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Making Sense of Digital Inequalities in Remote Contexts: Conceptions of and Responses to Connectivity Challenges in the Northwest Territories, Canada

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A large body of research focused on first-level digital divides in rural/remote contexts references structural factors including geography, market failure, limited infrastructure, policy gaps, and so on. It points out issues including access, affordability, reliability, and speed, but tends to overlook the perceptions and reactions of people living in these regions. Taking this observation as a starting point, this study investigates connectivity challenges—and responses to them—as experienced by residents of small-population, geographically dispersed communities in Northern Canada. Consistent with the paradox of telecommunications development in remote regions, we confirm that speed and cost remain primary challenges—despite desires for better connectivity. We also learned how Northern residents are innovating to address these challenges. Employing a network

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analysis, we argue that structural challenges reinforce one another in a dynamic spiral of digital inequality and propose support for nonprofit community networks (CNs) as one way to break this cycle.

Keywords: digital inequality, digital inclusion, digital divide, Internet, Northern Canada, Indigenous peoples

Remote Northern communities in Canada are a novel site to examine the evolving challenges of digital connectivity, which in many contexts has become a symbol of division that reflects and reinforces structural inequities. Internet connectivity and associated digital technologies can introduce intersecting forms of marginalization along lines of socioeconomic status, race/ethnicity, gender, and geographic location (Robinson et al., 2020). For example, research into digital divides identifies the multiple facets of first-level divides (access, reliability, affordability, etc.), second-level divides associated with skills and attitudes, and third-level divides that manifest in outcomes of Internet use (Hargittai, 2002; Robinson, Cotten, Schulz, Hale, & Williams, 2015). These studies tend to focus on divides between rural and urban areas (Salemink, Strijker, & Bosworth, 2017), among certain demographics, and in relation to socioeconomic factors (Hodge, Carson, Carson, Newman, & Garrett, 2017). Here, we focus on first-level access divides and specifically how challenges emerge from the design and deployment of connectivity infrastructures in remote areas, where residents continue to be disadvantaged by differentiated access, availability, affordability, and adoption.

In the context of Canadian telecommunications policy, "remote" communities are rural communities of fewer than 30,000 residents who lack year-round road access and/or require satellite-served telecommunications (Government of Canada, 2021). In these regions, the combination of climatic conditions (e.g., low temperatures that limit construction seasons, spring melt that affects travel on winter roads), geographically diffused communities with a few hundred residents, and limited availability of transportation and other enabling infrastructures such as electricity has limited the commercial deployment of adequate telecommunications infrastructures (Gauthier, 2014). Compared with southern and urban contexts, many remote Northern communities have slower, less-reliable, and more expensive services, an issue that remains a subject of public policy debate (Delaunay, 2017; McMahon, McNally, Fraser, Pearce, & Fontaine, 2018).

O'Donnell and Beaton (2018) present the paradox of telecommunications development in this context: Despite greater desire for connectivity because of limited (and in some cases, nonexistent) bricks-and-mortar services (Office of the Auditor General [OAG], 2018, para. 1.14), people living in remote communities typically experience lower speeds, reliability, and quality of services—and often pay much higher costs—than their urban counterparts (see Figure 1). While the rural penalty associated with telecommunications is a well-recognized challenge (e.g., Parker, Hudson, Dillman, Strover & Williams, 1995), we argue that O'Donnell and Beaton's (2018) framework is unique given its specific focus on communities that require connectivity to access essential public and commercial services, yet are dependent on for-profit providers that often fail to provide service levels required for such access.

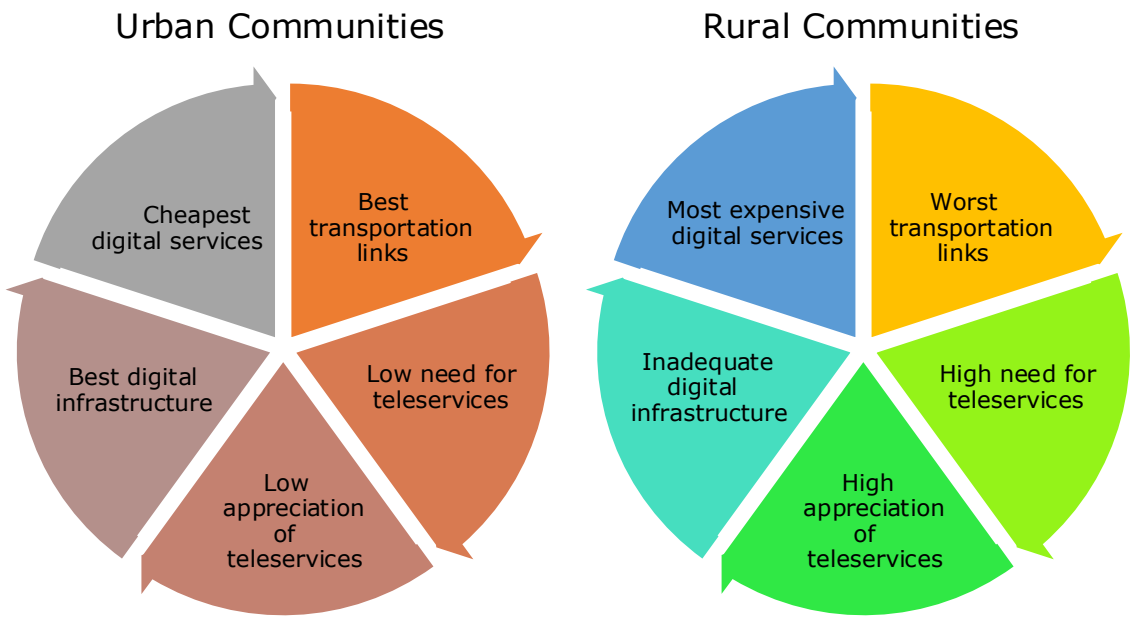

Figure 1. Geographic paradox of telecommunications development (O'Donnell & Beaton, 2018).

Some researchers argue that these conditions arise from a commercially driven deployment process that originates in urban centers and extends connectivity to less densely populated, remote areas (Burrell, 2018). Though network operators are supported with billions of dollars of public funding for infrastructure deployment in these regions, detailed information on the use of this funding is a closely guarded secret (Taylor, 2018). Many Northern residents continue to face significant access limitations, providing evidence that standard deployment models relying on "market forces" and facility-based competition do not apply, and policies, regulations, and funding programs generated in and for urban environments do not fit the circumstances of remote communities (McMahon, 2020; McNally, Rathi, Joseph, Evaniew, & Adkisson, 2018). One proposed solution to this issue is to support community involvement, control, and ownership of connectivity planning and deployment, particularly in rural, remote, Northern, and Indigenous regions (McMahon, Gurstein, Beaton, O'Donnell, & Whiteduck, 2014). Gallardo, Beaulieu, and Geideman (2021) suggested setting up device refurbishment and loan/sell programs, improving digital skills and literacy, as well as improving broadband infrastructure in rural areas.

While digital access divides are commonplace in many parts of the world, relatively little research has focused on rural perspectives of these and related issues (Bakardjieva, 2008; Freeman, Park, & Middleton, 2020). More specifically, there is very little research available on people's conceptions of and responses to access challenges in Northern Canada—and even less so in remote and Indigenous contexts (exceptions include Coelho, 2018; O'Donnell et al., 2016; Young, 2019). O'Donnell and Beaton's (2018) framework is a useful heuristic that suggests access inequalities in remote communities reinforce one another in different ways than in urban communities. For example, remote communities have limited access to large schools and hospitals, while many urban residents have a lower need and appreciation for teleservices because they can choose to

access those services in person (recognizing that urban residents—particularly elderly persons and persons with disabilities—may also face challenges accessing such services). The framework also shows the dynamic relationships among different forms of digital inequality present in first-level digital divides, which we examine in this study through the experiences of Northern residents. In this context, our study sought to identify how people living in remote communities in the Northwest Territories (NWT), Canada, make sense of their digital access challenges and explored two research questions:

RQ1: How do Northerners conceptualize and experience their digital connectivity challenges?

RQ2: How do Northerners respond to these challenges?

The Current State of Digital Connectivity in the NWT

Indigenous (First Nations, Inuit, and Métis) peoples have always lived in the territories now known as the NWT. Today, populations in the 33 primarily rural/remote communities range from 36 (Kakisa) to 21,372 (Yellowknife, the capital), with a median of 561 per community. The majority (approximately 70%) of the population is concentrated in the relatively urban centers of Yellowknife, Inuvik, Hay River, Norman Wells, and Fort Smith, where government and private-sector services are centralized. Indigenous peoples from nations such as the Inuvialuit, Sahtú Dene, Dinjii Zhuh (Gwich'in), Yellowknives Dene, Tłı̨chǫ, and Northwest Territory Métis Nation live in the other 29 communities. Most of these smaller communities rely on ice roads on frozen lakes and rivers during the winter; the only access otherwise is by plane or seasonally by boat. Housing and amenities such as water, sewage, and solid waste management are also substandard in many remote Northern communities (Centre for the North, 2014), and household incomes are typically lower than the Canadian average (Hudson, 2017). These diverse people continue to practice strong Northern cultures, with many living on the land for long stretches of time, engaging in activities like hunting, fishing, and trapping. Our work celebrates these vibrant communities while also examining the challenges their residents have expressed with regard to their adoption of digital technologies.

In recent years, government and private-sector organizations have increasingly focused on Northern connectivity—efforts expressed in a "basic service objective" set by the telecommunications regulator in 2016 (Canadian Radio-Television and Telecommunications Commission [CRTC], 2016, para 2) and a national broadband strategy combining universal service funding, partnerships, technology (e.g., spectrum access), and policy/regulation addressing access gaps (Government of Canada, 2020). Public policy is accompanied by several large-scale infrastructure developments, including a $16.8 million project for the monopoly service provider Northwestel, to improve local access and backhaul infrastructure in 18 NWT communities (CRTC, 2020b). The Government of the NWT has also invested significantly in regional infrastructure, including through an open-access fiber-optic link in the Mackenzie Valley. This and other regional networks such as one along the Dempster Highway provide points of connection to communities along their routes; some of Northwestel's recent funding is designed to connect homes and other buildings inside communities. As listed in Table 1, a few communities located along the Mackenzie Valley have fiber-optic Internet connections. However, news media point out the limitations in these projects—for example, there is still no clear plan for connecting communities not located on the fiber link path (Desmarais, 2020). The federal government has announced that remote communities will have access to a satellite "backbone,"

and satellite providers have stated intentions to connect individual households. However, these and other long-promised satellite-based solutions have also been critiqued (Freeman et al., 2020; Young, 2019). Therefore, people living in remote communities in Northern Canada continue to experience significant disadvantages compared with the majority of Internet users in the South, as well as in more urban centers in the NWT. Table 1 presents connectivity and transportation services currently available.

Table 1. NWT Communities and Associated Connection Services.

Community	Connection	Community	Connection
Aklavik*	DSL	**Inuvik**	Fiber
Behchokǫ	DSL	**Jean Marie River**	DSL
Colville Lake*	Satellite	**Kakisa**	DSL
Déljne*	DSL	**Łutsel K'e***	Satellite
Dettah*	DSL	**Nahanni Butte**	DSL
Enterprise	DSL	**Norman Wells***	Fiber/Coax
Fort Good Hope*	DSL	**Paulatuk***	Satellite
Fort Liard	DSL	**Sachs Harbour***	Satellite
Fort McPherson	DSL	**Sambaa K'e***	DSL
Fort Providence	DSL	**Tsiigehtchic**	DSL
Fort Resolution	DSL	**Tuktoyaktuk**	DSL
Fort Simpson	DSL	**Tulita**	DSL
Fort Smith	Fiber/Coax	**Ulukhaktok***	Satellite
Gamètì*	Satellite	**Wekweètì***	DSL
Hay River	Fiber/Coax	**Whatì***	DSL
Kátł'odeeche	Fiber/Coax	**Wrigley**	DSL
		Yellowknife	Fiber/Coax

**Means "remote"—accessible only by winter road, boat, or flight.*

Beyond this general information about services, there is very limited empirical data publicly available about the 29 rural/remote NWT communities. When the incumbent provider Northwestel was asked to provide information in recent telecommunications proceedings, it redacted details (Owen, Hunt, McMahon, Napier, & Marion, 2021). The limited number of studies that do exist indicate that Northerners are disadvantaged. Roth (2014) argued that commercial ISPs are not interested in establishing infrastructure in these regions because of high costs and limited opportunities for profit (see also Arctic Communications Infrastructure Assessment [ACIA], 2011; Fiser, 2013; OAG, 2018). O'Donnell et al. (2016) drew attention to limited partnerships among government, local communities, and ISPs, as well as high costs of connectivity. Existing Internet performance monitoring activities also lack robust connectivity data from these communities. For example, the CRTC contracts SamKnows to conduct tests using "white boxes" set up in households (CRTC, 2020a). However, the most recent SamKnows report, from June 2020, has been critiqued for collecting data during periods of inactivity, reflecting selection bias by excluding many rural/remote areas, aggregating data (e.g., combining results into "West and North"), reporting results that do not account for increased use during the COVID-19 pandemic, and limiting NWT testing to cable connections available only in the centers of Hay River, Fort Smith, Norman Wells, and Yellowknife (Lawford, 2020). Another test provided by the Canadian Internet Registration Authority (CIRA) provides end-user data

that we present in detail below. However, these data reflect limitations, including small sample sizes and connectivity requirements to run the Web-based test that are too high for low-bandwidth communities. Our study provides new research into the perspectives of Northerners on these and related issues.

Literature Review and Purpose of the Study

Rural and remote areas generally experience access limitations and poor connectivity (e.g., ACIA, 2011; Fiser, 2013; Lai & Widmar, 2021; OAG, 2018). Existing research has also found problems with Internet reliability in rural and remote regions (Strover, Whitacre, Rhinesmith, & Schrubbe, 2020). Low service quality (speed, unreliability, etc.) is one of the most reported issues (Hambly & Rajabiun, 2021; Park, 2017). Compared with urban areas, rural regions tend to be dependent on older connectivity infrastructures and experience lower speeds (Burrell, 2018; Whitacre, Strover, & Gallardo, 2015). According to Whitacre (2016), despite technology improvements, rural services continue to lag because of geographic distances, low population densities, and high cost of infrastructure deployment. Rendon Schneir and Xiong (2016) reported that the cost of deploying a network in rural areas is on average 80% higher than in urban areas.

Another factor that affects rural connectivity is the high cost of services (Strover et al., 2020). Findings from studies conducted in Canada (Hudson, 2017; O'Donnell et al., 2016), Australia (Freeman et al., 2020; Hodge et al., 2017), the UK (Philip, Cottrill, Farrington, Williams, & Ashmore, 2017), and the United States (Hudson, 2015) have determined that affordability is a barrier in remote communities. Reddick, Enriquez, Harris, and Sharma (2020) stated that monthly services cost more in remote locations because of higher deployment costs. Furthermore, small markets in low-density rural/remote areas may lead to increased service costs (Liu, Prince, & Wallsten, 2018; Prieger, 2003). Competing service providers are often unwilling to enter low-profit markets (Reddick et al., 2020) with the result that incumbents typically enjoy monopolies within rural/remote areas, leading to a lack of competition that makes broadband access more expensive to households, which also suffer from low-quality service (Prieger, 2003; Prieger & Hu, 2008). As Marshall, Dezuanni, Burgess, Thomas, and Wilson (2020) note, competition makes broadband more affordable to rural residents. Conditions and access to suitable devices in rural/remote regions may also affect Internet use and adoption, as well as levels of digital engagement (e.g., Gallardo et al., 2021; Katz, Moran, & Gonzalez, 2017); as van Deursen and van Dijk (2019) argue, material access to devices limits online opportunities. All these factors require further investigation.

There is also limited research on how users in remote/rural areas understand and report these challenges—and their responses to them (Beaton et al., 2016; Salemink et al., 2017). As Ali (2018) and Freeman et al. (2020) note, rural people's experiences and reactions are often overlooked, and these insights can provide valuable information for digital inclusion initiatives (Salemink & Strijker, 2018). Salemink (2016) argued that more location-based research is needed from rural regions; our research contributes to such efforts.

Further, most studies on first-level digital divides in rural/remote regions do not use primary data; rather, they collect and analyze secondary data from governmental departments such as the Australian Bureau of Statistics, the Federal Communications Commission, the National Broadband Map, and the U.S. Census Bureau (e.g., Park, 2017; Whitacre, Gallardo, & Strover, 2014; Whitacre et al., 2015). As discussed

in detail below, we employ a mixed-method approach that draws on household surveys, interviews, and user-based Internet performance monitoring. Our findings present a qualified and conditional representation of how residents of small-population, geographically remote communities experience Internet connectivity and present them as exploratory efforts to support more primary data collection in this area.

Method

Our study methodology examines the first-level digital divide factors highlighted in O'Donnell and Beaton's (2018) heuristic presented earlier. This involved examining issues related to access, affordability, speed, and reliability of digital connectivity infrastructure and services in rural NWT communities. We did this by employing a case study method (Yin, 2018) to investigate the perspectives of Northerners by collecting data from multiple sources (surveys, interviews, and Internet performance test data). Survey and interview questions elicit data about perceptions, adoption, and use of digital ICTs. For example, survey questions asked participants to identify key technical challenges that they face in their use of digital technology, while interviews expanded upon specific factors influencing use, such as Internet and device access, affordability, quality, and so on. To learn about user experiences of Internet speed and performance, we also report quantitative data collected through the CIRA IPT test, which we sorted and analyzed after verifying test site locations.

Data Collection Tools and Procedure

Because of COVID-19 social distancing and travel restrictions during the period of our study, we conducted all data collection activities remotely. This involved remotely training and hiring local researchers to conduct surveys, as well as applying Internet-enabled research methods including videoconference/telephone interviews and CIRA's Internet Performance Test (IPT), which users conduct by visiting a website. To increase the validity and reliability of our results, we used both qualitative and quantitative data (Creswell & Clark, 2007; Yin, 2018).

In 2020–21 local researchers conducted household surveys in their home communities. These individuals received payment for their work and signed a confidentiality agreement to protect the privacy of respondents. They conducted short questionnaires with heads of households using either tablets preloaded with a survey data collection app (Survey Monkey or Open Data Kit) or paper surveys. They transferred survey results to university-based researchers either through the app or via mail (for hard copies). We present responses from 212 households representing 682 individuals in 10 communities (eight of which are remote; see Table 2).

Table 2. Summary of Community Household Survey Participants.

Community	Number of Households	Represented Individuals
Aklavik*	7	18
Fort Good Hope*	18	49
Norman Wells*	6	11
Paulatuk*	23	84
Sachs Harbour*	22	53
Tsiigehtchic	27	69
Tulita	42	152
Ulukhaktok*	20	70
Wekweètì*	9	32
Whatì*	38	144
Total	**212**	**682**

Note: *Indicates a "remote" or fly-in community.

These household survey data are self-reported and voluntary; following ethical standards, respondents were not required to answer every question. The survey included an iPad prize draw as an incentive.

Although CIRA's IPT data have been available since 2015, in this study we analyze results from users in 212 unique NWT test locations in the time period from January 1, 2019 to December 31, 2020; a total of 1,415 tests. The IPT provides data on user experience in communities where alternatives are otherwise unavailable and offers a counterpoint to the results of other tests, such as the SamKnows initiative discussed earlier. To encourage NWT residents to use the CIRA IPT, we promoted data collection through social media, contests, and digital literacy courses, and provided periodic prize draws as incentives.

Our methodology also incorporates qualitative data from semistructured interviews with 26 individuals conducted in summer/fall 2020. Participants included key informants identified through personal connections and professional networks, as well as by snowball sampling. Semistructured interviews focused on challenges related to the development, adoption, and use of digital technologies in the NWT and responses/reactions to these challenges. Interviews by videoconference or telephone lasted for approximately 60–90 minutes, and interview participants could receive a $100 honorarium.

Limitations of the Study

We note the small sample size of our quantitative data and the difficulties of collecting data through remote methods, and therefore triangulate our sources to enhance the validity of results. For example, Internet-based performance tests inherently restrict our results to people who can access an Internet connection; this supports our decision to work with local researchers to conduct household surveys, as well as conduct interviews over telephone in cases where connectivity was insufficient to support videoconferencing.

We also recognize limitations in the data we collected. With respect to household surveys, we used local researchers who have not received formal postsecondary training in survey techniques. CIRA's IPT data also reflect several limitations. First, while the test attempts to identify the device being used (e.g.,

computer or mobile device), there is no way to determine the specific connection (e.g., wired or wireless; or household Internet versus cellular). Therefore, our IPT data may include mobile cellular as well as household Internet services. Second, we note the small sample size from communities outside of major population centers, which reflects only a handful of unique test locations. Third, we recognize that industry researchers have critiqued the IPT for understating actual Internet speeds and relying on user hardware (e.g., modems) rather than a controlled testing device hardwired to a household connection (Goldberg, 2020). Fourth, the connectivity requirements to run the IPT are too high for users in low-bandwidth communities (although we did share a low-bandwidth version of the test: https://performance.cira.ca/mini). Finally, IPT data are not verified by an independent auditor.

Data Analysis Procedure

In our initial analysis, we performed descriptive statistical analysis on quantitative data from community surveys and CIRA IPT results, calculating frequency, percentage, and mean. We analyzed data collected from interviews using quantitative content analysis, a systematic and objective categorization of qualitative data. While informed by existing research on Northern connectivity, we used a three-stage process of inductive content analysis so that data would lead to the emergence of concepts. First, we coded interview transcripts; then, we identified themes; third, we arranged coded responses according to themes (Emerson, Fretz, & Shaw, 2011). This was done through the software program Atlas.ti 7. To establish intercoder reliability, we randomly selected three interviews to code separately by two researchers. Then, we analyzed intercoder reliability using the SPSS program as measured by Cohen's kappa (Cohen, 1960). The Cohen's kappa was .702, which implies substantial agreement (Landis & Koch, 1977).

Our initial analysis indicated that Northern residents perceived connections among different aspects of first-level digital divides; therefore, our secondary analysis sought to reveal relationships among themes in interview data (Mckether, Gluesing, & Riopelle, 2009). We visualized these findings using Gephi 0.9.2 open source software (gephi.org; Bastian, Heymann, & Jacomy, 2009). This secondary analysis expands O'Donnell and Beaton's paradox of remote telecommunications development.

Results and Discussion

Phase 1 Results: Conceptions and Experiences of Digital Connectivity Challenges

We present our results in relation to O'Donnell and Beaton's (2018) framework, identifying throughout where our findings serve to validate, modify, or expand upon their work. Data obtained from community household surveys confirm "speed of Internet" and "cost of Internet" as the most prominent challenges expressed by NWT residents (see Table 3). A high number of respondents (70.28%) stated slow speed as a key challenge. This finding is supported by interview data; as participant (P1) stated, their average download speed is around 11 Mbps, even though it is supposed to be 50 Mbps. Only seven interview participants (26.92%) felt their Internet speed was good enough. This corresponds to O'Donnell and Beaton's (2018) presentation of telecommunications in remote/rural regions as expensive and inadequate.

Table 3. Challenges That Households Face in Their Use of Digital Technology.

Challenges	Number of Respondents	Percentage of Respondents
Speed of Internet	149	70.28
Cost of Internet	130	61.32
Quality of Internet	109	51.42
Cost of devices	97	45.75
Data caps	84	39.62
Availability of Internet	64	30.19
Reliability of online apps	45	21.23
Availability of devices	41	19.34
Difficulties purchasing/ordering devices	39	18.40
Condition of devices	39	18.40
Access to software	34	16.04
Total	212	

To examine how users in remote Northern communities experience Internet speeds in more detail, we analyzed CIRA IPT results. According to these data, 57.17% of the Internet speeds tested were lower than levels reported in interviews: between 0 and 5 Mbps (see Figure 2 below). Most—86.93%—of the test results do not meet the CRTC's 50 Mbps/10 Mbps objective for fixed broadband services. Tests also varied among communities: Smaller communities typically have much slower upload and download speeds than larger, more central communities. Further engagement, speed testing, and research are needed to better understand these challenges in the smallest communities.

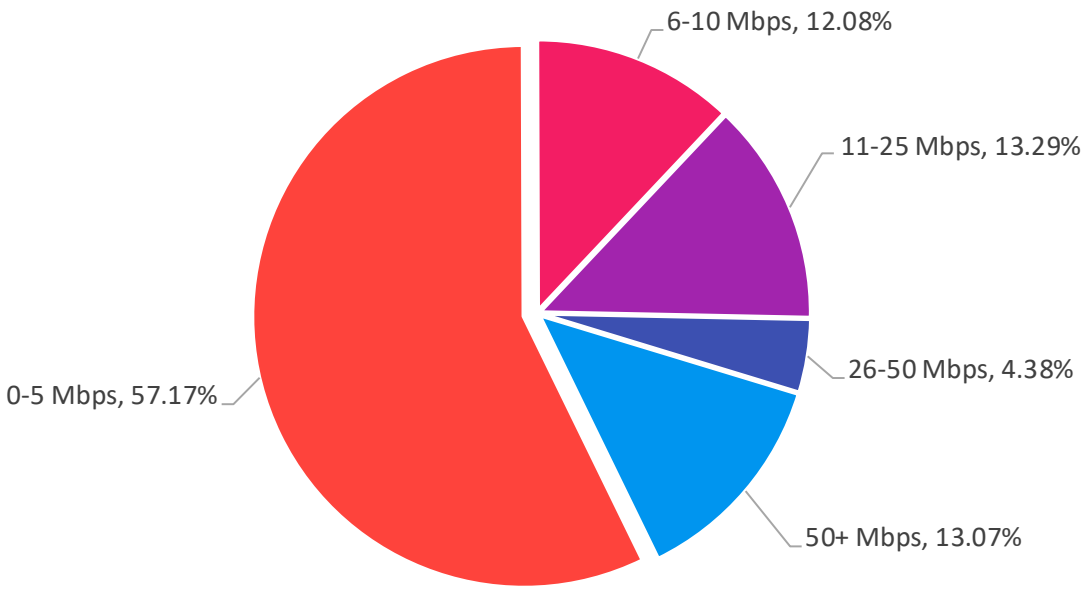

Figure 2. Data from the CIRA Internet performance tests (aggregated speeds for 1,415 tests).

Our research confirms that cost of Internet is a major challenge reported by many household survey respondents (61.32%). When considering this issue, we note the generally low incomes and high cost of living in the NWT, particularly in smaller remote communities, as well as limitations in bricks-and-mortar services that require telecommunications to access essential services. In the NWT, this affordability gap is particularly prominent in remote communities served by satellite. For reference, customers in Paulatuk, one of the remote fly-in communities, pay $79.95 per month for 5 Mbps (the fastest available plan), 60 GB cap with every additional gigabyte of data costing the user $3 (NorthwesTel, 2021).

Data caps are an important ancillary factor in how Northern residents experience affordability. Numerous (39.62%; *N*=84) household survey respondents stated they pay exceedingly high data overage fees. Unlike in many urban contexts, people in remote NWT communities must adhere to a monthly downloading quota; exceeding these caps results in data overage charges. The pricing and packages available in NWT communities reflect these limitations; for example, Northwestel's overage fees are inversely related to available speeds. In other words, satellite customers pay the most per GB in overage fees, DSL pay second most, and fiber/coax pay the least. Because of overage charges, six interview participants (23.08%) noted they experienced bill shock at the end of the month at least once. Issues about data caps should be included as indicators in O'Donnell and Beaton's (2018) presentation of affordability in remote regions.

Nearly all interview participants (87.5%; *N*=23) found the Internet expensive. One participant (P23) stated, "[Internet is] more expensive than any of our household bills, the highest expense for our family." Another participant (P14) said, "[Internet is provided] at a rate that is sometimes triple the national average." Some interview participants (23.08%; *N*=6) reported receiving monthly bills for hundreds of dollars—an experience also noted by several household survey participants. One interview participant (P9) noted recent changes in Internet costs: "The price has gone up, while the (Internet) service has become more necessary." Only two interview participants (P8 & P16) found the Internet price reasonable.

Quality of Internet was the third most prominent challenge reported by NWT residents. More than half of our survey respondents (51.42%) reported this challenge, which was more prominent in satellite-served communities. For example, nearly 80% of survey respondents from Paulatuk (18 of 23 participants) stated this. Perceived quality of Internet is also reflected in people's experiences of the reliability of online applications (e.g., Skype and Zoom). Interviews revealed that in many remote communities it is nearly impossible to conduct video Zoom calls. One participant (P14) from Inuvik said, "[The challenge is] not so much the access to the software, but the functionality of it [software] with limited speeds." We suggest these data support O'Donnell and Beaton's (2018) characterization of inadequate service in remote regions and reflect challenges not present in urban contexts.

Survey respondents also reported issues related to digital devices, with almost half (45.75%) indicating that "cost of devices" (laptops, tablets, mobile phones, etc.) is a challenge, with "availability of devices" (19.34%) and "condition of devices" (18.40%) lesser issues. One reason for the high cost of devices in this context is a lack of stores selling computers or mobile phones, which are available only in larger centers such as Yellowknife and Inuvik. Otherwise, people must purchase secondhand devices locally or pay high shipping fees to obtain devices. This is reflected in survey responses indicating "difficulties ordering or

purchasing devices" (18.40%). For example, P17 highlighted the high cost of shipping: "[If] you try to order something for $40 on Amazon, shipping would be $350." As P8 stated, more remote areas are excluded from commercial shipping. To address this challenge, remote residents ask friends to pick up orders from more central locations, where shipping is available. Several interview participants (e.g., P4, P10, P18) noted a thriving secondhand market for devices, including through applications such as Facebook Marketplace.

Transportation issues also prevent access to device repair services. Most interview participants (73.08%; *N*=19) mentioned limited access to local repair services, and people experience difficulties with shipping broken devices to be serviced. As P7 said, "If something breaks, it goes to the dump." Despite the unique characteristics of this challenge in remote regions vis-a-vis urban contexts, O'Donnell and Beaton's framework does not mention devices—and therefore should be modified to include it.

Phase 2 Results: Secondary Analysis of Perceptions of Digital Connectivity Challenges

Secondary analysis of interview data obtained more specific and detailed insights about how people perceive these challenges. The algorithm we used plots the nodes (circles) and lines between the nodes. The sizes of the nodes and associated text represent the frequency of their corresponding terms (or the number of connections in the network), while the thickness of the lines (also known as edges) represents the weight of the connections between nodes (see Figure 3). This revealed key relationships building on themes and subthemes found in interview data (and validated through surveys and IPT data). For example, the thick line between "expensive" and "very slow" suggests that participants who said the Internet is expensive also said it is very slow. By providing a means to analyze connections and relationships between self-reported challenges, this method supports the dynamic analysis of interrelated digital access inequalities articulated in O'Donnell and Beaton's (2018) framework.

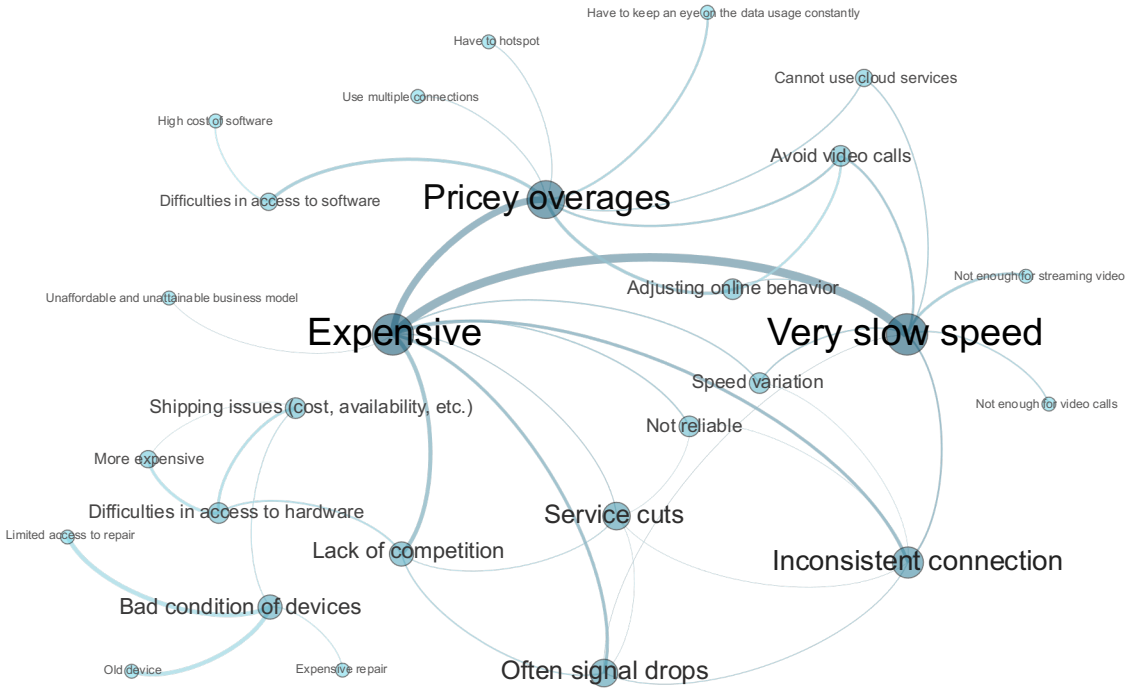

Figure 3. Secondary analysis of interview data.

A strong perceived link between "expensive" and "pricey overages" suggests that data overages are perceived by participants as one of the biggest factors in their conception of Internet affordability. One participant (P2) described data caps as a "vicious cycle of financial abuse," while another (P11) explained, "[Data caps are] really what the cost is, and that's how these companies recoup their costs." This is validated in interviews where most participants (57.69%) stated "pricey overages" are a main issue about Internet affordability.

In this context, the technical characteristics of applications, paired with limited connectivity, build upon each other in a dynamic cycle of digital inequality. Because of the ways that many contemporary cloud-based software and application services are provided to users, expensive data overages perpetuate additional costs for remote residents when compared with users in more connected rural and urban contexts. As P10 explained, "Especially with your data cap, it makes it pretty expensive to download software," while another participant (P26) stated, "Software that requires a lot of updates is a problem in the Northwest Territories." These perceptions are validated by survey respondents who highlighted both data caps (39.62%) and reliability of online apps (21.23%) as key challenges.

Figure 3 illustrates other relationships that help explain perceptions of digital inequalities. For example, there is a perceived connection among slow Internet connections, speed variations, and reliability of service. Reliability issues are linked to service cuts and signal drops and affect daily life. As stated by one participant (P9), who experienced Internet drops of six to 36 hours, "Everything shuts down—banking

systems, machines, everything. And it's a very stressful time in the community." These observations link to slow and variable speeds; as another participant (P7) stated, "I also use Dropbox, and I found that it was hard. Whenever we had to share [files], it definitely took a while." P20 noted, "If we are uploading at the same time [as a meeting], I have to pause the upload to attend the meeting."

A perceived relationship also appears between cost ("expensive") and competition ("lack of competition"). This perception disempowers Northern residents who cannot envision a viable solution to their challenges. Interview respondents believe that one reason for high costs is the lack of competition among ISPs in the NWT. Outside of NWT centers, there are very few—if any—alternative service providers. P9 said, "In the smaller communities, they're often only serviced by one [provider]. So, there are monopolies around." P4 stated, "It's a unique situation [in Northern Canada] that there is no competition." Finally, one person (P1) who found the Internet price "expensive" referred to the existing situation as symptomatic of an unaffordable and unsustainable business model.

NWT residents associate lack of competition not only with cost but also with the quality of the Internet (e.g., service cuts, signal drops) and access to hardware/devices (see Figure 3). P3 remarked: "I just don't have a choice...There is no other real or potential service provider…The quality of the service depends on whatever services they can provide." Participants believe that increased competition among providers may help lower prices and increase quality. Setting aside the inherent limitations of market-based competition in these regions and communities, we note that this situation has led to impressions among Northern residents that they have little control over connectivity; while some feel financially exploited, they have no options to access alternative providers.

Phase 3 Results: People's Responses to Digital Connectivity Challenges

This final section considers how people are modifying their behavior because of connectivity challenges. Findings from our interviews illustrate how NWT residents are creatively responding to issues they face; we contextualize these actions with reference to structural limitations (e.g., competing service providers; reliance on cloud-based services) present in remote regions. Consistent with O'Donnell and Beaton, NWT residents expressed a strong desire to access connectivity services. However, slow speeds, unreliable service, and expensive data caps led people to think twice about how they use the Internet. Many forgo Netflix or YouTube, or pay high data overage fees to use them. As a result, several people (e.g., P4, P10, P11) do not watch streaming videos. Interview participants also reported that pricey overage fees and data caps cause difficulties when accessing and using software such as cloud platforms or videoconferencing applications (see Figure 3). As one participant (P7) said, "Even if we started [a call] with video, we usually just ended up moving to chat." Other examples of modified behavior include pausing uploads before online meetings (P20), waiting until data caps allow for downloads and updates (P3), and leaving the computer on overnight to upload files (P12). As P11 noted: "It can take someone in Paulatuk three hours to upload a 20 Mb file." These experiences lead to one unfortunate response to access challenges: Some NWT residents told us they simply give up on certain applications, a significant outcome in regions that rely on them to access educational and professional opportunities, specialized health care, and online purchases.

A related practice is self-regulating uses of connectivity services. Some interview respondents react to pricey overage fees by monitoring their daily (sometimes hourly) data usage. P23 said, "I start to get very anxious when we're getting toward 85% [of our data cap]." Another participant (P19) stated, "I tried to get my children to be, you know, cognizant of the fact that it's [Internet] a very expensive thing here. So we've been trying to regulate [Internet use]" (P19). In some cases, residents will stop household Internet usage and wait until the end of the month before going online again. While unfortunate, these strategies illustrate the sophisticated ways that NWT residents attempt to mitigate the impacts of digital inequalities.

NWT residents have also developed innovative workarounds to try to address first-level digital divide challenges. For example, people told us they tether their mobile phones to computers to avoid overage fees on household services. As well, where possible, Northern residents attempt to increase access by setting up multiple household Internet connections. For two interview participants, it was cheaper to subscribe to a second household Internet connection from an alternative ISP than pay data overage fees charged by their primary ISP. As P11 said, "I had to have multiple connections because we've got data caps." However, the two participants who adopted this strategy were from Inuvik, where an alternative ISP is available; residents in smaller, remote NWT communities do not have this option. Where possible, some NWT residents are working to address limited and expensive bandwidth (albeit in a way that they must pay for). However, this points to higher levels of digital inequality (and more limited solutions) in smaller, more remote communities. Future research could explore these approaches further or see how they differ in various contexts (e.g., community size or location).

NWT residents are also innovating by adapting their uses of online applications to mitigate barriers of speed and cost. As a response to slow Internet and overage fees, many people use videoconferencing platforms for text-based chatting—but not for video. P14 explained, "With Skype, I have just given up all hope because every single time I log on, I have pixelated images or the images freeze." Instead, they use the networking features that these platforms provide (e.g., access to users) but connect using low-bandwidth features. Another participant (P12) described how they manually adjust network configurations: "[You] really get creative when you have these kinds of bandwidth problems...I'm sitting there, you know, tweaking quality of service settings on firewalls and running tests." A third participant (P11) noted they developed time-based workarounds: "We need to download this important Windows security patch. It's Friday at 2 p.m. I'm going to start it and leave for the day because it's not going to be done till the weekend's over." These solutions illustrate how frustrated Northerners are tinkering with network settings, application features, and time management to address challenges. This points to the willingness—and skill—of Northern residents in attempting technical solutions. It also illustrates how the promises of abundant e-health, online education, remote work, and Internet-based shopping in remote regions promoted by commercial telecommunications providers are in fact circumscribed by their own design choices and business practices. This presence of local innovation capacity in the face of problematic services suggests a path for alternative measures to address first-level digital divides in remote regions.

Conclusion

This study reported on first-level digital divide challenges that Northerners face and the creative ways they are working to address them. Our analysis provides an empirical contribution to the study of digital inequalities in remote and Northern contexts; importantly, it focuses on perspectives from residents of small, geographically dispersed communities often excluded from research. Our analysis validates and expands the paradox of telecommunications development in remote areas proposed by O'Donnell and Beaton (2018), arguing that it provides a useful framework to understand these issues. After investigating challenges faced by Northern residents, and their desires for increased access, we learned that people hold strong opinions about the inequities of first-level digital divides (e.g., expensive data caps, limited competition, restrictions on cloud services). This confirms prior studies that demonstrate slow speeds and high costs are main challenges in Northern Canada and points to a spiral of digital inequality that reflects the dynamic and interrelated nature of these challenges.

In the absence of adequate digital access, we also found that motivated individuals have adapted and innovated within their lived conditions, adjusting their behavior and responding to challenges they experience. While this demonstrates their agency and creativity, it also highlights the structural limitations they must contend with. Policy and technical solutions that reflect the conditions present in Northern and remote contexts, and more nuanced understandings of the spiral of digital inequality, are needed. In Canada, existing policies tend to focus on ensuring service availability through the provision of subsidies to (typically Southern, urban-based) commercial providers, and in some cases (such as in Northwestel's service area), setting tariffs for retail Internet (CRTC, 2013). Our research suggests these solutions are inadequate and, in fact, may entrench existing structural inequalities by failing to recognize the underlying problem of market failure and resulting competition for limited customers and funding. This situation can undermine cooperative efforts to connect communities—incentivizing parties to instead spend limited time and resources to secure resources in a zero-sum game that disempowers Northern residents. Another approach is required—one that disrupts the spiral of digital inequality that has arisen alongside the design choices and business practices of the telecommunications industry.

Locally oriented technology development initiatives provide a means for members of diverse communities to balance connectivity challenges with place-based innovations. For example, CNs involve communities in the deployment, ownership and control of digital infrastructures, services, and applications (Antoniadis, 2016; Belli, 2017; Song, Rey-Moreno, Esterhuysen, Jensen, & Navarro, 2018). CNs often emerge from necessity and reflect desires and experiences drawn from diverse local contexts. In remote regions, after initial capital investment and ongoing operational supports (the same supports that commercial organizations ask to receive in these contexts) nonprofits can reinvest any surplus revenue for activities such as deploying/updating infrastructure, improving quality of service, or lowering prices for users (Hudson & McMahon, 2021). In cases where capacity may not be in place to support a local or regional nonprofit service provider, organizations can partner with commercial providers tasked with building and managing services according to certain deployment requirements.

These kinds of efforts include a strong history of Indigenous-led initiatives in Mexico, Canada, the United States, and internationally, where CNs are positioned as a means for Indigenous Nations to exercise

their autonomy vis-à-vis technological developments. Many of these initiatives embody decision-making processes grounded in community life; they are strongly informed by governance practices tied to the stewardship of lands, resources, and knowledge (Duarte, 2017; McMahon et al., 2011). They also represent critical perspectives on digital forms of capitalism and colonization, as well as issues of intellectual property, language control and revitalization, and local content production and protection. This reflects calls from Global South scholars to reorient communication for development away from discourses and processes tied to modernization and technology transfer toward culture-centered (Dutta, 2020) and territory-centered (Hinojosa & Baca-Feldman, 2021) approaches. Such projects are guided by communal innovation (Reina-Rozo, 2019) and community informatics (Gurstein, 2012); two approaches that resist individualizing tendencies of technology development projects to refocus on collective approaches.

Overlapping contexts of places, communities, and infrastructures intersect in the co-creation of appropriate forms of digital development. In Canada, diverse Indigenous peoples living in remote Northern territories have led successful community development initiatives in various sectors—from local arts cooperatives and community radio stations to communal freezers that store food for sharing and distribution among community members. These initiatives range from a local fixed wireless network in Maskwacis, Alberta, to complex regional organizations such as K-Net services in Northern Ontario and Tamaani Internet in Nunavik (Carpenter, 2010; First Mile Connectivity Consortium [FMCC], 2018). Reflecting the passion and commitment of local innovators, they demonstrate ways to drive and sustain infrastructure deployment in areas with a limited case for private-sector investment, while retaining ownership and control of networks and services for the benefit of community members. In short, solutions to the spiral of digital inequality in Northern and remote regions can be found in projects led by the people living there.

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