KITSAP TRANSIT DIGITAL INCLUSION PROJECT

CASE STUDY REPORT

Autumn 2021 | 460 Planning in Context | Sanjay Bhatt

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Introduction

We would like to preface this report with a big thank you to Sanjay Bhatt, Kitsap Transit, BI Ride drivers, and our professors and peers from CEP 460. Our work and findings were made possible through the support given by each of these parties.

A little bit about us as a group-- as students in the Community, Environment, and Planning program, we set out to accomplish this work and the obligations attached to it as part of our core course for Fall of 2021, "Planning in Context". We each had different strengths and areas of expertise that helped us in the course of our research, among them QGis mapping, an interest in transportation planning, and equitable policy-making.

The project at hand and its associated deliverables were unique in how they integrated the importance of reliable and effective transportation, digital inclusion, and identifying areas of importance through real-time data collection. In an effort to increase public transit ridership and subsequently see greenhouse gas reduction targets get met, Bainbridge Island is transitioning their BI-Ride curb-to-curb bus service to a system run on an app not unlike Uber, but for hailing buses. However, poor cell coverage and high latency found in various parts of the island can drastically affect user experience and dissuade those who may be interested in utilizing such a service.

Digital technology and transit can work hand in hand to make public transit more accessible, usable, and efficient. In fact, *Metro Magazine* notes that with the pandemic, "the demand for contactless and distanced operations is becoming a norm"[1]. E-ticketing and mobile

[1] Katsarov, M. (2021, March 10). *5 Ways Tech Will Transform Public Transit in 2021*. Metro Magazine, https://www.metro-magazine.com/10138405/5-ways-tech-will-transform-public-transit-in-2021.

apps, whether those of a transit agency or apps like OneBusAway are also tools in increasing ridership and improving the experience of those using public transit.

Audience and Client

Our client was the Marketing and Public Information Director of Kitsap Transit, Mr. Sanjay Bhatt. Sanjay was very accommodating towards our group, some days contacting BI Ride bus drivers in advance to let them know of our trip to the island. In addition, through our weekly team meetings with Sanjay, we were able to clarify objectives and update him on our progress. Throughout the process with Mr. Bhatt, he also gave us valuable insight on our questions, methods of data analysis and presentation, and contacts who may be helpful.

The intended audience of this project wouldn't be much different from the stakeholders at play currently: Telecommunications companies, developers, the FCC, the city of Bainbridge, and most importantly, people who live in Bainbridge Island who are more likely to be transit dependent, like seniors for instance. They are among one of the demographics of interest, with over-65s constituting just under a quarter of Bainbridge's population[2]. Moreover, roughly 8.8% of residents make 200% of the federal poverty line or less.[3]

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[2] United States Census Bureau. (2019). *Age and Sex*. Explore Census Data, https://data.census.gov/cedsci/table?q=Age+and+Sex&g=1400000US53035090700%2C53035090800%2C53035091000.

[3] United States Census Bureau. (2019). *Poverty Status in the Past 12 Months*. Explore Census Data, https://data.census.gov/cedsci/table?q=Poverty&g=1400000US53035090700%2C53035090800%2C53035091000&tid=ACSST5Y2019.S1701.

Methodology

To try to best account for variability, our group used 5 different phone models with 3 different carriers, the most common being AT&T, followed by T-Mobile and Verizon. Then, the metrics of upload speed, download speed, latency, and jitter were chosen, with the former three being compared to the accepted FCC standards for "advanced telecommunications abilities." Those standards are 25 Mbps for download, 3 Mbps for upload, and 64 ms for latency.[4] In order to take these measurements, the FCC Speed Test app was used by every device for all tests. This was beneficial for the credibility of our results because this app is a recognized method to collect standardized data, and is how the FCC encourages the public to test their network performance.

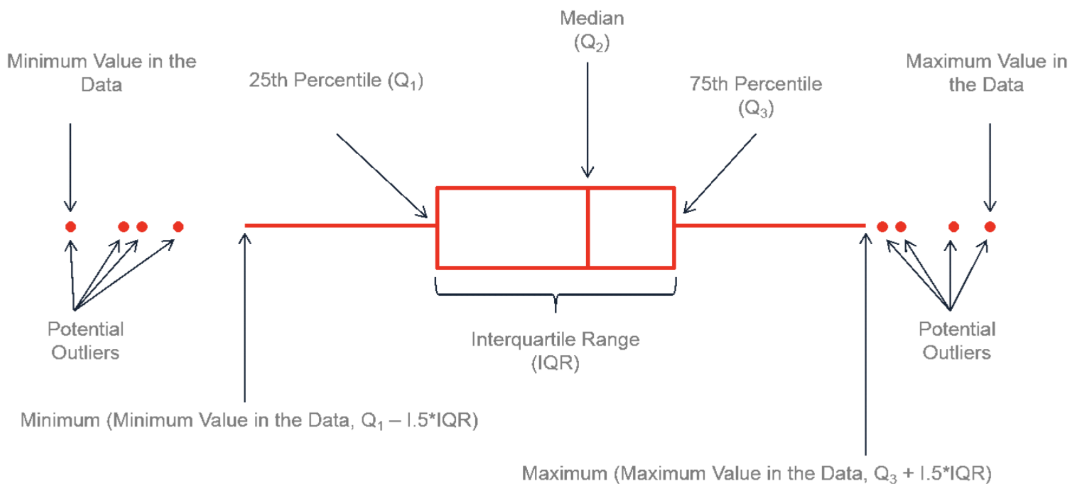
For transportation around the Island; a combination of personal cars, BI Ride buses, and walking were used to move from location to location while testing. Personal cars were helpful because they provided a shorter overall travel time between locations and allowed more control and flexibility for the trips to Bainbridge Island. The use of the BI Ride buses was great for better personal experience with the service; as well as providing further information for our project. The use of this combination of transportation methods was beneficial in the data collection process because it was the most time efficient while collecting all the data.

[4] U.S. Congressional Research Service. The Digital Divide: What Is It, Where Is It, and Federal Assistance Programs (R46613; Mar. 9, 2021, by Colby Leigh Rachfal.

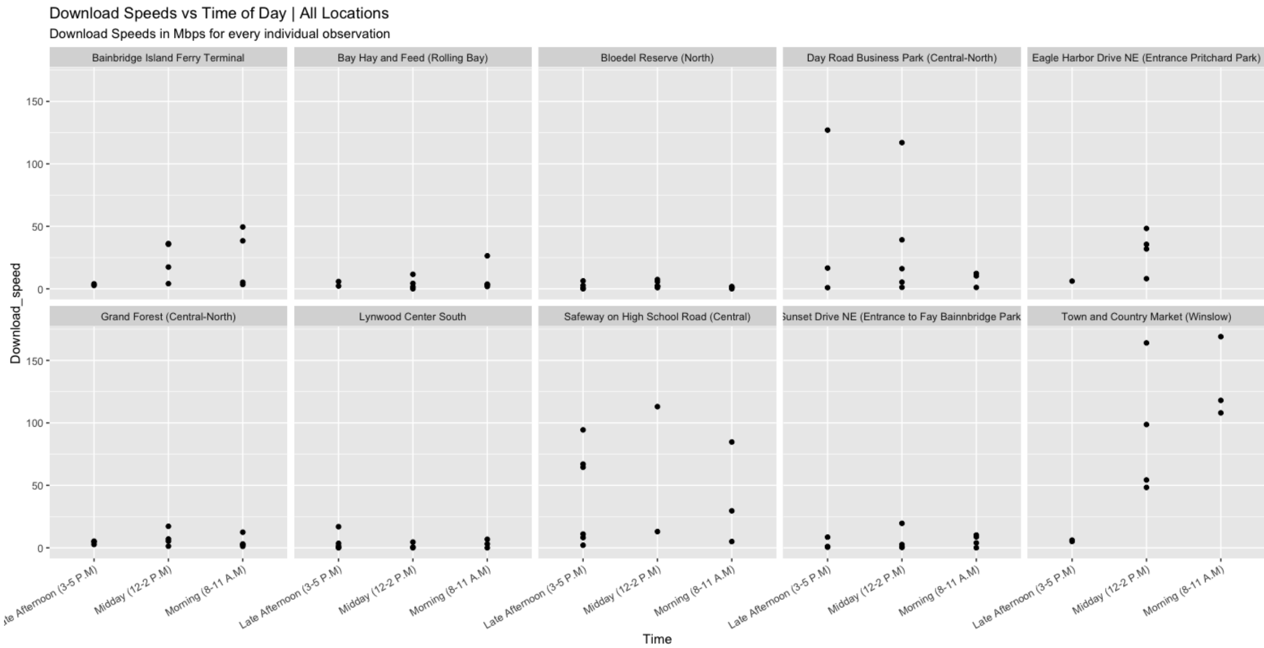
Data Findings and Charts

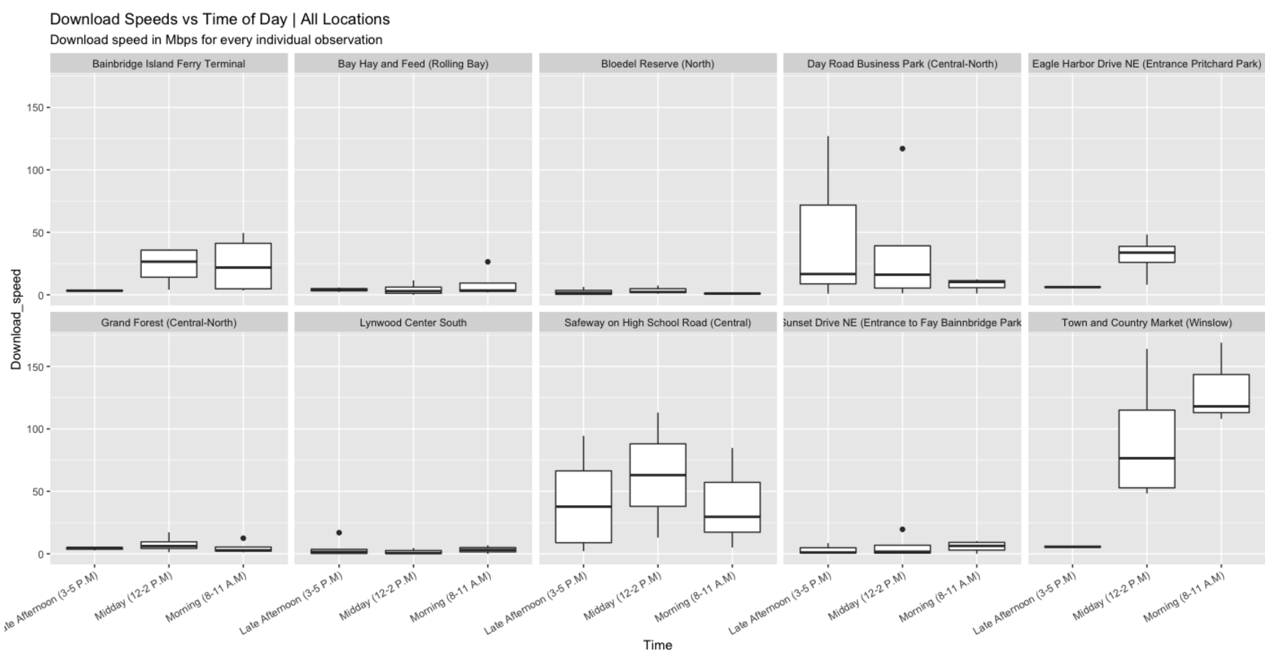
The first four graphs in this report show the Time of Day as the constant and hold download speed and upload speed as the variable across all locations. The next set is the same but instead differentiates by carrier type across all locations. The last few is an investigation on our subjective evaluations of the Ride BI and Pingo apps and if there is a correlation between our evaluations to certain average speeds.

The graphs below emphasise **download speeds at each time of day for every location.** It is shown in two ways: dot plot to highlight data at every individual observation taken at each location and a box plot, which summarizes information of the box plot into median speeds (thick black line), maximum (top line of box), minimum (bottom line of box), 25th percentile (bottom box), 75th percentile (top box), as well as outliers. These two diagram types were chosen because they can visualize in direct terms (dot plot) and also in a summarized format (box plot). A box plot explanation diagram is included below for further clarity:

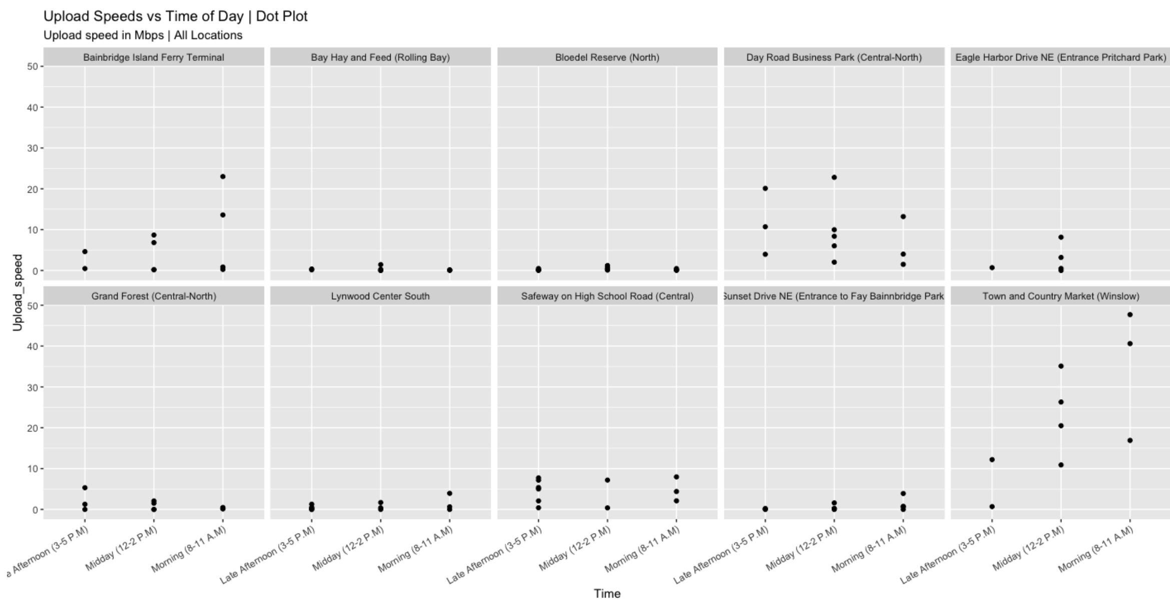


Overall, the **ferry terminal, Day Road Business Park, Safeway on High School Road, and Town and Country Market** were the only locations performing better than the average FCC



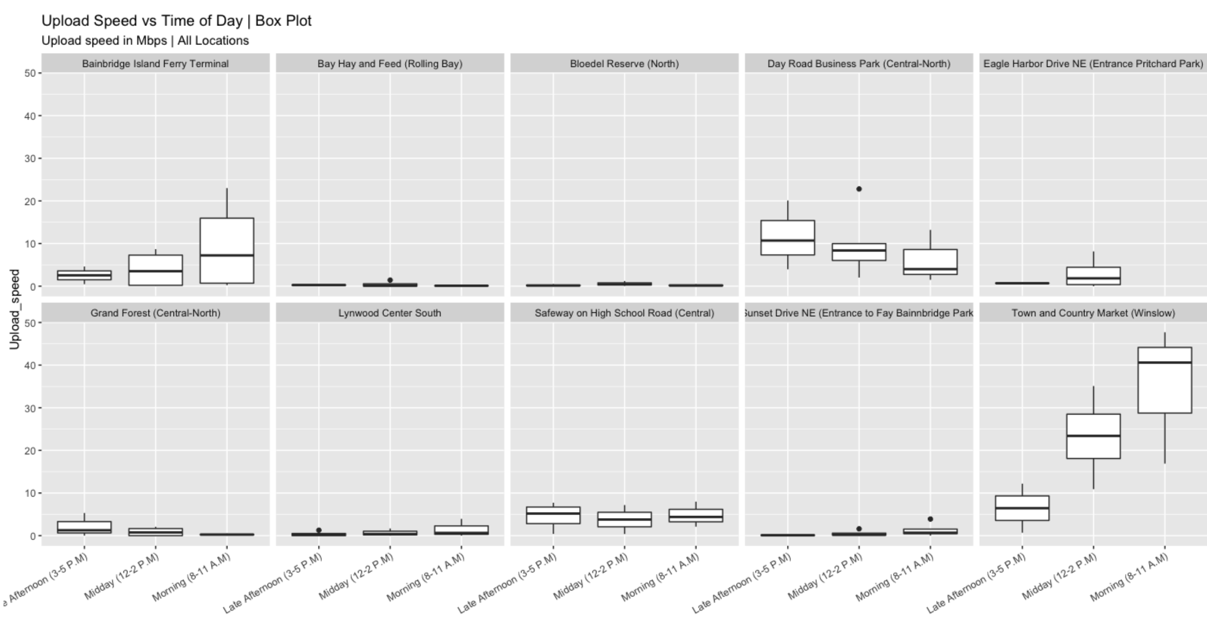


standards, which is 25 Mbps. On the same note, **midday hours have the best overall download speeds at all locations based on the high positioning of its box plots on all locations.** This indicates higher distribution of data towards higher download speeds, but most locations remain at 25 Mbps or lower, which according to our graphs on user evaluations on speeds, doesn't meet a

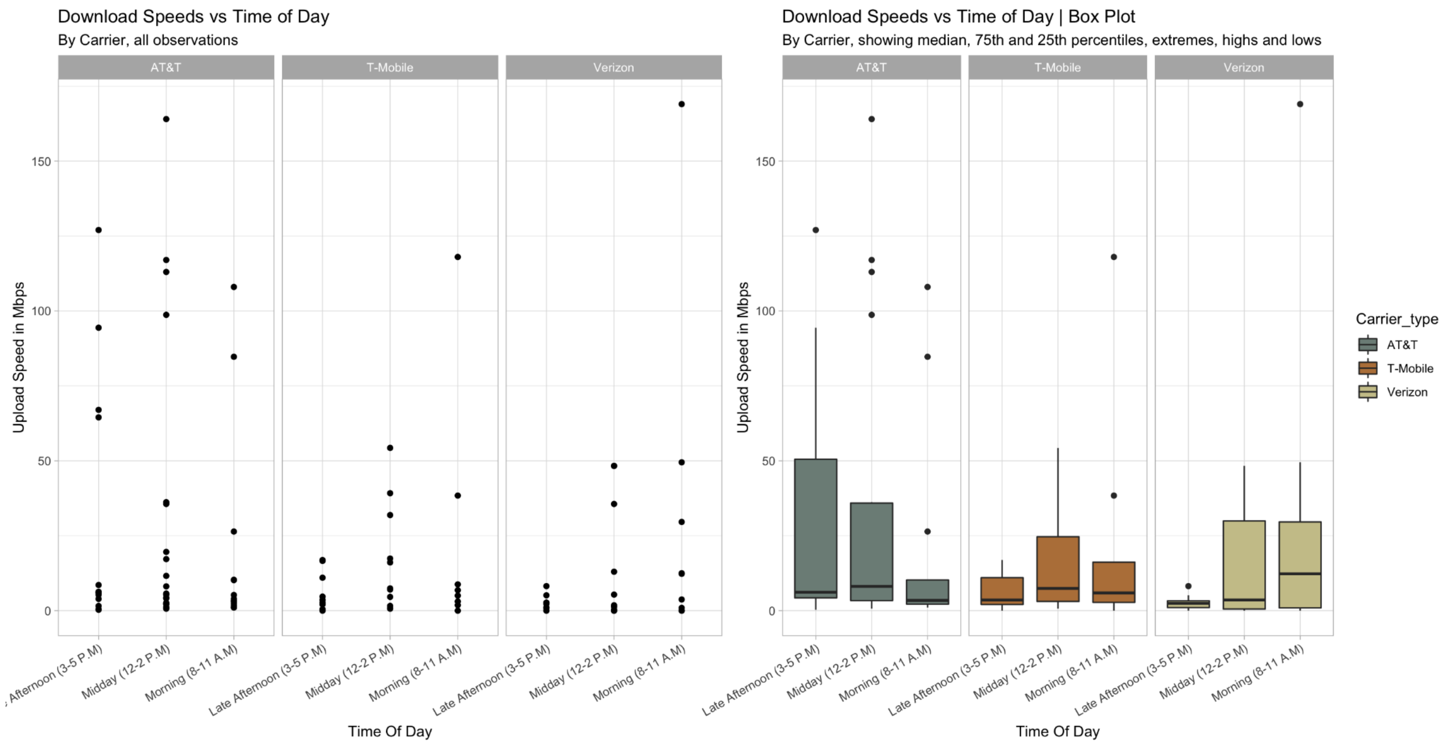


high usability score of the Ride BI and Pingo apps (more info on this later).

The next set of graphs are set up the same way, except now look into upload speeds. **The terminal, Day Road, and Market overall performed the best upload speeds throughout the day with generally at or below the FCC upload standard of 10 ms.** Usability evaluations



suggests that FCC standards are mostly met here, with the number of high evaluations over ⅗ and their corresponding averages, averaging to about 10 ms.



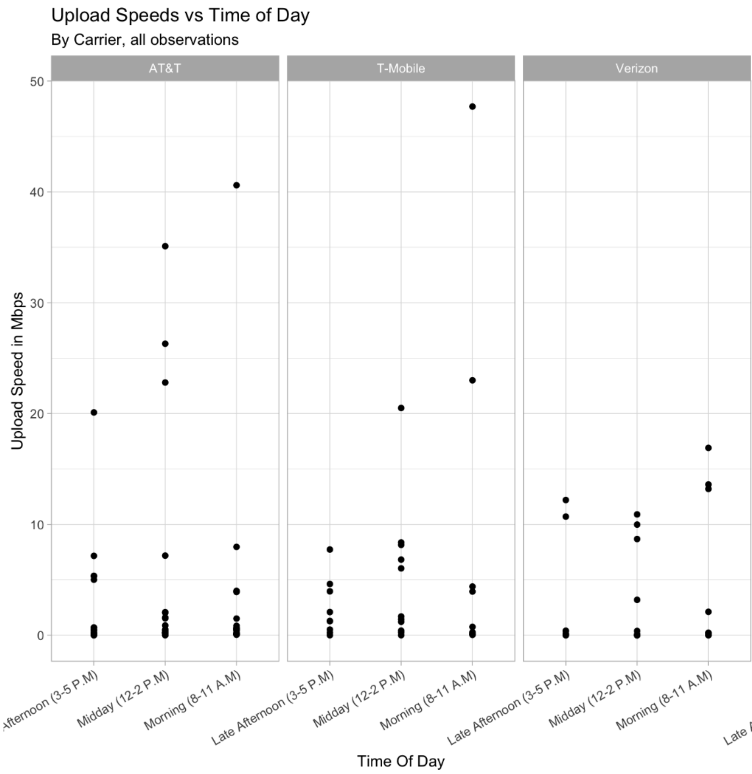
What is shows:

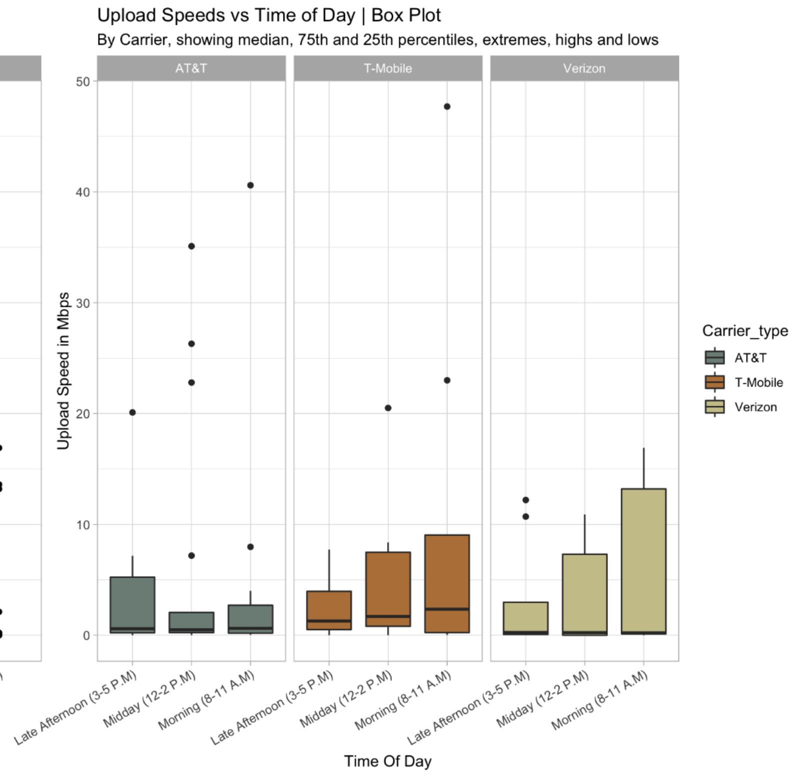
- Side dot and box plot, same y-axis scale, separated into carriers
- Dot plot shows all observations
- Box plot is color differentiated for visibility

Main takeaways:

- Download speeds for AT&T are the highest across all three carriers
- Median speeds are near FCC minimum of 10ms, which is barely usable
- AT&T shows the best speeds Midday to Late Afternoon
- Majority of observations near are close to the FCC minimum

Upload Speeds vs Time of Day





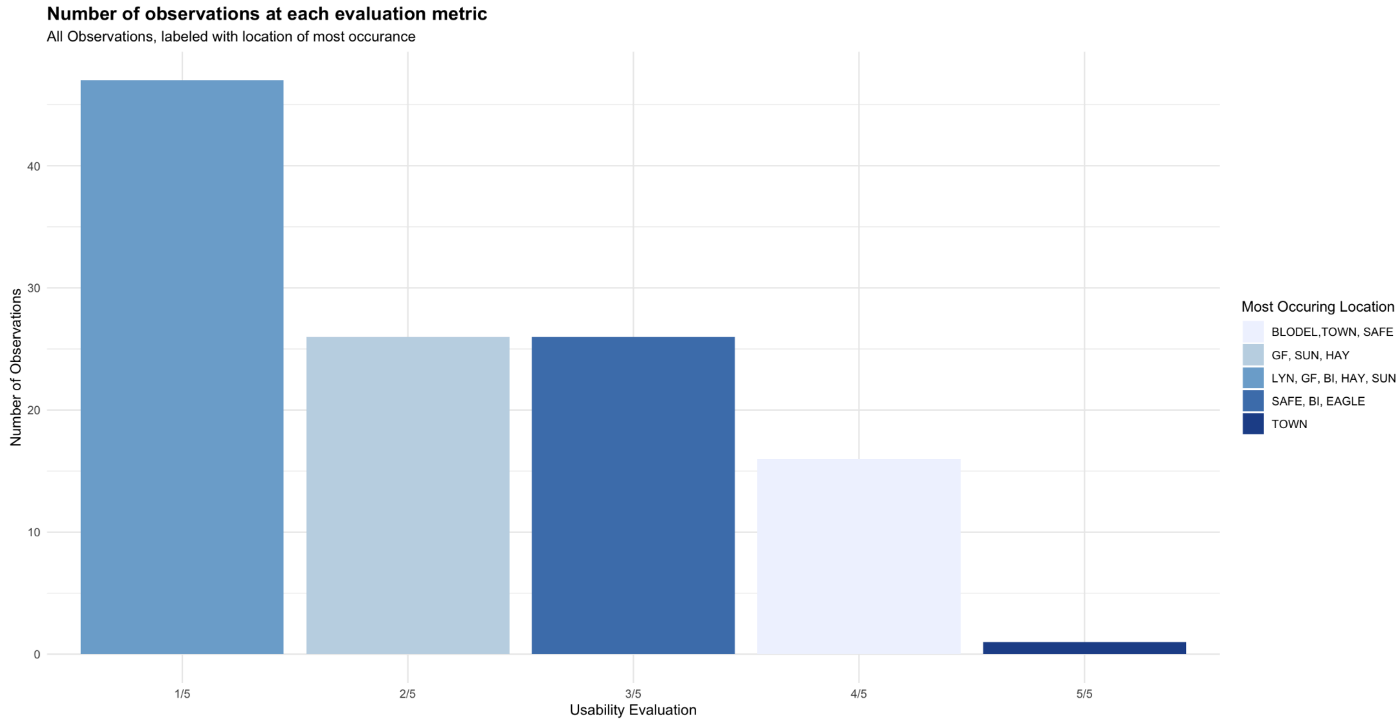
What is shows:

- Side dot and box plot, same y-axis scale, separated into carriers
- Dot plot shows all observations
- Box plot is color differentiated for visibility

Main takeaways:

- Median upload speeds are near FCC minimum of 10ms, which is barely usable
- Across all carriers, midday times show the most consistent speeds over 10ms
- Majority of observations near are close to the FCC minimum

Identifying where the concentration of each evaluations are, and how many

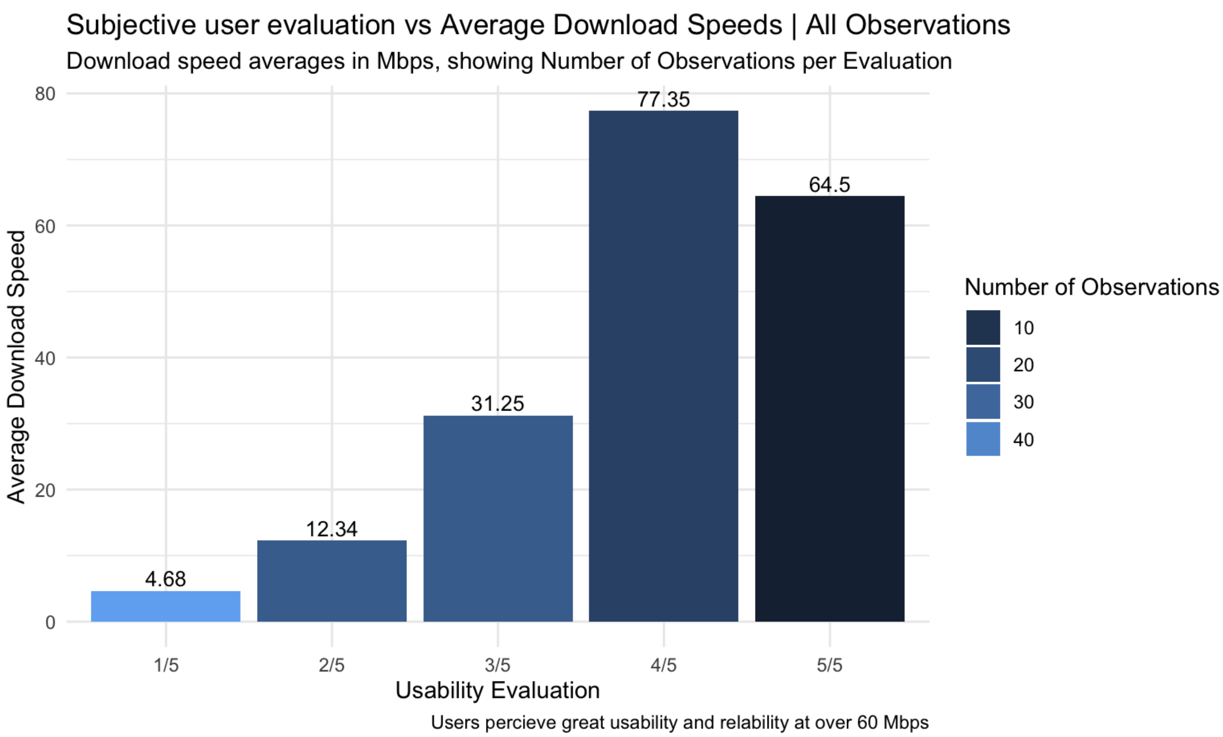


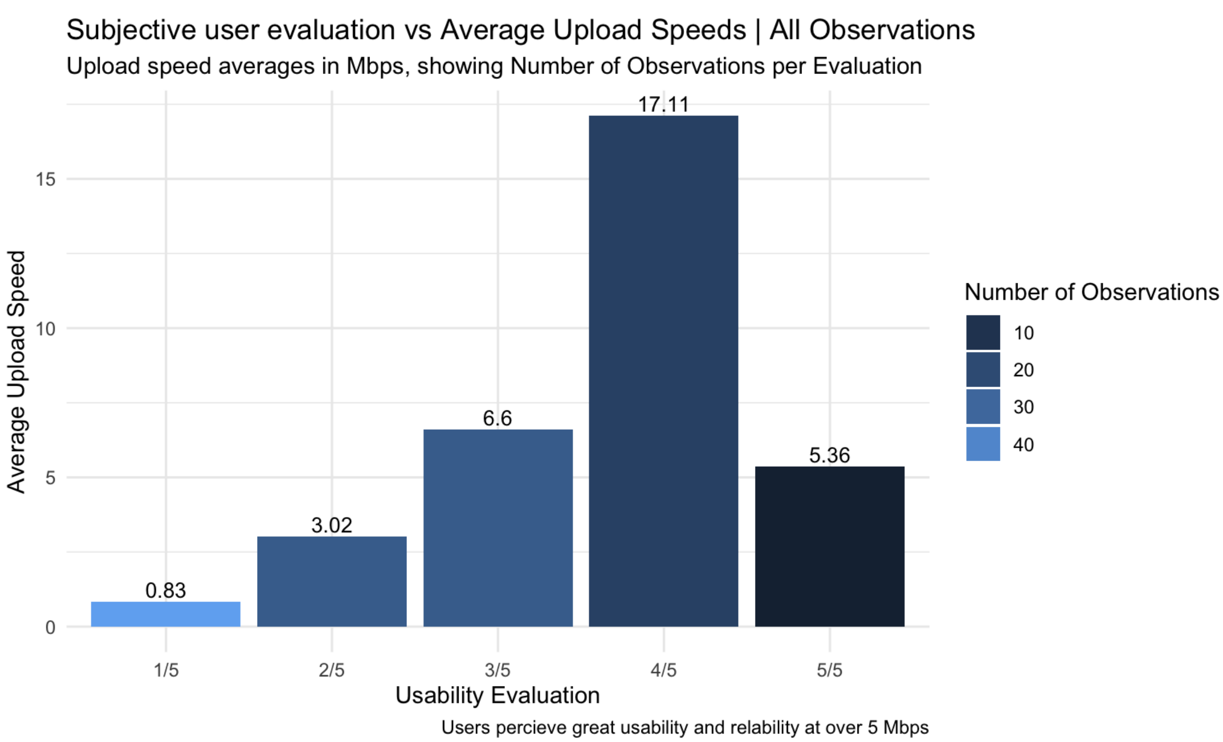
What is shows:

- Histogram chart, counting number of observations at each evaluation score
- Locations where that score showed up the most are shown by each different box color

Main takeaways:

- Most locations on Bainbridge have bad user experience (less than ⅗), reflecting general and widespread connectivity issues experienced from the users perspective


Subjective user evaluation vs Average Download Speeds | All Observations
Download speed averages in Mbps, showing Number of Observations per Evaluation
Average Download Speed
80
60
40
20
0
4.68
12.34
31.25
77.35
64.5
1/5
2/5
3/5
4/5
5/5
Usability Evaluation
Users percieve great usability and relability at over 60 Mbps
Number of Observations
10
20
30
40


Subjective user evaluation vs Average Upload Speeds | All Observations
Upload speed averages in Mbps, showing Number of Observations per Evaluation
Average Upload Speed
15
10
5
0
0.83
3.02
6.6
17.11
5.36
1/5
2/5
3/5
4/5
5/5
Usability Evaluation
Users percieve great usability and relability at over 5 Mbps
Number of Observations
10
20
30
40

The above final two graphs reflect the averages of both download and upload speeds at each evaluation score, supported by a third variable showing the number of observations made at that score. Both charts suggest that for excellent user experience, the average upload speed and average download need to be 12ms and at least 60 Mbps, respectively. In addition, both charts communicate that for the majority of the island, people experience incredibly poor network performances which in turn, lead to horribly slow or unusable ride hailing apps.

Recommendations

In the transport sector, networking and intermodal approaches offer enormous potential for solving traffic problems in both individual and logistics transport: Digitizing the transportation sector in Kitsap County promises to significantly improve traffic flow. Accordingly, our short-term and long-term recommendations are as follows:

Cell Signal Boosters

Where changes to zoning codes are not feasible, cell signal booster installation could provide a good fallback solution over the short term. There are various types of 4G signal booster for cell phones, which are designed and can be used for different purposes. While some can only cover a small area of up to 150 square meters (~1614 square foot) and are perfect for use in small offices, boats or small houses. Others, however, can cover a very large area of up to 2500 square meters (~26909 square foot). These provide an ideal solution for large buildings that need better cell phone reception in their premises.

In case users only receive one bar particularly poorly, choosing a high-performance amplifier can ensure excellent reception with minimal effort. With the latest technology and a powerful Yagi antenna, this 4G repeater can restore a full 5 bars of signal in even the weakest reception areas. As an added benefit, a 4G signal booster not only improves the quality of residents' voice calls, but also increases the speed of their mobile internet connection, allowing for much faster downloads and uploads from mobile devices.[5] This also helps to preserve the battery life of mobile devices, as it is no longer constantly busy trying to find a usable signal to access the network.[6]

Changes to Zoning Codes

This would be one of our long-term goals, and the particular changes to zoning would likely be unfeasible in large swathes of the surrounding area of locations that performed poorly on our given metrics. However, we include this section because of the obvious connection between zoning codes and cellular network performance that has persisted in spite the Telecommunications Act of 1996, which barred local municipalities from refusing to allow cellular service or discriminating unfairly amongst providers.[7] In spite of this landmark legislation and regulatory guidance, municipalities and localities can still "...make it difficult… Thus, it may not be AT&T, Sprint, T-Mobile or Verizon's fault that coverage is poor… It isn't

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[5] Khanifar, S. (2021, August 11). Cell phone signal boosters: The definitive guide [2021 edition]. Retrieved December 14, 2021, from https://www.waveform.com/pages/cell-phone-signal-booster-guide

[6] Verizon. (2018, August 3). *What is small cell technology*.News Center. Retrieved November 13, 2021, from https://www.verizon.com/about/our-company/5g/what-small-cell-technology.

[7] Schmidt, K. (2016, January 25). *We Assessed the Accuracy of Wireless Coverage Maps per Carrier, and the Results Disappoint*. Steel In The Air, https://www.steelintheair.com/blog/we-assessed-the-accuracy-of-wireless-coverage-maps-per-carrier-and-the-results-disappoint/.

for a lack of trying, as they get turned down in zoning hearings for new towers and wireless infrastructure on a regular basis…"[8] In this sense, the more mixed-use the zoning, the better the coverage. An example to support this observation from Bainbridge island would be Winslow, an area of the island with areas for high-density zoning and subsequently, some of the lowest latency that we experienced.

Utilization of Small-Cell Wireless Communications Facilities

Small Cells allow operators to solve problems such as capacity, coverage, latency, and spectrum availability at the very place where the problems exist. In the future, Small Cells will become increasingly important. There is a need, for example, for the future 5G wireless network to have a large number of wireless cells with small cell diameters. The spatial extent of mobile cells can vary greatly. In sparsely populated areas, GSM cells can have a diameter of up to 40 miles, in LTE networks only up to 10 miles. As all mobile network communications users within a cell have to share the available capacity for phone calls and Internet access, the cells in cities, for example, are designed to be much smaller.

In heavily frequented areas such as train stations or shopping streets, this dimension may still be too large. If a large number of mobile users use their cell phones to access the Internet, send messages or make phone calls in a confined space, even smaller cell diameters may be required. In this case, the term "small cells" is used, as opposed to the macrocells normally used in mobile communications. This means that data transmission speeds can be increased in specific areas where a particularly large number of customers are on the move or accessing the internet. As a result, data capacity is noticeably increased in their coverage area. At present, this could be

[8] Ibid.

up to an additional 150 Mbit/s. One example: Where 50 Mbit/s was possible in the past, it could - ideally - be up to 200 Mbit/s in the future.[9]

Estimated Wait-time and Coverage Map for RidePingo users

The use of most transit apps allows riders to spend less time preplanning, discover new travel options for the trips they take, and to engage in more opportunistic travel. Thus, it helps to ensure that these apps provide sufficient information that answer all basic pre and during trip background questions.[10] For RidePingo users, an estimated waiting time and coverage map, as a reference, can produce great benefits to prevent long waiting times. To determine popular times, waiting times and the duration of rides, we therefore recommend these extensions:

Real time bus schedule: Real-time bus schedule is especially important for transfers and connections. When passengers are able to predict the arrival of the bus, they get extra time to prepare for boarding.[11]

Live estimated waiting time: These data show how long BI-ride passengers have to wait to board at different times of day. These should also include peak wait times for each day of the week.

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[9] Land, M. (2021, July 28). A Complete Guide to Small Cells: Millman National Land Services. Retrieved December 14, 2021, from https://millmanland.com/company-news/small-cell/

[10] Steinfeld, A., Bloomfield, L., Amick, S., Huang, Y., Odom, W., Yang, Q., & Zimmerman, J. (2019). Increasing access to transit: Localized mobile information. *Journal of Urban Technology, 26*(3), 45-64. doi:10.1080/10630732.2019.1614896

[11] Mirzaei, F., Manduchi, R., & Kurniawan, S. (2018). Public transit accessibility: Blind passengers speak out. *Lecture Notes in Computer Science,* 277-282. doi:10.1007/978-3-319-94274-2_38

Vehicle fullness check: Although many online or mobile information services do not indicate how full a vehicle is, incorporating this can be very helpful. This information can be especially important for people who use mobility aids (wheelchairs).

Live-coverage map: Since BI-Ride passengers rely on good mobile network connectivity, which is highly dependent on time and location, live coverage data would be advisable. Thus, long transit waiting time due to slow network connectivity could be avoided.

Reflection and Next Steps

Equity in digital technology is the key to achieving equal living conditions and overcoming challenges in urban and rural areas. In our case study, the slowdown in the expansion of wireless cell networks is affecting the development of a well-run public transport system in Bainbridge Island. Rural areas like those in Kitsap County, are increasingly facing difficult structural upheavals. To counter, and reduce the existing accessibility deficits of rural areas, high hopes are pinned on the expansion of a high-performance broadband infrastructure, and the use of innovative broadband applications. However, it is precisely the rural regions that are often only inadequately supplied with high-performance broadband.

The reasons for this are to be found in both the supply and demand sides of the challenge: While connection costs in rural regions are significantly higher than in cities, users are not sufficiently willing to pay for fast bandwidths. In addition, the monopolization tendencies in the telecommunications market result in regulatory measures that make market-driven expansion by private network operators more difficult. Even if there is sufficient demand, planning permission procedures and/or coordination with various authorities often prove to be a time obstacle to the realization of a new site. Administrative processing times of two or more years are not uncommon. To address this market failure, innovative solutions are needed in all three areas of "supply", "demand" and "regulation". To gain an overview of possible innovative solutions for both regional broadband deployment, and innovative broadband applications, in our case study, we explored questions related to signal strengths of most visited sites on Bainbridge Island. Moreover, we explored communal challenges in planning for better broadband infrastructure, and ultimately the signal disruptions and their impact on mobile transit apps such as RindePingo.

By looking at our field data collection and analysis, we concluded that while not presenting the fullest and most thorough set of data points, our field research and data collection in Bainbridge was sufficient enough given the time constraints that factored into the project. Both the data collection and our personal experiences with occasional 30+ minute wait times for BI Ride buses seem to confirm one of these two judgments: that RidePingo is not suitable for the island to undertake, or that the island's poor cell coverage, with wide disparities based on time and place, make this tech-based ride-hailing effort often very frustrating. The answer would be the latter-- as evidenced by the introductory paragraph, technological changes in transit such as e-ticketing and apps like RidePingo have the potential to *increase* ridership and *improve* rider experience. However, all of the components that are required to make an app happen rely on cellular networks, and if the coverage available does not match the quality and upload required for the app in question, that is an opportunity gone awry.