in Arctic communities for the People of the North. Rather than non-Inuit/Alaska Native identity technicians and researchers producing content for, or on behalf of the communities, training Northern youth and Elders to be technical and digital leaders in their own right. He suggests this could begin the crowdsourcing of localised cultural production in Inuktitut or in whichever language is most suitable or appropriate for the Arctic region where the training is taking place.

As discussed earlier, the Assembly of First Nations (Whiteduck, J., 2010) outlined the requirements for "the e-Community digital technologies model." The model is similar to the network development and IT maintenance model employed by institutions and corporations across Canada. Every First Nation community requires a local technical team to provide ongoing support for the telecommunications infrastructure (Whiteduck, J., 2010); however as discussed earlier, these resources are very challenging to find for many Indigenous communities.

Examples of Indigenous owned and managed digital technologies applications and networks discussed in this paper highlight how some of these challenges are being addressed by Indigenous communities. When the local and regional language is supported by these communication tools, the people tend to embrace these technologies, identifying innovative and unique strategies for their adoption. Eady (2016, forthcoming) proposes some design principles for culturally-appropriate digital technologies in Indigenous communities. By harnessing the ability of digital technologies to facilitate sharing, which makes up a rich component of the holistic worldview that Indigenous cultures value, technologies can be adopted to benefit rather than marginalize these communities (Leclair & Warren, 2007).

6.3 Challenges for infrastructure to support technology adoption in communities

Adequate, affordable and reliable broadband infrastructure is the foundation for digital technology adoption in northern and remote Indigenous communities. The lack of ongoing and sustainable partnerships between governments, Indigenous communities and service providers to make these developments happen was identified by many of the research studies. The recent OECD Report (2014) proposes different models of partnerships and government intervention for broadband network development.

According to the latest analysis from the OECD (2014), fibre is the only technology that is certain to offer greater capacity than wireless networks, which are continually evolving to offer better performance in addition to the benefits of mobility and flexible deployment. Even when end-user devices are connected wirelessly, fibre will be the technology of choice for aggregation and backhaul to Internet core networks, as it is today for cellular towers. From the report: "*Wireless broadband networks still carry far less traffic than fixed networks, and they generally offer lower speeds and reliability. Moreover, the growth of mobile data actually increases demand for fixed networks. Mobile connections only travel over the air for a short distance, after which they are carried on high-capacity wired connections. The growth of Wi-Fi and other mechanisms for offloading cellular traffic will place greater demands on wired networks."*

The geography of remote and northern Canadian communities implies transportation access problems, long cable builds, and harsh climate. Building sustainable broadband infrastructure capable of telehealth delivery in northern and remote Indigenous communities is and will continue to be costly. Travel and shipping telehealth equipment to some northern and remote areas can account for up to 40% of the project budget (Muttitt, Vigneault & Loewen, 2004). Rolling it out could also generate new and interesting possibilities for

innovation and technical development. New engineering and technical solutions are needed to reduce these and related infrastructure costs.

The most recent research on Indigenous community connectivity suggests that significant new investments will be needed to increase broadband capacity in northern and remote Indigenous communities. To be sustainable, building, upgrading and maintaining broadband infrastructure in northern and remote Indigenous communities across Canada will need significant ongoing investment by government partners. Some examples of successful funding partnerships are the Northern Indigenous Community Satellite Network (McMahon, 2014), the Kuhkenah Network (Carpenter, 2010), and, most recently, GwaiiTel, that brings broadband to two northern islands in BC. That service was created as a not-for-profit society made up of three municipalities, two Band councils, two unincorporated areas and the Council of the Haida Nation (Leask, 2015a).

As discussed earlier, across Canada, telecommunications firms are slow, and in many cases unwilling, to extend their broadband networks (backhaul networks) to northern and remote communities without significant government investment (McMahon et al., 2014; Philpot et al., 2014). The "first mile" approach supports Indigenous communities and their intermediary organizations to build their own local community networks and partner with existing networks (McMahon et al., 2010; 2011). In their recent submission to the CRTC, the First Mile Connectivity Consortium (2015) proposed the creation of a Northern Infrastructure and Services Fund to support this infrastructure development work.

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