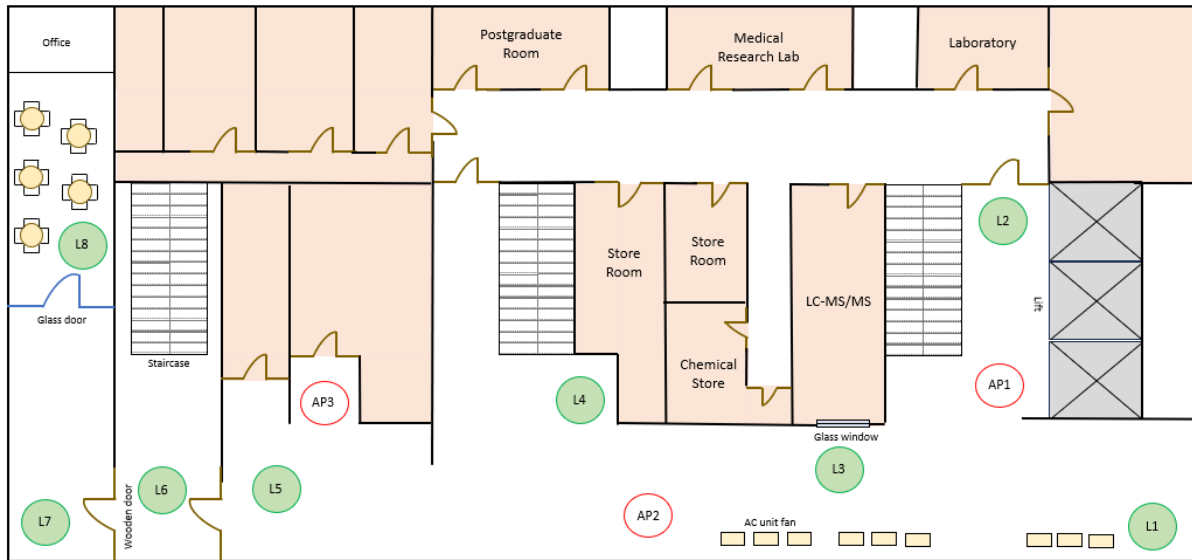


Task 1.1: Survey

Floor plan of Level 2 Building 3



- All walls are made up of concrete wall.
- The area labelled with red are restricted area.

Location 1:

| SSID | BSSID | Graph (Signal) | Channel | Frequency | Channel wid... | Band | Security | Vendor | Mode | Level (Signal) | Signal | Signal % | Avg | Max | Min |
|-----------------|-------------------|----------------|-----------|-----------|----------------|------|---------------|-------------|------|----------------|--------|----------|-----|-----|-----|
| HUAWEI P30 Pro | 42:CB:34:FD:B0:FA | | 11 | 2462 | 20 | 2.4 | WPA2-Personal | - | ac | | -78 | 21 | -79 | -52 | -91 |
| jwsn's | 1E:18:55:55:FF:04 | | 149 (155) | 5745 | 80 | 5 | WPA3-Personal | - | ax | | -79 | 20 | -61 | -28 | -79 |
| Monash-Malaysia | 70:B3:17:4D:F7:EF | | 100 | 5500 | 20 | 5 | Open | Cisco Sy... | n/ac | | -43 | 62 | -66 | -26 | -96 |

Tabulated Version

| Access Point (AP) | | AP1 | AP2 | AP3 |
|--------------------------|----------------------------------|-------------------|-------------------|-------------------|
| SSID | | Monash-Malaysia | HUAWEI P30 PRO | jwsn's |
| MAC Address | | 70:B3:17:4D:F7:EF | 62:B9:B7:C2:18:DE | 1E:18:55:55:FF:04 |
| Security | | WEP-OPEN | WPA2-Personal | WPA3-Personal |
| 802.11 version supported | | n/ac | ac | ax |
| Frequency Band (GHz) | | 5 | 2.4 | 5 |
| Frequency Channel Used | | 100 | 11 | 149(155) |
| Signal Strength | Signal (dBm) | -43 | -78 | -79 |
| | Percentage of current signal (%) | 62 | 21 | 20 |
| | Minimum value of signal (dBm) | -96 | -91 | -79 |
| | Maximum value of signal (dBm) | -26 | -52 | -28 |
| | Average value of signal (dBm) | -66 | -79 | -61 |

Location 2:

| SSID | BSSID | Graph (Signal) | Channel | Frequency | Channel wid... | Band | Security | Vendor | Mode | Level (Signal) | Signal | Signal % | Avg | Max | Min |
|-----------------|-------------------|----------------|-----------|-----------|----------------|------|---------------|-------------|------|----------------|--------|----------|-----|-----|-----|
| HUAWEI P30 Pro | 42:CB:34:FD:B0:FA | | 11 | 2462 | 20 | 2.4 | WPA2-Personal | - | ac | | -69 | 31 | -71 | -56 | -84 |
| jwsn's | 66:E9:09:A7:74:17 | | 149 (155) | 5745 | 80 | 5 | WPA3-Personal | - | ax | | -76 | 23 | -62 | -29 | -76 |
| Monash-Malaysia | 70:B3:17:4D:F7:EF | | 100 | 5500 | 20 | 5 | Open | Cisco Sy... | n/ac | | -46 | 58 | -58 | -46 | -74 |

Tabulated Version

| Access Point (AP) | | AP1 | AP2 | AP3 |
|--------------------------|----------------------------------|-------------------|-------------------|-------------------|
| SSID | | Monash-Malaysia | HUAWEI P30 PRO | jwsn's |
| MAC Address | | 70:B3:17:4D:F7:EF | 62:B9:B7:C2:18:DE | 66:E9:09:A7:74:17 |
| Security | | WEP-OPEN | WPA2-Personal | WPA3-Personal |
| 802.11 version supported | | n/ac | ac | ax |
| Frequency Band (GHz) | | 5 | 2.4 | 5 |
| Frequency Channel Used | | 100 | 11 | 149(155) |
| Signal Strength | Signal (dBm) | -46 | -69 | -76 |
| | Percentage of current signal (%) | 58 | 31 | 23 |
| | Minimum value of signal (dBm) | -74 | -84 | -76 |
| | Maximum value of signal (dBm) | -46 | -56 | -29 |
| | Average value of signal (dBm) | -58 | -71 | -62 |

Location 3:

| SSID | BSSID | Graph (Signal) | Channel | Frequency | Channel wid... | Band | Security | Vendor | Mode | Level (Signal) | Signal | Signal % | Avg | Max | Min |
|-------------------|-------------------|----------------|-----------|-----------|----------------|------|---------------|-------------|------|----------------|--------|----------|-----|-----|-----|
| 🔴 HUAWEI P30 Pro | 42:CB:34:FD:80:FA | | 11 | 2462 | 20 | 2.4 | WPA2-Personal | - | ac | | -64 | 37 | -71 | -56 | -84 |
| 🟡 jwsn's 🐼❤️ | 66:E9:09:A7:74:17 | | 149 (155) | 5745 | 80 | 5 | WPA3-Personal | - | ax | | -76 | 23 | -57 | -29 | -76 |
| 🟢 Monash-Malaysia | 70:B3:17:4D:F7:EF | | 100 | 5500 | 20 | 5 | Open | Cisco Sy... | n/ac | | -61 | 41 | -61 | -50 | -74 |

Tabulated Version

| Access Point (AP) | | AP1 | AP2 | AP3 |
|--------------------------|----------------------------------|-------------------|-------------------|-------------------|
| SSID | | Monash-Malaysia | HUAWEI P30 PRO | jwsn's 🐼❤️ |
| MAC Address | | 70:B3:17:4D:F7:EF | 62:B9:B7:C2:18:DE | 66:E9:09:A7:74:17 |
| Security | | WEP-OPEN | WPA2-Personal | WPA3-Personal |
| 802.11 version supported | | n/ac | ac | ax |
| Frequency Band (GHz) | | 5 | 2.4 | 5 |
| Frequency Channel Used | | 100 | 11 | 149(155) |
| Signal Strength | Signal (dBm) | -61 | -64 | -76 |
| | Percentage of current signal (%) | 41 | 37 | 23 |
| | Minimum value of signal (dBm) | -74 | -84 | -76 |
| | Maximum value of signal (dBm) | -50 | -56 | -29 |
| | Average value of signal (dBm) | -51 | -71 | -67 |

Location 4:

| SSID | BSSID | Graph (Signal) | Channel | Frequency | Channel wid... | Band | Security | Vendor | Mode | Level (Signal) | Signal | Signal % | Avg | Max | Min |
|-------------------|-------------------|----------------|-----------|-----------|----------------|------|---------------|-------------|------|----------------|--------|----------|-----|-----|-----|
| 🔴 HUAWEI P30 Pro | 42:CB:34:FD:80:FA | | 11 | 2462 | 20 | 2.4 | WPA2-Personal | - | ac | | -59 | 43 | -69 | -56 | -86 |
| 🟡 jwsn's 🐼❤️ | AE:A5:34:40:8A:22 | | 149 (155) | 5745 | 80 | 5 | WPA3-Personal | - | ax | | -59 | 43 | -51 | -36 | -63 |
| 🟢 Monash-Malaysia | 70:B3:17:4D:F7:EF | | 100 | 5500 | 20 | 5 | Open | Cisco Sy... | n/ac | | -78 | 21 | -68 | -46 | -78 |

Tabulated Version

| Access Point (AP) | | AP1 | AP2 | AP3 |
|--------------------------|----------------------------------|-------------------|-------------------|-------------------|
| SSID | | Monash-Malaysia | HUAWEI P30 PRO | jwsn's 🐼❤️ |
| MAC Address | | 70:B3:17:4D:F7:EF | 62:B9:B7:C2:18:DE | AE:A5:34:40:8A:22 |
| Security | | WEP-OPEN | WPA2-Personal | WPA3-Personal |
| 802.11 version supported | | n/ac | ac | ax |
| Frequency Band (GHz) | | 5 | 2.4 | 5 |
| Frequency Channel Used | | 100 | 11 | 149(155) |
| Signal Strength | Signal (dBm) | -78 | -59 | -59 |
| | Percentage of current signal (%) | 21 | 43 | 43 |
| | Minimum value of signal (dBm) | -78 | -86 | -63 |
| | Maximum value of signal (dBm) | -46 | -56 | -36 |
| | Average value of signal (dBm) | -68 | -69 | -51 |

Location 5:

| SSID | BSSID | Graph (Signal) | Channel | Frequency | Channel wid... | Band | Security | Vendor | Mode | Level (Signal) | Signal | Signal % | Avg | Max | Min |
|---|-------------------|----------------|-----------|-----------|----------------|------|---------------|-------------|------|----------------|--------|----------|-----|-----|-----|
| <input checked="" type="checkbox"/> HUAWEI P30 Pro | 42:CB:34:FD:B0:FA | | 11 | 2462 | 20 | 2.4 | WPA2-Personal | - | ac | | -77 | 22 | -68 | -21 | -84 |
| <input type="checkbox"/> jwsn's | 86:84:5F:86:AE:06 | | 149 (155) | 5745 | 80 | 5 | WPA3-Personal | - | ax | | -60 | 42 | -49 | -33 | -66 |
| <input checked="" type="checkbox"/> Monash-Malaysia | 70:B3:17:4D:F7:EF | | 100 | 5500 | 20 | 5 | Open | Cisco Sy... | n/ac | | -80 | 19 | -79 | -76 | -80 |

Tabulated Version

| Access Point (AP) | | AP1 | AP2 | AP3 |
|--------------------------|----------------------------------|-------------------|-------------------|-------------------|
| SSID | | Monash-Malaysia | HUAWEI P30 PRO | jwsn's |
| MAC Address | | 70:B3:17:4D:F7:EF | 62:B9:B7:C2:18:DE | 86:84:5F:86:AE:06 |
| Security | | WEP-OPEN | WPA2-Personal | WPA3-Personal |
| 802.11 version supported | | n/ac | ac | ax |
| Frequency Band (GHz) | | 5 | 2.4 | 5 |
| Frequency Channel Used | | 100 | 11 | 149(155) |
| Signal Strength | Signal (dBm) | -80 | -77 | -60 |
| | Percentage of current signal (%) | 19 | 22 | 42 |
| | Minimum value of signal (dBm) | -80 | -84 | -66 |
| | Maximum value of signal (dBm) | -76 | -21 | -33 |
| | Average value of signal (dBm) | -79 | -68 | -49 |

Location 6:

| SSID | BSSID | Graph (Signal) | Channel | Frequency | Channel wid... | Band | Security | Vendor | Mode | Level (Signal) | Signal | Signal % | Avg | Max | Min |
|---|-------------------|----------------|-----------|-----------|----------------|------|---------------|-------------|------|----------------|--------|----------|-----|-----|-----|
| <input checked="" type="checkbox"/> HUAWEI P30 Pro | 42:CB:34:FD:B0:FA | | 11 | 2462 | 20 | 2.4 | WPA2-Personal | - | ac | | -84 | 14 | -74 | -56 | -90 |
| <input type="checkbox"/> jwsn's | EE:66:6C:5C:C4:D0 | | 149 (155) | 5745 | 80 | 5 | WPA3-Personal | - | ax | | -72 | 28 | -56 | -32 | -76 |
| <input checked="" type="checkbox"/> Monash-Malaysia | 70:B3:17:4D:F7:EF | | 100 | 5500 | 20 | 5 | Open | Cisco Sy... | n/ac | | - | - | -68 | -46 | -96 |

Tabulated Version

| Access Point (AP) | | AP1 | AP2 | AP3 |
|--------------------------|----------------------------------|-------------------|-------------------|-------------------|
| SSID | | Monash-Malaysia | HUAWEI P30 PRO | jwsn's |
| MAC Address | | 70:B3:17:4D:F7:EF | 62:B9:B7:C2:18:DE | EE:66:6C:5C:C4:D0 |
| Security | | WEP-OPEN | WPA2-Personal | WPA3-Personal |
| 802.11 version supported | | n/ac | ac | ax |
| Frequency Band (GHz) | | 5 | 2.4 | 5 |
| Frequency Channel Used | | 100 | 11 | 149(155) |
| Signal Strength | Signal (dBm) | Out of Range | -84 | -72 |
| | Percentage of current signal (%) | Out of Range | 14 | 28 |
| | Minimum value of signal (dBm) | Out of Range | -90 | -76 |
| | Maximum value of signal (dBm) | Out of Range | -56 | -32 |
| | Average value of signal (dBm) | Out of Range | -74 | -56 |

Location 7:

| SSID | BSSID | Graph (Signal) | Channel | Frequency | Channel wid... | Band | Security | Vendor | Mode | Level (Signal) | Signal | Signal % | Avg | Max | Min |
|-----------------|-------------------|----------------|-----------|-----------|----------------|------|---------------|-------------|------|----------------|--------|----------|-----|-----|-----|
| HUAWEI P30 Pro | 42:CB:34:FD:B0:FA | | 11 | 2462 | 20 | 2.4 | WPA2-Personal | - | ac | | -87 | 10 | -77 | -62 | -90 |
| jwsn's | 96:45:E3:26:B2:73 | | 149 (155) | 5745 | 80 | 5 | WPA3-Personal | - | ax | | -75 | 24 | -58 | -50 | -75 |
| Monash-Malaysia | 70:83:17:4D:F7:EF | | 100 | 5500 | 20 | 5 | Open | Cisco Sy... | n/ac | | - | - | -78 | -77 | -96 |

Tabulated Version

| Access Point (AP) | | AP1 | AP2 | AP3 |
|--------------------------|----------------------------------|-------------------|-------------------|-------------------|
| SSID | | Monash-Malaysia | HUAWEI P30 PRO | jwsn's |
| MAC Address | | 70:B3:17:4D:F7:EF | 62:B9:B7:C2:18:DE | 96:45:E3:26:B2:73 |
| Security | | WEP-OPEN | WPA2-Personal | WPA3-Personal |
| 802.11 version supported | | n/ac | ac | ax |
| Frequency Band (GHz) | | 5 | 2.4 | 5 |
| Frequency Channel Used | | 100 | 11 | 149(155) |
| Signal Strength | Signal (dBm) | Out of Range | -87 | -75 |
| | Percentage of current signal (%) | Out of Range | 10 | 24 |
| | Minimum value of signal (dBm) | Out of Range | -90 | -75 |
| | Maximum value of signal (dBm) | Out of Range | -62 | -50 |
| | Average value of signal (dBm) | Out of Range | -77 | -58 |

Location 8:

| SSID | BSSID | Graph (Signal) | Channel | Frequency | Channel wid... | Band | Security | Vendor | Mode | Level (Signal) | Signal | Signal % | Avg | Max | Min |
|-----------------|-------------------|----------------|-----------|-----------|----------------|------|---------------|-------------|------|----------------|--------|----------|-----|-----|-----|
| HUAWEI P30 Pro | 42:CB:34:FD:B0:FA | | 11 | 2462 | 20 | 2.4 | WPA2-Personal | - | ac | | -88 | 9 | -80 | -62 | -90 |
| jwsn's | 96:45:E3:26:B2:73 | | 149 (155) | 5745 | 80 | 5 | WPA3-Personal | - | ax | | -78 | 21 | -68 | -50 | -83 |
| Monash-Malaysia | 70:83:17:4D:F7:EF | | 100 | 5500 | 20 | 5 | Open | Cisco Sy... | n/ac | | - | - | -78 | -77 | -96 |

Tabulated Version

| Access Point (AP) | | AP1 | AP2 | AP3 |
|--------------------------|----------------------------------|-------------------|-------------------|-------------------|
| SSID | | Monash-Malaysia | HUAWEI P30 PRO | jwsn's |
| MAC Address | | 70:B3:17:4D:F7:EF | 62:B9:B7:C2:18:DE | 96:45:E3:26:B2:73 |
| Security | | WEP-OPEN | WPA2-Personal | WPA3-Personal |
| 802.11 version supported | | n/ac | ac | ax |
| Frequency Band (GHz) | | 5 | 2.4 | 5 |
| Frequency Channel Used | | 100 | 11 | 149(155) |
| Signal Strength | Signal (dBm) | Out of Range | -88 | -78 |
| | Percentage of current signal (%) | Out of Range | 9 | 21 |
| | Minimum value of signal (dBm) | Out of Range | -90 | -83 |
| | Maximum value of signal (dBm) | Out of Range | -62 | -50 |
| | Average value of signal (dBm) | Out of Range | -80 | -68 |

Signal to Noise Ratio for 3 access points at 8 different locations

Assume Noise Strength = -95dBm

Access Point 1: Monash-Malaysia

| Location | Signal Strength (dBm) | Signal to Noise Ratio (dB) |
|----------|-----------------------|----------------------------|
| 1 | -43 | 52 |
| 2 | -46 | 49 |
| 3 | -61 | 34 |
| 4 | -78 | 17 |
| 5 | -80 | 15 |
| 6 | Out of Range | - |
| 7 | Out of Range | - |
| 8 | Out of Range | - |

Access Point 2: HUAWEI P30 PRO

| Location | Signal Strength (dBm) | Signal to Noise Ratio (dB) |
|----------|-----------------------|----------------------------|
| 1 | -78 | 17 |
| 2 | -69 | 26 |
| 3 | -64 | 31 |
| 4 | -59 | 36 |
| 5 | -77 | 18 |
| 6 | -84 | 11 |
| 7 | -87 | 8 |
| 8 | -88 | 7 |

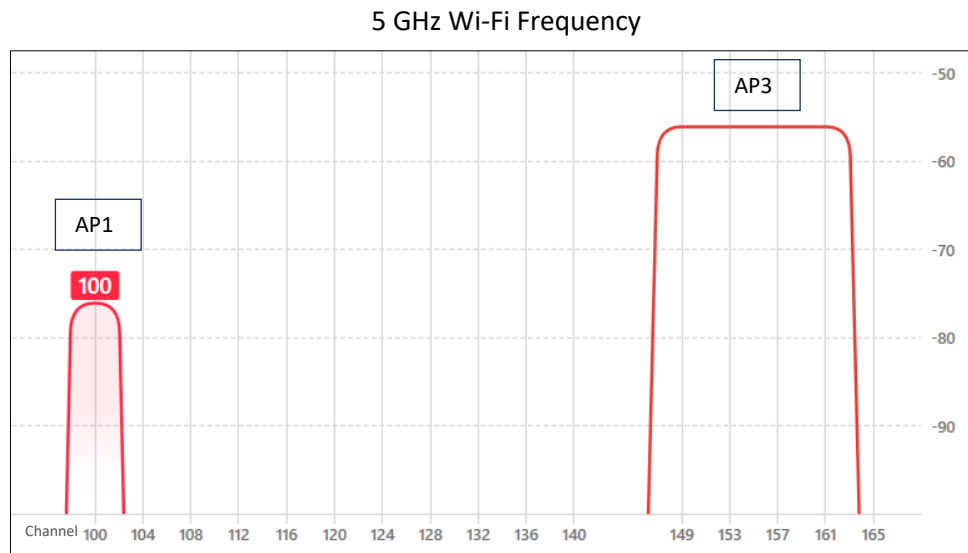
Access Point 3: jwsn's 🐻❤

| Location | Signal Strength (dBm) | Signal to Noise Ratio (dB) |
|----------|-----------------------|----------------------------|
| 1 | -79 | 16 |
| 2 | -76 | 19 |
| 3 | -76 | 19 |
| 4 | -59 | 36 |
| 5 | -60 | 35 |
| 6 | -72 | 23 |
| 7 | -75 | 20 |
| 8 | -78 | 17 |

Task 1.2: Report

Channel Occupancy

All 3 access points does not competing on the same channel. For 3 access points, AP2 is 2.4 GHz band while AP1 and AP3 are 5 GHz. In this case, overlapping will only occurs in the 5GHz band.



From the graph above, we can notice that both AP1 and AP3 are not configured to use overlapping channels. From the channel width aspect, AP1 (40 MHz channel width) and AP3 (80 MHz channel width) use different widths. After considering that only three access points are in that area (low network density), I recommend changing AP1's channel width to 80 MHz to increase the data transfer rate. It is considerable in this case because 80 MHz channels would only lead to greater potential for interference if the network's density in that area is high. At the same time, AP2 operates on Channel 11 in the 2.4GHz band, which can avoid the interference caused by channel overlapping if I increase the number of APs. In summary, the configuration regarding channel occupancy is good, but improvements can be made on channel width.

Interference from walls and doors

Different building materials for walls and doors can lead to attenuation through reflection or absorption of the signals.

For example, the wooden door between location 5 and location 6 cause attenuation of approximately 3dB. After considering the attenuation due to distance, the total attenuation ranges from 7dB to 12dB between 2 locations.

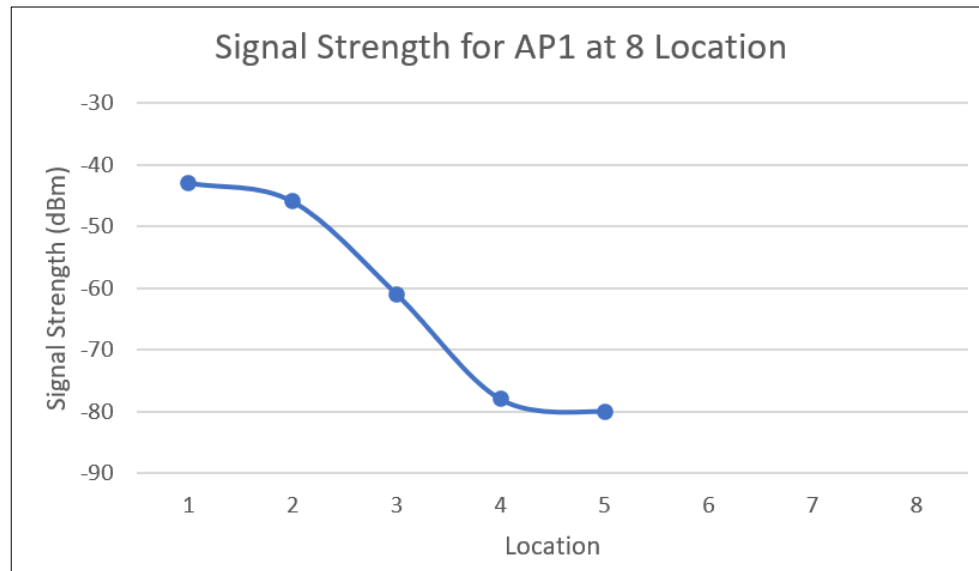
| Access Point | Location | Signal to Noise Ratio (SNR) (dB) | Difference in SNR (dB) |
|--------------|----------|----------------------------------|------------------------|
| AP2 | L5 | 18 | 7 |
| | L6 | 11 | |
| AP3 | L5 | 35 | 12 |
| | L6 | 23 | |

Besides, the glass door between location 7 and location 8 cause attenuation of approximately 2dB. After considering the attenuation due to distance, the total attenuation ranges from 1dB to 3dB between 2 locations.

| Access Point | Location | Signal to Noise Ratio (SNR) (dB) | Difference in SNR (dB) |
|--------------|----------|----------------------------------|------------------------|
| AP2 | L7 | 8 | 1 |
| | L8 | 7 | |
| AP3 | L7 | 20 | 3 |
| | L8 | 17 | |

From both tables above, it can be clearly seen that wooden door cause more attenuation as compared to glass door because wooden door is denser than glass door.

At the same time, the LC-MS/MS laboratory, which is closest to AP1, contains electronic devices, such as microwaves, mass spectrometers, and computers, that will interfere with Wi-Fi signals by emitting electromagnetic signals. As a result, these cause interference and can be shown by a noticeable decrease in signal strength for AP1 in Location 3.



Coverage

The three access points does not sufficiently covered the desired area because there are certain areas experience low signal strength. Improvements can be made to improve the connection quality at specific locations. AP1 and AP2 cooperate closely in providing network access from Location 1 to Location 4. AP3 should be providing network access to Location 6,7 and 8 yet due to attenuation and interference it weakens the signals.

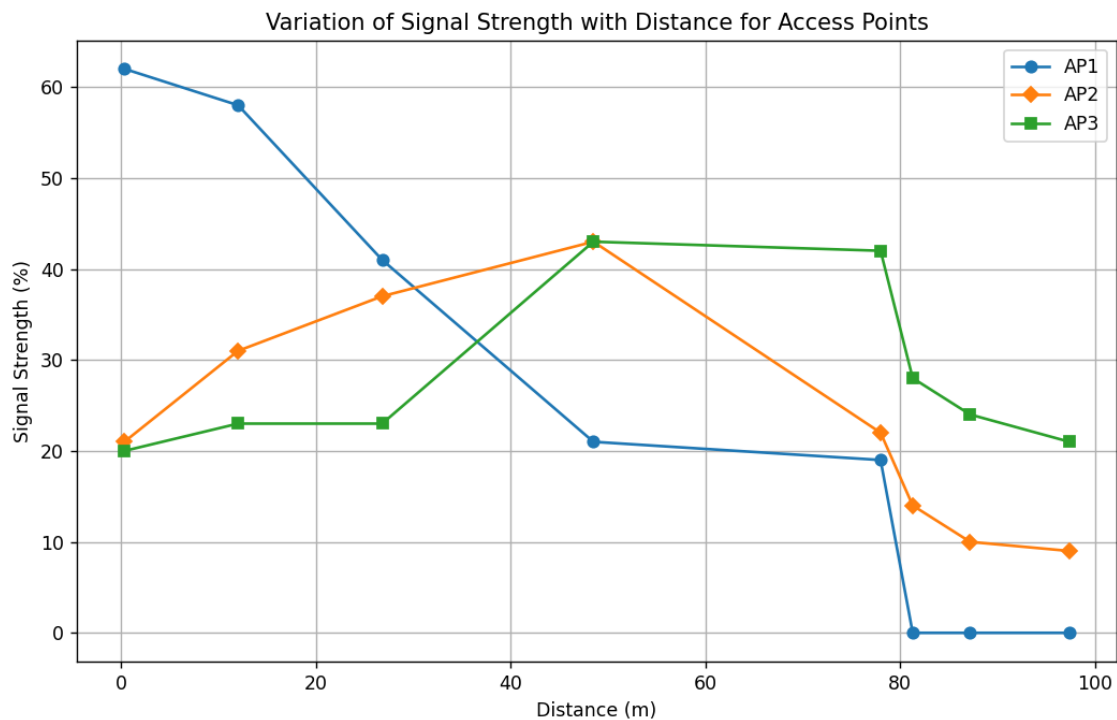
Connection Quality at Location 6,7 and 8 for 3 Access Point based on SNR.

| Location | Location 6 | | Location 7 | | Location 8 | |
|--------------|------------|-----------------------|------------|-----------------------|------------|-----------------------|
| Access Point | SNR (dB) | Connection Quality | SNR (dB) | Connection Quality | SNR (dB) | Connection Quality |
| AP1 | - | No connection | - | No connection | - | No connection |
| AP2 | 11 | Unreliable connection | 8 | Unreliable connection | 7 | Unreliable connection |
| AP3 | 23 | Poor | 20 | Poor | 7 | Unreliable connection |

The table indicates difficulty accessing Wi-Fi at the locations based on the Signal-to-Noise Ratio (SNR). Improving the configuration would increase the signal strength for these 3 locations as it minimises the attenuation caused by building materials. I recommend repositioning AP3 to Location 6 area to reduce the attenuation caused by distance and obstacles at Location 6 and 7. Besides, placing extra APs inside Location 8's area and corridor near the laboratory to improve the connection's quality by reducing interference.

Interpolation of the access point location using signal strength

To interpolate the location of the access points, I have collected data on the distance of each location and the signal strength to all access points. The measurement of the location starts from the bottom right to left.



The graph illustrates that specific region shows strong signal strength along the distance. Within the first 20 meters, AP1 shows a strong signal strength. AP2 offers a strong signal strength between 40m to 60m and gradually decreases due to attenuation. AP3 also indicates a strong signal strength between 40m to 80m. This provides key information about the location of the access points within which region in the survey area.

I also collected signal strength from different directions at each location. This provides more insights in providing accurate interpolation of the location of the access points. For instance, signal strength may be affected when we capture the data from different directions due to the building structures, materials or obstacles that might reflect, absorb or interfere with the Wi-Fi signals.

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