Yeditepe University Faculty of Fine Arts

Network Infrastructure and Performance Analysis Document

Yeditepe University Network Infrastructure

The internet infrastructure at our university is designed to ensure efficient and reliable connectivity across all faculties. The distribution system is organized as follows:

1. User Connections (Switch <-> Nodes):
   - o Connection Type: Ethernet (RJ45)
   - o Speed: 100 Mbps or 1 Gbps

     These connections provide access to the network from the various user devices, ensuring a stable and flexible network experience. The Ethernet-based connections support different speeds, catering to varying requirements of user devices and network loads.

1. Connection to the Central System Room (Switch <-> Central System Room):
   - o Connection Type: Fiber Optic
   - o Speed: 1.25 Gbps

     The connection between the network switches and the central system room utilizes fiber optic cables, which offer high-speed, reliable, and scalable data transmission. The 1.25 Gbps bandwidth ensures sufficient capacity for managing the data flow from all faculties and supporting high-demand applications.

This infrastructure provides a robust foundation for the university's internet services, allowing for seamless data transmission between users and the central system.

Faculty of Fine Arts Network Infrastructure

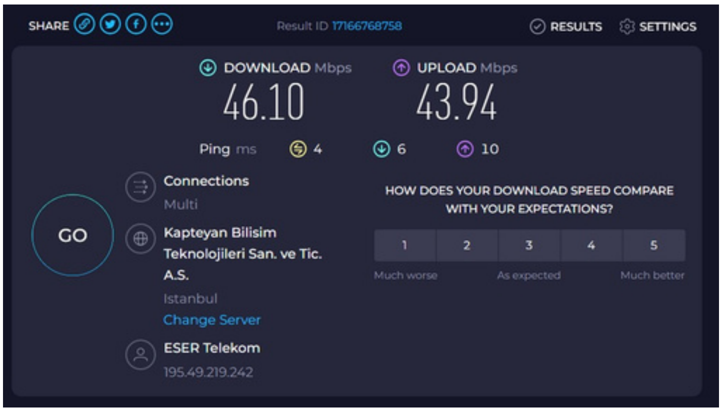
The Faculty of Fine Arts benefits from an advanced internet infrastructure, which is managed through two dedicated system rooms located within the building. The system room on the 4th floor is responsible for distributing internet services to the first six floors (0-5), while the system room situated on the 6th floor handles the internet distribution for floors 6 through 8. Both of these rooms are strategically placed to ensure optimal coverage across the building.

Internet access to the building is provided via fiber optic cable, ensuring high-speed delivery to the main distribution points. However, once the internet reaches the system rooms, the distribution within the building is carried out using copper cables (Ethernet). This setup allows for reliable and stable connections for users on each floor.

The network infrastructure in both system rooms is organized through the use of switches. These devices manage and control the data traffic, ensuring that the internet connection is distributed effectively across all floors of the building. According to the results of the speed tests conducted within the building, the total internet speed allocated to the Faculty of Fine Arts is measured at approximately 50 Mbps. This bandwidth is shared among all users within the faculty, with the internet speed being distributed across all users within the building.

As part of our assessment, we also analyzed how the bandwidth is divided among the floors and system rooms to understand how the internet speed might fluctuate depending on network congestion and the number of active users at any given time.

Results of the Speed Tests Conducted in the Faculty of Fine Arts:



Is the Current Connection Method Cost-Effective?

While fiber optic technology provides high speed and low latency, the use of Ethernet cabling for distribution within the building somewhat limits its full potential. The fiber optic connection to the system rooms is an efficient and high-performance method of bringing internet access into the building. However, once inside the building, the reliance on Ethernet cables for distribution creates a bottleneck. This results in suboptimal performance, particularly as the number of connected devices increases.

Though the current setup is a balanced solution, the Ethernet distribution does not fully capitalize on the speed capabilities of the fiber optic connection. Given this limitation, exploring alternative solutions could offer a more efficient and scalable network infrastructure for the Faculty of Fine Arts.

More Suitable Alternatives:

1. **FTTR (Fiber To The Room)**
   By expanding fiber optic cabling inside the building, it would be possible to achieve the full potential of the fiber optic technology, offering higher speeds and greater reliability across all floors. However, this solution would involve high installation costs due to the need for extensive fiber optic cabling and infrastructure upgrades.

2. Wireless Systems (Wi-Fi 6/Mesh)

A wireless solution, particularly Wi-Fi 6 or Mesh networks, could be a cost- effective alternative, especially for high-traffic areas. With wireless connectivity, users could benefit from higher speeds and greater flexibility in terms of device placement and mobility. Additionally, Wi-Fi 6 offers improved performance in dense environments with many connected devices. A mesh system could ensure more consistent coverage throughout the building, eliminating dead spots and improving overall network performance.

3. **PoE Technology (Power over Ethernet)**
   Power over Ethernet (PoE) technology is another potential solution. It allows both data and power to be transmitted over the same Ethernet cable, offering cost savings and simplifying installation. This would eliminate the need for separate power supplies and reduce the complexity of the network setup. While PoE may not provide the same speed as fiber optic or Wi-Fi 6, it offers an affordable and practical solution for smaller areas or specific use cases, such as supporting access points or other network devices.

In conclusion, while the current Ethernet-based connection method provides a reasonable solution, exploring alternatives such as FTTR, Wi-Fi 6/Mesh, and PoE technology could help overcome the limitations of the current setup and provide a more scalable and efficient network infrastructure for the future.

Infrastructure Improvement Suggestions

Increasing the Internet Speed Allocated to the Faculty

The current speed of 50 Mbps allocated to the building appears insufficient, especially considering that it is shared among all faculty users. As the number of connected devices and the demand for bandwidth increases, this speed may no longer meet the needs of users. It is recommended to engage in discussions with the university administration to explore the possibility of securing a higher speed allocation for the faculty. This could ensure a more stable and efficient internet connection for all users, particularly in areas with high demand traffic areas, such as lecture halls and common rooms. This would ensure that the Wi-Fi performance remains stable even during peak usage hours, offering better support for multiple devices simultaneously.

Dedicated Solution for the Cafeteria

The cafeteria, being a high-usage area, could benefit from a dedicated internet connection to manage the increased demand for bandwidth. A separate internet line could be allocated to this area, connected directly to the system room on the 4th floor. This setup would allow for better performance and ensure that high traffic does not affect the rest of the faculty's network. Additionally, deploying a dedicated switch and router specifically for the cafeteria would help to maintain reliable connectivity even during peak times, ensuring that students and staff can access the internet without disruption.

Network Security and Traffic Management

Implementing network management software would significantly improve the overall network performance by monitoring and optimizing it based on the number of active users. This software can help manage bandwidth allocation more effectively, ensuring that critical services receive the necessary resources. Moreover, managing network traffic by limiting unnecessary activities, such as video streaming or large file downloads during peak hours, could help prevent network congestion and ensure that essential academic services remain unaffected. This would also help improve the overall security of the network by monitoring for potential vulnerabilities and providing insights into traffic patterns that may indicate unauthorized access or cyber threats.

Internet Access in Common Areas and User Density

In the Faculty of Fine Arts, internet access is currently limited to a few specific areas. Wi-Fi coverage is available on the 4th floor, but it is restricted to certain zones, with the cafeteria also having Wi-Fi coverage. However, this coverage is insufficient for the entire faculty, and there is no internet access in many common areas, especially in corridors and classrooms.

The 2nd floor has a temporary Wi-Fi network in place, which was set up because mobile internet does not function well in that particular area. This network serves as a short-term solution for users in that zone who are unable to rely on mobile data. However, aside from the 2nd and 4th floors, wireless internet access is not available on other floors or in classrooms.

For classroom computers, internet access is currently provided via Ethernet cables, which offer stable connections but do not support the mobility needs of users across the building. Given the increasing need for connectivity and mobile access, the lack of Wi-Fi coverage in many parts of the building is an issue that needs to be addressed to enhance overall network accessibility and performance. Expanding Wi-Fi coverage to corridors, classrooms, and other high-traffic areas would greatly improve the user experience and accommodate the growing demand for reliable internet access across the faculty.

Cafeteria User Density Tests

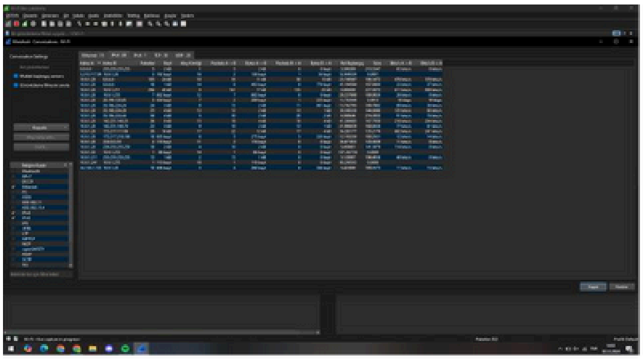
During our tests in the cafeteria, we observed a significant difference in internet speed based on user density. Between 12:00 PM and 2:00 PM, during peak hours, approximately 54 people were connected to the Wi-Fi network. At this time, Speedtest results revealed that the internet speed dropped drastically to around 2 Mbps, indicating network congestion and insufficient bandwidth to handle the high number of concurrent users.

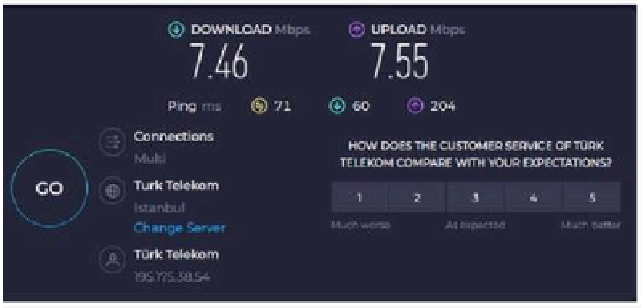
In contrast, during off-peak hours, specifically between 2:00 PM and 4:00 PM, the number of connected users dropped to about 20. As a result, the internet speed improved to around 8-9 Mbps, demonstrating that a lower user density leads to better network performance.

To better understand the connection patterns, we used Wireshark to analyze the number of users connected to the Wi-Fi network. This analysis confirmed that network performance is directly influenced by the number of active users. The data gathered highlights the need for improving the network's capacity in high-traffic areas, such as the cafeteria, to ensure consistent and reliable internet access for all users.

In the cafeteria, the signal strength for the Wi-Fi connection was consistently strong throughout the testing period. Our phones showed high signal levels, indicating that there were no issues with the strength or coverage of the signal. Despite this, a noticeable decrease in network speed occurred as the number of users increased.

Results of the Speed Tests Conducted in the Cafeteria:





Is the Bandwidth Sufficient Based on the Number of Users?

The current bandwidth allocation for the faculty is approximately 50 Mbps, shared among all users. Based on observations in the cafeteria, it is evident that this allocation is insufficient to meet the demands of peak user density.

During peak hours (12:00-14:00), when approximately 54 users were connected to the Wi-Fi network, the internet speed dropped significantly to around 2 Mbps. This translates to approximately 0.037 Mbps per user, which is far below the requirements for modern applications that demand stable and faster internet connections. Such a speed is inadequate for tasks such as video conferencing, large file downloads, or streaming services, which are increasingly common in academic environments.
In contrast, during off-peak hours (14:00-16:00), when only 20 users were connected, the speed increased to approximately 9 Mbps, providing around 0.45 Mbps per user. While this is an improvement, it remains suboptimal for anything beyond basic web browsing and email. With modern educational tools and digital resources requiring higher bandwidth, the speed provided during non-peak hours is still not sufficient to meet the needs of users engaging in more bandwidth-intensive activities.

The analysis clearly shows that the current bandwidth allocation cannot adequately support the peak user density, particularly in high-traffic areas like the cafeteria. To ensure a better user experience and support modern digital needs, increasing the total allocated bandwidth for the faculty is essential.

How Can the Network's Performance in Shared Areas Be Improved?

1. **Increase Allocated Bandwidth:** Allocating additional bandwidth to the faculty will directly enhance the overall internet speed, especially during peak times. By increasing the bandwidth, the network can handle more users simultaneously, reducing congestion and improving the experience for users in shared areas.
2. **Optimize Wireless Coverage:** Expanding the Wi-Fi coverage in high-traffic areas such as the cafeteria, hallways, and classrooms is essential for improving performance. Deploying additional access points with stronger signal capacity and adaptive frequency selection can help manage the load more efficiently. This will prevent areas from experiencing weak signal strength and ensure that users have stable and reliable connectivity.

3. **Traffic Management and Prioritization:** Implementing Quality of Service (QoS) protocols can help prioritize critical applications, such as educational platforms or administrative tools, over bandwidth-intensive activities like video streaming or large file downloads. This will ensure that essential tasks receive the necessary bandwidth during peak hours, improving the overall performance of the network.
4. **Upgrade Networking Equipment:** Transitioning from copper-based Ethernet cables to fiber optic cables within the building can significantly enhance data transmission speeds and overall network reliability. Fiber optic technology offers higher bandwidth and lower latency, improving the user experience across the entire network.
5. **Load Balancing Strategies:** Introducing multiple Wi-Fi networks—such as separate guest and staff/student networks—can distribute the load more evenly across different users and prevent network overcrowding. This will help balance user demand and avoid congestion on a single network.
6. **Periodic Performance Audits:** Regularly monitoring the network's performance using tools like WirelessMon and Wireshark will allow network administrators to identify bottlenecks and areas for improvement. Regular audits will ensure that the network operates efficiently and that any issues are quickly addressed.

By addressing these factors, the faculty can create a more reliable and faster network, especially in shared spaces. These improvements will enhance the user experience, reduce network congestion, and ensure that all users can access the internet smoothly, even during peak usage times.

Signal Strength Analysis and Performance Testing Using Access Point and WirelessMon

In this project, the TP-Link Omada EAP110 model Access Point (AP) was utilized to assess the wireless network performance. The TP-Link Omada EAP110 is designed for small to medium-sized offices, educational institutions, and similar environments, making it an ideal choice for our study.

The AP supports Power over Ethernet (PoE), which allows both power and data transmission over a single Ethernet cable. Since our project used only one computer, we took full advantage of this feature. By utilizing PoE, we were able to supply both data transmission and power to the Access Point through a single Ethernet cable, eliminating the need for a separate power source and simplifying the setup process.

To measure the performance and signal strength of the wireless network, we employed WirelessMon, a software tool designed to monitor and analyze Wi-Fi networks. We used WirelessMon to measure signal strength at various locations within the Faculty of Fine Arts, with the goal of identifying areas that might suffer from weak signal strength. The software provides real-time data on the signal strength of each access point in terms of both percentage and dBm.

As we conducted measurements at different points, we observed and recorded the signal strength, marking areas where the signal strength dropped below 10%. These results indicated that the signal strength decreased rapidly as we moved further away from the AP, especially in areas not in direct line of sight. This analysis allowed us to pinpoint specific locations in the building that required additional attention in terms of wireless coverage.
By evaluating these measurements, we gained a better understanding of the wireless network's performance, enabling us to identify weak signal zones and optimize the network to ensure better coverage and user experience throughout the facility.

AP Signal Strength Measurements and Results

In our project, we utilized WirelessMon to measure the signal strength of the Access Point (AP) at various distances, allowing us to calculate the AP's maximum range. Based on the measurements collected, we observed the following signal strength levels:

- At 0 meters (next to the AP), the signal strength was -32 dBm.
- At 2-3 meters, the signal strength decreased to -40 dBm.
- At 5-6 meters, the signal strength was recorded at -45 dBm.

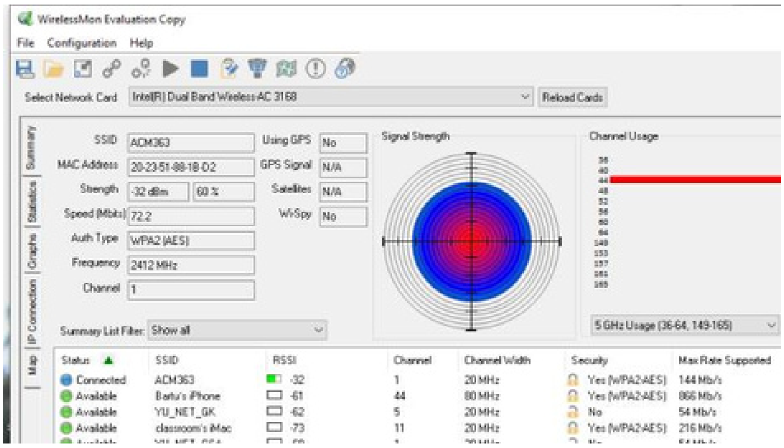
We considered -67 dBm as the minimum signal strength at which the signal begins to weaken, and this threshold was used to evaluate the effective range of the Access Point.

Using the data, we calculated the drop in signal strength per meter. By observing the difference in signal strength between 0 meters and 6 meters, we found the signal drop rate to be -2.17 dBm/meter. This rate of decrease helped us determine the distance over which the signal would weaken from -32 dBm to -67 dBm, which we calculated to be approximately 16.1 meters. This indicates that the Access Point's signal remains reliable up to a distance of 16.1 meters under ideal conditions.

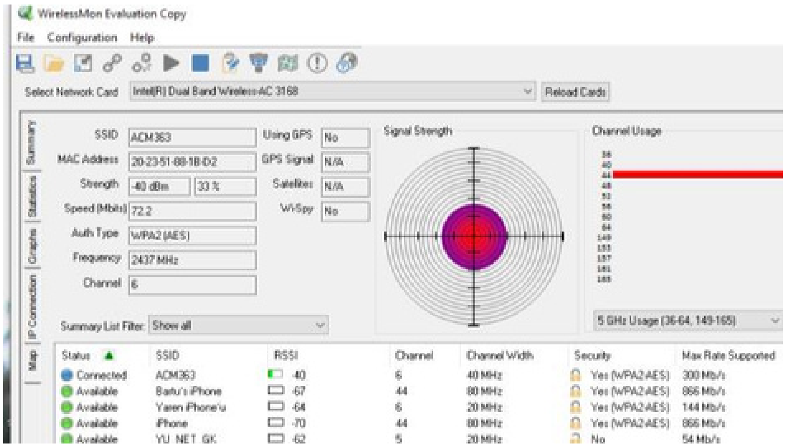
Since these measurements were taken in an open area, such as the cafeteria, they provide an estimate of the signal performance in clear, unobstructed spaces. Based on these results, we concluded that placing an Access Point every 12 meters would be an optimal configuration to ensure sufficient signal strength and uninterrupted internet access across the space.

Additionally, we performed measurements in areas with obstacles and in less open spaces to test how the signal strength behaved under such conditions. These tests were crucial in understanding how the presence of walls, furniture, and other obstructions could impact the AP’s performance and signal reach, providing insights into how to plan for better coverage in areas with potential interference.

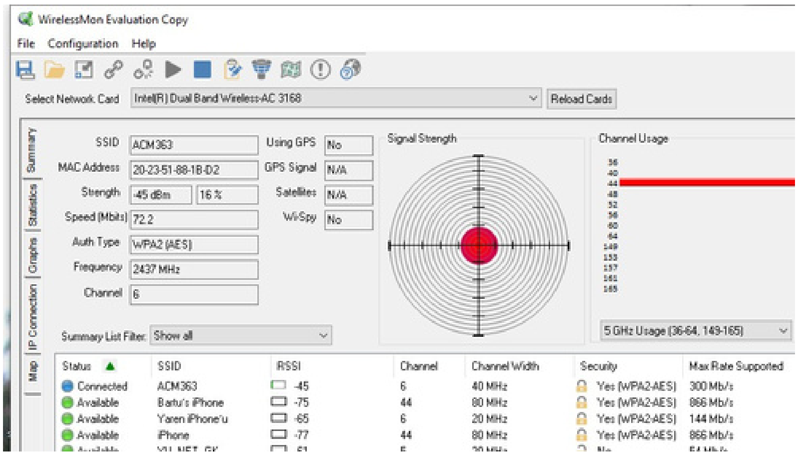
Measurement Next to the AP:



Measurement Taken 2-3 Meters Away from the AP:



Measurement Taken 5-6 Meters Away from the AP:



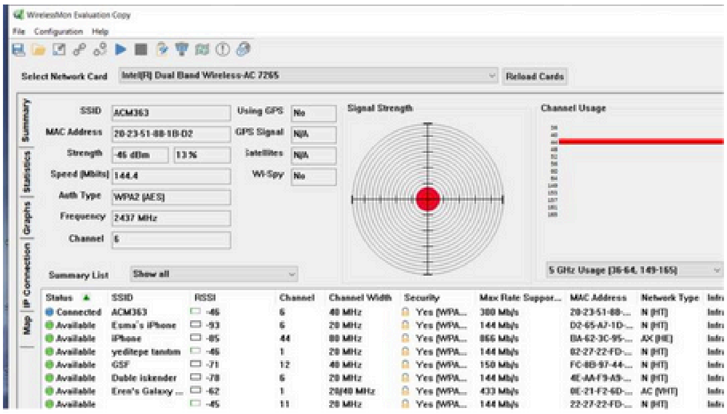
Distance (m)	Signal Strength (dBm)
0 (Next to AP)	-32 dBm
2-3 m	-40 dBm
5-6 m	-45 dBm

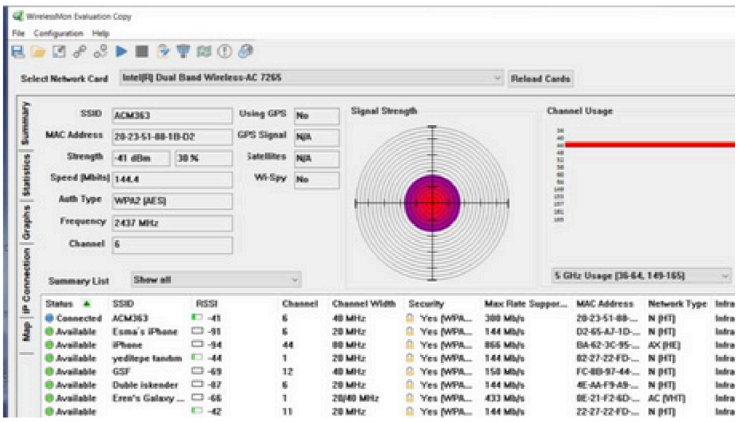
Conference Hall Measurements

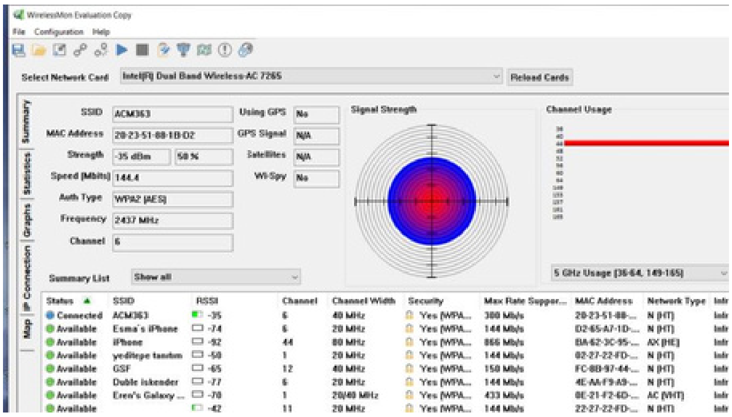
To evaluate the adequacy of Wi-Fi coverage in the conference hall, we utilized WirelessMon to measure the signal strength provided by the Access Point (AP) installed in the center of the hall. Initially, a measurement was taken right next to the

AP, where the signal strength
was recorded at -35 dBm. As we moved towards the corners of the hall, the signal strength decreased to -41 dBm. Finally, when we moved to one of the far corners of the conference hall, the signal strength was recorded at -45 dBm.

Based on these measurements, we determined that the signal strength from the AP was adequate to cover the entire conference hall. The absence of large physical objects or obstacles that could obstruct the signal allowed the AP to maintain strong coverage throughout the hall. Furthermore, we discovered that the conference hall already had a pre-existing Wi-Fi network in place, which provided full coverage, further confirming the effectiveness of the AP.
In conclusion, our measurements confirmed that a single AP was sufficient for the conference hall. With the current Wi-Fi network and the AP's signal strength, no additional hardware was required.





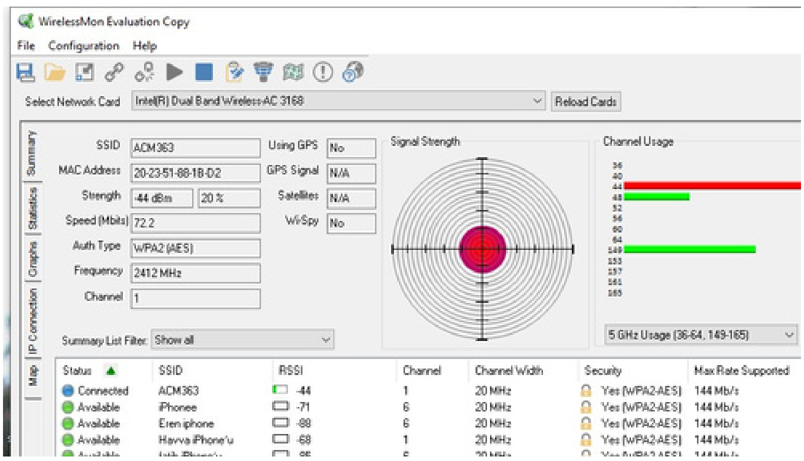


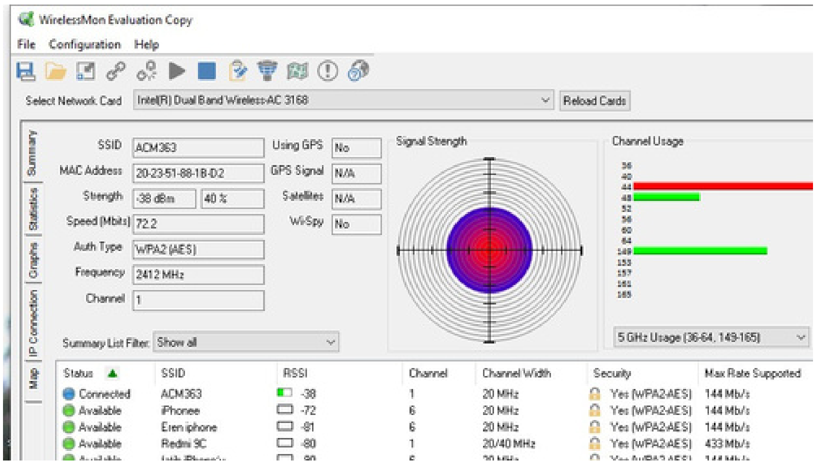
Lecture Hall Measurements

In the faculty's lecture halls, we measured the signal strength of the Access Point (AP) using WirelessMon to assess its coverage at various points within the space.

The first measurement, taken near the AP, recorded a signal strength of -38 dBm. As we moved towards the corner of the lecture hall, we observed a decrease in signal strength, which dropped to -44 dBm.

These results indicate that a single Access Point is sufficient to provide adequate coverage across the entire lecture hall. The minimal signal loss observed was due to the absence of significant physical obstructions within the hall. As such, one AP was deemed suitable for each lecture hall to ensure reliable coverage.

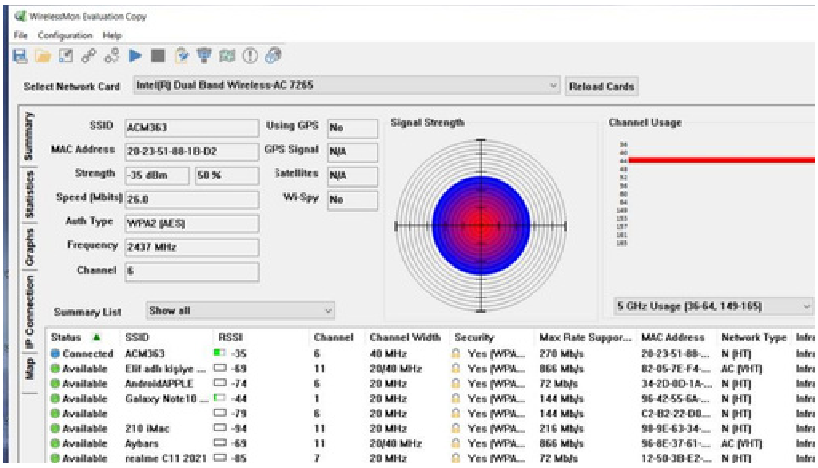


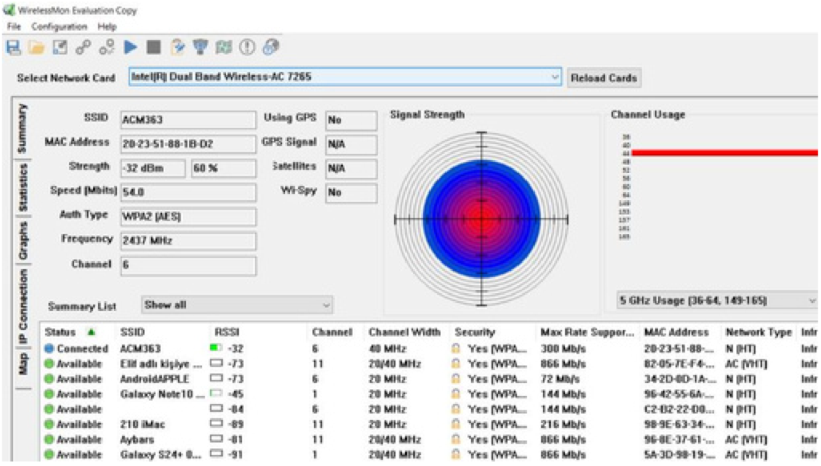


Classroom Measurements

In the measurements conducted in the classrooms, the Access Point was placed at the center of the room, where the signal strength was measured at -32 dBm. As we moved towards the edges of the room, the signal strength gradually decreased to -35 dBm.

Based on these results, we concluded that it is not necessary to place a separate Access Point in each classroom. Instead, to ensure adequate coverage, we decided to place 3 Access Points to service 6 classrooms. This setup provides sufficient coverage without the need for an individual AP in each classroom.

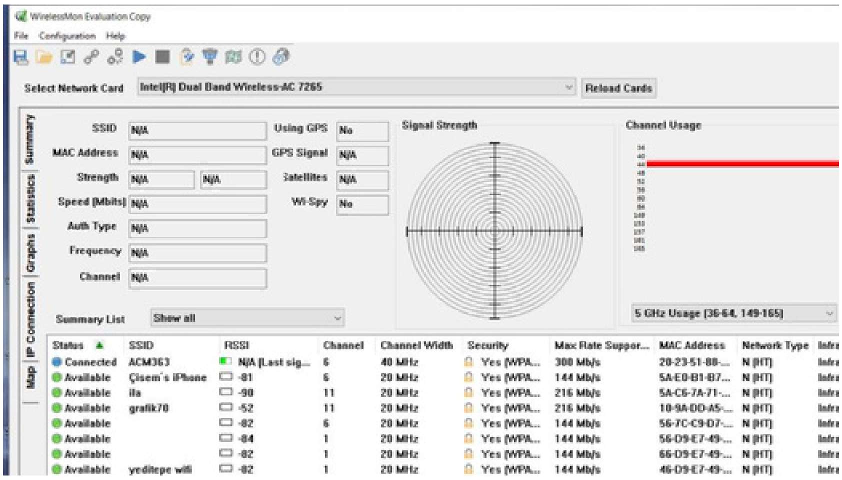


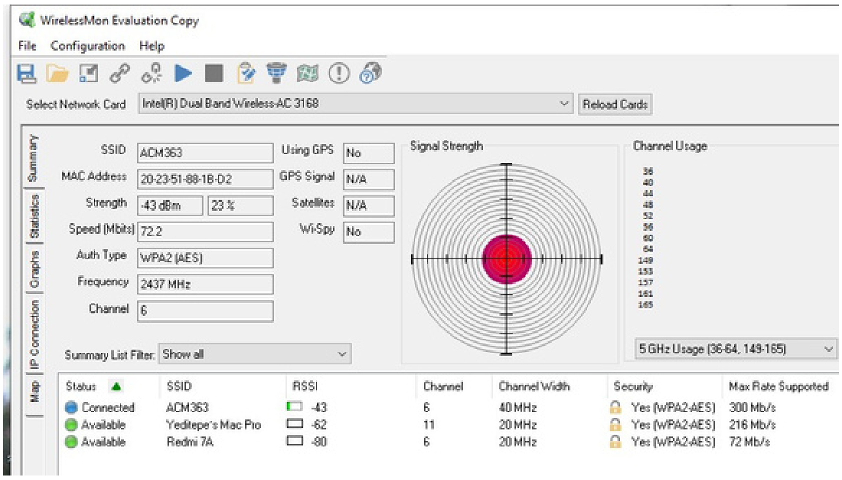


Studio Measurements

In the measurements conducted in the studios of the faculty, we observed a significant drop in signal strength due to the thick walls, which hindered the signal's ability to pass through. This issue was particularly noticeable as the signal quality rapidly decreased when moving toward the interior of the studios.

Given the consistent signal loss across all studios measured, we concluded that to ensure uninterrupted internet access in these areas, it is necessary to place an Access Point in each studio. This will help provide stable and reliable coverage despite the challenges posed by the studio’s structural design.



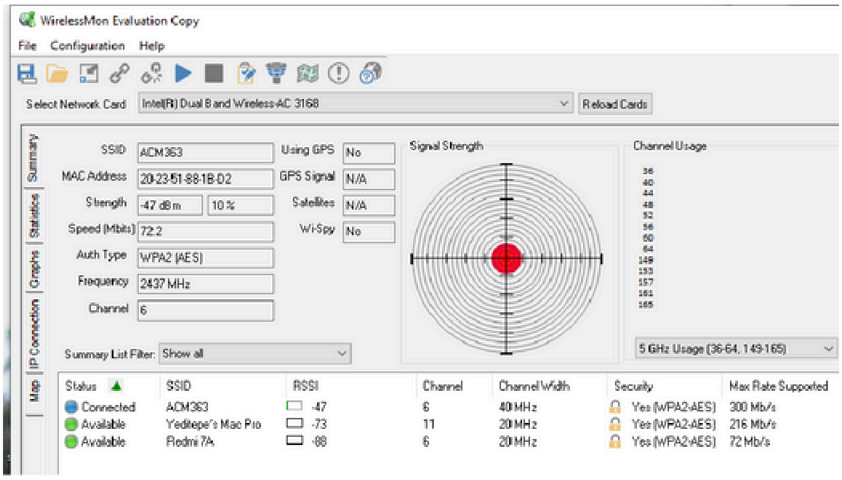


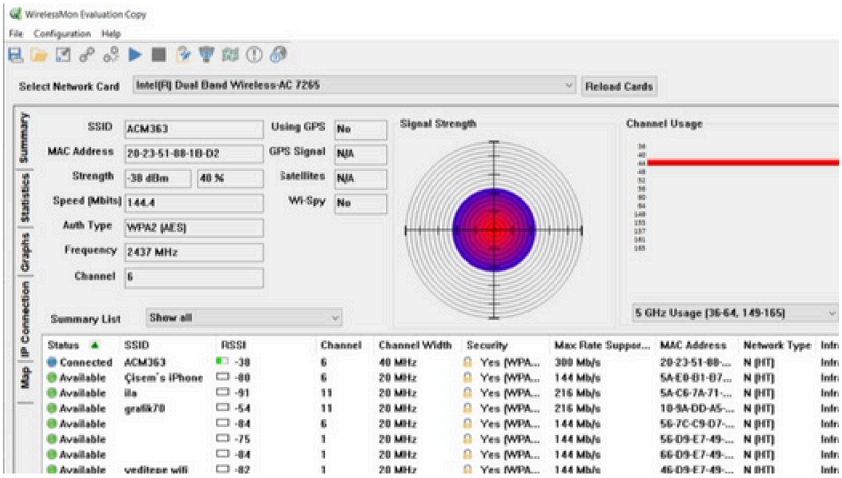
Gallery Area Measurements

In the measurements conducted in the gallery area on the ground floor, we placed the Access Point (AP) at the center of the space and tested the signal strength at varying distances. Close to the AP, the signal strength was recorded at -38 dBm. As we moved further into the gallery, the signal strength gradually decreased, reaching -47 dBm. We observed that the pictures, decorative items, and other objects in the gallery

partially obstructed the signal transmission. However, despite these obstacles, the signal did not experience a complete drop in strength. The signal remained strong enough to provide coverage across the entire gallery area.

Based on these measurements, we concluded that one Access Point would be sufficient for the gallery. By strategically placing the AP at the center of the space during installation, we ensured that the signal would be evenly distributed, providing uninterrupted connectivity throughout the gallery.



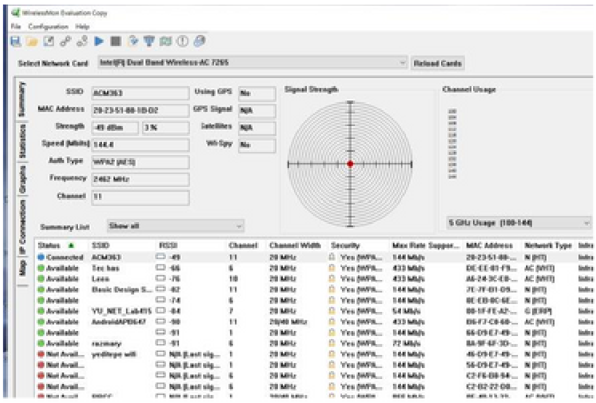


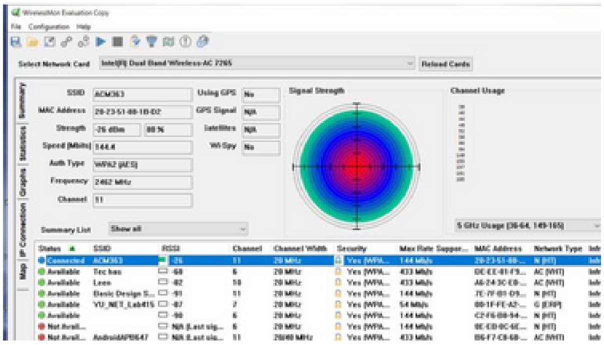
Corridor Measurements

During the measurements conducted in the corridors, the Access Point (AP) provided a strong and consistent signal throughout the length of the corridor. The signal strength was notably high at various points along the corridor, indicating effective coverage in the open areas. However, upon entering the nearby rooms, we observed a significant drop in signal strength. This decline suggests that the thick walls within the faculty are negatively affecting the signal transmission and reducing its quality as it passes through. The measurement results showed that the signal

strength in the corridor started at a
high value of -26 dBm, but as we moved into the nearby rooms, the signal dropped considerably to -49 dBm. This drop in signal strength was particularly caused by the walls, which obstructed the signal and prevented it from maintaining the desired quality inside the rooms.

To ensure optimal signal coverage in the rooms as well, we strategically placed the Access Points (APs) in the corridors, allowing the signal to cover both the open spaces in the corridor and extend to the rooms. This placement ensures that there is minimal interference from the thick walls while providing adequate signal strength throughout the faculty.





Floor Plans and Access Point Locations

First, we used the Unifi Designer website to draw the walls and rooms for each floor of the faculty building. These drawings were carefully placed to simulate the building's structural features accurately. Then, to simulate the access point (AP) we measured, we optimized the settings of the available AP in Unifi Designer. In this step, especially for large areas (such as conference rooms and student studios), we placed two or more APs to ensure strong signal strength and avoid weak coverage.

The overall design within the faculty aimed to use the minimum number of APs. However, in areas where the signal was weak, additional APs were placed to fill in these gaps. In the images, the walls shown in dark blue are simulated as thick walls. These walls block the signal and cause power loss, so we were careful when placing the APs.

Since the signal loss between classrooms was not too high, instead of placing an AP in every classroom, we placed APs in the corridors at regular intervals. This strategy allowed us to provide internet access while also saving on costs. The APs placed in the corridors covered the classrooms as well, providing a more efficient solution. This way, we improved the network performance and minimized costs by avoiding unnecessary AP placements.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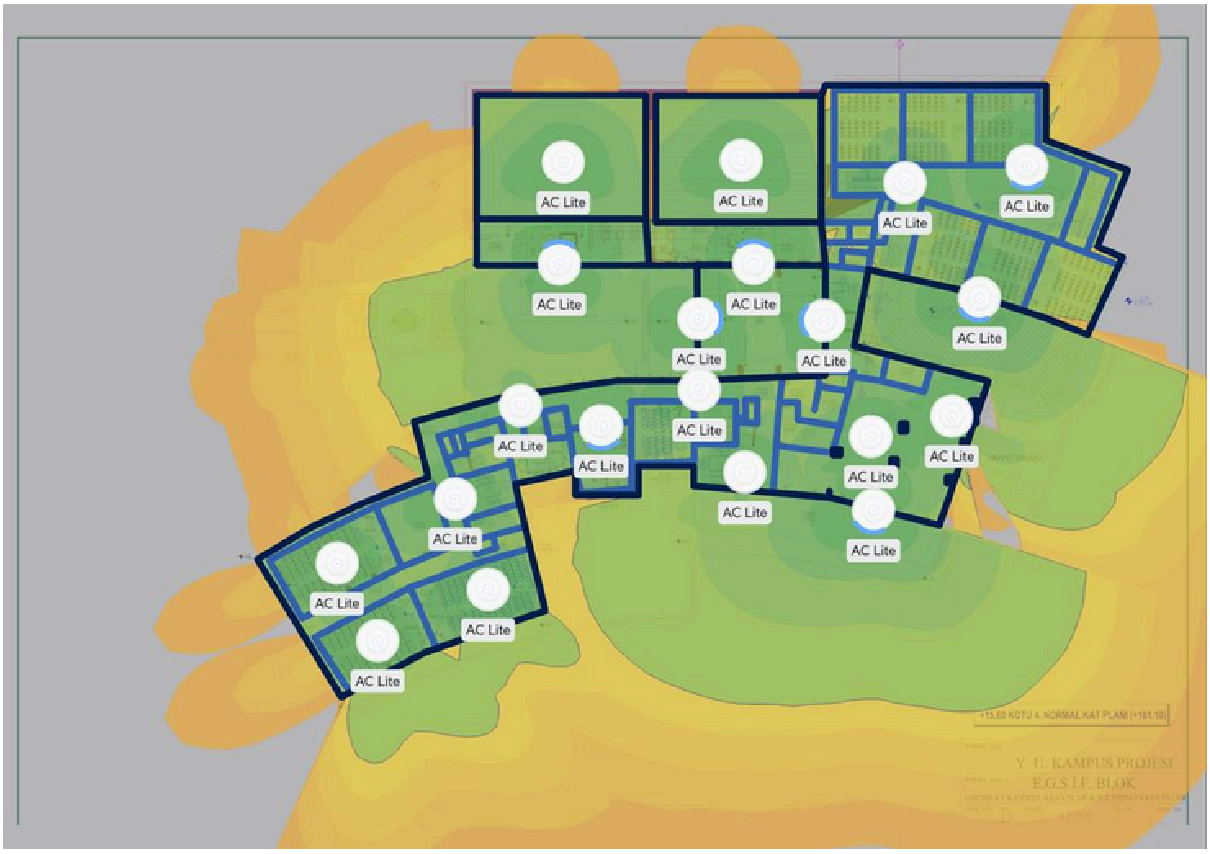
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Conclusion

In this project, we have successfully designed and implemented a comprehensive wireless network solution for a large-scale area within the faculty. Through careful planning and systematic measurements using WirelessMon, we assessed the signal strength across various locations, including conference halls, lecture halls, classrooms, studios, gallery areas, and corridors. By analyzing these measurements, we determined the optimal placement of Access Points (APs) to ensure robust and seamless network coverage throughout the entire facility.

The findings of our measurements demonstrated that, in open spaces like conference and lecture halls, a single AP could provide adequate coverage, while areas with thicker walls and obstructions, such as studios and certain rooms, required dedicated APs for each space. The implementation of a strategic AP distribution plan, based on the specific needs of each area, allowed us to achieve strong and uninterrupted wireless connectivity across all zones.
The total deployment of 130 Access Points ensured that the network was not only efficient in handling the current number of users but also capable of accommodating future growth. By optimizing the placement of APs and taking into account the environmental factors, we were able to build a network infrastructure that offers high reliability and minimal interference.

Ultimately, this wireless network system enhances the overall user experience within the faculty, providing a stable and fast internet connection for academic and administrative activities. The project not only improved the efficiency of the existing infrastructure but also prepared the system to meet future demands, ensuring long-term scalability and performance.

NAZ CAMİŞ

BAYRAM BEŞER

OSMAN UĞUR TAŞ

DENİZ BERFİN YAĞIZ

ESAT CAN KARABAĞ