Analyzing Broadband Reliability

Insights from Alaskan Arctic Communities

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Intro

Acknowledgment

- Data was collected as part of the Telehealth Broadband Pilot (TBP) Program, which “analyzed broadband capacity in four state communities: Alaska, Michigan, Texas, and West Virginia.”
- The Alaskan component of this research was supported by the Alaska Native Tribal Health Consortium (ANTHC) which deployed Raspberry Pi devices in Alaska Native community healthcare facilities and other anchor institutions across the state.
- The software on these devices was developed by Exactly Labs, and collects client speed tests (both Ookla Speedtests and Measurement Lab’s Network Diagnostic Tests (NDT7) multiple times a day) in addition to other metadata.

Alaskan Infrastructure

Early History of Govt Leadership

- **1904:** Washington-Alaska Military Cable and Telegraph System (WAMCATS)
- **1950s:** Alaska Communications System (ACS) builds out early warning system
- **1969:** ACS is sold to the RCA Corporation as RCA Alscom and the Applied Technology Satellite 1 (ATS-1) project connects AK villages.
- **1974:** Applied Technology Satellite 1 (ATS-6) project brings early telemedicine
- **1979:** Founding of GCI and Learn Alaska network provides educational distance programming
- **1998:** Alaska Communications Systems (ACS) formed as a private company.

FCC Broadband Map

Figure 3: Screenshot of FCC Broadband Map (June 2023)

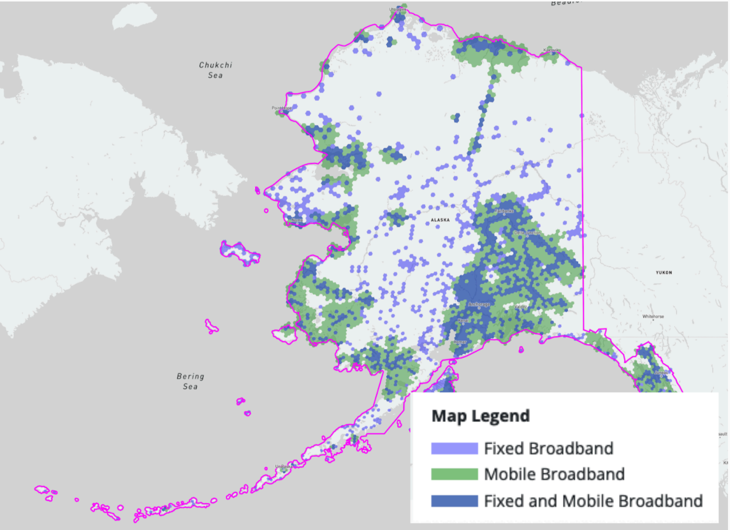


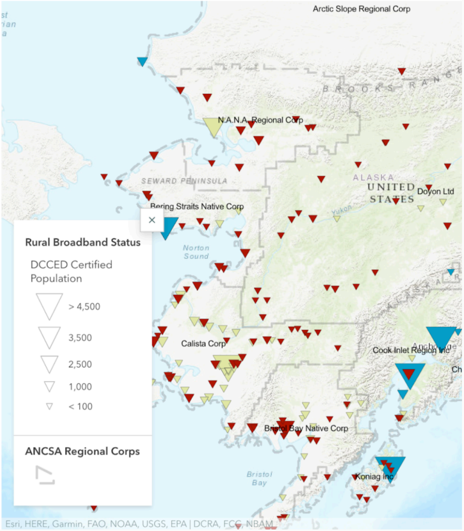
Figure 2: Unserved and Underserved Rural Communities in Alaska

Unserved and Underserved Rural Communities

Data synthesized from FCC Form 477 and DCCED certified population count.

- > 100 Mbps Down, 20 Mbps Up
- Underserved (greater than 25 Mbps Down, 3 Mbps Up)
- Unserved (less than 25 Mbps Down, 3 Mbps Up)

Legend for service levels.



State Infrastructure

Figure 3: Alaskan Broadband Map: Governor's Broadband Report(2021)

Alaskan Infrastructure Projects

- **2017:** Quintillion activates submarine cable trunk from Nome to Prudhoe Bay with a terrestrial connection to Fairbanks.
- **2017:** GCI completes microwave broadband "Terrestrial for Every Rural Region in Alaska" (TERRA) network, a 3,300 mile loop around Southeastern Alaska.
- **2020:** Matanuska Telephone Association (MTA) completes first overland fiber backbone from Fairbanks to the Lower 48.
- **2021:** Alaska Communications partners with OneWeb to provide satellite internet
- **2021:** A GCI fiber line is extended from Kodiak Island to Unalaska.
- **2021:** Completion of Quintillion-ATLAS ground station, at 72 degrees, this is the highest-latitude satellite ground station in the US bridging satellite and fiber networks.
- **2022:** Starlink provides high-speed satellite internet in Alaska.

Recent Academic Literature

Critical Literature

- **MacMillion et al. (2023)** described the difference between Ookla and NDT7 which measure ”slightly different phenomena.” [3]
- **Gill et al. (2022)** reintroduce M-Lab and discuss bias issues with M-Lab data on both the server and client side. [2]
- **Clark and Wedeman (2021)** differentiate between appropriate and inappropriate use of M-Lab data. [1]
- **Paul et al (2022)** describes the importance of contextualizing Ookla and M-Lab data with speed tiers.[5]
- **Paul et al. (2021)** finds “statistically significant differences in performance between Speedtest users in urban and rural areas” [4]

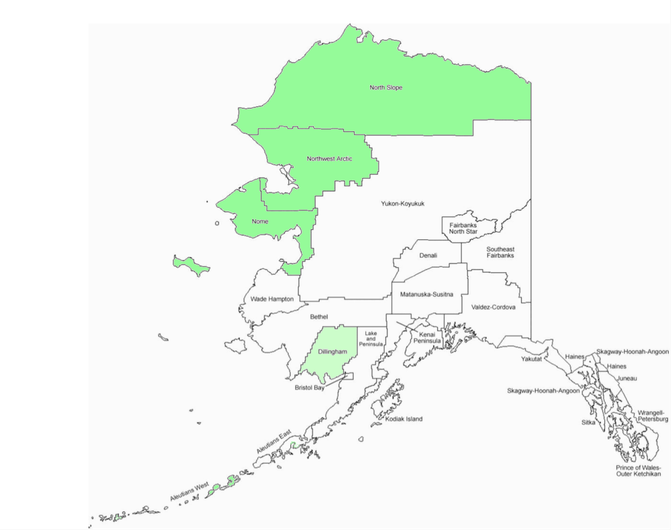
Methodology

Overcoming challenges from the literature

- Collecting both NDT7 and Ookla data: Ability to compare competing metrics
- Daily measurements: Reduce time selection
- Raspberry Pis across all locations: Reduce client side bias

Sampling Areas Selected for Analysis

Figure 4: A map of selected borough and census areas in Alaska



Descriptive Statistics of Analyzed Measurements

Table 2: Descriptive Statistics of Analyzed Measurements (1/3)

	No.	Perc.
Total Measurements	91,906	100%
Measurement Frameworks		
Ookla	47592	52%
NDT7	44314	48%

Descriptive Statistics of Analyzed Measurements

Table 2: Descriptive Statistics of Analyzed Measurements (2/3)

ISPs		
Alaska Communications Systems Group, Inc.	5891	6%
Cogent Communications Holdings, Inc.	13201	14%
GCI Communication Corp.	72249	79%
Starlink Services, LLC	552	1%
Viasat, Inc.	13	0%

Descriptive Statistics of Analyzed Measurements

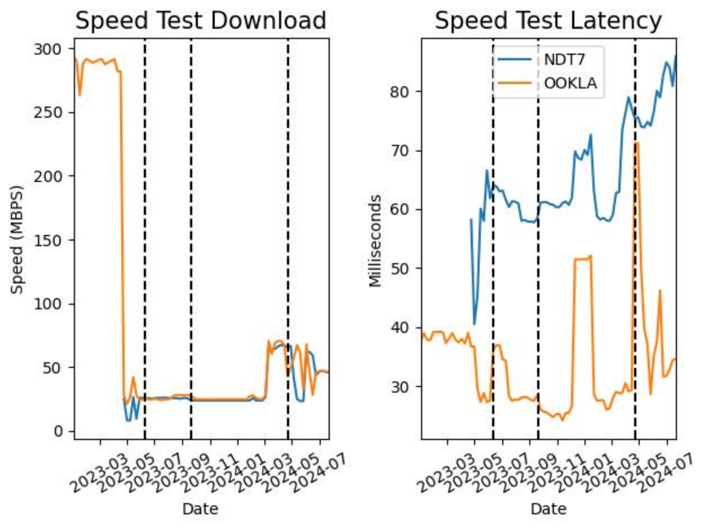
Table 2: Descriptive Statistics of Analyzed Measurements (3/3)

Boroughs and Census Areas		
Aleutians West Census Area	44925	49%
Nome	19887	22%
Unorganized Borough	18692	20%
Northwest Arctic Borough	8340	9%
North Slope	62	0%

Findings

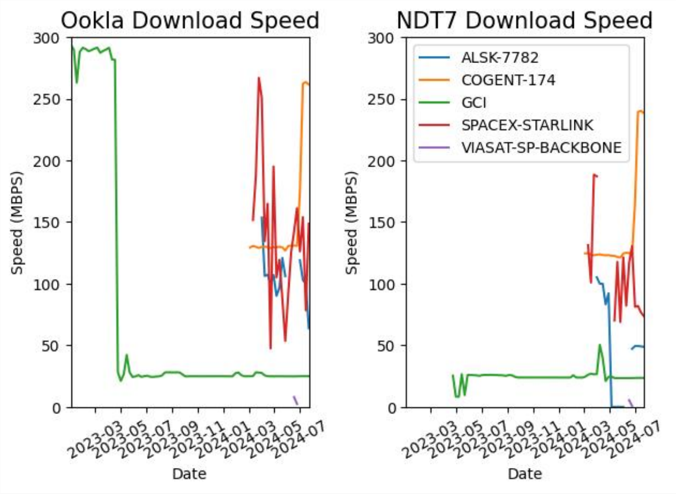
Speed Tests

Figure 5: Comparison of Ookla and NDT7 Download and Latency Speeds



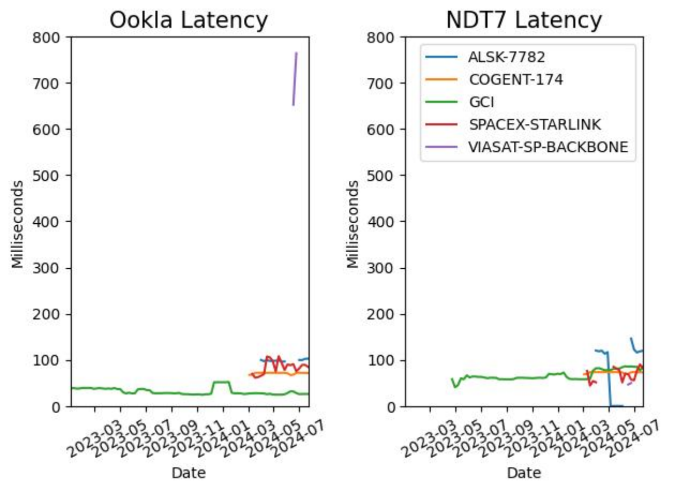
Comparison of ISPs based on ASN Names (1/2)

Figure 6: Comparison of NDT7 Download and Latency Speeds for Different ISPs



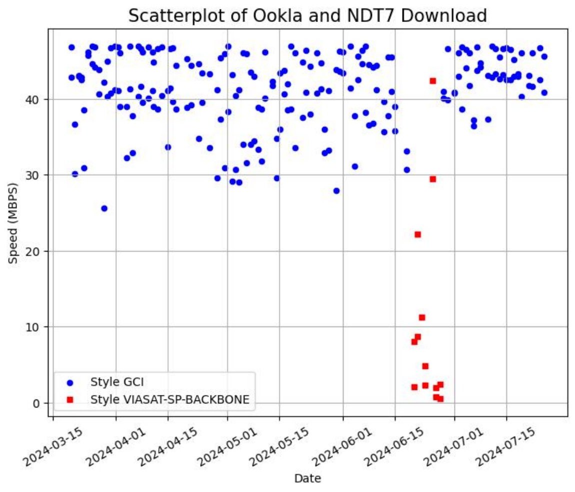
Comparison of ISPs based on ASN Names (2/2)

Figure 7: Comparison of NDT7 Download and Latency Speeds for Different ISPs



Failover from one ISP to Another

Figure 8: Scatter-plot of Download Speed measurements reported from the Noatak Clinic.



Client Locations (1/3)

Figure 9: Comparison of Median Weekly Download Speed measurements reported by 28 Clinics.

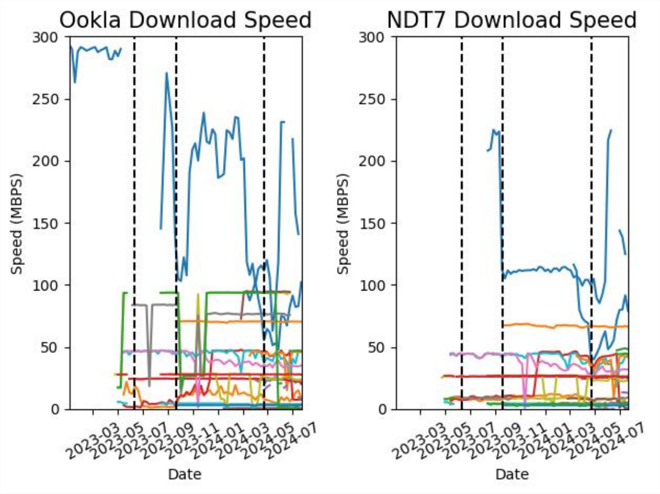


Figure 10: Comparison of Median Weekly Upload Speed measurements reported by 28 Clinics.

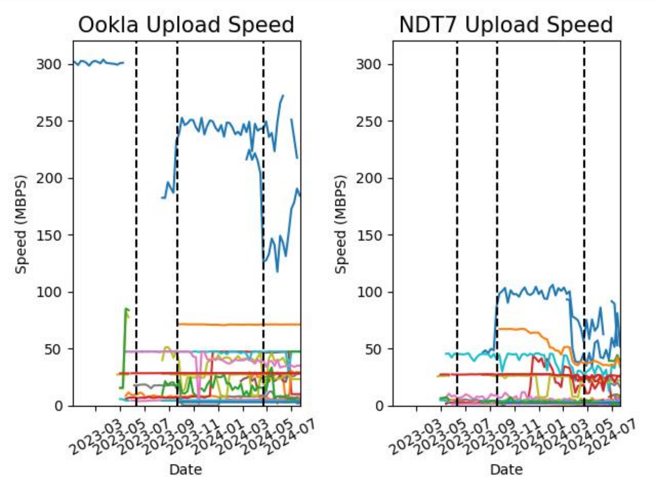
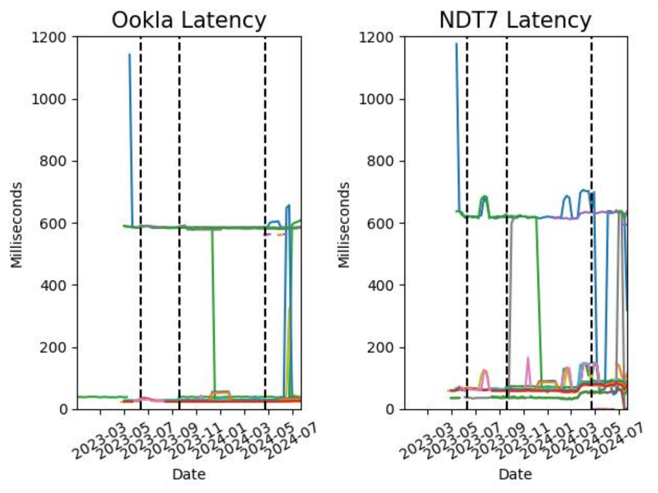
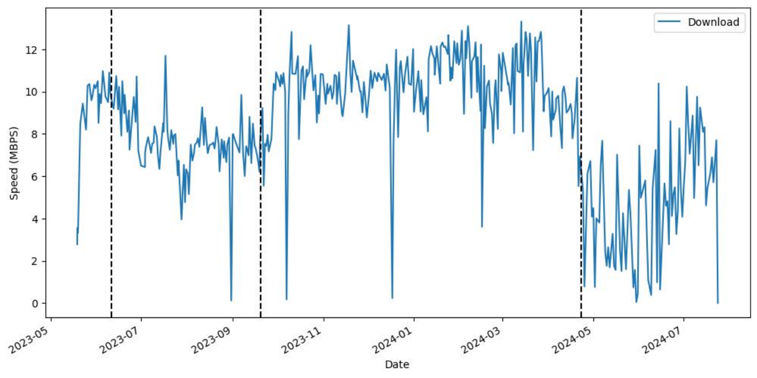


Figure 11: Comparison of Median Weekly Latency measurements reported by 28 Clinics.



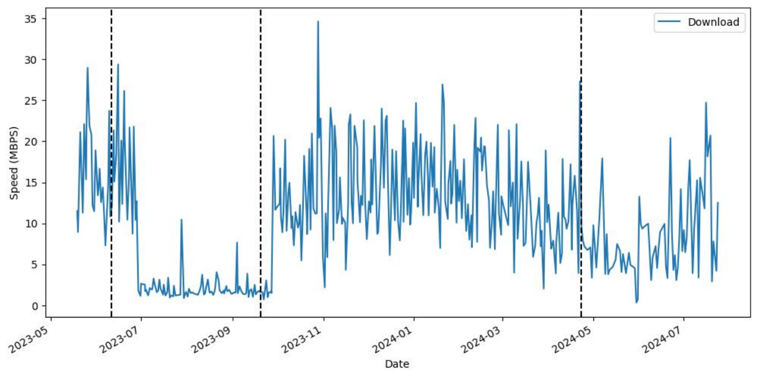
Modeling Disruptions

Figure 12: Time Series of NDT7 Downloads Speeds for the Ambler Clinic



Modeling Disruptions

Figure 13: Time Series of Ookla Downloads Speeds for the Ambler Clinic



Conclusion

Compelling Findings

- Serious latency issues in targeted clinics that make teleconferencing inviable.
- Significant infrastructure disruptions can slow downloads speeds and increase latency
- Some clinics showed redundant ISP subscriptions for both terrestrial and satellite broadband taxing small clinic budgets.
- The presence of failover when existing ISP solutions are unavailable providing potential resilience.

Sharing Code

Get the code used for this project and presentation at:

`github.com/kgrindal/arctic_resilience`

Slide deck theme developed in LaTeX
by Matthias Vogelgesang.

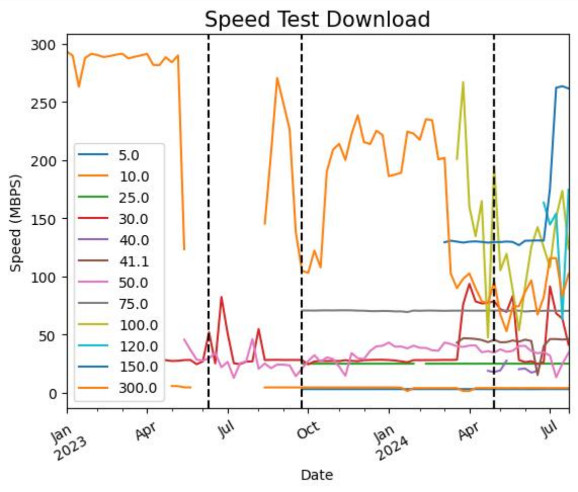
My Questions for TPRC

- What might be some explanations for the 600 milliseconds of latency seen by specific GCI clients? Any suggestions to confirm these hypothesis?
- Given the challenges of grouping across varied speed tiers and latency distributions, how might we better compare boroughs and ISPs?
- Are there specific articles you'd recommend that might inform this research agenda?
- Do you have suggestions for additional approaches to analyze this data, that would help us convey more compelling stories?

Questions?

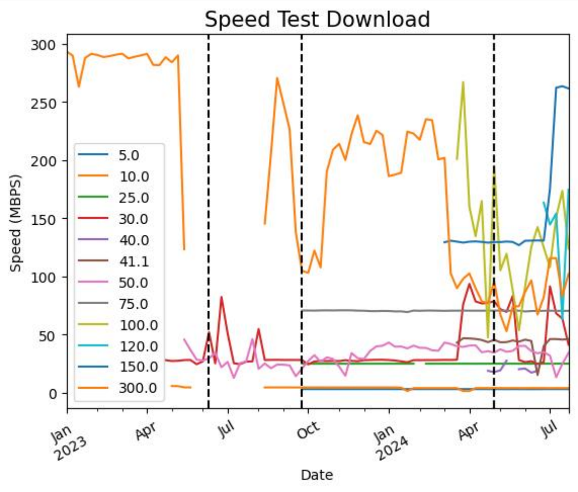
Tiers (1/4)

Figure A1.1: Comparison Speed Tier Lists of Median Weekly NDT7 Download Speeds



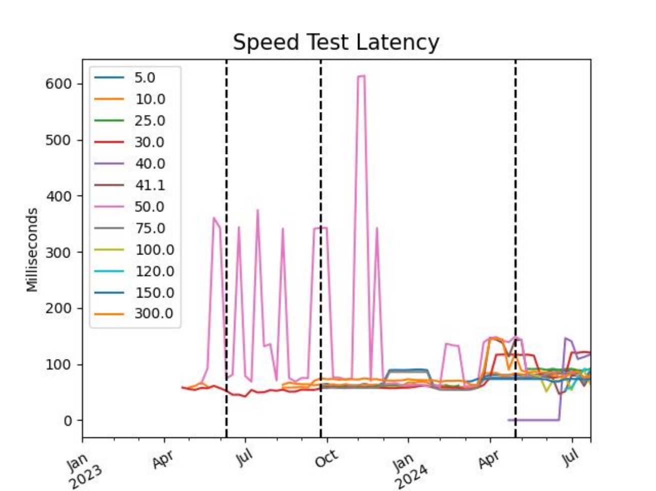
Tiers (2/4)

Figure A1.2: Comparison Speed Tier Lists of Median Weekly Ookla Download Speeds



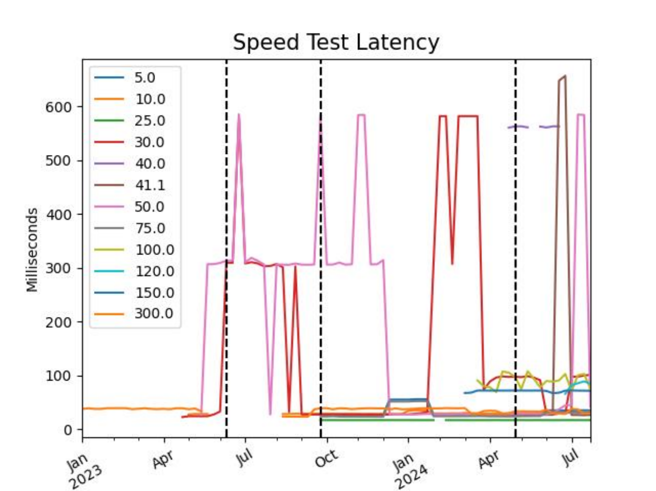
Tiers (3/4)

Figure A1.3: Comparison Speed Tier Lists of Median Weekly NDT7 Latency



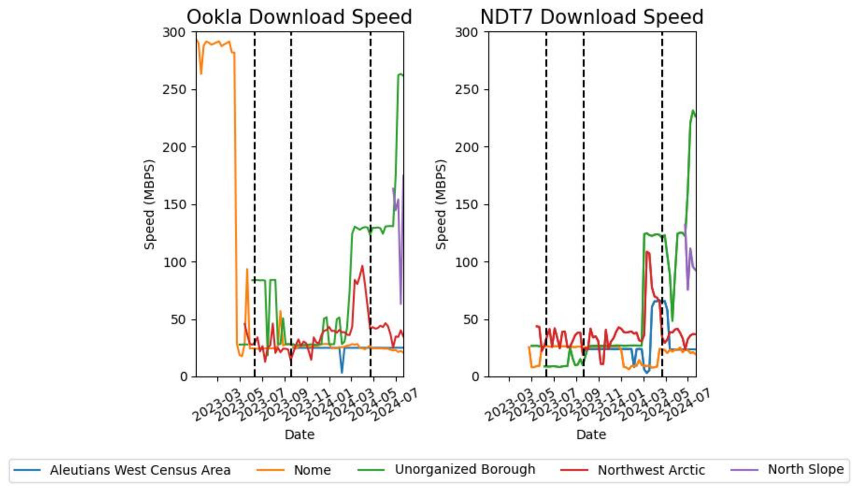
Tiers (4/4)

Figure A1.4: Comparison Speed Tier Lists of Median Weekly Ookla Latency



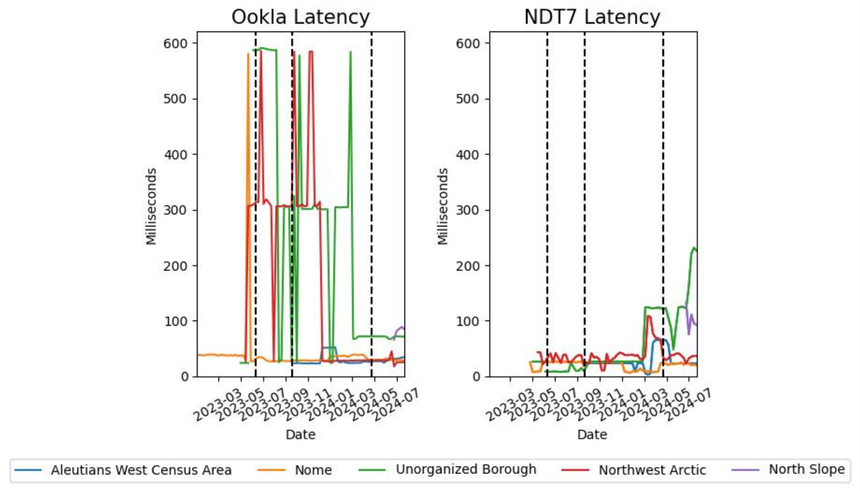
Regions (4/2)

Figure A2.1: Comparison of Median Weekly Latency measurements reported by region



Regions (2/2)

Figure A2.2: Comparison of Median Weekly Latency measurements reported by region



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