George Eastman Building 3rd Floor

Wireless Survey

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Executive Summary

This wireless site survey was performed by Deajah Barbour, V.J. Goh, Jason Ricca. Through our operations for this project, we each gained a better understanding of network performance, structure, and access point metrics. The site we surveyed was the George Eastman building's 3rd floor, the School of Communication. The floor is a lengthy U-shaped hallway with offices at both ends of the U-shape. The shorter end of the U is where the School of Communication office is located, and that is conveniently near the two main elevators. At the corners of those hallways are tables for students to do work at. Our goal as surveyors was to assess and evaluate the effectiveness of the access points in their current location. Then, we worked together to brainstorm improvements that could be made to the layout for smoother connectivity throughout the floor.

We concluded that the following topics reflect the results of our survey best:

- Floor Study
- AP Placement
- Network Performance
- Technology/Tools Utilized
- Summary

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Introduction

Before starting our site survey we wanted to understand the impacts of performing such an operation. A wireless survey analyzes the physical and radio frequency environment where a Wi-Fi network was set up. Using this data, surveyors would place APs around the environment to optimize their effectiveness. There are multiple types of surveys, and they each reflect different stages of network infrastructure for an area. For example, the type of survey we conducted would be a passive survey. There are also predictive surveys performed before moving into a new space and active surveys that focus on a specific signal or set of them. The difference between those and the one we performed is that ours reported on all access point signals and any sources of interference.

Our goal for this project was to collect network metrics from the access points in our selected environment. Using these metrics we sought to infer any causes of interference and recognize technologies we learned about in lectures. We utilized familiar technologies such as iPerf3 and Wireshark to run network throughput tests. In analyzing these results we populated our network details for each AP which allowed us to understand their operational speeds. Using these metrics we could then measure signal strength and infer area coverage. The placement of the APs was acceptable but not optimized, and the floor we chose is one that many people don't stay on for long. That being so, we also found the majority of APs being placed in offices or classrooms surrounded by walls affected throughput. Not only that but also the reliance on roaming creates an issue where people are connected to APs with worse signals.

In the following sections, we will identify exactly which factors brought issues to our attention and how we managed to discover these factors. The **Technologies and Applications Utilized** section will provide an overview of all the tools that we used in our survey. The **Floor Study** section will provide an analysis of our floor's layout and any means of interference we found. The **Access Point Placement** section will follow after, as it coincides with the previous section. It will tackle where exactly the access points were placed and our thoughts on their locations. The **Performance Study** section will detail the network performance for the APs and what could be affecting it positively or negatively. Lastly, the **Summary** will provide another overview of our goal going into this project and how we worked towards achieving it in this project.

Technologies and Applications Utilized

One technology we were looking into using was LiveAction Omnipeek. Omnipeek is a very powerful tool that has a lot of the features we were looking for. It offers packet capture and analysis, network performance monitoring, wireless network analysis, visualization and reporting, and many other useful features. We were able to obtain a free 15-day trial via the LiveAction website. Upon opening the application though, we quickly learned that there would be a large learning curve with using it, so we opted for more beginner-friendly options.

Another beginner-friendly tool we came across and ended up using for this report was NetSpot. NetSpot is available on macOS and Windows and offers a free edition which we ended up using. One feature of NetSpot that was very useful for us was the "Inspector" tab. Using this tab you can see information on all of the WiFi networks around you including their SSID, BSSID, Channel, Frequency, Security, and Signal Strength average, max, and minimum values in dBm. These values helped us identify APs based on their signal strength and gave us valuable information that we would use later in this report. The only issue with NetSpot that we ran into was how it would become very laggy and unresponsive on Windows 11 machines. We are not sure what is the cause of this, but fortunately, we have a machine running macOS on which NetSpot seemed to run fine.

We used iPerf3 as a tool from lab 3 of this course. iPerf3 is a free-to-use tool that is available on many different operating systems and allows you to test the limits of the network you are connected to. iPerf3 includes tests for TCP and UDP that we ended up using for this project. To set up an iPerf test you just need one machine to be listening for connections as a server and another machine to connect to that server as a client. Once the client connects to the server, it sends over data depending on the parameters that you choose. There are parameters for choosing the protocol to use, the time to run the tests, the amount of data that is transferred, and setting the target bandwidth. With iPerf3 tests we were able to determine the total transfer and bandwidth using TCP, and the total transfer, bandwidth, jitter, and packet loss using UDP, on each AP.

NetSetMan is a Windows-exclusive tool that we sought out from the sample wireless survey report on myCourses. This tool, like NetSpot, was rather beginner-friendly and intuitive. We used the Non-Commercial Freeware version and made use of the WiFi Management tab. This tab gave us information on the wireless networks around us including the signal RSSI value in dBm, the SSID, BSSID, Encryption type, Channel, Frequency, Mbps, and Protocol. The most important feature of NetSetMan is the ability to connect to specific APs. This was useful when conducting our iPerf3 tests. This is because we wanted to ensure that both the server and client were connected to the same AP when performing those tests, to make sure that we were only measuring the network capabilities of that specific AP. If the client and server were connected to two different APs, too many variables would be introduced and we wouldn't get an accurate representation of the network capabilities of that specific AP.

Speedtest by Ookla was a vital tool for testing network quality. It is a web application that allows you to determine the connection speeds of the network you are currently connected to. The data that this speed test provides is the average upload and download speeds in Mbps as well as the idle, download, and upload latency in ms. We used this tool at several of the locations on the floor to determine the connection speeds of the network at those locations.

The hardware that we used includes one Dell XPS 15 laptop with an Intel(R) Core(TM) i7-10750H CPU processor and Killer(R) Wi-Fi 6 AX1650s 160MHz Wireless Network Adapter (201D2W) running Windows 11. We also had another Windows laptop and one laptop running macOS. The macOS system was a Macbook with Apple M2 Pro. As mentioned earlier, the two laptops running Windows were primarily used for using NetSetMan to connect to specific APs while performing the iPerf3 tests. The laptop running macOS was primarily used for running NetSpot as we found that applications ran better on machines running macOS.

Floor Study

As stated in our introduction, we selected the third floor of the George Eastman building as our location to perform our wireless site survey. The Eastman building gets quite busy, as students and faculty alike tend to visit this building only for work. As such, there were not many students using the available study spaces. This building meant business, but the floor we chose was rather expressive in comparison to the floors. That is due to it being the School of Communication floor, and the personnel here were far more lively than any other floor we visited in this building.

The third floor is shaped like an upside-down U, as are all the other floors in the building. To see a map of AP locations and a map of the locations labeled please look at **Appendices A** and **D** respectively. Upon exiting the elevator, the School of Communication office and other offices will be on the left end of the U shape. Walking further onto the floor will reveal study spaces, floor bathrooms, and one of two stairwells. Turning from there leads to a hallway containing multiple department centers, offices, labs, and classrooms. At the end of that hallway, there is another study space, a stairwell, and a singular bathroom. Another turn will reveal the last hallway on the floor. There are vending machines near its entrance, and further down are more classrooms, offices, and labs.

There were plenty of areas within offices that we could not access. For example, the Department of Multicultural Studies had an AP we were receiving weak signals from, but ultimately we could not access it to extract data. We had to try our luck on certain days with classrooms, as plenty had APs but only a few were left open. There were also APs installed in certain offices that were either in use or locked up. We were able to take photos and extract data from them, but it was not easy and felt a bit intrusive. Regardless we studied those spaces to the best of our ability to provide the details we amassed.

The outer walls of the building are lined with bricks, and the inside seems reinforced with concrete. Typically this wouldn't matter as much for spacious venues, but the many rooms on the Eastman 3rd floor make it feel cramped. However, it feels like it doesn't matter because the rooms and offices being so close to each other impacted the connections to APs throughout the floor. As will be discussed in our Access Point Placement section, there are a myriad of APs in the center of classrooms. However, there are very few in the hallways, and this creates frustrating results when trying to reconnect to nearby APs while in the halls.

Without getting into the specifics, we made initial observations of APs when first surveying the floor. The resounding first take we all had was how "cooped up" a lot of the APs felt with their placements. The layout of the floor and these initial APs we found shocked us as we speculated more to be around in the hallways. We also noticed that they all were hung up on the ceiling and in inaccessible areas there.

An important factor of this study includes the acknowledgment of possible sources of interference. One of our first objectives was to walk around the floor and take note of any possible sources of interference that we could find. These sources of interference are denoted by a red "x" symbol in **Appendix A**.

Firstly, there are large elevators right outside of the School of Communication offices. These elevators are made out of metal which is known to cause interference with WiFi signals. Additionally, the electrical components and motors within the elevators can produce electromagnetic interference when the elevators operate. To our dismay, there is an AP positioned right outside of these elevators, which is probably receiving interference from them.

The large printers found inside the School of Communications and the offices at the other end of the U were other sources of interference that we noticed. The large printers are mostly made out of metal and have WiFi connection capabilities which can both cause interference.

Another source of interference would be the multiple microwaves positioned around the floor. There is one outside of the offices on the other side of the School of Communications, with an AP right above it. There is also a microwave and other kitchen appliances in the kitchen in the north hallway, with two APs nearby. There is another microwave in the back hallway behind the Department of Anthropology and Sociology. Microwaves are known to cause interference to WiFi signals because they operate at the 2.4 GHz frequency band which many WiFi signals also operate at. Even though microwaves are designed with shielding to contain the majority of electromagnetic radiation, some leakage may occur.

The stairwells that are found on the edges of the hallway would also be considered points of interference. The walls of these stairwells are made out of concrete bricks and the stairs and handrails are made out of metal. The thick walls prevent a majority of WiFi signals from making it inside and the metal stairs dissipate the signals that do make it through.

A final source of interference that we noticed would be the metal projectors and audio equipment control boxes found in many of the classrooms. As mentioned earlier, since these devices are made out of metal they can dissipate the WiFi signal. Many of the APs found in classrooms are in close proximity to these devices.

Access Point Placement

Most of the APs that we found on this floor were either in classrooms or in offices. Workstation 1 and Workstation 2 both had an AP directly above them. There was surprisingly a lack of APs in the North Hallway and the East Hallway. We noticed that there would be a degradation of signal when walking through these hallways. The AP placement inside of classrooms makes sense to us because in these classrooms you are going to have a large number of students using wireless devices. The same can be said for the workstation areas found in the corners of the hallways. The AP placements in offices are questionable to us because we noticed that some of the professors in those offices are using ethernet and many of these APs are far away from areas where other people are going to need a wireless connection. Additionally, the walls of the office are going to add a layer of interference to the signal, degrading it for users outside of the office. In these situations, we believe that these APs should be moved outside of offices and positioned in an area where that AP can service a larger area of users. Some other questionable AP placements would be the AP right outside of the elevators and the AP inside of the kitchen area. As mentioned in the interference portion of the **Floor Study** section, elevators and kitchens are common causes of interference for wireless signals.

The APs that are on this floor we believe are from the Aruba 303 series. These APs support WiFi 5 (802.11ac) MU-MIMO technology. They also deliver a maximum concurrent data rate of 867 Mbps in the 5 GHz band and 300 Mbps in the 2.4 GHz band, for a combined peak data rate of 1.2 Gbps.

When we did our first analysis of the floor we had some assumptions of what the coverage would look like from the APs. We expected there to be pretty good coverage throughout the hallways. Our reasoning for this would be that these areas have a lot of foot traffic when students are going to and from their classrooms and these hallways are accessible to everyone, unlike some offices or classrooms. So we expected these areas to have good coverage. This assumption was true for the workstation areas found in the corners of the hallways where there were APs located, giving a pretty good signal. But as you get further away from these study areas the signal starts to degrade. We expected there to be a good signal strength in the classrooms because as mentioned earlier, these are areas where you are going to have an aggregation of students. This assumption was mostly true to our pleasure, as most classrooms had an AP, or were adjacent to a classroom that had one. Another assumption we made was that there would be poor coverage in the offices as we expected these offices to use ethernet. This assumption was half true because some of the offices had APs inside of them, giving those offices great coverage and some offices were far away from APs and had poor coverage.

One area that we noticed was very poorly covered would be in the back of the anthropology offices. This area received some of the worst signal on the whole floor. One reason for this could be that it is relatively far from other APs and there are multiple walls separating it from those APs. There is also a microwave and printer located in this area which are known sources of interference. We believe all of these combined factors lead to it having such poor coverage. A possible solution would be to move the AP that is in the kitchen into this area and to move the printer and microwave somewhere else. There are a couple of reasons for this. The first reason would be that it is generally a bad idea to have an AP in a kitchen due to problems with interference from the various kitchen appliances that are inside. Another reason is that there is an AP very close to the kitchen AP and the proximity of these APs could cause interference between them. By moving the AP in the kitchen to the back of the anthropology offices you could solve the issues of all of the interference possibilities of that AP and increase the signal strength in that area.

Performance Study

During our initial survey of the premises, we engaged with various stakeholders, including students, professors, and office staff, to gain a comprehensive understanding of the wireless networking environment. This interaction allowed us to gather valuable insights into user behaviors, preferences, and potential challenges faced by different segments of the academic community. Concurrently, we meticulously identified each access point throughout the facility and systematically associated their Basic Service Set Identifiers (BSSID) using advanced tools such as NetSpot and NetSetMan. This strategic approach ensured a thorough examination of the network infrastructure, laying the groundwork for a detailed analysis of the wireless landscape.

In addition to pinpointing access points, our survey encompassed a comprehensive assessment of the surroundings, with a particular focus on identifying any potential sources of interference. By keenly observing the immediate environment, we aimed to uncover factors that could impact the overall performance and reliability of the wireless network. Furthermore, our evaluation extended to the testing of Access Point (AP) throughput, involving the execution of iPerf tests. This rigorous testing methodology provided quantitative data on the network's capacity and efficiency, contributing to a comprehensive evaluation of the wireless infrastructure's capabilities.

To perform these essential iPerf3 transmission tests, we needed to specify the APs we were connecting to. NetSetMan proved an invaluable resource in performing these tests, as it allowed us to connect APs based on their BSSIDs. However, as we mentioned earlier NetSetMan is only available on Windows devices, and so we struggled to perform iPerf3 tests in our early site visits. That was due to one of our team members' Windows computers failing, and so we focused on other aspects of the survey before running iPerf3 tests.

The algorithms for different devices roaming were relevant to us, as we realized how the MacBook device was not roaming to the highest signals, unlike the Windows computers we utilized. The mediocre signal throughout the hallways would make it difficult to reconnect to a stronger AP once in a classroom. There were many instances where we would leave a classroom with an AP and go to another nearby. If that classroom had an AP, there was a good chance the MacBook wouldn't connect due to the signal strength not reaching the threshold for roaming. This issue is due to the placement of these APs being sometimes so congested that one simply can't connect to the better-quality AP.

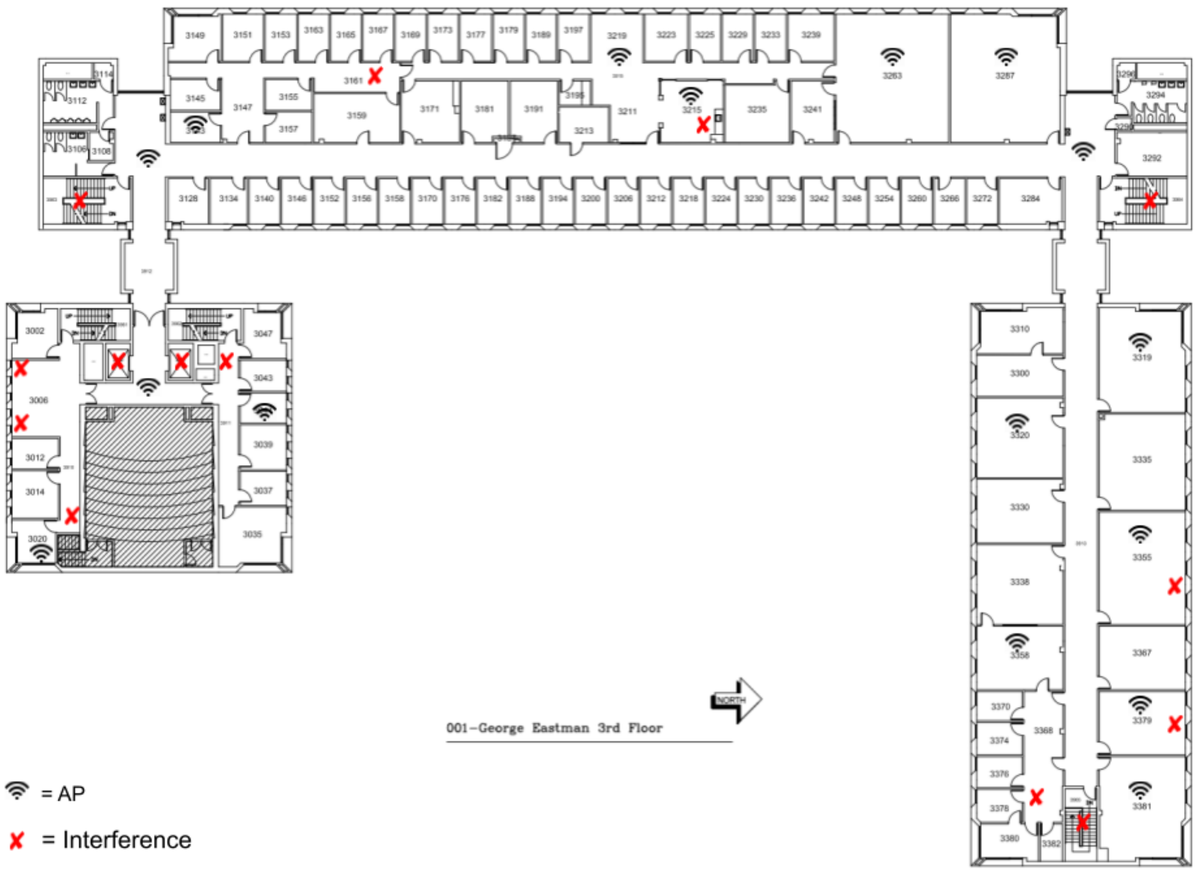
Our solution for these issues would be for offices to adopt ethernet dock stations so they would rely less on APs. This is due to the office computers typically being connected to an Ethernet source and the workers constantly roaming about the building. An Ethernet dock in their offices would be convenient for when they are stationary and working. However, it also would replace the plenty of APs we found in offices, as we concluded that it would be best for more to populate the hallways. The 3rd floor tends to have plenty of people passing through the halls daily, so ensuring they have the best network experience while roaming would be most impactful. As displayed in **Appendix C**, the areas with the most consistently poor signal strength were the hallways. The School of Communications, anthropology offices, and north and east hallways all provided weaker signals surrounding APs. Specifically, the School of Communications and Anthropology offices had APs inside of rooms, leaving their pubic areas and pathways with weaker signals.

Summary

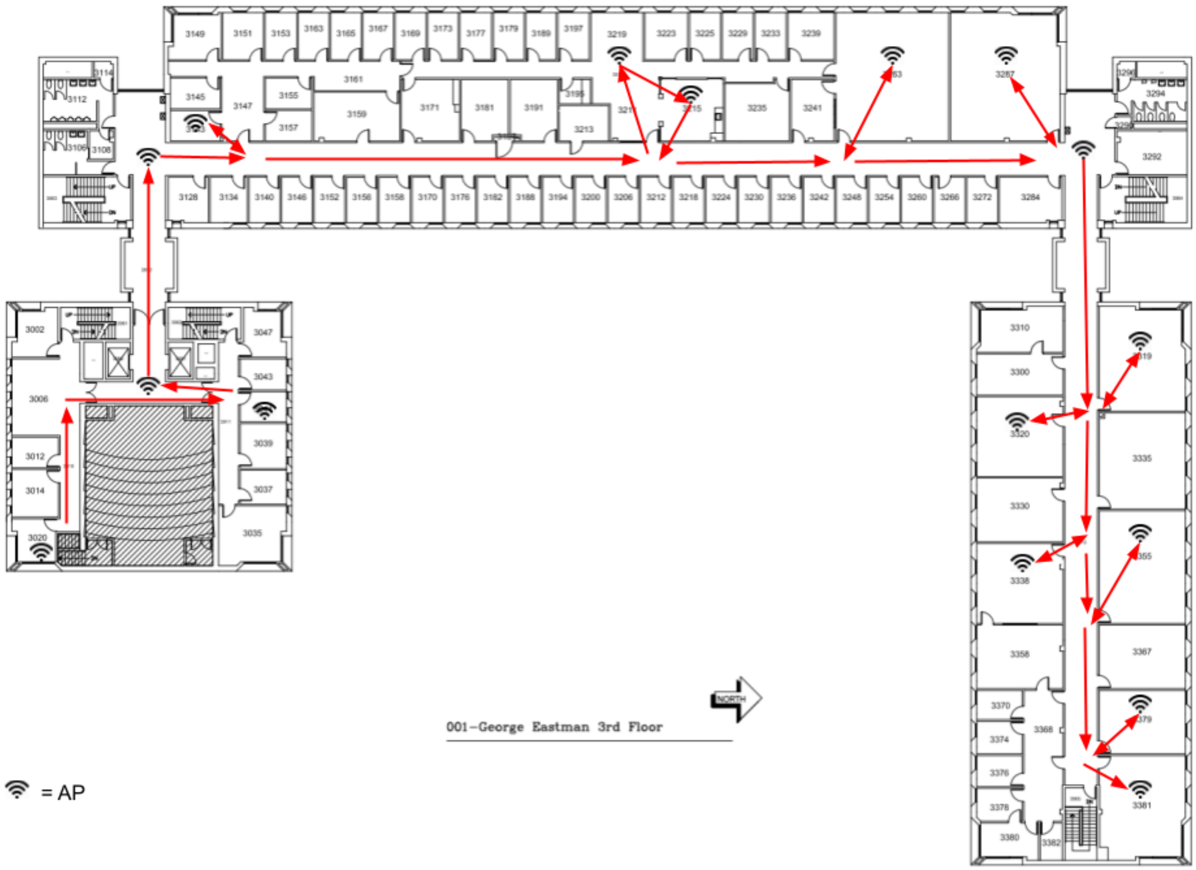
In summary, the goal of this project was to examine the current WiFi network layout and configuration on the third floor of the George Eastman building. Through our site survey, we have analyzed AP placement, points of interference, and various other factors that could affect the WiFi coverage on the floor. We used multiple different network analysis tools to gather, aggregate, and analyze various sets of data to come to conclusions about the network performance. From our analysis of both physical and digital data, we have come to inferences on how improvements could be made to increase the coverage and signal strength of WiFi connections on the floor. Through this assignment, we have learned a lot about what makes a good wireless network configuration and we hope that our recommendations could be used to improve the wireless network performance of George Eastman's third floor.

Appendix

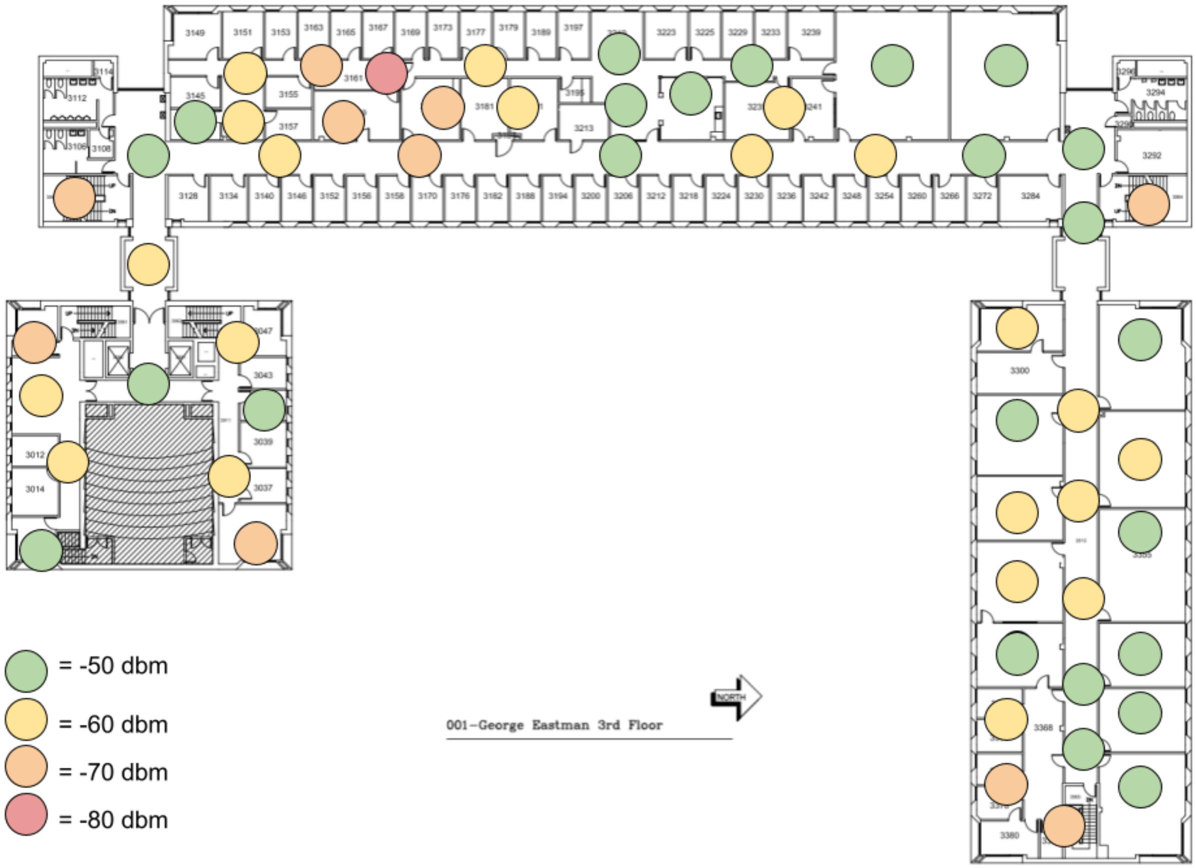
<u>Appendix A</u>: AP placements with possible sources of interference



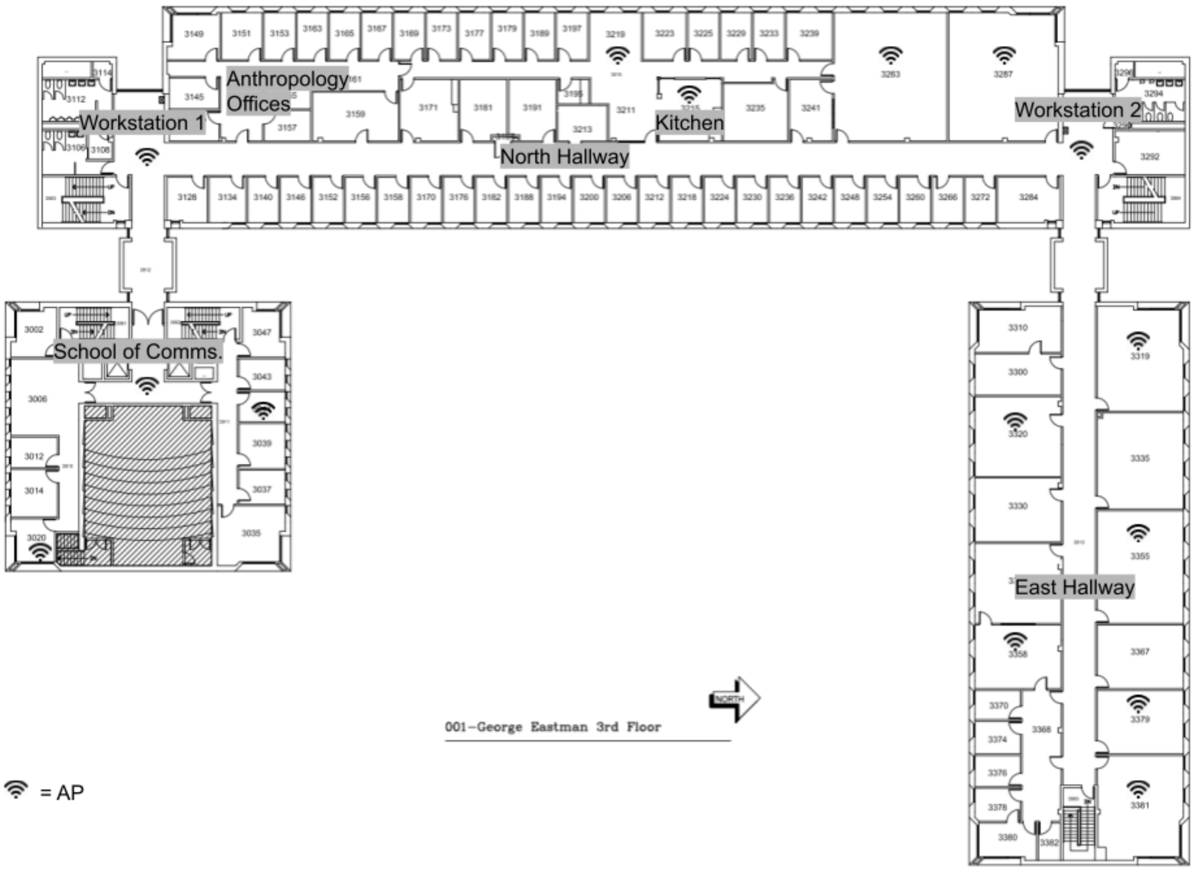
<u>Appendix B</u>: Survey Path



Appendix C: Heat Map



Appendix D: Locations Labeled



= AP

<u>Appendix E</u>: Speedtest Results

Location	Download Speed	Upload Speed
School of Communications Main Office	134.65Mbps	252.70Mbps
Workstation 1	184.47 Mbps	301.65 Mbps
School of Anthropology Main Office	198.08 Mbps	300.88 Mbps
School of Modern Language Main Office	184.95 Mbps	272.01 Mbps
Workstation 2	184.11 Mbps	350.86 Mbps
School of Psychology Main Office	166.14n Mbps	263.20 Mbps

Appendix F: iPerf3 AP transmission test results

BSSID	TCP Transfer	TCP Bandwidth	UDP Transfer	UDP Bandwidth	UDPJjitter	Packet Loss
34-FC-B9-11-60-F2	52.6 mbyte	44.1 mbit/sec	513 mbytes	431 mbits/s	5.486 ms	57%
70-3A-0E-96-51-72	69.6 mbyte	58.4 mbit/sec	389 mbytes	327 mbits/s	0.359 ms	67%
34-FC-B9-11-58-D2	36.4 mbyte	30.5 mbit/sec	400 mbytes	335 mbits/s	0.312 ms	31%
34-FC-B9-11-55-B2	54.8 mbyte	45.9 mbit/sec	501 mbytes	420 mbits/s	6.336 ms	90%
34-FC-B9-11-3C-52	42.7 mbyte	35.8 mbit/sec	432 mbytes	363 mbits/s	0.15 ms	44%
34-FC-B9-11-41-D2	54.7 mbyte	45.9 mbit/sec	300 mbytes	252 mbits/s	1.063 ms	57%
34-FC-B9-11-4A-B2	46.2 mbyte	38.8 mbit/sec	401 mbytes	336 mbits/s	0.17 ms	46%
34-FC-B9-11-48-72	52.6 mbyte	44.1 mbit/sec	487 mbytes	408 mbits/s	0.26 ms	57%
34-FC-B9-11-49-32	56.3 mbyte	47.2 mbit/sec	510 mbytes	428 mbits/s	0.171 ms	57%
34-FC-B9-05-63-51	45.6 mbyte	38.2 mbit/sec	496 mbytes	416 mbits/s	0.389 ms	52%
34-FC-B9-11-40-72	46 mbyte	38.5 mbit/sec	486 mbytes	408 mbits/s	0.923 ms	52%
34-FC-B9-11-48-B2	45.4 mbyte	38.1 mbit/sec	488 mbytes	409 mbits/s	0.796 ms	53%
34-FC-B9-11-3C-32	49.8 mbyte	41.8 mbit/sec	517 mbytes	434 mbits/s	0.373 ms	66%
34-FC-B9-11-3F-52	44.8 mbyte	37.6 mbit/sec	475 mbytes	399 mbits/s	0.498 ms	55%
34-FC-B9-11-5F-72	49.7 mbyte	41.7 mbit/sec	394 mbytes	331 mbits/s	1.36 ms	28%
34-FC-B9-11-61-12	45.1 mbyte	37.8 mbit/sec	479 mbytes	402 mbits/s	0.234 ms	53%
34-FC-B9-11-60-B2	45.9 mbyte	38.5 mbit/sec	486 mbytes	407 mbits/s	0.16 ms	58%