A Comparative Analysis of Wi-Fi Performance Between Science and Humanities Buildings: Evidence of Infrastructure Inequality on a College Campus

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H_T: There is no difference in average WI-FI speed between Old Main and Hanson.

H_A: There is a difference in average WI-FI speed between Old Main and Hanson.

$\alpha = 0.05$

Abstract

Lorem

I. Introduction

In today's academic landscape, reliable and high-speed internet access is crucial for various aspects of college life, including coursework, social interactions, and entertainment, all of which are increasingly reliant on online platforms such as Moodle and Google services. However, the accessibility and quality of internet networks across Augustana College campuses are not uniform, creating disparities among students.

This study focuses on the comparative analysis of Wi-Fi infrastructure quality in two distinct buildings: Hanson Hall, representing the STEM disciplines, and Old Main Hall, associated with the humanities. Rather than assuming a preconceived bias regarding the superiority of Wi-Fi infrastructure in one building over the other, our objective is to explore potential differences in internet speeds and assess if there are grounds to support claims of inequality.

Over the course of a week, our team conducted Wi-Fi speed tests from morning to afternoon at specific locations within Hanson Hall and Old Main Hall. Using the Augustana homegrown Internet Speed Test (speedtest.augustana.edu), we gathered data on download and upload speeds, providing 16 data points for each location in the two buildings. Our hypothesis centers on investigating whether average download speeds in either Hanson Hall or Old Main significantly surpass the download speeds in the other, and if upload speeds exhibit a similar trend.

The findings presented in this report shed light on the observed variances in Wi-Fi speeds between these academic buildings. It's important to note that while our focus is on wireless speeds, we acknowledge that the potential inequality might not solely be a result of wireless infrastructure bias but could also be influenced by the physical layout and construction of the buildings. Additionally, it's crucial to clarify that our study specifically examines wireless speeds and does not encompass an analysis of wired speeds via an Ethernet port. This distinction is essential as the physical layout of the building, along with the choice of network connectivity, can impact the overall internet experience. Even more, the physical layout and construction of the building doesn't have as much of an effect, if any at all, on wired speeds.

Table 1: Data taken in Hanson Hall of Science

Date	Actual Time	Download Speed (Mbps)	Upload Speed (Mbps)
2023-12-02	1899-12-31 10:26:00	240.00	259.00
2023-12-02	1899-12-31 13:27:00	97.80	97.80
2023-12-02	1899-12-31 15:01:00	97.30	90.30
2023-12-02	1899-12-31 16:33:00	44.90	88.00
2023-12-04	1899-12-31 10:27:00	28.20	62.70
2023-12-04	1899-12-31 13:47:00	35.80	27.10
2023-12-04	1899-12-31 03:15:00	68.50	26.60
2023-12-04	1899-12-31 16:30:00	124.00	56.70
2023-12-05	1899-12-31 10:33:00	1.34	1.69
2023-12-05	1899-12-31 13:30:00	11.30	22.30
2023-12-05	1899-12-31 15:25:00	140.00	81.40
2023-12-05	1899-12-31 16:30:00	245.00	189.00
2023-12-06	1899-12-31 10:24:00	4.62	37.30
2023-12-06	1899-12-31 01:35:00	61.80	105.00
2023-12-06	1899-12-31 03:00:00	106.00	139.00
2023-12-06	1899-12-31 04:45:00	20.40	50.20

II. Experimental Setup

Before diving into our methodology for data collection and our analysis, we feel it's necessary to provide contextual foundation for our study by taking a closer look at the wireless infrastructure in each building.

```r
# get the differece between download and upload speeds for each building
result <-
  data.frame(
    download_diff = hanson_data$`Download Speed (Mbps)` - oldmain_data$`Download Speed (Mbps)`,
    upload_diff = hanson_data$`Upload Speed (Mbps)` - oldmain_data$`Upload Speed (Mbps)`
  )
```

Here is a summary of the data:

```r
h_download_mean = mean(hanson_data$`Download Speed (Mbps)`)
h_upload_mean = mean(hanson_data$`Upload Speed (Mbps)`)
h_download_sd = sd(hanson_data$`Download Speed (Mbps)`)
h_upload_sd = sd(hanson_data$`Upload Speed (Mbps)`)
```

Hanson

$$\bar{X}_{Hanson\ download} = 82.935$$

$$\bar{X}_{Hanson\ upload} = 83.380625$$

$$s_{Hanson\ download} = 75.7139672$$

$$s_{Hanson\ upload} = 66.8327555$$

```r
o_download_mean = mean(oldmain_data$`Download Speed (Mbps)`)
o_upload_mean = mean(oldmain_data$`Upload Speed (Mbps)`)
o_download_sd = sd(oldmain_data$`Download Speed (Mbps)`)
o_upload_sd = sd(oldmain_data$`Upload Speed (Mbps)`)
```

Old Main

$$\bar{X}_{OldMain\ download} = 60.1025$$

$$\bar{X}_{OldMain\ upload} = 73.74125$$

$$s_{OldMain\ download} = 93.8963707$$

$$s_{OldMain\ upload} = 107.4404898$$

```r
download_sd = sd(result$download_diff)
download_mean = mean(result$download_diff)

upload_sd = sd(result$upload_diff)
upload_mean = mean(result$upload_diff)
```

DIFF

$$\bar{X}_{DIFF\ download} = 22.8325$$

$$\bar{X}_{DIFF\ upload} = 9.639375$$

$$s_{DIFF\ download} = 68.6649584$$

$$s_{DIFF\ upload} = 67.4312574$$

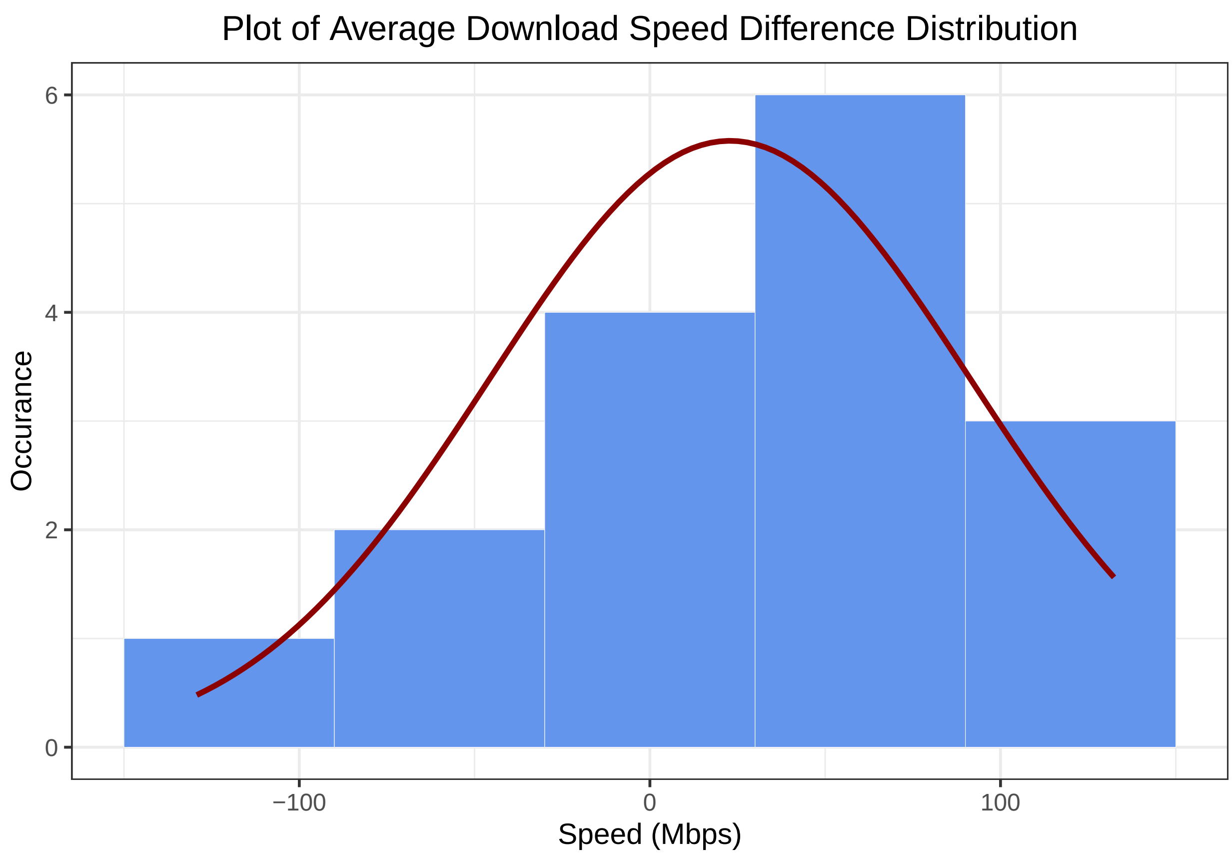
```r
summary(result$download_diff)
```

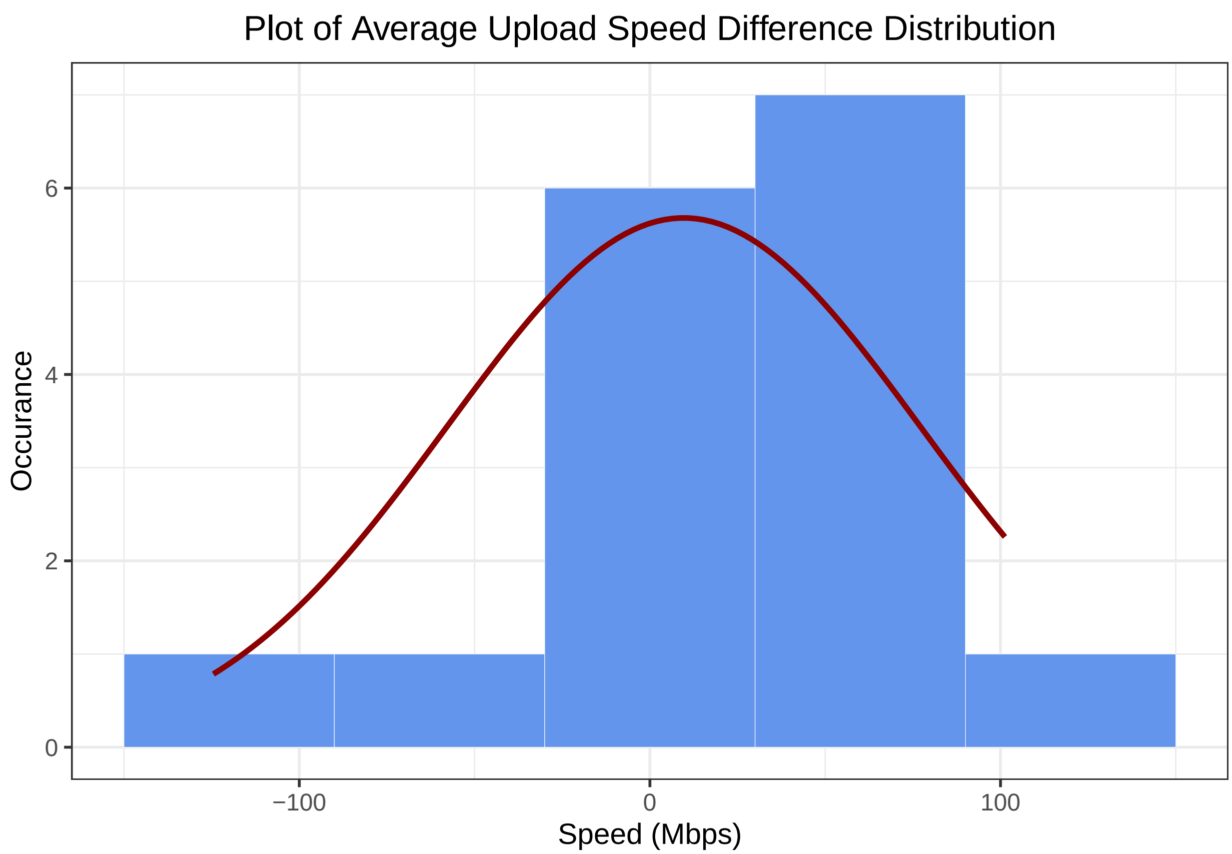
```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## -128.100   -5.525   30.460   22.832   58.157  139.520
```

```r
summary(result$upload_diff)
```

```
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
## -157.000   -2.600   14.485    9.639   42.305  128.400
```

Now to get some of the statistics:


Plot of Average Download Speed Difference Distribution
Occurance
6
4
2
0
−100
0
100
Speed (Mbps)



$$P(-t < \frac{(\bar{X}_A - \bar{X}_B) - (\mu_A - \mu_B)}{\sqrt{\frac{S_A^2}{n_A} + \frac{S_B^2}{n_B}}} < t)$$

```
download_n <- length(result$download_diff)
download_sd <- sqrt((h_download_sd^2/download_n)+(o_download_sd^2/download_n))
download_t.value = download_mean/sqrt((h_download_sd^2/download_n)+(o_download_sd^2/download_n))
alpha = 0.05
download_df = download_n - 1
download_p_val = 2*(1 - pt(download_t.value,download_df))
print(download_p_val)
```

```
## [1] 0.4606757
```

```
upload_n <- length(result$upload_diff)
upload_t.value = upload_mean/sqrt((h_upload_sd^2/upload_n)+(o_upload_sd^2/upload_n))
alpha = 0.05
upload_df = upload_n - 1
upload_p_val = 2*(1 - pt(upload_t.value,upload_df))
print(upload_p_val)
```

```
## [1] 0.7647606
```

```r
h_download_t.score = qt(p=alpha/2, df=download_df)
h_download_se = h_download_sd/sqrt(download_n)
h_download_margin.error <- h_download_t.score * h_download_se
h_download_lower.bound <- h_download_mean - h_download_margin.error
h_download_upper.bound <- h_download_mean + h_download_margin.error
if (h_download_upper.bound < h_download_lower.bound)
{
  print(c(h_download_upper.bound,h_download_lower.bound))
}else {
  print(c(h_download_lower.bound,h_download_upper.bound))
}
```

```
## [1]  42.58987 123.28013
```

```r
o_download_t.score = qt(p=alpha/2, df=download_df)
o_download_se = o_download_sd/sqrt(download_n)
o_download_margin.error <- o_download_t.score * o_download_se
o_download_lower.bound <- o_download_mean - o_download_margin.error
o_download_upper.bound <- o_download_mean + o_download_margin.error
if (o_download_upper.bound < o_download_lower.bound)
{
  print(c(o_download_upper.bound,o_download_lower.bound))
}else {
  print(c(o_download_lower.bound,o_download_upper.bound))
}
```

```
## [1]  10.06866 110.13634
```

```r
download_t.score = qt(p=alpha/2, df=download_df)

download_margin.error <- download_t.score * sqrt((h_download_sd^2/download_n)+(o_download_sd^2/download_
download_lower.bound <- download_mean - download_margin.error
download_upper.bound <- download_mean + download_margin.error
if (download_upper.bound < download_lower.bound)
{
  print(c(download_upper.bound,download_lower.bound))
}else {
  print(c(download_lower.bound,download_upper.bound))
}
```

```
## [1] -41.44125  87.10625
```

$$P(-t < \frac{(\bar{X_A} - \bar{X_B}) - (\mu_A - \mu_B)}{\sqrt{\frac{S_A^2}{n_A} + \frac{S_B^2}{n_B}}} < t)$$

III. Results

Lorem

IV. Discussion

The outcomes of our study do not substantiate a definitive causation due to the limitations within a small-scale experiment. Our network specialist, Scott D. Dean, shared insights into the campus internet infrastructure, focused on Old Main and Hanson buildings. Notably, Old Main recently underwent an upgrade in its Internet access points to align with those in Hanson, with the intent of minimizing variations in quality of the Wi-Fi signal strength. Despite these upgrades, Figures 1 and 2 revealed a notable disparity in the numbers of access points between the two buildings.

A potential confounding variable arises from the distinct number of access points in each building; Old Main's 1st floor has only 2 access points, while Hanson's 2nd floor boasts 6. This difference may contribute to the observed differences in Wi-Fi performance.

Scott D. Dean emphasized a crucial aspect—namely, that an increased number of internet devices (clients) connected to an access point inside a building can lead to a decrease in Wi-Fi speed. This principle sheds light on the observed variations and prompts us to consider the impact of user load on the network.

Taking into account the general class schedule, it is reasonable to infer that higher Wi-Fi demand on specific days, such as Monday, Wednesday, and Friday, could influence the observed differences in Wi-Fi speed. Moreover, the 2023 Fall Term received a higher number of freshmen FYI101 classes in Old Main, as opposed to Hanson, where classrooms are primarily reserved for foundation science classes, introduces another layer of complexity.

In conclusion, while our study establishes a foundation for understanding the Internet speed between Old Main and Hanson, these confounding variables must be accounted in drawing a causal relationship. Further investigations are needed to well-explored the variations in Wi-Fi signal strength, potentially to address the differences of internet speed between a STEM building and a humanities building on Augustana College campus.

References

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