Analyzing and Optimizing Wi-Fi Access PointPerformance

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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 should satisfy the needs of the clients and give the best performance especially data sharing within the network thus Access Points (AP) is used in an area. Even with the usage of APs, propagation inside buildingsuffers from interference and overlap channel. Hence it is necessary to identify the quality of the wireless connection and how to improve the communication through WLAN by positioning the AP. Therefore, in this paper, Analyzing and Optimizing WiFi Access Point Performance has been proposed to analyze a study case with APs network problems and its performance. The case study area used in the research is in the Intelek Building located in the Universiti Teknologi MARA, Terengganu.**

Keywords-component; Data sharing,interference,WiFi Access Points performance

I. INTRODUCTION

As large-scale wireless networks continue to proliferate, a reliable way to test coverage and communicate requirements becomes increasingly important. The drastic escalation usage of wireless devices has resulted high-density WLAN that induces many problems into a network. A reliable network should satisfy the needs of the clients and give the best performance especially data transfer within the network thus access point (AP) is used in an area. APs act as a transmitter and receiver in a network to give connection for the users to connect to the Internet. The geometric configuration of WiFi APs provides knowledge on the nature of networks, such as density, connectivity, and interference characteristic which is used for the management of WiFi networks.

Regularly managed and monitored APs can help the network administrator to increase the performance and the efficiency each of the network and building the network topologies by find the number of users, the AP's name, location, signal and many more. Before the deployments of AP, there are some matters need to be defined;

A. AP Wireless Management

By introducing an AP in area, a Wireless Local Area Network (WLAN) is built. The increase development of WLAN networks under IEEE 802.11a, 802.11b and 802.11g standards increases the challenges in network management as such data quality maintenance, signal strength, network data collection and the performance of the WLAN. WLAN managements should provide configuration management, performance management, mainly influenced by signal strength and quality, accounting management, real-time monitoring, fault management and security management.

B.AP Observation in Area

To detect an AP in area, a device needs to be used to survey the wireless connection in the area. There are numerous methods to observe AP in an area. One of the methods is by using Netstumbler [1].Netstumbler is an application that allows the user to monitor the MAC address, SSID, the channel AP used and many more. The application also can verified each access point bandwidth to identify which access point has a strong bandwidth in an area, This can be used to find the locations of the APs.

It is not easy to find access points to connect to the internet. Based from the research in [2], they propose a system named Neighbor WiFi Access Point Advertisement System. The systems continuously detect and collect information on nearby WiFi APs within its radio detection range. The informationis shared between mobile terminals in proximity with each other and the information is advertised to clients through their personal access points.

For this research, the application used to observe APs in the case study area is by using inSSIDer. The Intelek building has 4 levels. To scan each of the levels access points, the mobile device that is a laptop used with the application mentioned. The application scans the network using the computer WiFi antenna, keep tracks of signal strength over time, signals channel, network security and etc. The application is chosen because of its high sensitivity, fast

response and quite accurate measurement of signal strength. This is vital to pin point the locations of access point that are scattered in the case study area. Furthermore it is user friendly by giving graphics results such as time graphs, MAC Address, SSID, channel and frequency.

C. Received Signal Strength Indication (RSSI)

There are some approaches to positioning problem in WiFi networks. The most popular ones are client-based and rely on the RSSI from network's APs. The use of RSSI parameter in positioning is important as to estimate the problem by the transmission path loss. It is extremely complex and dependent when focus on wide variety assumptions (e.g. type of building, construction, materials, doors and windows positions, etc.) to predict the nature of the path loss in an indoor environment[3].Precise estimation of the path loss remains a fairly complex task, even if the basic parameters are known.The majority of techniques based on the RSSI parameter are statistical.

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

D.Non-Overlapping Channel and Frequency Used

Channel of the access points need to be selected accordingly for a better network performance for the user [6]. Non-overlapping channels are used to minimize interference in the network[7].802.11b or 802.11g provide 3 non-overlapping channels and 802.11a provide12 channels. Even though 802.11a provides more non-overlapping channels than 802.11b and 802.11g, it has more channels to be considered and it also has its own disadvantages. The 802.11a works on a higher spectrum compare to 802.11b or 802.11g that is 5 GHz and 2 GHz respectively, it is more difficult to penetrate obstacles such as walls and ceiling thus reduces its transmission range. Furthermore the 802.11a GHz is a regulated frequency spectrum thus it is costly compare to 802.11b or 802.11g. It is more efficient to use 802.11b or 802.11g for the network access points. IEEE 802.11b and 802.11g has 3 non-overlapping channels that are 1, 6 and 11[8].To allocate each of the channels for the access points a channel planning need to be made. In an area, it is not adequate to use the same channels for transmission. For example in a small office environment which is surrounded by channel 6, the office needs to assigned channel 1 or 11 to avoid interference with the neighboring networks.

E. WiFi Interference

There are many factors that may introduce interference in a wireless network. Interference may occur caused by co-channel/adjacent channel interference from WLAN, hidden nodes in the environment or non-WiFi devices operating in the 802.11 band. There have been some studies to decrease or prevent from interference to happen [9]. It is proposed to use an interference avoidingapproach based on multi-channel for ZigBee network called MuZi that includes interference assessment, channel switch and connectivity maintenance. In this research, the interference is measured and calculated based on WiFi interference score for the devices contributing to the interference. There are three factors that determine the effect of an interference device:

- Output power. As the output power of the interference device
- Signal behavior with respect to time. As the time 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 operate at a single frequency and affect only a single WiFi channel. Some change between one frequency to another effect 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.

II. RELATED WORK

In [10], the research has found that by applying centrally managed Wi-Fi deployments, report-based topology can be made by using AP-base measurement, trusted user and non-trusted user. The technique by the author uses AP and user to give feedback report to the collector that are centralized. Using the report, the network topology can be gain and reducing the interference between each AP. Reports from the client gave a user-perceived view of interference condition that AP might fail to capture. User may face a lack of connection, low rate of downlink and uplink rate that the AP does not measure. This can be implemented in this research by using the report from the AP and user, the network topology can be built using the tools provided to analyze the signal that propagate from the AP to the user and vice versa. The capability and performance of an AP can be extended [11] by using multiple communications channels and by having more capable nodes employ multiple radios module.

As emphasized by [12], WiFi Access Point (AP) locations are hard to find because most of the APs are easily installed but their location are not published. To obtain the APs locations, the author implemented Locky.jp system into the network. The system is not accurate enough to determine the exact locations of the APs so the author applies statistical and heuristic methods to improve location data quality. For this case study, a different approach is applied. Different software and tools are used that are AirMagnet

WiFi Analyzerand inSSIDer. The tools can perform wireless discovery and network availability, interference detection, locate APs location and etc.

The research in [13] uses an ad-hoc wireless as access point and the effects of network topology control via research and analysis. Using their method, the network performance were improved greatly as shown in the results by comparing energy, packet delivery and packet end-to-end average delay between using the network with topology and network without topology. Ad hoc is preferable for a small amount of users since as the numbers of devices grows the performance suffers greatly and it is hard to manage since it does not uses a central access point[14].

Based from [15] research, the author proposed to use a wireless network system management based on Simple Network Management Protocol (SNMP). 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 days goes by, many more user will connect to the AP. With the increasing number of user, the network traffic needs to be controlled and monitored. To manage a wireless network proves to be challenging in [15].The SNMP can be used to collect data and monitor wireless network performance and control access to wireless network through AP.

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

III. METHODOLOGY

The research includes finding the Access Point (AP) scattered around the Intelek building in Universiti Teknologi MARA (Terengganu). This is done by environmental observation in each location using the equipment provided. Sniffing the wireless connection is used to find each AP. As each AP is found, the AP needs to be monitored using the network analyzer to find the AP names, number of users and AP network performance. Based from the information, the network problems can be recorded for the research. Figure 1 show the steps taken for this research.

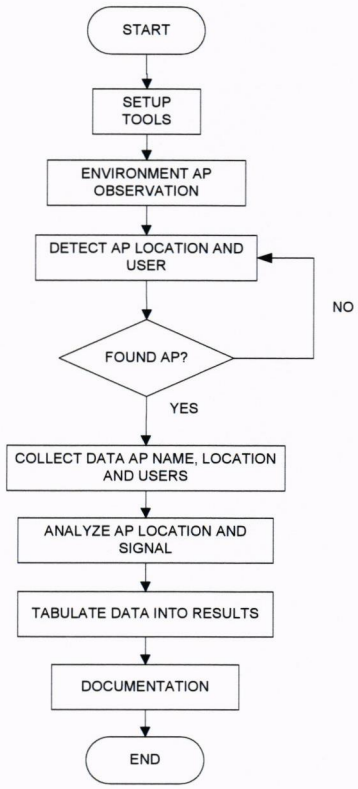

Fig.1 – Flow Chart of Methodology

IV. ANALYSIS RESULTS

A. Finding Access Point Locations

This section will cover locating the access points in the Intelek building, UiTM Terengganu. As mentioned in the introduction, the preference method to find AP is by using the inSSIDer application. The application can inspect surrounding networks, find and scan more than hundreds of nearby access point swiftly, highlights APs with high WiFi concentration, details of each APs and etc.To find 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 illustrates the sample data acquisition to allocate the position of access points. Each figureexplains based from the distance from the computer to the access points.

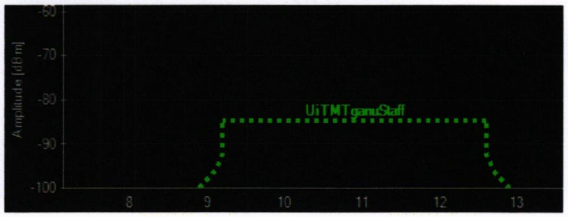

Fig.2 – Signal strength for 35 meter distance

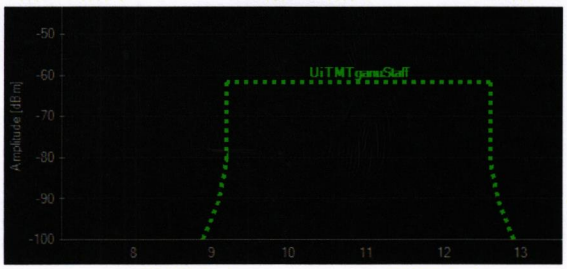

Fig.3 – Signal strength for 15 meter distance

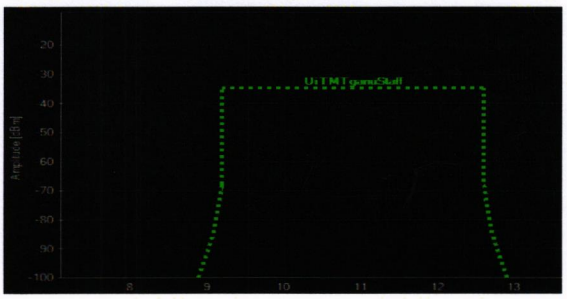

Fig.4 – Signal strength for 3 meter distance

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

Figure 5 shows the numbers of access point in the area for case study. It is found that the location for the access points is strongest when the mobile device near to the location of the access points rather than other access points. It is found that the green colour graph has the highest signal strength that shows it is the nearest access point location to the mobile device. This method is preferably for locating access points in a small area or building since the detection is made by measuring the wireless signal strength accurately. This can help network administrator to locate each of the access points that are deployed without requiring the usage of Global positioning system (GPS).

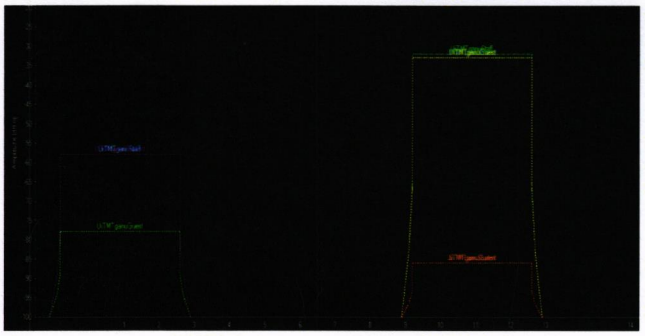

Fig.4– Access Points Location Strength

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

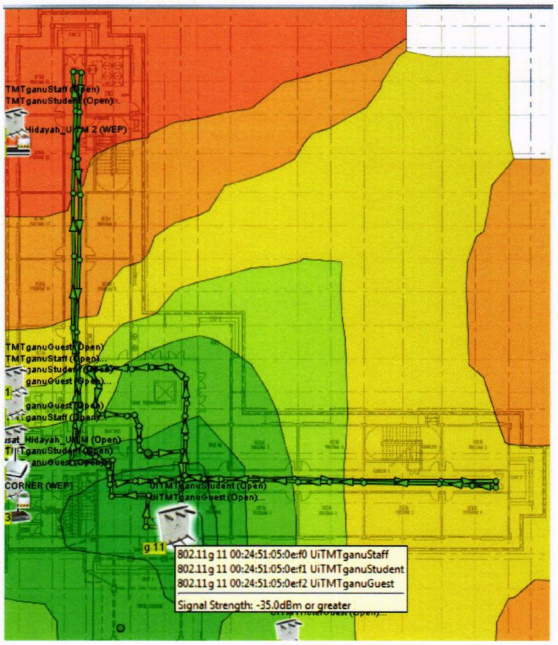

Fig.6 –Coverage and Signal strength for AP at area case study

B. 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 of unmanaged network is caused by ineffectively assignments of channels for access points. For this research, most of the

access points use 802.11b and 802.11g. As mentioned before, both of the IEEE standards have three non-overlapped channels that is channel 1, 6 and 11. The assignments of non-overlapped channel into each of the access points may minimize the interference between each access points 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 thoroughly interference however it can be reduced by using partially overlapping channels. By utilising both non-overlapped channel and partially overlapping channel can improve the network performance.

In the case study area, it is found that many areas did consider the non-overlapping channel for the access point channel before deploying them. This has caused the wireless network performance enhance and affect the clients to connect to the internet.Table 1 shows the results of the channel implemented into the access points with the implementation of non-overlap channels. By implementation of non-overlap channels, the interference is lower than using multiple channels in ground level of the building as shown in figure 7.

TABLE1 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

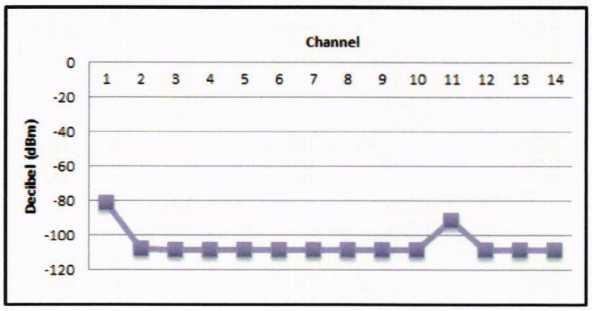

Fig.7 – Interference Score according to channel

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

TABLE2 Access Points 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

C. Wireless Network Interference

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

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

TABLE3 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 from theanalyser results, the highest number of access point is at level 1 and level 2. Even though both levels have same number of access point but level 1 has the highest score for interference level. This can shows that the interference is caused by the neighbour wireless network are different depending on other characteristic since the area is surrounded by different types of access points and other devices. Increasing the numbers of access point in an area is very tempting since it will increase the number of user connected to the WiFi but it will have negative consequences.

As a high density of access points are deployed in an area, co-channel interference tends to happen. To reduce the effects of co-channel interference is by reducing the transmit signal power for each access points. As mentioned before, the output power of wireless device is one of the factors that had consequence to the interference level. The interference level for level 0 is moderate may cause by other interference factor since the numbers of APs at the level is low but the interference score is moderate.

D. Maximum Numbers of Clients

The analyses also involve finding the maximum numbers of client. Wireless networks need to have limit of clients connected to the access points so that the network performance does not degraded. As the numbers of clients connected to the access points increases, the throughput will decrease. Table 4shows the maximum number of clients for each levels and figure 8 shows the connection between the access point and the clients in the wireless network.

TABLE4 Maximum Numbers of Users for each level

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

Fig.8 – Wireless Connection of AP and clients

To elaborate more on maximum number of client, noise floor was measured. Noise floor is the measure of the signal created from the sum of all the noise sources and unwanted signals within a measurement system. The noise floor limits the smallest measurement that can be taken with certainty since any measured amplitude can on average be no less than the noise floor[20].Table 5 shows the noise floor score for each channel at three different times. According to this data collect, peak hour for clients turn on their device is at 12.30pm and this makes noise floor higher.

TABLE5 Noise Floor Score for level 0 according to Time

Channel	Noise Floor (-dBm)		
	9am	12.30pm	5pm
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

E. Estimation of 5GHz and 2.4GHz Access Point

For this section, Aerohive Online Planner was used to estimate the suitable number of 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 predicted coverage. It uses intelligent algorithms to examine AP behavior based upon an imported floor plan with assigned building characteristic.For both band, 2.4GHz and 5GHz need 6 access point to cover up entire building with a good RSSI signal's strength.

Figure 9 shows RSSI signal strength for 2.4GHz access point. The 2.4-GHz band provides the greatest range, but is unregulatedand is susceptible to interference from other household RF devices. This canresult interference and degraded performance [21].

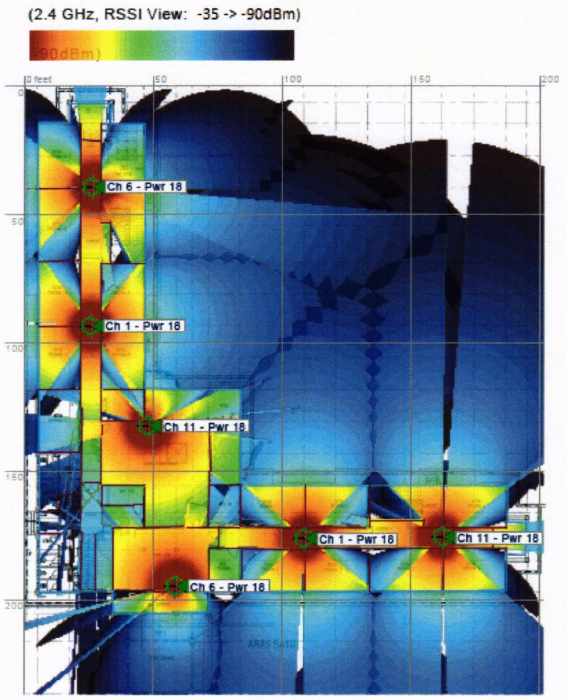

Fig.9– Estimation location for Access point with 2.4GHz band

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

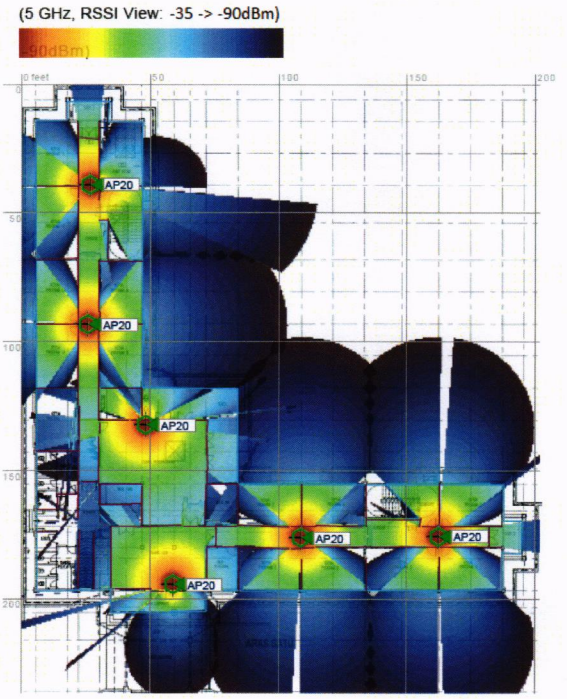

Fig.10– Estimation location for Access point with 5GHz band

V. CONCLUSION

The analysis ofWiFi access point is to help network administrator to manage and observe easily access points that are surrounding the building. The Access Points are located beforehand via software and hardware based. The detected access point will be analyzed for information and data of its signal. The analyzed data can help network administrator to manage and solve networks problems involving interference and its solution to increase the efficiency and network performance. The authorize party that control the network performance for this research is Info Tech can isolate unmanaged and managed access points using this research. AP localization also must be considered again to cover entire building with the good signal strength. Without a proper management of access points, the efficiency of network performance will be degraded that causing low throughput for the clients. Based from the findings it can be concluded that the results can help network administrator solving their network problems. It is recommended that network administrator analyze network in the area before the deployment of access points to prevent unnecessary problems.

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