# CPP Wireless Network Analysis

## Isaac Blekhman
## Faculty Mentor: Dr. Anas Salah Eddin

## Problem Statement

The campus Wi-Fi network frequently experiences congestion and performance degradation, particularly during peak usage times, leading to inconsistent connectivity and reduced user satisfaction. This issue appears to stem from a combination of factors, including high-density user access, insufficient bandwidth, and potential configuration inefficiencies in network infrastructure such as access points, IP address allocation, and authentication servers. Despite campus IT's efforts to resolve these issues, the underlying causes remain unclear, necessitating a systematic analysis of the network to identify bottlenecks and propose sustainable solutions.

## Objective

The objective of this project is to investigate the root causes of Wi-Fi performance issues across the campus network by collecting and analyzing performance metrics, modeling network behavior, and simulating the impact of potential solutions. The ultimate goal is to provide data-driven recommendations to optimize network performance, reduce congestion, and improve overall user experience.

## Potential Reasons For Slowdown

**Access Point Overload:** Insufficient distribution or capacity of access points (APs) may lead to overcrowding, especially in high-density areas such as classrooms, libraries, and dormitories. Many users connecting to a single AP can exceed its handling capacity, resulting in degraded performance for all connected devices.

**Bandwidth Limitations:** The total bandwidth allocated to the network may not be sufficient to support simultaneous users during peak hours. Streaming, large downloads, and other bandwidth-intensive activities can exacerbate the strain, causing slower speeds and increased latency.

**IP Address Exhaustion:** A limited pool of IP addresses can create connection issues if more devices attempt to join the network than the pool can accommodate. This may particularly impact users in high-density areas.

**Authentication Server Delays:** The RADIUS server, responsible for handling user authentication on networks like eduroam, could be experiencing delays or misconfigurations. This could lead to slow or failed connections, compounding user frustrations during peak periods.

**Lack of Quality of Service (QoS) Implementation:**
Without QoS measures, critical applications and users may compete equally with non-critical traffic, resulting in inefficient allocation of network resources.

## Testing Methodology

- **Signal Strength and Coverage Mapping**: Use Wi-Fi analyzer apps to survey signal strength and AP coverage in high-density areas without needing direct network access.
- **Network Response Time Tests**: Perform frequent ping tests to the campus gateway IP while moving through high-traffic areas to detect latency spikes that may indicate AP overload.
- **Crowdsourced Speed Data**: Collaborate with other network users to gather speed test results from various locations during peak and non-peak hours.
- **Public Speed Testing Tools**: Use external speed testing services to evaluate download, upload, and latency performance during different times of the day.
- **Concurrent Device Simulation**: Utilize multiple personal devices to connect to the network and simultaneously stream content or run downloads to observe the effects on bandwidth.
- **Peak vs. Off-Peak Comparisons**: Record performance metrics during high-traffic times and compare them with metrics from low-traffic times.
- **Connection Success Monitoring**: Note any patterns of difficulty connecting to the network, particularly in high-density locations. Inconsistent connections or the inability to acquire an IP address can suggest exhaustion issues.
- **Network Drops During Peak Hours**: Monitor the frequency of being disconnected and needing to re-authenticate during high-traffic times.
- **Application Performance Monitoring**: Use external tools to monitor the performance of time-sensitive applications compared to less critical activities.
- **Latency and Jitter Tests**: Conduct ping tests to a consistent endpoint(8.8.8.8) during activities like video calls to identify QoS prioritization or lack thereof.
- **Real-World Activity Simulation**: Test multiple simultaneous activities such as streaming, gaming, and file transfers on different devices to observe whether critical applications are impacted.

## Result

**Signal Strength and Coverage Mapping**
•**Findings**: The Wi-Fi analyzer results showed generally good signal strength and minimal interference. However, certain campus areas lacked dedicated wireless access points (WAPs), leaving coverage gaps.
•**Analysis**: The lack of WAPs in specific corners may contribute to poor connectivity in those areas. While signal strength was adequate elsewhere, the primary issue appears to stem from insufficient WAPs or overloaded WAPs due to high device density.

**Network Response Time Tests**
•**Findings**: Ping tests revealed significant spikes when connected via WAPs, while devices connected via Ethernet showed no latency issues.
•**Analysis**: The disparity suggests that congestion or overload at the WAP level is a key issue, as the Ethernet connection through the same switch remains stable. It's possible the WAPs are overwhelmed by the volume of connected devices or affected by suboptimal Quality of Service (QoS) configurations.

**Peak vs. Off-Peak Comparisons**
•**Findings**: Speed tests demonstrated a stark contrast between peak (10–50 Mbps) and off-peak (200+ Mbps) performance.
•**Analysis**: The speed drop during peak times points to congestion at the WAPs. It is likely the WAPs are connected to 1 Gbps switch ports shared with other devices, causing bottlenecks when serving 20–30 users simultaneously.

**Network Drops During Peak Hours**
•**Findings**: Disconnections and the need to re-authenticate occurred frequently in crowded environments, particularly during high-traffic times.
•**Analysis**: These drops further support the hypothesis of RADIUS server overload or poor handling of simultaneous authentication requests. The high user density likely exacerbates existing weaknesses in the network infrastructure.

## Conclusion

The analysis of the campus Wi-Fi network revealed significant periods of high congestion, particularly during peak usage times, corroborating the hypothesis that performance bottlenecks are linked to user density and bandwidth limitations. However, while these findings highlight congestion as a major contributor to connectivity issues, additional investigation is required to identify specific factors such as access point configurations, authentication server performance, and network hardware limitations. Further analysis and collaboration with campus IT are necessary to develop targeted and sustainable solutions to improve network reliability and user satisfaction.
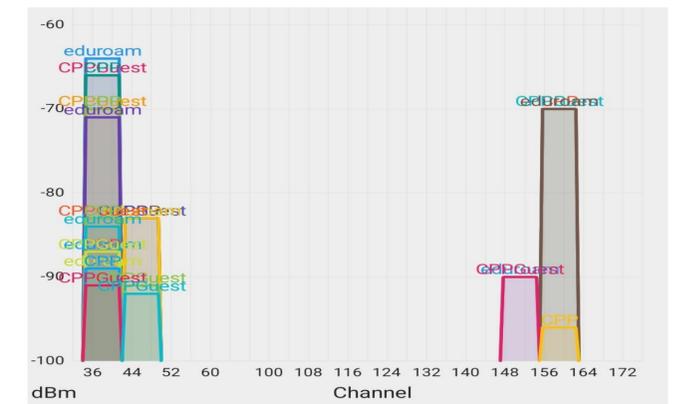


## Github QR Code



## References

Aruba Manuals/Website
Cisco Manuals/Website
CCNA Guides WWW CPP IT