Phase 2 Report

Introduction

Uniwide WiFi network is crucial to UNSW campus, supporting countless academic and extracurricular activities. The primary objective of this analysis is to evaluate the efficiency and coverage of the Uniwide WiFi network on UNSW Kensington campus, and to identify potential areas of improvement. Utilizing collected data, signal strength variation, access point coverage, signal interference and OS-specific issue are explored. Based on findings, potential solution to improve service quality of Uniwide WiFI network is proposed.

Data Analysis and Visualization

<u>Signal Strength Variation</u>

Figure 1. Uniwide RSSI map

Figure 1 shows received signal strength (RSSI) distribution of uniwide network across UNSW Kensington campus. Signal strength is indicated by size, larger data point → stronger signal, and color, green → stronger signal. In this analysis, RSSI lower than -70 dBm, the edge of reliable packet delivery, is considered poor signal strength (Determining Your Wi-Fi Signal Strength (RSSI), 2020). Orange and red data points, < 70 dBm, concentrate around open field areas at Village Green and Physics Lawn as well as areas heavily obstructed by buildings at Library Road, John Lions Garden, Southern Drive and some parts of University Mall.

Cause of poor signal strength in open field areas is simply caused by the long distance from access points which can only be situated at the edge of the field. Clear example of this is on right edge of Village Green area, where data points gradually shift toward yellow and subsequently green as receiver is moved closer to access point. On the left edge, Southern Drive, most data points are still orange-red since the route is heavily obstructed by building on both sides. Poor signal strength in areas obstructed by buildings is due to the effect of multipath, fig. 2, where portion of signal that reflect off building travels further distance, resulting in lower overall signal strength (Hassan, 2022).

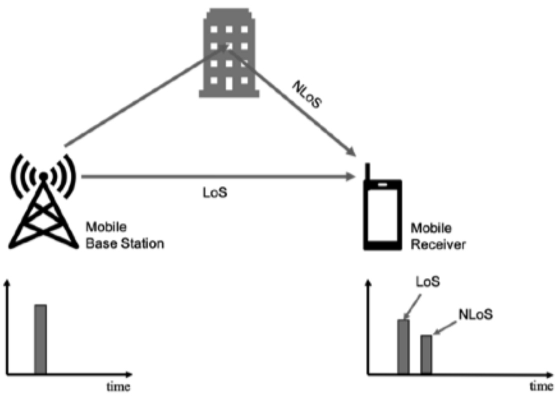

Figure 2. Effect of multipath (Hassan, 2022)

Access Point Coverage

Figure 3. Uniwide Network Delay Map

Figure 3 shows network delay map of uniwide WiFi network on the campus. Red data points, delay of > 4000 ms, suggest WiFi disconnection due to access point coverage gap. Multiple coverage gaps are observed in the area between Village Green and Physics lawn as well as the area between University Mall and Village Green.

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<u>Signal Interference</u>

Due to limitation of receiver with Windows operating system, majority of data lacks noise level figure. To circumvent this issue, we evaluate the number of potentially interfering network for each frequency band instead. Figure 4 and 5 show interfering signal for different SSID occupying the same frequency band, 2.4 GHz and 5 GHz, respectively. Green data points indicate uniwide network. Significantly greater variance in color, distinct SSID, across the campus is observed with 2.4 GHz band, indicating more interference in comparison to 5 GHz band. Coupled with greater range, uniwide 2.4 GHz network experiences high level of network interference essentially anywhere on the campus. Figure 6 confirms this with 2.4 GHz network experiencing double the number, 13.1 to 6.6, of average number of potentially interfering networks at any specific coordinate.

Figure 4. Different SSIDs in 2.4GHz band (uniwide indicated by green color)

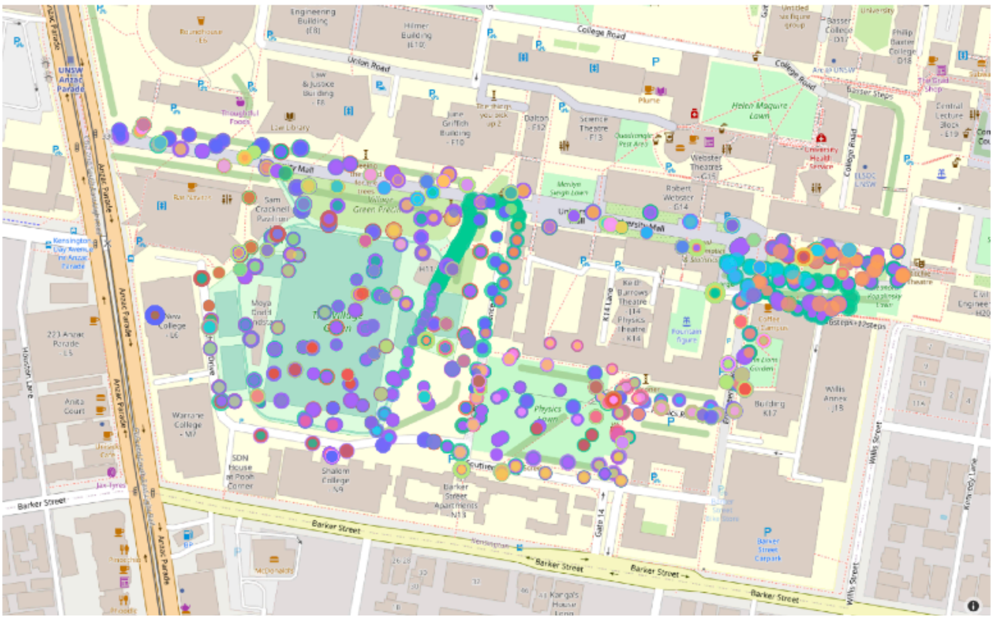

Figure 5. Different SSIDs in 5GHz band (uniwide indicated by green color)

Band	Min no. of SSID	Max no. of SSID	Avg no. of SSID
2.4 GHz	1	86	13.1592689
5 GHz	1	38	6.63636364

Figure 6. Summary of distinct network operating in 2.4 GHz and 5 GHz frequency band detected at different GPS coordinates.

To pinpoint areas of high interference, number of distinct SSID at specific coordinates is plotted for both 2.4 GHz and 5 GHz band, fig. 7. Yellow to red data points indicate high interference, > 40 distinct SSIDs. For 2.4 GHz band, high interference is observed on the left and center of Village Green as well as between Village Green and Physics Lawn. For 5 GHz band, high interference is observed in the same areas but much less severity.

Figure 7. Number of distinct SSID at each specific GPS coordinate operating in 2.4 GHz band

Figure 8. Number of distinct SSID at each specific GPS coordinate operating in 5 GHz band

<u>OS-specific issues</u>

There exist some limitations of receiver operating system. Firstly, Windows operating system doesn't show noise level reading in data collected. Secondly, MacOS receiver was unable to collect WiFi readings at fine grained GPS coordinate for some reason, resulting in only 23 coordinates from MacOS receiver in the dataset, fig. 8. Further comparison between Windows and MacOS operating system might be inaccurate due to insufficient data on MacOS part.

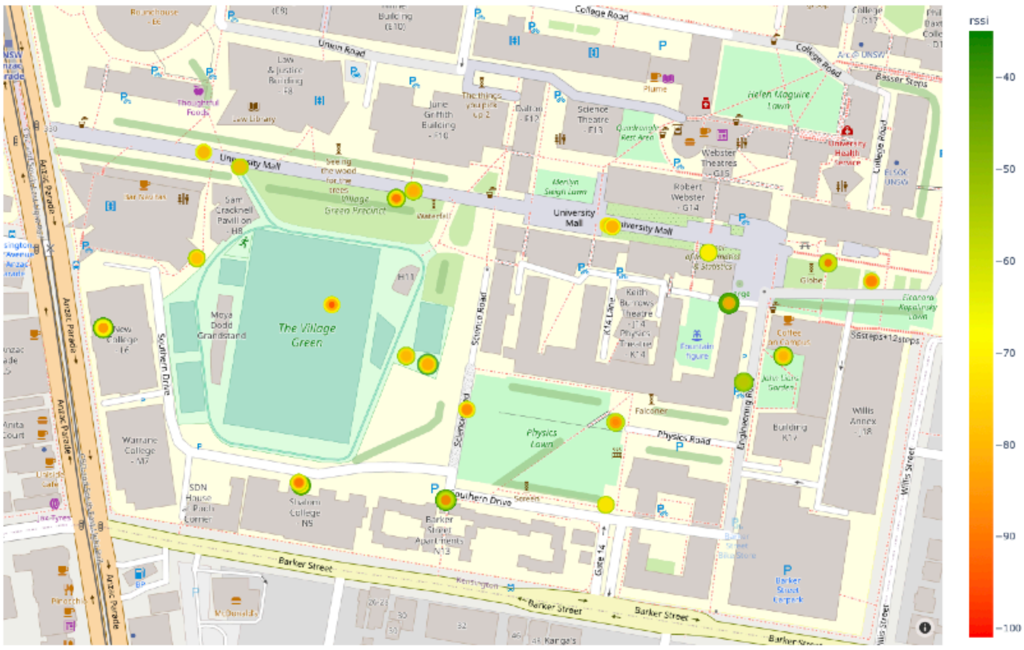

Figure 9. RSSI map for all networks, MacOS receiver

Recommendation and Solutions

To address low signal strength in open field area at Village Green and Physics Lawn, since deploying extra access points in the middle of the field isn't feasible, we can consider deploying access points with directional antenna placed along the edges of the field. Coupled with MIMO beamforming configuration, access points along the edges should be able to increase uniwide coverage and signal strength in the middle of the field (Hassan, 2022). Figure 10 shows an example of access point deployment at Village Green.

Figure 10. Staggered access point with directional antenna deployment at Village Green

To address low signal strength in heavily obstructed area at Library Road, John Lions Garden and Southern Drive, repositioning access point to the middle of the area so receiver can receive signal before it is reflected back from buildings is advisable. For example, fig. 11, lamp posts with access points could be installed along Library Road instead of on the side of buildings.

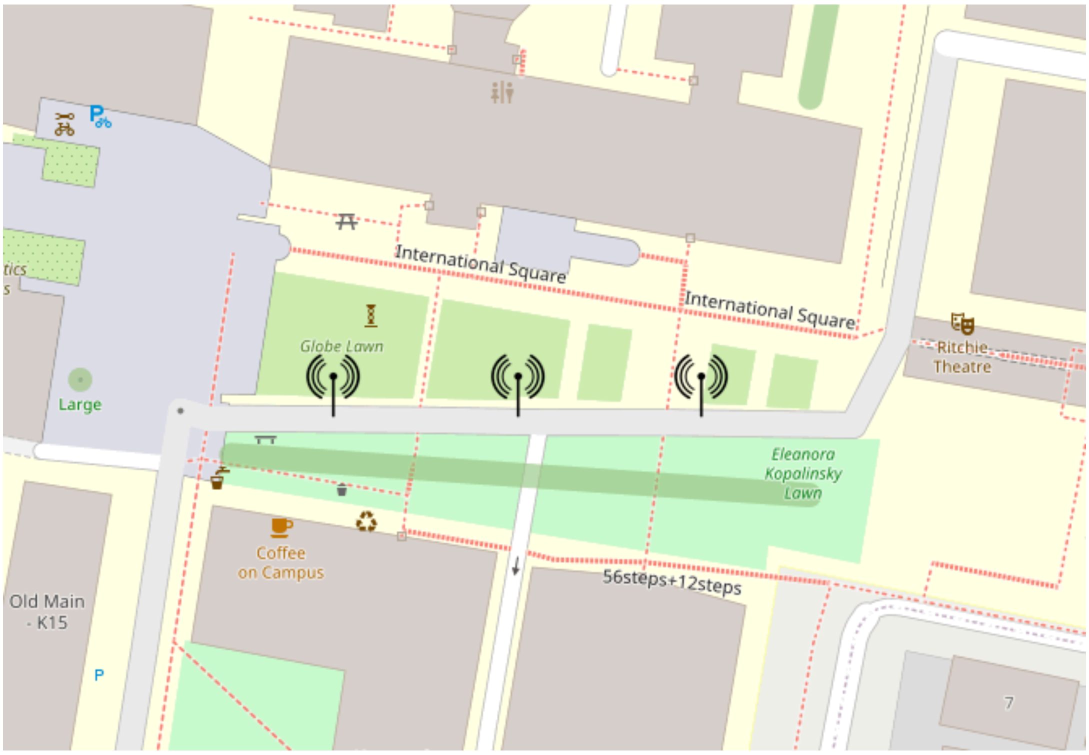

Figure 11. Access points deployment at Library Road

For disconnection due to coverage gap in the area between Village Green and Physics lawn as well as the area between University Mall and Village Green, access points should be repositioned for coverage of each AP to overlap. Moreover, to prevent disconnection between access point, user roaming should be implemented according to 802.11k and 802.11r standards (802.11k and 802.11r Overview, 2020).

Solution to high interference at the left and center of Village Green as well as between Village Green and Physics Lawn, would be to prioritize total coverage of 5 GHz signal in uniwide network deployment and only treat 2.4 GHz band as fallback since 2.4 GHz experience double the number of potentially interfering networks, fig. 6. Furthermore, UNSW could limit number their own network that is not uniwide or eduroam, connect devices to uniwide and Local area network wherever possible.

Conclusion

In this analysis, main issues of uniwide WiFi network, along with proposed solution, are identified. These issues include low signal strength in open field areas and areas with building obstructions, disconnections due to coverage gaps and signal interference issue. Drop in signal strength in open field areas can be rectified with directional antenna along the edge and MIMO beamforming. Proposed solution for poor signal strength in areas with building obstructions is to reposition access points toward the center of the area to minimize multipath effect. Disconnection due to coverage gap can prevented by deploying access points in the way that overlap their signal coverage along with implementing user roaming according to 802.11k and 802.11r standards. To circumvent signal interference issue apparent in 2.4 GHz, 5 GHz signal coverage should be prioritize to avoid situation where device switch over to the heavily congested 2.4 GHz band.

References

Determining your Wi-Fi signal strength (RSSI). (2020, May 27). University of Michigan - Knowledge Base. https://teamdynamix.umich.edu/TDClient/47/LSAPortal/KB/ArticleDet?ID=1644

Hassan, M. (2022). Wireless and mobile networking. CRC Press

802.11k and 802.11r Overview. (2020, October 5). Cisco Meraki. https://documentation.meraki.com/MR/Wi-Fi_Basics_and_Best_Practices/802.11k_and_802.11r_Overview