The Results of Physical Distance on Wi-Fi Bandwidth

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Section I: Introduction and Literature Review

A. The experiment I have chosen for this report pertains to the signal loss of a basic home wi-fi network based on the distance from the signal source. This will be used to illustrate the principles of electromagnetism, specifically radio waves. Based on previous studies and calculations all electromagnetic waves, including radio waves, lose their signal the further they are tested from the source (Sengupta, 2021). I am attempting to discover how much the network speeds will diminish based on distance. The is also known as the measurement of attenuation (CASDataloggers, 2023).

Wi-Fi radio waves transmit from the wireless access point to different types of devices to provide internet connectivity. Wi-Fi specifically uses the 2.4GHz and 5GHz bands, which means the waves oscillate $2.4x10^9$ or $5x10^9$ times per second at the speed of light ($3x10^6$ km/s) (Sengupta, 2021).

The attenuation, measured in decibels, can be affected by any object that stands between the origin of the electromagnetic wave (the access point, in this case) and the endpoint. Different materials have a predetermined signal path loss based on the amount they will reflect or scatter the signal wave, for instance a sheet of drywall has a path loss of 4db while a concrete wall in the same location would result in 10-15db of path loss (CASDataloggers, 2023).

Section II: Hypothesis

B. My hypothesis is that the signal will decrease by a factor greater than 1mbps in download and upload speeds per foot at each of my predetermined markers between zero feet and 100 feet from the source.

C. Because of the distance that the electromagnetic waves will have to travel this will inevitably change the strength of the signal. A weaker signal

will be able to carry fewer network packets and data (Sengupta, 2021). I expect the difference to be drastic and reduce the bandwidth speeds by more than 100mbps over 100 feet.

Section III: Method

D. The independent variable for this experiment will be the distance between the wireless access point and my laptop, measured in feet from zero to 100. I will be moving the laptop away from the access point and recording the results in four locations.

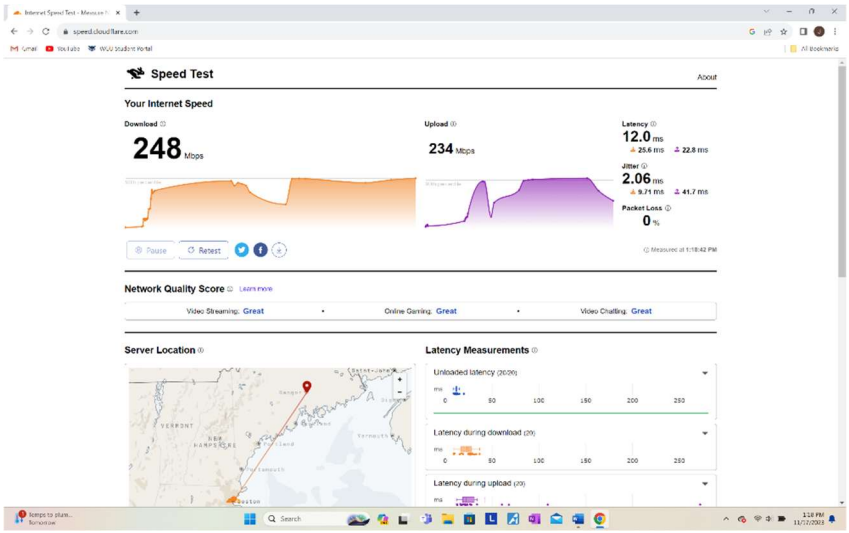
E. The dependent variable in this case would be the network speed, measured in mbps (megabits per second). Also known as bandwidth or throughput. This will be recorded as download and upload speeds.

F. As for the confounding variables, I also foresaw the speed being influenced by any additional applications that may be open on the laptop using bandwidth (corrected by closing every application except my speed testing tool) and the interference of any other devices emitting electromagnetic waves (microwave ovens, remote controls, etc.) those devices were verified to be offline before testing began. These steps should ensure accurate and consistent test results and help to avoid unnecessary signal scattering, reflection, or general interference.

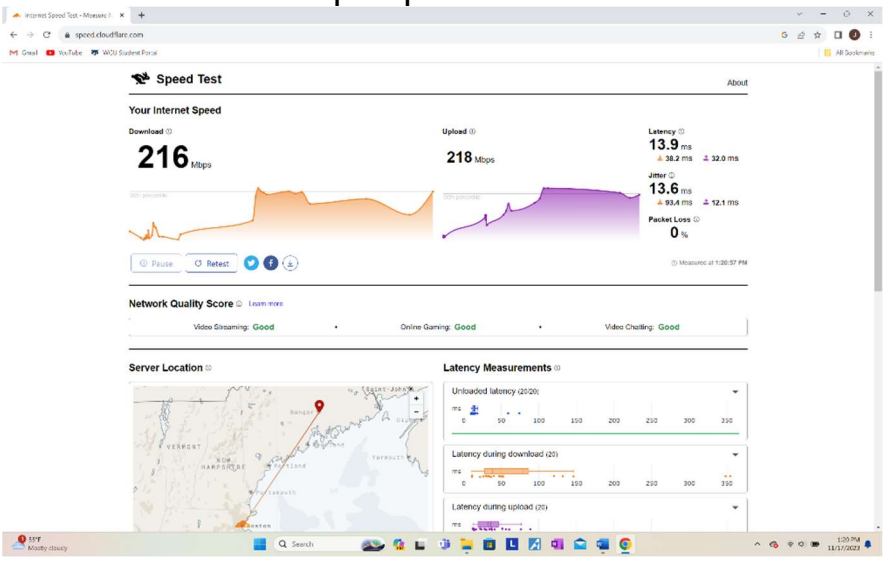
G. I will be measuring the bandwidth using my Lenovo Legion 7i laptop with the Google Chrome browser running a Cloudflare.com (speed.cloudflare.com) speed test application. This application will send outgoing and receive incoming network packets from a designated server to determine the speed with which the packets travel. I will also be using a standard tape measure and green tape to mark each of the four distances to gather incremental results. The wireless access point is a Nokia Wi-Fi Beacon 2, which is connected to a Nokia x5-110g-a router. The maximum speed allowed by my fiber optic Internet Service Provider is 250mbps. All speeds were recorded using the 5GHz spectrum.

H. I began by measuring the distance from the WAP (wireless access point) and marking increments of 0ft, 25ft, 50ft, and 100ft. with small pieces of tape. If a wall or door blocked my path, I would measure the obstruction and account for it in my overall distance between points to remain accurate.

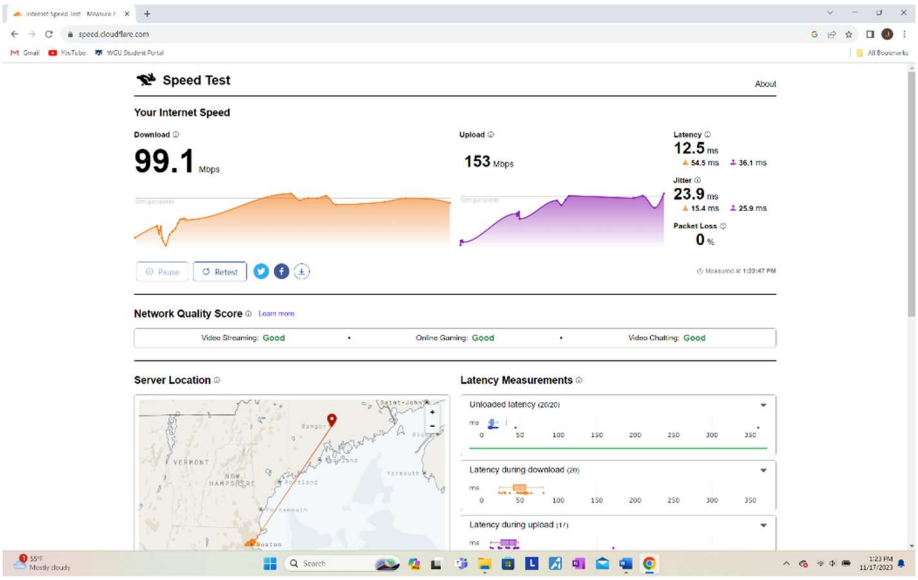
I then prepared my laptop by closing all other applications and opened just one Google Chrome browser window to navigate to the Cloudflare.com web application. I gathered the first test result by placing my laptop directly next to the WAP. The results were 248mbps Download speed and 234mbps upload speed (pictured below).



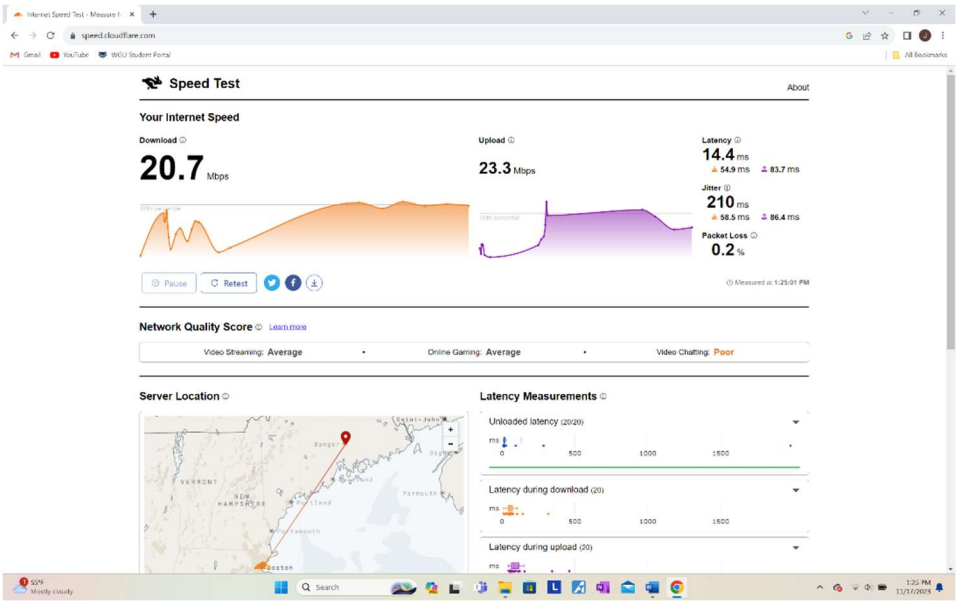
My next marker was placed at 10 feet from the WAP. I ran the test again at that location and recorded the results. The total speeds decreased to 216mbps download and 218mbps upload.



I moved to the third marker and repeated the test at 50ft. which resulted in the speed decreasing to 99.1mbps download and 153mbps upload.



My final test was at 100ft from the signal source. The result was a decrease to only 20.7mbps download and 23.3mbps upload for the total speed.

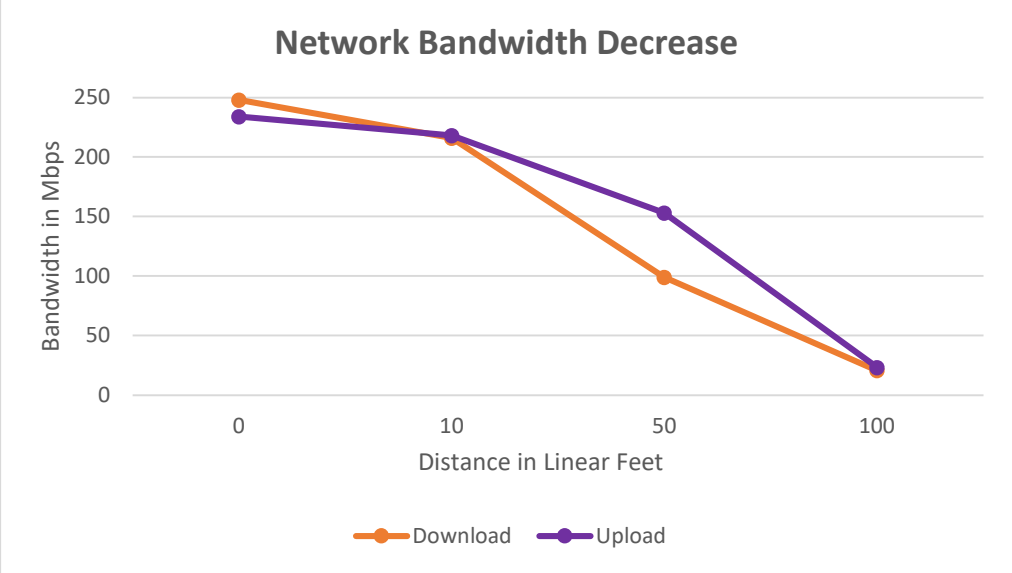


Section IV: Result

I. The results of these tests proved that the network speeds decreased by only 32mbps download and 16mbps upload at the 10ft marker, then decreased significantly by 116.9mbps download and 65mbps upload at the 50ft marker, and finally decreased by another 78.4mbps download and

129.7mbps upload at 100 ft. for a total speed decrease of 227.3mbps download and 210.7mbps upload. This is roughly a 2mbps decrease per foot at 100ft., though that measurement does not remain consistent at each marker.

J.



Section V: Conclusions

K. My hypothesis was confirmed with a total drop in bandwidth greater than 1mbps per foot for both download and upload speeds. The results of the speed test very clearly illustrates that the radio waves in this test were significantly decreased over 100 ft. by at least 2mbps. I did expect a more consistent result between markers, however.

L. Unfortunately, the wireless access point is directly in the center of my house in a small closet. The major confounding variable for this test was the walls that are in the way of a truly accurate test. In an ideal situation, this could be tested in an open area so that the radio waves could travel without the risk of scattering. I was able to control this slightly by verifying that each wall between the source and the endpoint was of similar construction (wood and drywall) with no excessive wiring or concrete, which can severely dampen the signal.

M. Based on the literature review conducted prior to the experiment, I noticed a similar decline in bandwidth to the research conducted by previous theoretical experiments. The bandwidth decreased exponentially with distance (Sengupta, 2021) though the potential attenuation can be a factor in this experiment (CASDataloggers, 2023). The oscillation of the electromagnetic waves decreased over the distance and resulted in a diminished capacity to carry network packets.

Section VI: Sources

N.

Argha Sengupta. (2021). ScienceABC.com. Does Distance From the Wi-Fi Router Impact Download Speeds? From: https://www.scienceabc.com/innovation/does-distance-from-the-wi-fi-router-impact-download-speeds.html

CASDataloggers. (2023). The Basics of Signal Attenuation. https://dataloggerinc.com/resource-article/basics-signal-attenuation/#:~:text=Wireless%20signal%20attenuation%20is%20the,such%20as%20automated%20temperature%20monitoring.

Coudflare Network Speed Testing Tool.

https://speed.cloudflare.com/