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Analyzing and Optimizing WiFi Access Point Performance

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ABSTRACT

A Wireless Local Area Network (WLAN) is a type of Local Area Network (LAN) that uses high frequency radio waves to communicate and transmit data. A reliable WLAN network will satisfy clients' needs and offer the best performance especially in data sharing within the network, where Access Points (AP) is used in the area. Even with the usage of APs, the propagation inside the building will suffer from interference and overlap channel. Hence, it is necessary to identify the quality of the wireless connection and how to improve the communication performance through WLAN by positioning the AP. Therefore, the performance of WiFi AP is optimized. It also analyses the study case of APs network problems and its performance. The scope of work area of the research is within the building, namely *Intelek* (which means Intellect) of Universiti Teknologi MARA (UiTM) Terengganu.

KEYWORDS: SSID, IEEE 802.11, AP, WLAN, MAC.

INTRODUCTION

As large scale wireless networks continue to proliferate, a reliable procedure to test the coverage and communication requirements becomes increasingly important. The drastic escalation usage of wireless devices has resulted high density Wireless Local Area Network (WLAN) that induces many problems into the network. A reliable network has to satisfy the needs of the clients and produce the best performance especially in data transfer within the network, thus access point (AP) is applied. The APs act as a transmitter and receiver in the network to provide a connection for the users to access the Internet. The geometric configuration of Wireless Fidelity (WiFi) APs provides knowledge on the nature of networks such as density, connectivity and interference characteristics. It is then be used for the management of WiFi networks.

Regularly, managing and monitoring the APs can assist the network administrator to increase the performance and efficiency in each network. The development of network topologies is based on number of users, AP's name, location, signal and so forth. Before the deployments of the AP, there are some factors need to be considered.

APs Wireless Management

By introducing the AP in the area, a WLAN is built. The rapid development of WLAN networks based on IEEE 802.11a, 802.11b and 802.11g standards increases the challenges in the network management such as data quality maintenance, signal strength, network data collection and the performance of the WLAN. The WLAN managements need to provide configuration management, performance management (mainly influenced by signal strength and quality), accounting management, real-time monitoring, fault management and security management.

APs Observation in Area

To detect the AP in the area, a device needs to be used to survey the wireless connection. There are numerous methods to observe the AP in the area. One of the methods is by using Netstumbler [1]. The Netstumbler is an application that allows the user to monitor the Media Access Control (MAC) address, Service Set Identification (SSID), AP channel used and so forth. The application also can verify each AP bandwidth and identify which AP has the strongest bandwidth in the area. This can be used to obtain the locations of the APs.

It is not easy to determine the APs to connect to the internet. Based on research in [2], it proposes a system namely Neighbor WiFi Access Point Advertisement System. The system continuously detects and collects information nearby the WiFi APs within its radio detection range. The information is shared between the mobile terminals in proximity with each other, and be advertised to the clients through their personal APs.

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For the research, the application used to observe the APs in the case study area is inSSIDer. The *Intelek* building has 4 floor levels. To scan each APs level, a mobile device which is a laptop is used and installed with the application mentioned. The application scans the network using the computer WiFi antenna, keep tracks the signal strength over time, signals channel, network security and so forth. The application is chosen due to its high sensitivity, fast response and quite accurate measurement of signal strength. This is vital to pin point the locations of the AP that are scattered in the case study area. Furthermore, it is really user friendly which resulting graphics analysis such as time graphs, MAC address, SSID, channel and frequency.

Received Signal Strength Indication (RSSI)

There are some approaches to positioning the problem in the WiFi networks. The most popular is a client-based and relies on the RSSI from the APs network. The use of the RSSI parameter for positioning purpose is important as to estimate the problem of the transmission path loss. It is extremely complex and dependent when focusing on wide variety of assumptions such as type of building, construction, materials, doors, windows positions and so forth. It is to predict the nature of the path loss in an indoor environment [3]. Precise estimation of the path loss remains a fair complex task, even if the basic parameters are known. Majority of the techniques which based on the RSSI parameter are parameter in statistical value.

According to [4], the RSSI parameter is more dependent on the client's position than Signal to Noise Ratio (SNR). Thus, it is better to use RSSI than SNR for positioning purpose. For the RADAR [5] study, the positioning in the WLAN networks has been explored for almost exclusively through the use of the RSSI parameter.To maximize the APs performance, the localization of the APs needs to be considered. For the research, the application used to estimate the best location for the APs is Aerohive Online Planner.

Non-Overlapping Channel and Frequency

The channel of the APs need to be selected accordingly for a better network performance [6]. The non-overlapping channels are used to minimize the interference in the network [7]. The 802.11b or 802.11g provides 3 non-overlapping channels and 802.11a has 12 channels. Even though 802.11a produces high non-overlapping channels than 802.11b and 802.11g, it has greater channels to be considered. The 802.11a works in a higher spectrum compared to 802.11b or 802.11g, that is 5GHz and 2GHz respectively. It is more difficult to penetrate obstacles such as walls and ceiling, thus reducing its transmission range. Furthermore, the 802.11a band is a regulated frequency spectrum and costly compared to 802.11b or 802.11g. It is extremely efficient to use 802.11b or 802.11g for the APs network. The IEEE 802.11b and 802.11g have 3 non-overlapping channels that are 1, 6 and 11 [8]. To allocate each channel for the APs, a channel planning needs to be made. In the area, it is not adequate to use the same channels for the transmission. For example, in a small office environment which is surrounded by channel 6, the office needs to assign channel 1 or 11 to avoid interference with the neighboring networks.

WiFi Interference

There are many factors that lead to interference in the wireless network. The interference occurs due to a co-channel or an adjacent channel interference from the WLAN, hidden nodes in the environment or non-WiFi devices operating in the 802.11 band. There are some studies that focus on how to decrease or prevent the interference from occuring [9]. It proposes to use an interference avoiding approach based on multi-channel for ZigBee network called MuZi that includes interference assessment, channel switch and connectivity maintenance. In the research, the interference is measured and calculated based on WiFi interference score for the devices that contribute to the interference. There are three factors that make the effect of the interference device such as:

- Output power: As an output power of the interference device.
- Signal behavior with respect to time: As the time of the interference devices is turn on, the greater the impact to the throughput of the wireless devices.
- Signal behavior with respect to frequency: Wireless device normally operates at single frequency and affects only a WiFi channel. A few changes between one frequency to another affects every channel but lesser degree. Others sweep across the frequency spectrum causing serious interruption to the wireless network, but only in a brief of period.

RELATED WORK

In [10], the research has found that by applying central managed Wi-Fi deployments, a report-based topology can be made by using the AP based measurement, trusted user and non trusted user. The technique makes the AP and the user to give feedback report to the collector which has been centralized. Using the report, the network topology can be gained and reduce the interference between each AP. The reports from the client provide an user-perceived view of interference condition that AP might fail to capture. The user faces a lack of connection, low rate of downlink and uplink rate that make the AP unable to measure. This can be implemented in the research by using the report from the AP and the user. The network topology can be built using tools provided to analyze the signal that propagates from the AP to the user and vice versa. The capability and performance of the AP can be extended [11] by using multiple communications channels and using more capable nodes which employs multiple radios module.

As emphasized by [12], the WiFi AP locations are difficult to obtain. Most of the APs are easy to be installed but their locations are not published. To obtain the APs locations, it implements a Locky.jp system into the network. The system is not accurate enough to determine the exact locations of the APs. It applies statistical and heuristic methods to improve the location of data quality. For the case study, a different approach is applied. Different software and tools are used such as AirMagnet WiFi Analyzer and inSSIDer. The tools can perform wireless discovery, network availability, interference detection, locate APs location and so forth.

The research in [13] uses an ad-hoc wireless as the AP and the effects of network topology control via research and analysis. Using the method, the network performance is greatly improved by comparing the energy, packet delivery and packet end to end average delay between network with topology and network without topology. The ad-hoc is preferable for a small group of users since as the number of devices grows, the performance will suffer greatly. It is uneasy to manage, since it does not use a central AP [14].

Based on [15] research, it proposes to use a wireless network system management based on Simple Network Management Protocol (SNMP). The SNMP is an application layer communication protocol that allows network devices to share network information within the network devices and devices outside the network [16]. It is important to manage a wireless network, as everyday, many users will be connected to the AP. With the increasing number of user, the network traffic needs to be controlled and monitored. To manage the wireless network, it is proven that it is really so challenging, as stated in [15].The SNMP can be used to collect data, monitor the wireless network performance and control the access to the wireless network through the AP.

It is important to determine the best location for the AP for a maximum range of coverage for the user without interference and with neighbor AP. In [17], it proposes to minimize the maximum channel utilization for the channel assignment in WLANs. If one of the AP uses the same channel assigned to the neighboring AP, the WLAN performance is significantly degraded due to the channel interference. Thus, it is more appropriate for the neighboring APs to use different channels. This is evidently show the importance of the channel assignment in reducing the interference that can decline performance in the network.

METHODOLOGY

The research focuses on finding the AP scattered surrounding the *Intelek* building in UiTM Terengganu. This is done by environmental observation in each location using the equipment provided. Sniffing the wireless connection is used to determine each AP. As each AP is obtained, the AP needs to be monitored using the network analyzer to obtain the AP names, number of users and AP network performance. Based on the information provided, the network problems can be recorded for the research. Figure 1 depicts the methodology steps taken for the research.

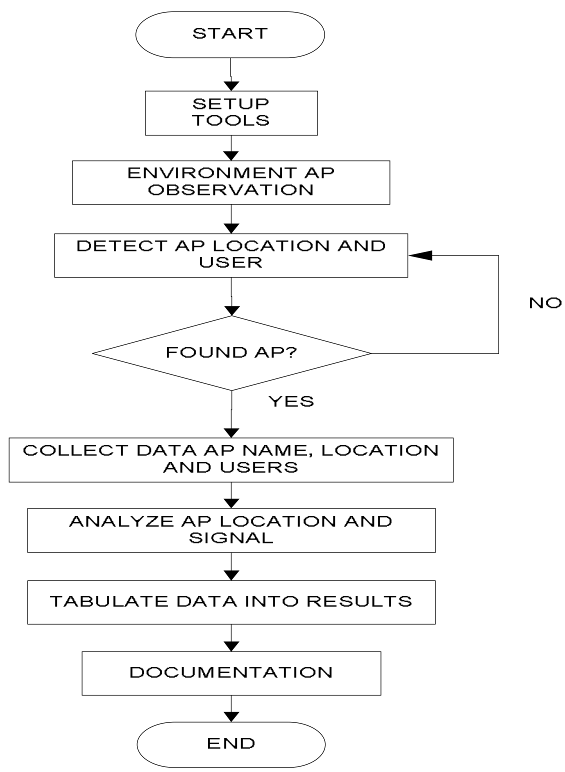

Figure 1: Flowchart of analyzing and optimizing the performance of WiFi access point

RESULTS AND DISCUSSION

Finding AP **Locations**

This section covers the location of the APs in the *Intelek* building, UiTM Terengganu. As mentioned earlier, the preference method to obtain the AP is by using the inSSIDer application. The application can inspect surrounding networks, obtain and scan more than hundreds of nearby AP swiftly, highlights the APs with high WiFi concentration, details of each APs and so forth. To determine the position of each AP accordingly, the WiFi signal produce by the AP is used. The stronger the signal strength measured in decibel (dB), the nearer the location of the computer uses the application to the APs.

Figure 2, 3 and 4 illustrate the sample of data acquisition to allocate the position of APs. It indicates the effect of the distance from the computer to the APs.

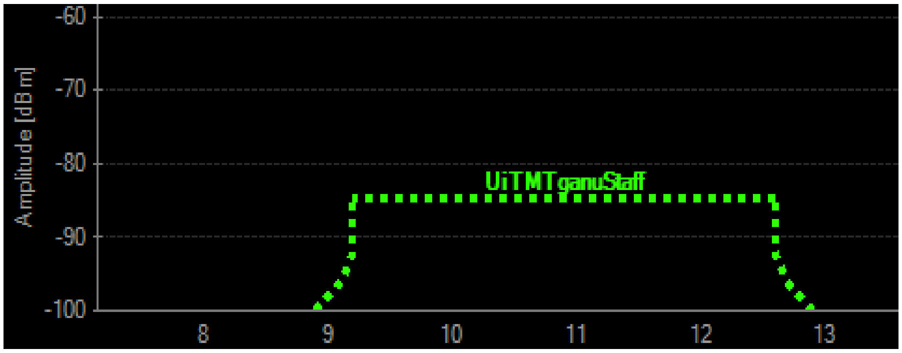

Figure 2: Signal strength for 35 meter distance

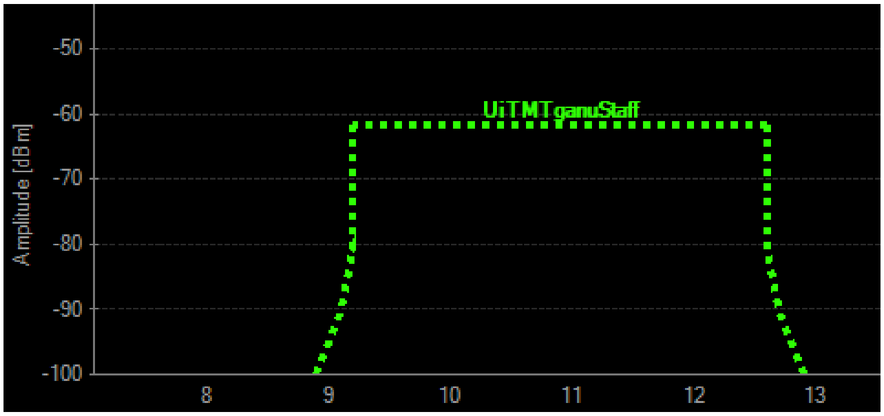

Figure 3: Signal strength for 15 meter distance

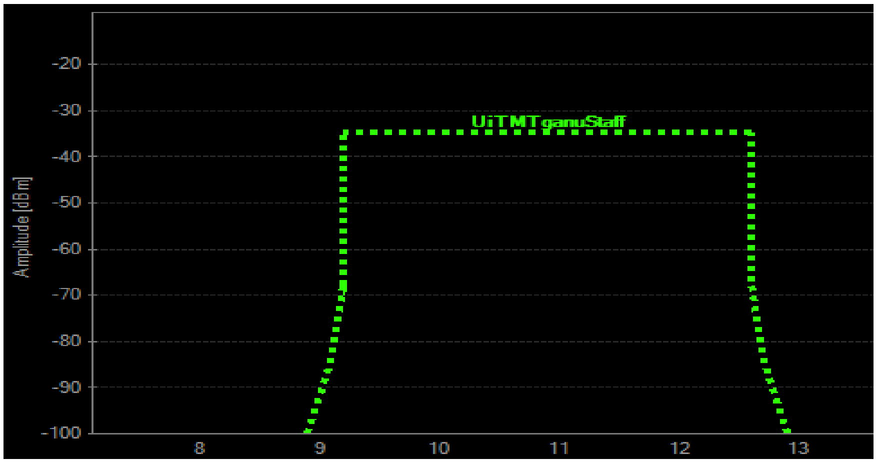

Figure 4: Signal strength for 3 meter distance

By referring to the APs signal strength, its location can be obtained by moving the mobile devices around the facilities equipped with the application. It depicts that the distance between each APs are appropriate by considering the maximum number of the user connected to the APs and the number of APs. In high traffic of users in the area, it is needed to increase the number of APs on that area to comprehend the number of users.

Figure 5 shows the numbers of AP in the area of the case study. It is evidently show that the location for the APs is strongest when the mobile device is near to the location of the APs rather than other APs. It illustrates that the green colour graph has the highest signal strength that show it is the nearest AP location to the mobile device. This method is preferably for locating the APs in the small area or building since the detection is made by measuring the wireless signal strength accurately. This can help the network administrator to locate each APs that they deployed without requiring the usage of Global Positioning System (GPS).

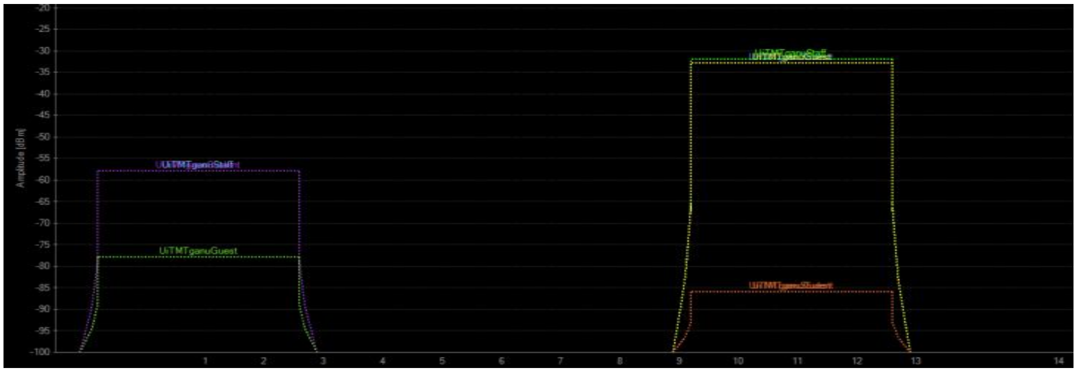

Figure 5: APs location strength

For the research, two applications are used to determine the location of APs. Ekahau Site Survey (ESS) is the second application used in the research instead of using inSSIDer. The ESS is an user friendly software tool which is suitable for a professional WiFi network planning, site surveys and administration. The ESS shows a ground level view of coverage and performance, enabling them quickly and easily create, improve and troubleshoot the WiFi networks. The ESS works over any 802.11 network and is optimized for modern, centrally and managed 802.11n WiFi networks [18].

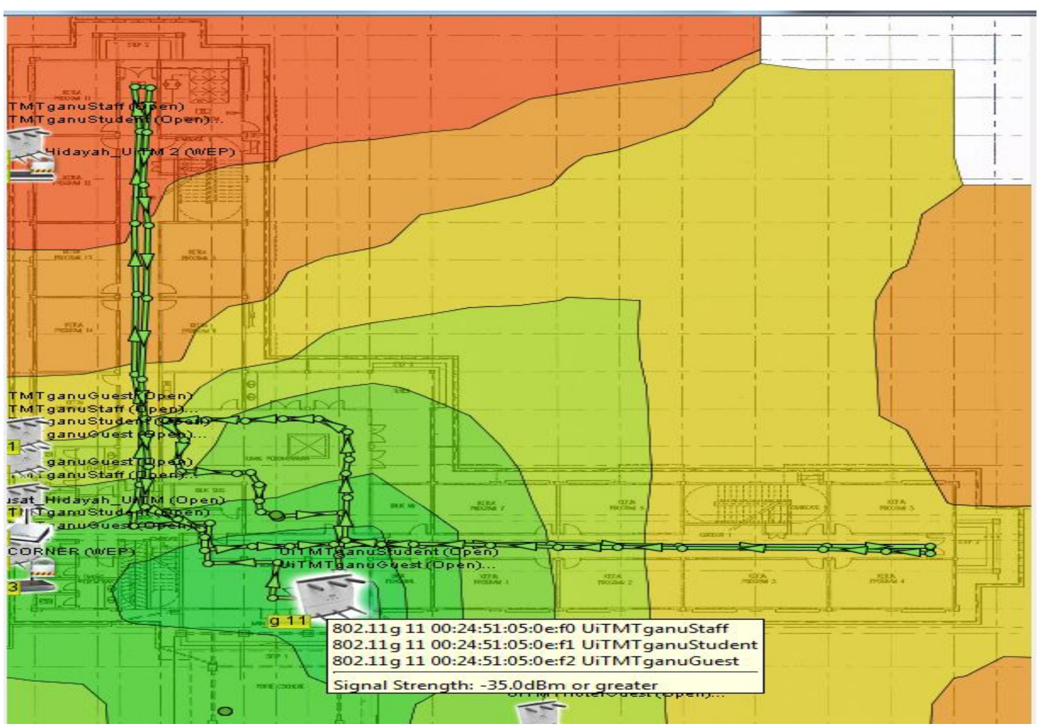

Figure 6: Coverage and signal strength for AP in case study area

Non-Overlapping Channels

The unmanaged wireless network may inflict many problems to the network clients since it may affect the performance of the connection. One of the effects is caused by ineffectively assignments of channels for the APs. For the research, most of the APs use 802.11b and 802.11g. As mentioned before, both of the IEEE standards have three non-overlapped channels that are channel 1, 6 and 11. The assignments of non-overlapped channel into each APs will minimize the interference between each APs and devices connected to the APs, thus increase the throughput [19]. The limited number of non-overlapped channels in 802.11b and 802.11g cannot eliminate interference thoroughy. However, it can be reduced by using partially overlapping channels. By utilising both non-overlapped channel and partially overlapping channel, it can improve the network performance.

In the case study area, it indicates that many areas have not considered the non-overlapping channel for the AP channel before deploying them. It has enhanced the wireless network performance and affect the clients to connect to the internet. Table 1 shows the results of the channel implemented into the APs with the implementation of non-overlap channels. Through the implementation of the non-overlap channels, the interference is lower than using multiple channels in ground level of the building, as shown in Figure 7.

Table 1: Non-overlap channels interference score

Channel	Interference score (-dBm)
1	-82
2	-108
3	-109
4	-109
5	-109
6	-109
7	-109
8	-109
9	-109
10	-109
11	-92
12	-109
13	-109
14	-109

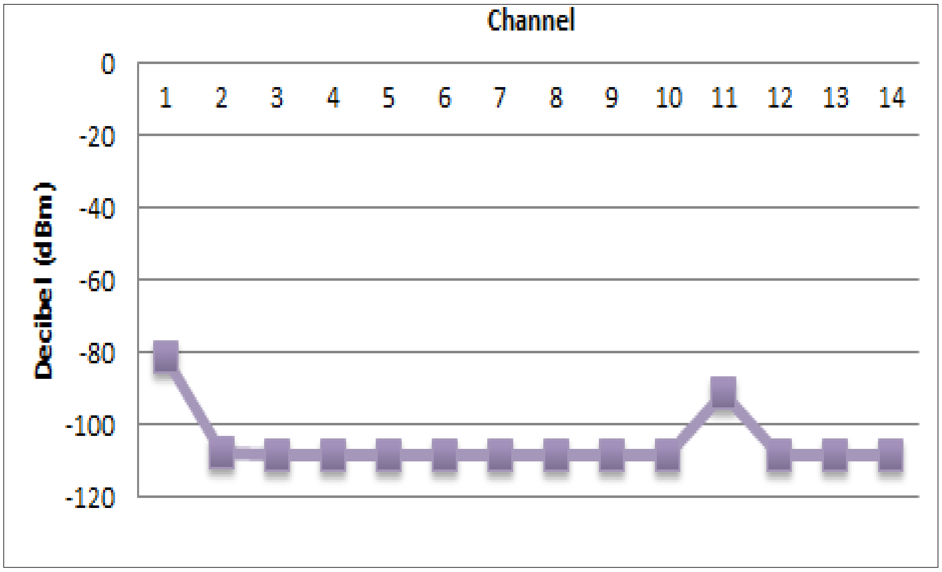

Figure 7: Interference score according to channel

Table 2 shows several APs that use non-overlap channel in the study case area. The interference score for the APs by using non-overlap channels are lesser than APs using multiple types of channels in the area.

Table 2: APs non-overlap channels

SSID	Channel	RSSI	MAC Address
UiTMTganuStaff	**1**	**-68**	**00:24:51:05:62:60**
UiTMTganuStudent	1	-71	00:24:51:05:62:61
UiTMTganuGuest	1	-69	00:24:51:05:62:62
UiTMTganuStaff	1	-66	00:24:51:05:18:70
UiTMTganuStaff	6	-82	00:3A:99:82:A1:30
UiTMTganuStudent	6	-82	00:3A:99:82:A1:31
UiTMTganuGuest	6	-82	00:3A:99:82:A1:32
MobileWiFi-90ed	11	-53	0C:37:DC:9A:90:ED
UiTMTganuGuest	11	-83	00:3A:99:89:5E:12
UiTMTganuStaff	11	-84	00:3A:99:89:5E:10

Wireless Network Interference

Wireless interference is one of the major causes that negatively affect the network performance. The interference can be explained by the presence of an unwanted signal that interferes the transmitting packets. Each APs or stations only transmit the packets when there are no other APs or stations are transmitting it. When there are other APs or stations that are transmitting the packets in the AP coverage, it will wait for the next transfer to be completed before transmitting its packets. The undefined time for the packets to be sent has created interference for the AP to transmit its packets to be received by the receiver. There are many devices that uses 2.4GHz wireless that may interfere with the APs transmission of the packets such as microwave ovens, Bluetooth enabled devices, wireless phones, other APs and so forth.

The case study area involving 4 floor levels and just two numbers of APs are implemented at the ground and first level. Table 3 shows the number of all APs (interior and exterior) obtained with its interference score.

Table 3: Interference score of APs according to level

Level	Number of APs	Interference
0	12	Moderate
1	17	High
2	17	Moderate
3	12	Low

Based on analyser results, the highest number of the AP is at level 1 and 2. Even though both levels have the same number of AP, but level 1 has the highest score for interference level. This is evidently shows the interference is caused by the neighbour wireless network are different, depending on other characteristic since the area is surrounded by different types of APs and other devices. Increasing the numbers of AP in the area is very tempting since it will increase the number of user connected to the WiFi with negative consequences.

As a high density of APs are deployed in the area, the co-channel interference tends to occur. To reduce the effects of co-channel interference is by reducing the transmit signal power for each AP.. As mentioned earlier, the output power of wireless device is one of the factors that has a consequence to the interference level. The interference level for level 0 is moderate which is caused by other interference factors. The numbers of APs at the level is low but the interference score is moderate.

Maximum Numbers of Clients

The analysis involves the step of finding the maximum number of client. The wireless networks need to limit the clients connected to the APs, so the network performance does not degrade. As the number of clients connected to the APs increases, the throughput will decrease. Table 4 tabulates the maximum number of clients for each level, and Figure 8 depicts the connection between the AP and the clients in the wireless network.

Table 4: Maximum numbers of users in each level

Level	Maximum No. of Clients
0	45
1	30
2	10
3	10

Figure 8: Wireless connection of AP and clients

To elaborate details on maximum number of client, a noise floor is measured. The noise floor is the measurement of the signal created from the sum of all noise sources and unwanted signals within the measurement system. The noise floor limits the smallest measurement that can be taken with certainty since any measured amplitude must in average or not less than the noise floor level. [20]. Table 5 shows the noise floor score for each channel at three different times. According to the data collect, the peak hour for the clients turn on the device is at 12.30 p.m., where this makes the noise floor score higher.

Table 5: Noise floor score for level 0 according to time

Channel	Noise Floor (-dBm)		
	9 a.m.	12.30 p.m.	5 p.m.
1	-77	-71.5	-79.5
2	-78.5	-73	-82
3	-81.5	-77.5	-82
4	-84	-79.5	-83.5
5	-86	-81	-83
6	-86	-80.5	-85
7	-87	-81.5	-83.5
8	-86.5	-81.5	-84
9	-85	-81.5	-84
10	-83	-80	-82.5
11	-82	-79	-81
12	-84.5	-82	-81.5
13	-88.5	-88	-87.5
14	-97	-95	-95

Estimation of 5GHz and 2.4GHz AP

For this section, the Aerohive Online Planner was used to estimate the suitable number of the APs to cover up the whole building. This tool calculates the loss in signal strength as its passes through open air and various materials to show the predicted coverage. It uses intelligent algorithms to examine the AP behavior based on an imported floor plan with an assigned building characteristic. For both bands, the 2.4GHz and 5GHz need 6 APs to cover up entire building with a good RSSI signal strength.

Figure 9 shows RSSI signal strength for 2.4GHz AP. The 2.4GHz band provides the greatest range, but it is unregulated and susceptible to interference from other household Radio Fequency (RF) devices. This can result interference and degrade its performance [21].

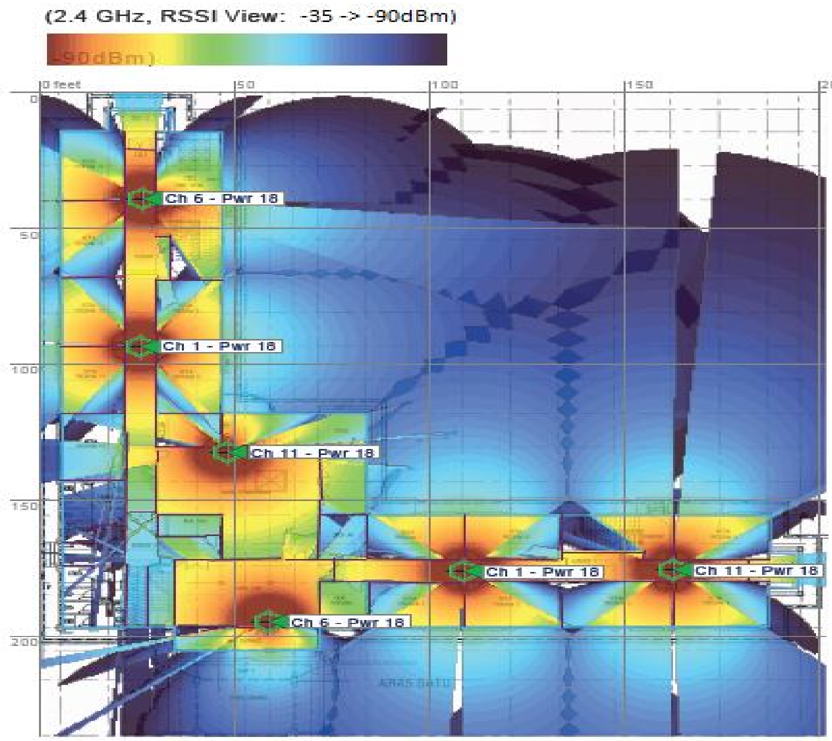

Figure 9: Estimation location for AP with 2.4GHz band

Figure 10 shows the RSSI signal strength for 5GHz AP. The 5GHz band is regulated and thus generally free of interference. However, the higher frequency reduces the effective distance of the signal. It is more susceptible to being absorbed by obstructing objects or walls [21].

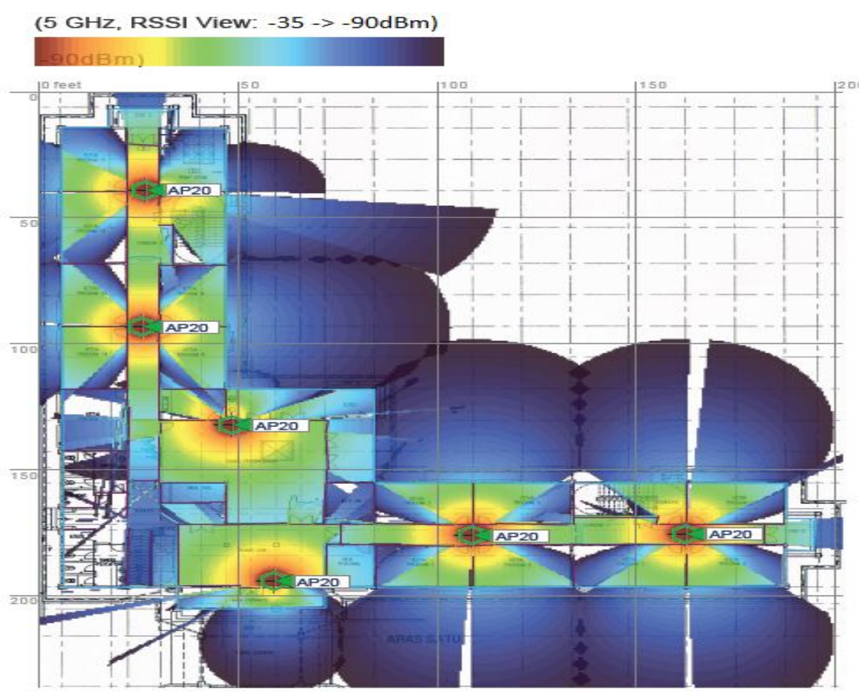

Figure 10: Estimation location for AP with 5GHz band

CONCLUSION

The analysis of WiFi AP is to help the network administrator to manage and observe easily the APs surrounding the building. The APs are located beforehand via software and hardware based. The detected AP will be analyzed for information and data of its signal. The analyzed data can help the network administrator to manage and solve the network problems which involves interference and the solution to increase the efficiency and the network performance. The authorize party who controls the network performance for the research is Info Tech can isolate unmanaged and managed APs using this research. The AP localization also must be considered again to cover the entire building with a good signal strength. Without a proper management of APs, the efficiency of the network performance will be degraded that causes a low throughput for the clients. Based on the findings, it can be concluded that the results can help the network administrator to solve their network problems. It is recommended that the network administrator analyzes the network in the area before the deployment of APs to prevent unnecessary problems.

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The authors declare that they have no conflicts of interest in this research.

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