BRIDGING THE DIGITAL DIVIDE TO SUPPORT COMMUNITY-BASED MONITORING IN THE CIRCUMPOLAR NORTH

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COMMUNITY-BASED MONITORING & TELECOMMUNICATION

Community-Based Monitoring (CBM) initiatives are being used more frequently throughout Canada to track, analyze, and respond to common community concerns, such as public health, environmental trends, and community development [1]. Particularly in the Circumpolar North, CBM is being promoted due its ability to recognize and respect the values, culture, and knowledge of local residents [2]. Many CBM programs in Canada are taking advantage of increasingly ubiquitous information and communication technologies (ICT) such as environmental sensors, cloud-based databases and processing centres, remote surveys, online services, and wireless communications to simplify the collection, analysis, and dissemination of data [3,4,5]. Unfortunately, not all regions have an equal opportunity to develop ICT-based CBM initiatives, as not all regions have equitable resources when it comes to telecommunication infrastructure and ICTs, a disparity known as *the Digital Divide* [6].

THE DIGITAL DIVIDE

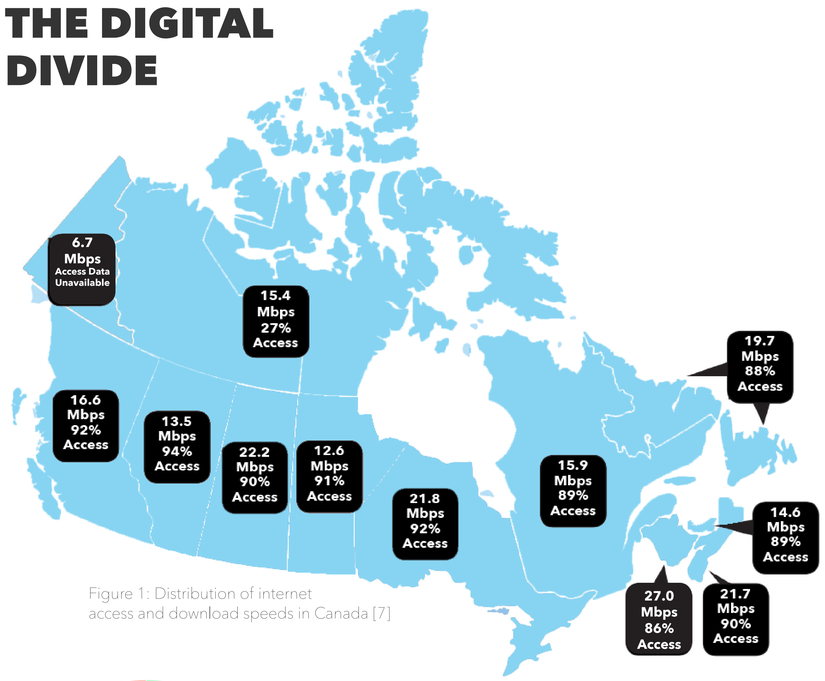

Figure 1: Distribution of internet access and download speeds in Canada [7]

Figure 2: Percentage of Canadians with high-speed access, and any access in rural and urban regions [7]

The Digital Divide in remote Northern communities is likely more pronounced than these provincial and territorial figures convey due to reduced competition between Internet Service Providers (ISP), higher costs of developing telecommunication infrastructures, and less economic incentives than most regions of Canada [8]. For example, the average download speed in St. John's is 29.5 Mbps, compared to 0.7 Mbps in Rigolet, Labrador [7]. A representative from the Kativik Regional Government, which encompasses most of the Nunavik region, described this disparity as "the difference between being remote and being isolated" [9].

Given the Digital Divide, there is a need to explore alternative ICT to improve connectivity in Northern communities, and in particular, to support CBM initiatives. One potential solution is a MANET (Figure 4). Here we explore specific challenges associated with traditional broadband networks (Figure 3), and how MANETs might address these challenges.

TRADITIONAL INTERNET NETWORKS

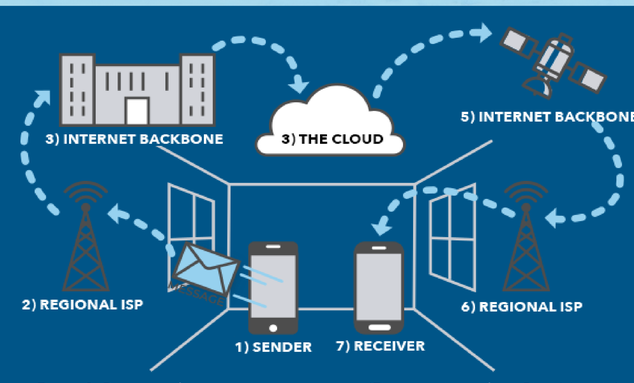

Figure 3: Diagram of standard internet network (Figure retrieved from RightMesh.io)

The modern internet is a global system of interconnected computer networks, in which the vast majority of routing is reliant on the internet backbone (See Figure 3), a large interconnected, hierarchical and centralized networks. Other than through the use of satellites, the backbone depends on broadband lines such as coaxial, fios or twisted cables.

MOBILE AD-HOC NETWORKS

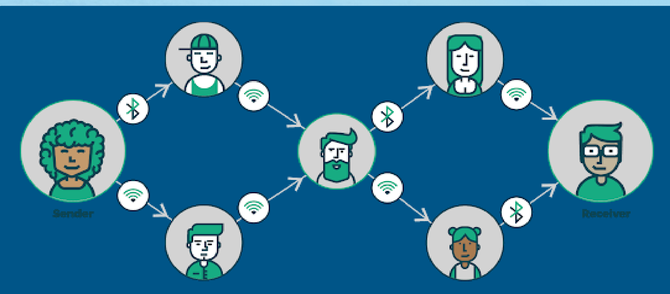

Figure 4: Diagram of mesh network, using WiFi and Bluetooth (Figure retrieved from RigthMesh.io)

A Mobile Ad-Hoc Network (MANET) is an infrastructure-less, peer-to-peer, wireless, mesh network of mobile devices. Like other mesh networks, they are decentralized and include redundant network paths. Unlike other mesh networks, MANETs are robust, extendable and self-healing, meaning devices are able to move freely without manual configurations [10].

CURRENT PITFALLS FROM THE DIGITAL DIVIDE IN REMOTE REGIONS

Ridgid Network & Poor Coverage
High costs of infrastructure maintenance and development can leave some regions outside of broadband range [6].

Low Bandwidth
Even when internet access is available, long distance cables often suffer from extremely low data-throughput [6].

Sporadic Connectivity
Connectivity can sometimes be sporadic due to weather, increased network traffic, or infrastructure issues [6].

No Local Communication
Many regions lack access to cellular towers, meaning local communication is only available from home networks.

POTENTIAL ADVANTAGES OF MESH NETWORKS IN REMOTE REGIONS

Robust & Extendable Network
With a sufficient device distribution, a MANET could potentially cover an entire community, cost-free [10].

Local Network & Data Sharing
Properly positioned servers could store and serve data, and host websites and apps, reducing broadband reliance.

Stable & Self-Healing
Self-configuring MANETs could route existing networks more efficiently, and provide a backup local network [10].

Seamless Local Communication
Given a sufficient device distribution over time, there is potential for seamless texting within a community.

TESTING THE BRIDGE: UNDERSTANDING THE KEY VARIABLES

MANETs won't allow for internet access without an existing connection to a broadband network, and they won't close the Digital Divide. They do, however, show promise in providing a bridge that some communities may be able to use to mitigate its effects and to support their CBM efforts. To evaluate the use of MANETs within a community, it is necessary to collect and analyze the following datasets;

- **Geospatial Data of Broadband Costs**
- **Geospatial Time Series of Download Speeds**
- **Geospatial Data of ICT Device Distribution**
- **Evaluation of MANET Characteristics**

By collecting and combining all of these data in a respective region, we can begin to evaluate the utility of a MANET and understand; how it might support existing internet bandwidth and coverage, how stable and complete a local network will be, if introducing a MANET is viable. The data could also be used to further optimize the network and other CBM initiatives such as the number and placement of local servers and routers, or when best to cache and transfer data. Ultimately while much data is still required to truly evaluate the applications of a Mobile Ad-hoc Network, this preliminary research seems to indicate that local networks can be tailored to specific situations to support CBM in the Circumpolar North.

References:

[1] Whitelaw, G., Vaughan, H., Craig, B., & Atkinson, D. (2003). Establishing the Canadian community monitoring network. Environmental Monitoring and Assessment, 88(1-3), 409-418. http://doi.org/10.1023/A:1025545813057 **[2]** Kouril, D., Furgal, C., & Whillans, T. (2016). Trends and key elements in community-based monitoring: a systematic review of the literature with an emphasis on Arctic and Subarctic regions. Environmental Reviews, 24(2), 151-163. http://doi.org/10.1139/er-2015-0041 **[3]** Carpenter Penny Beaton, Brian. Digital technology innovations in education in remote first nations. in education, 22(1):42–60, 2016. **[4]** McMahon R. Hudson E. Williams D. Whiteduck T. ODonnell S., Beaton B. Digital Technology Adoption in Remote and Northern Indigenous Communities in Canada. Sociological Association, University of Calgary, 2016. **[5]** George C. Beaton B. Peter-Paul S. Perley D., ODonnell S. Supporting Indigenous Lan- guage and Cultural Resurgence with Digital Technologies, journal = Mikmaq Wolasto- qey Centre. University of New Brunswick, year = 2016.. **[6]** Smith R. Walmark B. Beaton B. Simmonds J. McMahon R., ODonnell S. Digital Divides and the First Mile: Framing First Nations Broadband Development in Canada. The International Indigenous Policy Journal, 2(2), 2011. **[7]** Canadian Internet Registration Authority (2018, March). CANADA'S INTERNET FACTBOOK 2018. Retrieved from https://cira.ca/factbook/canada%E2%80%99s-internet-factbook-2018. Last accessed December 6, 2018. **[8]** Canadian Radio-Television and Telecommunications Commission (2017b, November 9) What you should know about Internet speeds. Retrieved from https://crtc.gc.ca/eng/Internet/performance.htm. Last accessed February 27, 2018. **[9]** Kilpatrick, S. (March 24, 2017) CRTC faces hard truths about Internet access in Canada's North. The Globe and Mail **[10]** Akyildiz, F., Wang, X., Wang, W. (2005). Wireless mesh networks: a survey. Computer networks, 47(4), 445-487.

Acknowledgments:

We recognize that our research takes place in the ancestral and treaty lands of several Indigenous peoples. We recognize that the University of Guelph resides on the ancestral land of the Attawandaron people and the treaty land of the Mississaugas of the Credit, and we recognize the significance of the Dish with One Spoon Covenant to this land and offer our respect to our Anishinaabe, Haudenosaunee and Métis neighbours. We also recognize the original people of Labrador: the Inuit of Nunatsiavut, the Inuit of NunatuKavut, the Innu of Nitassinan, and their ancestors. We continue to strive to strengthen our relationships with our Indigenous neighbours and with the land that sustains us, as we build lasting partnerships that respect, honour, and value the culture, traditions, and wisdom of those who have lived here since time immemorial. This research has been partially funded through the Canadian Internet Registration Authority's Community Investment Program, The Northern Scientific Training Program and MITACs Accelerate.