



INDIVIDUAL ASSIGNMENT

TECHNOLOGY PARK MALAYSIA

CT090-3-2-MWT

MOBILE AND WIRELESS TECHNOLOGY

**APU2F2006IT (CC), APU2F2006IT (IOT), APU2F2006IT (ISS),
APU2F2006IT (MBT), APU2F2006IT (NC), APU2F2006IT,
APU2F2006CS**

Hand Out Date: 26th June 2020

Hand In Date: 11th September 2020

Weightage: 40%

Online Submission Time before = 7: 00 PM

INSTRUCTIONS TO CANDIDATES:

1. Students are advised to underpin their answers with the use of references (cited using the Harvard name system of Referencing)
2. Late submission will be awarded zero (0) unless Extenuating circumstances (EC) are upheld.
3. Cases of plagiarism will be penalized.



INDIVIDUAL ASSIGNMENT

TECHNOLOGY PARK MALAYSIA

CT090-3-2-MWT

Mobile and Wireless Technology

APU2F2006CS

HAND OUT DATE: 26 JUNE 2020

HAND IN DATE: 11 SEPTEMBER 2020

WEIGHTAGE: 40%

NAME : TAN ZE YAN (TP051424)

INTAKE CODE : APU2F2006CS

MODULE CODE : CT090-3-2-MWT

ASSIGNMENT : INDIVIDUAL ASSIGNMENT

LECTURER : MS. SALMIAH BINTI AMIN

Table of Contents

Abstract.....	4
1.0 Introduction.....	5
2.0 WLAN Site Survey.....	6
2.1 Current Site Details.....	7
2.2 Design Considerations.....	8
2.2.1 Physical Location.....	9
2.2.2 Intended Use of the Wireless Network and Number of Users.....	10
2.3 Radio Frequency (RF) Coverage Considerations.....	11
2.3.2 WLAN Hardware and Output Power.....	11
2.4 RF Range and Speed Considerations.....	14
2.4.1 Line of Sight.....	14
2.4.2 Interference.....	14
2.4.3 Environment.....	17
2.5 RF Radiation Consideration.....	18
3.0 WLAN Deployment.....	19
3.1 WLAN Deployment Diagram.....	19
3.2 Recommended Hardware.....	20
3.2.1 Routers.....	20
3.2.2 Access Points.....	23
3.2.3 Types of Cables.....	25
3.3 Recommended Software.....	27
3.3.1 Intrusion Detection Software / Intrusion Prevention System – Snort.....	27
3.3.2 Antivirus.....	28
4.0 Conclusion.....	29
5.0 References.....	30

Abstract

The objective of this report is related to deploying a wireless Local Area Network as a solution for a Small Office / Home Office (SOHO) environment. The designed solution is intended towards EVOTECH, a startup online business company which stands for Evolution Technology, the name of the company was intended as technology has to keep evolving in order to keep up with the changes that is happening all around the world. This WLAN Survey Report will include details about the site survey of client's office, hardware used in deployment such as printers, servers, computer equipment, switches, routers, and other shared peripherals that could be specific for the business. The software used in WLAN by the company include Microsoft Teams, OneDrive, Microsoft Outlook, MS Dynamics, web browsing software such as Google Chrome, online business software and accounting software such as QuickBooks. Based on the report, there are a few important findings that I have discovered that helps me to increase my insights. The findings include wireless deployment in a SOHO environment and figuring out the limitations of networks through site survey as well as taking part in survey to figure out and improve the mentioned limitations.

1.0 Introduction

Quite a number of growing small business choose to adopt a wireless solution instead as a way to increase productivity as the solution provided are much faster, flexible, and affordable to most organizations. Wireless solution is reported to have an increase of worker satisfaction and productivity. A wireless LAN is to be deployed after receiving this project request in which the wireless LAN is intended to be designed as a solution for the SOHO mentioned above. Site surveys are conducted in order to determine the hardware and software needed in order to establish the network solution.

Before wireless LAN is deployed, there are a few requirements that are being put into considerations such as the SOHO environment must not be more than 10 employees when deciding the software and hardware to be used. Besides, a printer and a server are required during wireless LAN deployment to be maintained by the business owner as to store business data related to daily operations.

The purpose of setting this WLAN deployment is to ensure that the employees and guests of EVOTECH are able to access the Internet and software that is to be used for their startup online business as well as day-to-day operation.

A few assumptions had been made during the deployment of WLAN. The assumptions include the size of EVOTECH office to be estimated approximately 1400 square feet. There is a total of 8 staffs estimated to be situated in the office. The deployment of network is meant for the staffs and guests of EVOTECH only.

2.0 WLAN Site Survey

With the purpose of deploying a wireless network in a Small Office Home Office (SOHO) environment, tasks have been assigned to the network consultant of EVOTECH in building a WLAN for the company's office that is located at Bukit Jalil. Being the network consultant of EVOTECH, a WLAN site survey is necessary in order to discover the coverage and interference sources of radio frequency for WLAN devices that will be used on site. The reason behind conducting site survey is because it is considered as the best solution to identify the obstacles and areas of channel interference which reduces the chances of RF jamming occurring before building a network for the users. Location for access points and other equipment such as cables and antennas are determined beforehand before installing. In order to further understand the requirements needed during WLAN deployment, an interview is conducted on site with the clients to gather information. The list of questions asked are in the form of a questionnaire and is shown in the figure below.

1. Has a site survey been performed in the past?
☐ Yes
☐ No
2. Are there any blueprints, floor plans or any other site-specific documentation available?
☐ Yes
☐ No
3. How many estimated users will be using the wireless network?
4. List down the coverage area required for the wireless network
5. What are the applications that will be used for the wireless network?
6. What are the obstructions that is known to cause RF interference on site?
7. What types of client devices will be used on the wireless LAN? (Tick those that apply.)
☐ Laptops ☐ Desktops ☐ Thin Clients ☐ Agency-owned Mobile
☐ Printers ☐ Cameras ☐ VoIP Phones
☐ Tablets ☐ Video Codec ☐ Others
8. What are the wireless security requirements?
9. What are the types of wireless services required for your company? (Tick those that apply)
☐ Agency ☐ Roaming ☐ Guest ☐ Sponsored Guest
10. Are there enough switch ports available for the new access points to be accommodated? If yes, what are the port speed?
☐ Yes ☐ No
☐ 100mbps ☐ 200mbps ☐ 500mbps ☐ 1gbps

Figure 1: Questionnaire Form

2.1 Current Site Details

Once the requirements are gathered and reviewed, a wireless site survey will be generated by the network consultant to determine the optimal wireless coverage using the least amount of wireless access points or other equipment. Out of the four different categories of wireless site survey which are predictive, physical, passive and post validation site surveys that are stated by Pierce (2018), the chosen wireless survey for this situation is a mixture between passive site survey and predictive site survey as it uses software to analyze problems and gather radio frequency data related to signal strength, access points placements and environmental disturbance. According to SONICWALL (2020), the purpose of conducting a wireless site survey is to determine the feasibility of deploying a wireless network and work around within the constraints of wireless deployment site. The figure below shows two different wireless site survey of two different frequencies bands of wireless LAN (IEEE 802.11) standard generated by the network consultant with the usage of EKAHAU Heatmapper software.

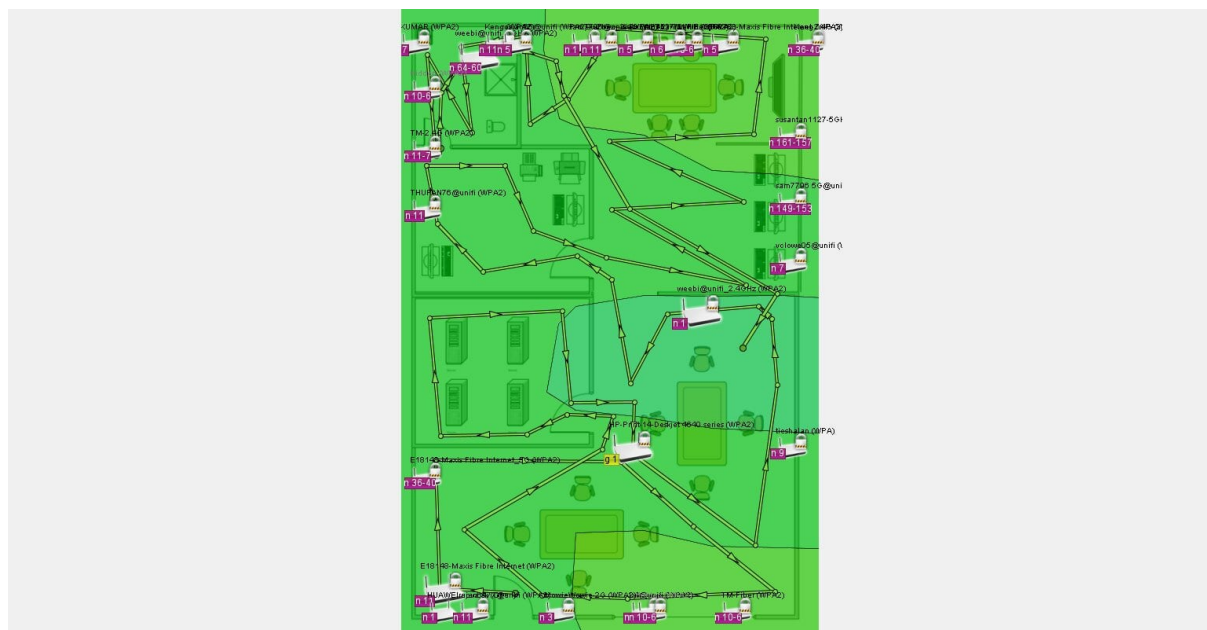


Figure 2: 2.4 GHz Site Survey Floor Plan of EVOTECH

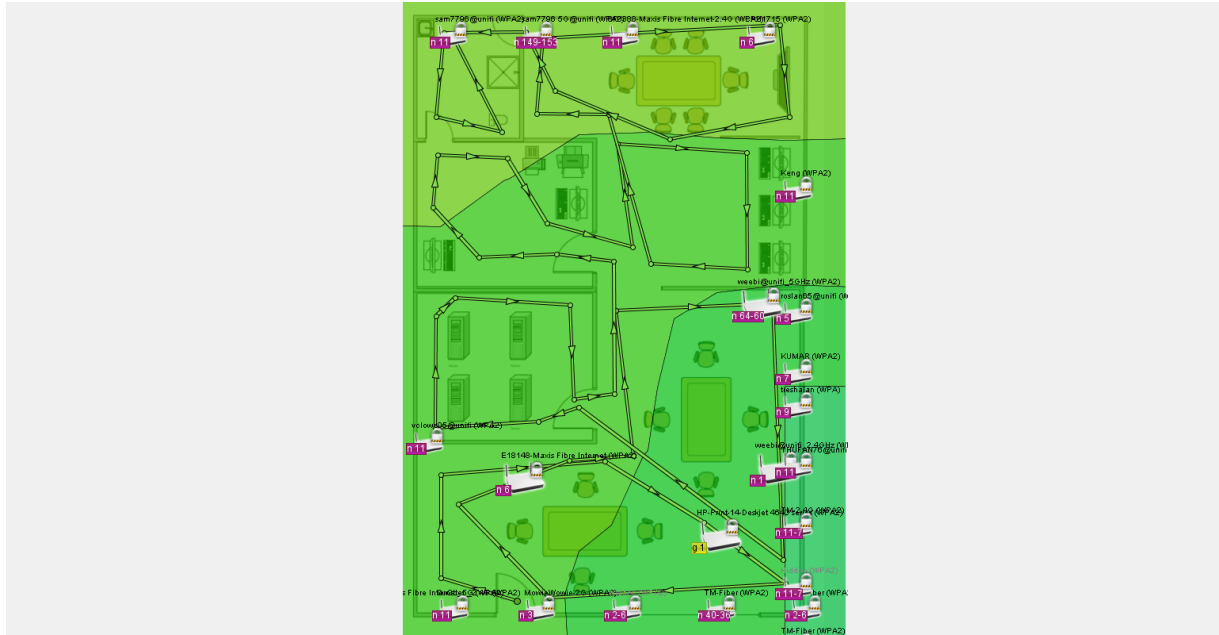


Figure 3: 5 GHz Site Survey Floor Plan of EVOTECH

As identified by (Patil et al, 2018), the advantages of using EKAHAU Heatmapper includes the software able to be mapped using image provided. With this, a wireless site survey can be carried out easily as long as a blueprint or floor plan image is available for use. Besides, it also provides individual as well as single AP mapping.

2.2 Design Considerations

Implementing a wireless network takes a lot of planning thus the network consultant hired has to undergo a network design phase where factors are thoroughly planned out (AccessAgility, 2017). During the wireless site survey, there are a few factors regarding the company site such as the physical location of the office, radio frequency coverage, speed and radiation are taken into consideration by the network consultant.

2.2.1 Physical Location

Characteristics of EVOTECH office

EVOTECH is a SOHO startup online business company and its office is situated near Bukit Jalil, Kuala Lumpur. The size of the office is approximately 1400 square feet as mentioned above. The office consists of a server room, employees' workstation, meeting room and toilet. The main room would be where the clients would be having discussions regarding project requests with the employees of EVOTECH. The office bathroom includes a shower, toilet, and a sink for basic needs.

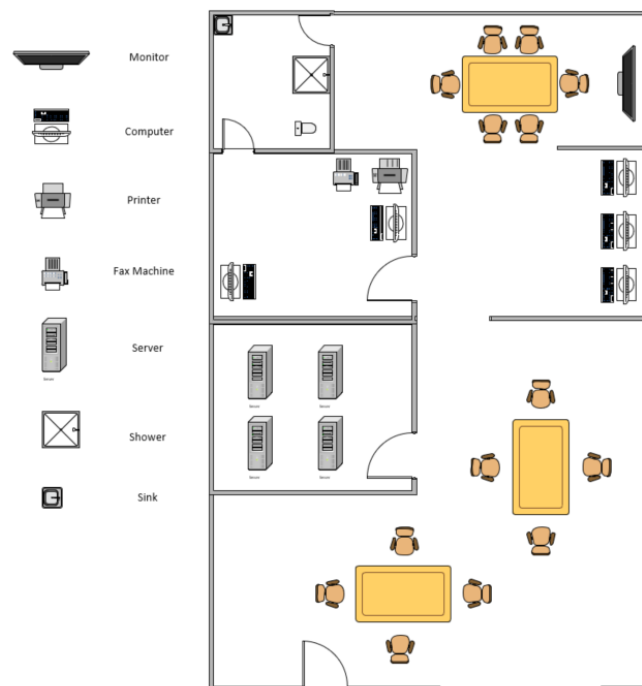


Figure 4: Office Floor Plan of EVOTECH

Obstacles found in EVOTECH

During the deployment of a wireless network, obstacles are also taken into considerations. A few examples of obstacles include physical obstructions such as windows, walls, and other furniture which the material and thickness of these obstacles may be a factor affecting the quality and coverage of the wireless network implemented. As the planning tool used by the network consultant does not provide features for obstacles consideration, the network consultant decides to make estimation on the obstacles during the network implementation process.

2.2.2 Intended Use of the Wireless Network and Number of Users

The main purpose of deploying a wireless network for EVOTECH is to allow the employees to access to software which includes Microsoft Outlook to send and reply emails between clients, usage of web browsing software such as Google Chrome to surf the web and browse for information. Since EVOTECH is a startup online business company, there are applications such as EVOTECH's personal online business software and QuickBooks accounting software to manage finances. There is also hardware that uses internet connection such as the printers and fax machines which allows internet access to perform printing tasks without the need of cables to be connected to the computers.

User Group	Minimum	Maximum
Employees	1	8
Clients	0	3
Total	1	11

Since the frequent users of network within EVOTECH office will be the employees of the company, the priority goes to them as they require internet connection to perform day-to-day operation. There are times when clients or customers would enter the office and be using the network provided in EVOTECH office. The remaining priority goes to the clients who were waiting at the office and would like to have access to the Internet. The number of users and intended use of wireless network are factors that are taken into considerations as there might be an increase of clients and employees in EVOTECH office during the deployment of wireless network.

2.3 Radio Frequency (RF) Coverage Considerations

Based on the analysis made for the current WLAN site survey above, EVOTECH is not satisfied with the result which causes coverage to be taken into considerations as the current WLAN site survey shows that the company requires improvements towards their wireless network implementation. Coverage and capacity are important as it is to ensure that the wireless network signal strength and speed has to be equivalent throughout the office without any sorts of interference which may lead to poor performance of the company. Unlike calculating the area to determine its coverage there is no specific rule in determining how much space an access point can cover with its radio frequency. The factors determining the coverage includes the size of area, number of users, application in use, obstacles, propagation, and radio frequency range as well as WLAN Hardware and Output Power which will be covered later on.

2.3.2 WLAN Hardware and Output Power

Output power

After going through a selection of routers that are available in the market, the router that is chosen by the network consultant for EVOTECH is the ASUS RT – AC68U Wireless AC1900 Dual Band Gigabit Router which supports the 802.11ac standard which is an improvement of the previous version 802.11n. The table below shows the comparison between calculating the speed of 802.11n and 802.11ac (Cisco, 2018).

PHY	Bandwidth (as number of data subcarriers)		Number of spatial streams		Data bits per subcarrier		Time per OFDM symbol		PHY data rate (bps)
802.11n or 802.11ac	56 (20 MHz)		1 to 4		Up to $5/6 \times \log_2(64) = 5$		3.6 microseconds (short guard interval)		
	108 (40 MHz)	X		X		÷	4 microseconds (long guard interval)	=	
802.11ac only	234 (80 MHz)		5 to 8		Up to $5/6 \times \log_2(256) \approx 6.67$				
	2 × 234 (160 MHz)								

Figure 5: Comparison table of 802.11n and 802.11 ac

Extracted from: <https://www.cisco.com/c/dam/en/us/products/collateral/wireless/aironet-3600-series/white-paper-c11-713103.pdf>

In addition, the RT – AC68U also support both 2.4 GHz with speed of up to 450 Mbps and 5 GHz with speed of up to 1300 Mbps for a total of 1.75 Gbps of available bandwidth (TP-link, n.d.). With the selection of both frequency bands allows users whose device do not have the capability of connecting to 5GHz to connect to 2.4 GHz which provides more range but less bandwidth output. Users that require faster internet connection can choose to opt for 5 GHz at the cost of a much lower signal range.

2.3.2.1 Transmit Power Settings

Router	Channel	Power (dBm)					
		Chain 0	Chain 1	Chain 2	Chain 3	Total	Limit
ASUS RT-AC68U F/W: 3.0.0.4.374_5656	1	18	18.1	17.8	-	22.74	30
	6	17.9	17.7	16.8	-	22.26	30
	36	5.6	5.8	5.9	-	10.54	17
	48	5.4	6.8	6.2	-	10.94	17
	149	21.1	20.8	21	-	25.74	30
	153	21.1	20.8	20.9	-	25.71	30
ASUS RT-AC66U F/W: 3.0.0.4.374_5517	1	22.9	23.6	22.7	-	27.86	30
	6	22.9	23.6	22.1	-	27.68	30
	36	20.5	19.7	20	-	24.85	17
	48	20.6	20	20.8	-	25.25	17
	149	20.7	19.7	20	-	24.93	30
	153	20.8	19.7	20.2	-	25.03	30

Figure 6: Transmission power testing and CE/FCC restrictions

Extracted from: <https://www.smallnetbuilder.com/wireless/wireless-features/32431-is-your-routers-transmit-power-juiced>

According to a testing done by Higgins (2014) in SmallNetBuilder, the measurements exceeding the Federal Communications Commission (FCC) are marked in bold red. Starting from the left-most antenna facing the router (Chain 0) to (Chain 2), measurements taken for the 2.4 GHz frequency band by setting the channel bandwidth to 20 MHz and 20/40/80 MHz setting for the 5 GHz frequency band. This proves that the transmit power for the router used does not exceed the FCC regulation standard. Both wired and wireless communication technologies are required to meet compliance with local standards which are usually strict and harder to pass stated in the Federal Communications Commission (FCC) regulations (Digi-Key, 2017).

2.3.2.2 Antennas

Gain of antenna

As stated by (tp-link, 2016), the measurement of power in which electricity is converted into radio waves that represents the states of efficiency it is in is called as antenna gain. The unit that is used to represent this measurement of power is known as decibel (dB). Another measurement which is known as decibel-isotropic is when an isotropic antenna transmits signal in a perfect sphere but is rarely measured since a perfect sphere is almost impossible to create. For each 3dBi calculated the antenna power doubles. The AC1750 router consist of 3 high performance external antennas which form a signal-boosting to cover large areas in different directions.

Antenna Type

The type of antenna used for the chosen router is Dipole Antenna. Dipole antennas also commonly known as omnidirectional antennas is best used to transmit and receive from the broadside of the antenna and sensitivity towards matching horizontal positioning is high (Caputo, 2014).

Anthony C.C. (2014) *Digital Video Surveillance and Security (Second Edition)*. [Online]. Butterworth: Heinemann, Page xiii. Available from:
<http://www.sciencedirect.com/science/article/pii/B9780124200425110019>

Antenna Orientation / Polarization

In order to ensure that the omnidirectional signals are both received and transmitted, the antennas are usually vertically polarized even though they can be circularly polarized or dual polarized (Hardesty, 2019). Reflections are caused by the nature of omnidirectional antennas in which the circular polarization mitigates it.

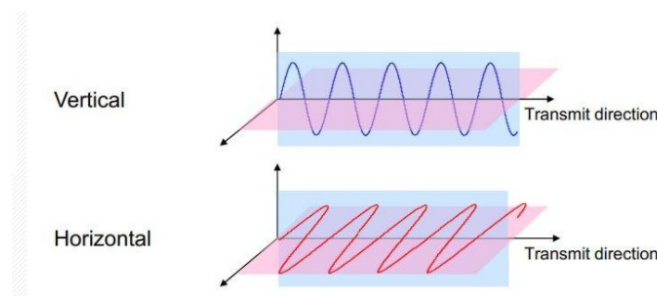


Figure 7: Vertical and horizontal antenna polarization

Extracted from: <https://www.data-alliance.net/blog/antenna-polarization-vertical-linear/>

2.4 RF Range and Speed Considerations

RF range and speed are also taken into consideration by the network consultant when wireless network is being deployed. The speed and range of RF signals are determined by a few factors such as line of sight, interference, and environment which is also known as the RF behaviour.

2.4.1 Line of Sight

The two types of line of sight in factors of RF range and speed are visual and RF line of sight. Visual line of sight as the name describes is the ability of transmitter and receiver to see from one site to the other. RF line of sight on the other hand is the radio transmission between the transmitter and receiver. Since the router chosen by the network consultant support RF line of sight, there is no use for visual line of sight as it requires little to no obstacles between connected devices. The main issue with having RF line of sight to be chosen for the network implementation is that the total area of radio frequency transmissions must not be blocked by more than 40% which is commonly known as the Fresnel zone.

EVOTECH office has obstacles such as doors, windows, and walls which indicates that it is more suitable to implement RF line of sight as compared to visual line of sight.

2.4.2 Interference

Radio frequency interference happens when two different signals on similar frequencies received at the same time by the receiver in which it causes distortion in signals. Symptoms of radio frequency interference includes failure of wireless communications or equipment when users could not communicate between multiple devices using multiple bands, significant changes or loss of functionality is being detected or even realizing that communication improves after moving from a certain fixed area or “dead zone” (CISA, 2020).

Interference in radio frequency may result in affecting the quality of signal received by the wireless devices. Thus, unlicensed 2.4 GHz devices such as cordless phones, medical devices, and industrial devices may cause poor performance of network. In this case, the network consultant of EVOTECH has to identify the source of interference and ensure that minimal interference can be achieved during network implementation.

Co-channel and Adjacent Channel Interference

Co-channel interference or is commonly known as CCI is a deployment issue where the cause of interference is when transmissions occur on the same frequency in the same area (Dionicio, 2016). However, this issue can be resolved with the help of tweaking the configuration. In a CCI environment, the stations will only attempt to transmit data when the medium is in idle mode through **CSMA/CA** (Carrier Sense Multiple Access/Collision Avoidance) method or else it will defer its transmission. Co-channel interference highly affects wireless networks when there is an increase in competition between access points in a channel. In this case, the end users which is the employees and clients of EVOTECH will notice a decrease in WIFI speed.

Adjacent channel interference (ACI) on the other hand occurs when transmissions are sent to adjacent or partially overlapped channel. The effects of adjacent channel interference are much worse than co-channel interference as the channel adds noise and interference when channels are being overlapped over one another. The two figure below shows an example of how co-channel interference and adjacent channel interference are able to affect wireless network in terms of its signal strength and speed.

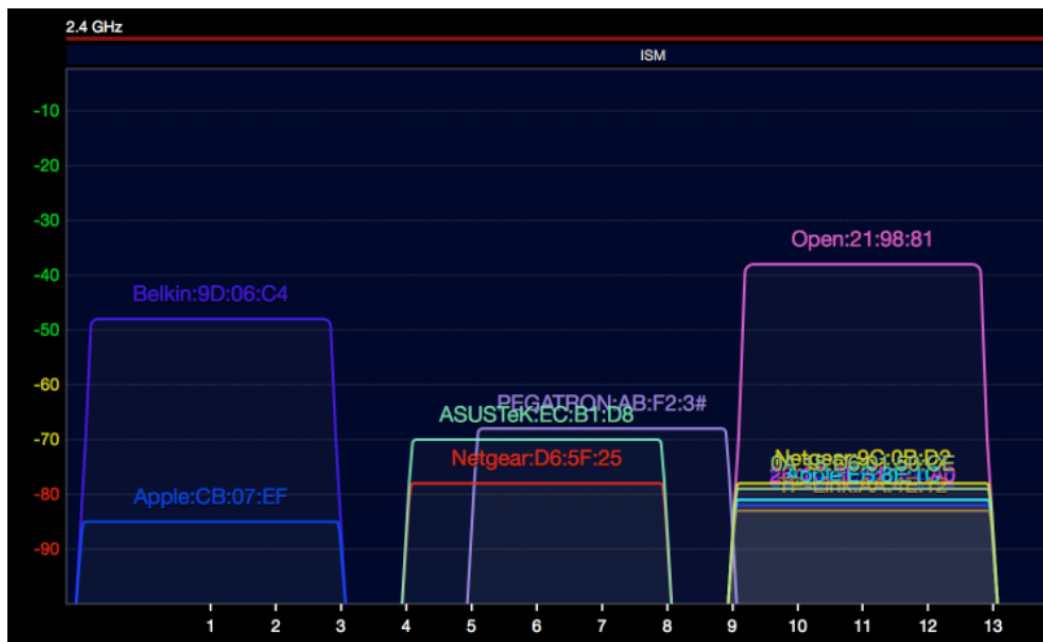


Figure 8: Example of Co-channel Interference

Extracted from: <https://www.networkcomputing.com/wireless-infrastructure/reducing-wifi-channel-interference>

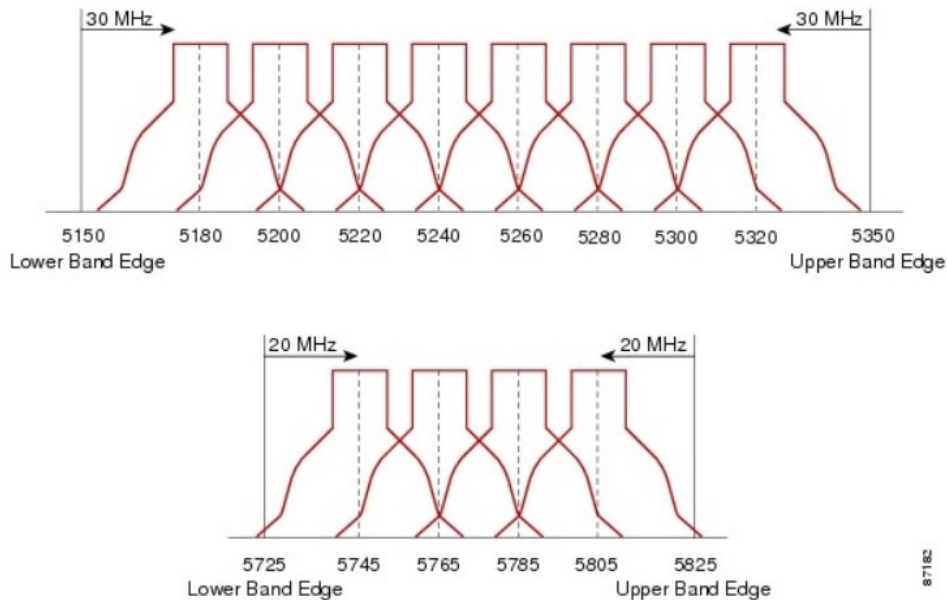


Figure 9: Example of Adjacent Channel Interference

Extracted from: <https://www.networkcomputing.com/wireless-infrastructure/reducing-wifi-channel-interference>

Channel planning

Even though the interference in WLAN can bring detrimental effects to the company, there is a way to reduce the mentioned interference above. One of the solutions provided is the usage of good channel planning. With the help of predictive planning software, planning can be visualized and performed in a given environment by assigning and utilizing the given channel of 2.4GHz and 5GHz spectrum (Dionicio, 2016).

WLAN / WPAN Interference

When IEEE 802.15 wireless personal area networks such as Bluetooth comes into contact or is within range of IEEE 802.11 wireless networks, the performance is degraded resulting in slow and interrupted network connection. Bluetooth uses a technique called frequency-hopping spread spectrum (FHSS) where energy burst is being transmitted across a narrow frequency band for a certain period of time before hopping to another and the process is repeated in a pseudorandom fashion. Wi-Fi on the other hand uses direct sequence spread spectrum in which the energy is being distributed among a set of frequency bands when a device communicates without hopping (Chaube, 2016). Since there are no specific solutions in handling WLAN / WPAN interference, a constraint or system is required in order to ensure that both networks can co-exist between one another. The employees of EVOTECH have to manage between the existing networks.

Bright Sunlight Interference

Bright sunlight does not affect wireless LAN communications between 2.4 GHz ISM and 5 GHz UNII bands and will not be taken into consideration for current WLAN site survey.

2.4.3 Environment

Another major consideration taken for radio frequency range and speed is the environment or phenomena. It is important to know the different types of materials and how it affects wireless signal in a different way. RF signals radiates away from an antenna which is determined by properties such as wavelength, frequency, amplitude, and phase (Extreme Networks, 2019). The environmental factors include reflection, refraction, diffraction, scattering, and absorption.

2.4.3.1 Reflection

Reflection occurs when the wave bounces in another direction when it hits a smooth, non-absorptive object or surface that is larger than the wave itself such as doors, walls, tables, and metal objects depending on the interior of the building may widen and disperse causing it to degrade the quality and strength of the signals received which decreases the throughput and results in poor network performance. Since there are many tables being used in the chosen site, the access points are being placed in the center of the office to reduce the chances of signals being reflected.

2.4.3.2 Refraction

Refraction occurs when the RF signal passes through a different density medium causes the wave to slow down and change its direction which resulting the signal to bend. Materials that causes refraction are materials that allows signal to be passed through and the most commonly known material is glass. The effects of refraction in RF signal include lower data rates, high retries and reduced capacity (Cook, 2015). In order to minimize refraction in EVOTECH, glasses are only used in for windows and mirrors in the bathroom where wireless connection are not necessary in those areas.

2.4.3.3 Diffraction

Diffraction occurs when the RF signals encounter an obstacle and travel around it which causes the speed and direction to be affected. The intensity of diffraction depends on the size and shape of the obstacle. An example of things that would result in diffraction are building or tall structure. RF signals that experience diffraction will result in weaker, degraded and loss of signals. Diffraction might occur in EVOTECH office.

2.4.3.4 Scattering

Scattering occurs when a RF signal unexpectedly encounters an obstacle causing it to scatter in all directions. The impact of scattering is similar to diffraction as it is another form of loss that may severely degrade the RF signal. In the case of current site survey, scattering would not be a concern as there is no uneven surface that can be found in EVOTECH office.

2.4.3.5 Absorption

Absorption is the exact opposite of reflection in which the material absorbs the RF signal that passed through instead of bouncing it off. An example of absorption would be the human body as it contains high water content. This is due to the fact that the molecules in the medium being unable to move quickly enough for the waves to pass through it. Depending on the materials, each have different absorption rate and ultimately affects the signal strength.

2.5 RF Radiation Consideration

Radio frequency radiation could not be determined using observations and it can only be done through repeated testing from the end users. Based on the current WLAN site survey of EVOTECH, there are many factors ranging from line of sight, interference, and environment in which the network consultant and the employees of EVOTECH has to consider before improving and implementing new wireless network for the chosen site survey.

3.0 WLAN Deployment

3.1 WLAN Deployment Diagram

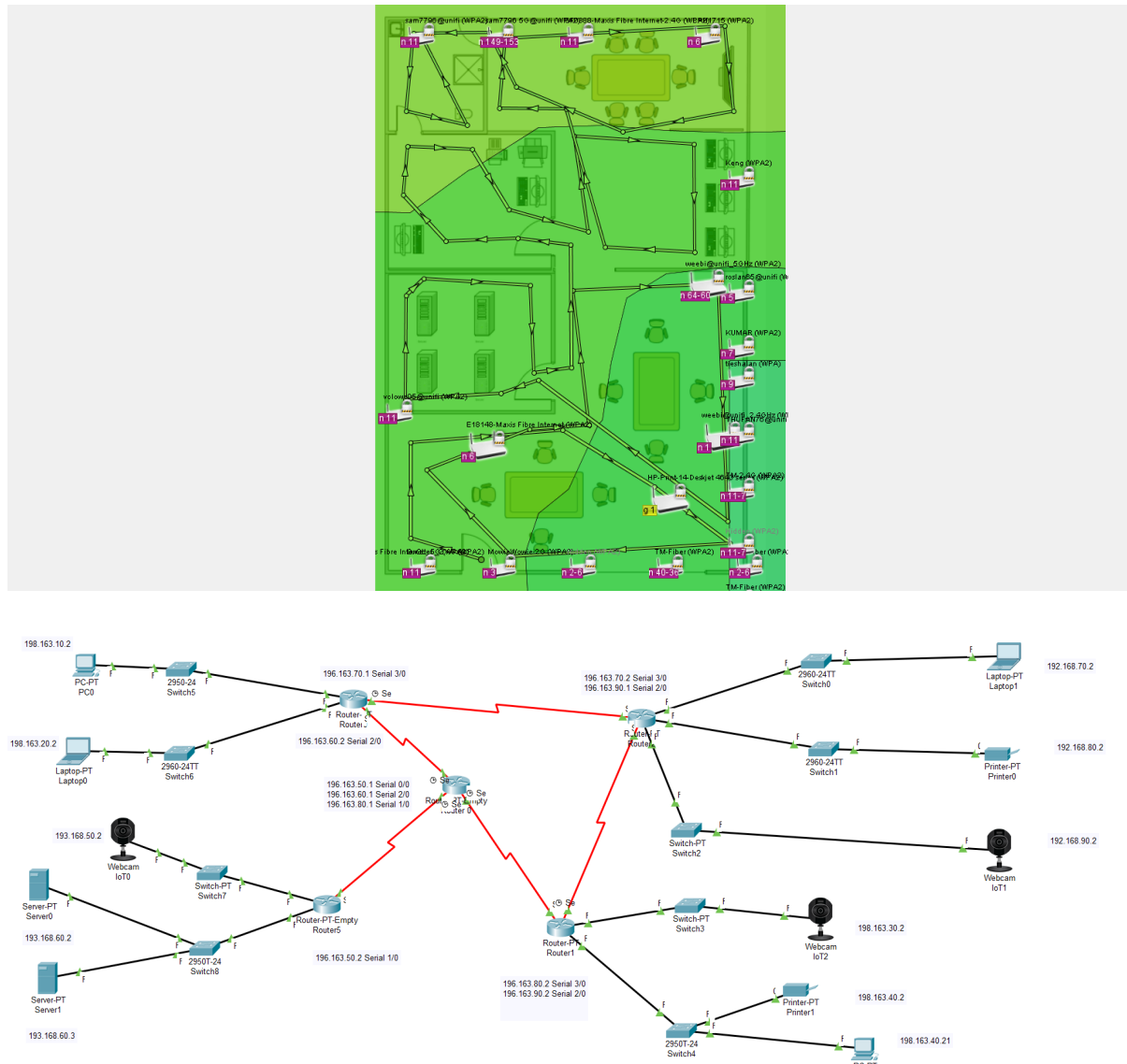


Figure 10: WLAN Deployment for EVOTECH office

For the WLAN deployment, the network consultant has decided to place the router in the living room since the initial location of the router is at the entrance of the office. The main purpose of placing router in the living room is that the clients and customers of EVOTECH will be in the living room which causes network traffic. A few access points are needed in between each room as the clients of EVOTECH are employees of an online business startup company which requires the usage of high bandwidth applications. Some of the access points are represented as routers in Figure 10. As a result, signal strength could be maximized at all

corners of the office. The placements are adjusted according to the factor discussed during site survey such as RF line of sight and environment.

3.2 Recommended Hardware

When the employees of EVOTECH subscribe to an Internet Service Provider (ISP), they are given a free router with all the configurations being set properly. However, the router provided may not be suitable for the usage of online business in EVOTECH and may affect the overall performance of the company. The network consultant prepared a better alternative router that might solve all the business needs required by the employees of EVOTECH. Other hardware such as access points and cables are also taken into consideration in improving the current implementation of wireless network.

3.2.1 Routers



Figure 11: Router chosen (RT-AC68U)

Extracted from: <https://www.asus.com/my/Networking/RTAC68U/overview/>

Based on the figure that is shown above, the network consultant has decided to go with the Asus RT-AC68U. The router comes with three high performance antennas that can provide more Wi-Fi signal coverage and is able to be adjusted to provide a better sense of Wi-Fi direction signals. The Asus RT-AC68U is a dual-band router which comes with both 2.4GHz and 5GHz band where the employees of EVOTECH can choose the frequencies based on the bandwidth needed to perform specific tasks.

The Asus RT-AC68U comes with a total of 5 Gigabit Ethernet ports which consists of one gigabit WAN port and four LAN ports which allows multiple devices to be connected by plugging in the router for optimal performance. Besides, the router also come with a USB 2.0 and USB 3.0 port which allows for connections for remote network storage devices or shared printers that is to be used among the employees of EVOTECH.

The Asus RT-AC68U also features AiMesh support and is compatible with other ASUS routers to create a flexible whole-home Wi-Fi network. The router itself has four buttons including WPS button, reset button, power button, and wireless on/off button. The router power supply comes with an ac input of 110V-240V which is around 50-60Hz and a DC output of 19V at max 1.75 A current.

In order to further test the performance and limitations of the chosen router, three different models of routers are being made for comparison. Since the chosen router will be used in EVOTECH home office, a laptop is being used as a measurement tool to test the signal strength in each part of the office. The table below shows the comparison made between three different routers.

Model	ASUS RT-AC68U	ASUS RT-AC56U	ASUS RT-N66U
Network Standard	IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, IEEE 802.11ac, IPv4, IPv6	IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, IEEE 802.11ac, IEEE 802.11d, IEEE 802.3, IEEE 802.3u, IEEE 802.11i, IEEE 802.11e, IPv4, IPv6	IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, IPv4, IPv6
Data Speed	802.11n : up to 450 Mbps 802.11n TurboQAM : up to 600 Mbps 802.11ac : up to 1300 Mbps	802.11n : up to 300 Mbps 802.11ac : up to 867 Mbps	802.11n : up to 450 Mbps
Memory	128 MB Flash 256 MB RAM	128 MB Flash 256 MB RAM	32 MB Flash 256 MB RAM

Operating Frequency	2.4 GHz / 5 GHz	2.4 GHz / 5 GHz	2.4 GHz / 5 GHz
Encryption	64-bit WEP, 128-bit WEP, WPA2-PSK, WPA-PSK, WPA-Enterprise , WPA2-Enterprise , WPS support	64-bit WEP, 128-bit WEP, WPA2-PSK, WPA-PSK, WPA-Enterprise , WPA2-Enterprise , Radius with 802.1x, WPS support	64-bit WEP, 128-bit WEP, WPA2-PSK, WPA-PSK, WPA-Enterprise , WPA2-Enterprise , WPS support
Operation Mode	Wireless router mode Range extender mode Access point mode Media bridge mode	Wireless router mode Range extender mode Access point mode Media bridge mode	Wireless router mode Range extender mode Access point mode Media bridge mode

According to the comparison table made above, all the routers except the ASUS RT-N66U supports older and network standards. The highest data speed among the three routers chosen is the ASUS RT-AC68U with the speed of up to 1300mbps as compared to the other routers. The chosen router has a memory of 128 MB flash and 256 mb ram with its operating frequency at both 2.4 GHz and 5 GHz band.

3.2.2 Access Points

Compared to a router which serves as a hub for setting up local area network and managing all devices, an access point is a sub-device within the local area network that helps to enable more devices from another location to be connected into the same network. Access point are commonly used to extend the wireless coverage of an existing network which allows for users to connect to the same network (LigoWave, n.d.).



Figure 12: Access Point Chosen (Ubiquiti UniFi AP AC Pro)

Extracted from: <https://www.ui.com/unifi/unifi-ap-ac-pro/>

Based on the figure that is shown above, the network consultant has decided to choose Ubiquiti UniFi AP AC Pro as the access points in EVOTECH office. The access points that comes under the model UniFi features the latest wifi standard technology, 802.11ac with a 3X3 MIMO technology which stands for multiple-input and multiple-output is used to increase the number of antennas for both receiving and transmitting which results in improving capacity for wireless connections (Shaw, 2018). The chosen access point is suitable in terms of industrial design and is ideal for maximizing the performance of wireless networks in an extended network environment.

The Ubiquiti UniFi AP AC Pro is also designed to optimize RF performance based on the customer's needs. The features include spectral analysis which collects feedback on channel interference on 2.4GHz and 5GHz, band steering which the customers are able to

select whether they would want to prefer 5 GHz channels and last but not least airtime fairness which minimizes effects on system performance by limiting airtime access.

Model	UAP-AC-LITE	UAP-AC-LR	UAP-AC-PRO
Environment	Indoor	Indoor	Indoor/Outdoor
2.4 GHz Speed	300 Mbps	450 Mbps	450 Mbps
5 GHz Speed	867 Mbps	867 Mbps	1300 Mbps
PoE Mode	802.3af/A PoE & 24V PoE	802.3af/A PoE & 24V PoE	802.3af PoE/802.3at PoE+

According to the comparison table made above, all three access points can be used indoor with UAP-AC-PRO providing outdoor capability. The speed of UAP-AC-LITE comes at the speed of 300Mbps and both UAP-AC-LR and UAP-AC-PRO comes at the speed of 450 Mbps for 2.4 GHz frequency band. The speed of UAP-AC-LITE and UAP-AC-LR comes at the speed of 867 Mbps whereas the UAP-AC-PRO comes at the speed of 1300 Mbps for 5 GHz frequency band. Based on the comparison made, the UAP-AC-PRO is superior when it comes to the network speed for both 2.4 GHz and 5 GHz frequency bands which makes it a solid choice to pick from due to the fact that the router chosen also has the same data speed. After comparing and analyzing the different access points that are available, the Ubiquiti UniFi AP AC Pro is the most suitable access point to be implemented in EVOTECH office.

3.2.3 Types of Cables

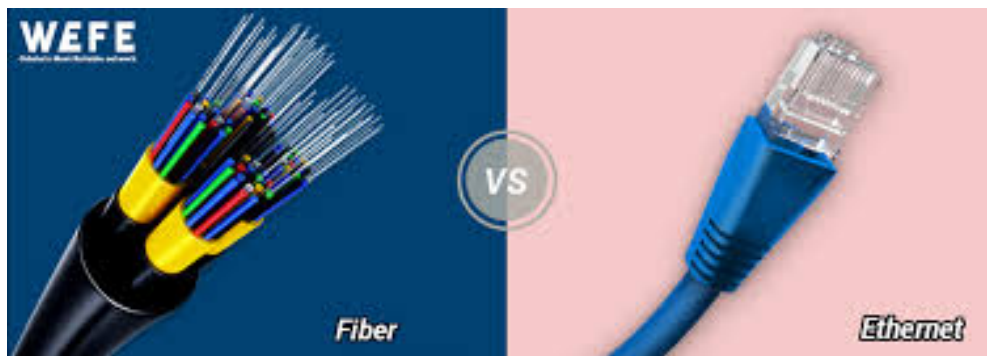


Figure 13: Image of a fiber optic cable and an ethernet cable

Extracted from: <https://wefe.in/the-cable-war-ethernet-vs-fiber/>

Ethernet cables are most commonly used for devices that require wired networks and at the same time is able to share network resources between different devices under the same local area network. The types of ethernet cables chosen for network may affect the internet speed and throughput in a chosen network environment.

Ethernet cables are mainly made up of copper cables and is being classified as “Cat-” which stands for category. The number stands for the specification version supported by each cable. Since ethernet cable uses electrical signals to transmit data between one another, there is a high possibility that electromagnetic interference might occur. Therefore, “shielded” cables are being used instead as a protective layer that surrounds the cable wires from electromagnetic leakage and interference (RouterSwitch, 2020).

Before moving on to deciding the cables that will be used for EVOTECH, there are a few things that are needed to be taken into considerations. First of all, picking a suitable cable is determined by the speed of internet connection at network site. Router is also a determinant factor in choosing the right cable as if you have a router with slow internet connection, having better cables might not be effective as the speed of the internet connection has already reached its limit.

Category	Shielding	Max Transmission Speed (at 100 meters)	Max Bandwidth
Cat 3	Unshielded	10Mbps	16 MHz
Cat 5	Unshielded	10/100Mbps	100 MHz
Cat 5e	Unshielded	1,000Mbps / 1Gbps	100 MHz
Cat 6	Shielded or Unshielded	1,000Mbps / 1Gbps	250 MHz
Cat 6a	Shielded	10,000Mbps / 10Gbps	500 MHz
Cat 7	Shielded	10,000Mbps / 10Gbps	600 MHz
Cat 7a	Shielded	10,000Mbps/10Gbps	1,000Mhz

Figure 14: Table of comparison between different category of ethernet cables

Extracted from: <https://www.digitaltrends.com/computing/different-types-of-ethernet-cables-explained/>

Cable Type	Cat6	Cat7	Cat8	Fiber Optic
Throughput	1Gbps/10Gbps	10Gbps	25Gbps/40Gbps	10Gbps
Transmission	Electromagnetic Wave	Electromagnetic Wave	Electromagnetic Wave	Pulses of light
Bandwidth	250Mhz	600Mhz	2000Mhz	20Ghz
Cable Type	UTP or STP	STP	STP	Ferrule

According to the comparison table made above, the fiber optic cable may seem like the most obvious choice. Fiber optic cables contains tiny strands of pure glass that transfer data in the form of light compared to the tradition Ethernet cable which uses electrical impulses. Even though there are many advantages of using fiber optic cable instead of ethernet cable, fiber optic is very fragile and as they are thin and light and may be prone to damage especially in a home office. Therefore, Cat6 ethernet cable is chosen as the cable that will be used other than fiber optic cable. The reason behind Cat7 and Cat8 not being an option is due to the fact that the throughput is overkill and is not needed as the chosen router has only a data speed of up to 1300 Mbps.

3.3 Recommended Software

3.3.1 Intrusion Detection Software / Intrusion Prevention System – Snort

In a world filled with information technology, Intrusion Detection Software is a must and its main purpose is used to perform monitoring network environment for suspicious activity. According to SoftwareTestingHelp (2020), more than 40 percent of cyber-attacks are targeted towards small businesses. The network consultant of EVOTECH have to recommend the software which will be used to monitor the network traffic of the online business. There are two main types of IDS which are Network Intrusion Detection System (NIDS) and Host Intrusion Detection System (HIDS).

Intrusion Detection Software	Bro	Snort	Security Onion
Platform	Unix, Linux, and Mac-OS	Unix, Linux, and Windows	Linux and Mac-OS
Types of IDS	NIDS	NIDS	HIDS and NIDS
Features	Traffic logging and analysis, Provides visibility across packets, Event engine, Policy scripts, Ability to monitor SNMP traffic, Ability to track FTP, DNS, and HTTP activity.	Packet sniffer, Packet logger, Threat intelligence, Signature blocking, Real-time updates for security signatures, In-depth reporting, Ability to detect a variety of events including OS fingerprinting, SMB probes, CGI attacks, buffer overflow attacks, and stealth port scans.	Complete Linux distribution with focus on log management, Enterprise security monitoring, and intrusion detection, runs on Ubuntu, integrates elements from several analysis and front-end tools including NetworkMiner, Snorby, Xplico, Sguil, ELSA, and Kibana, Includes HIDS functions as well, a packet sniffer performs network analysis, Includes nice graphs and charts.

Suitable for	All business that rely on networking	Small and medium sized business	Medium and large business
--------------	--------------------------------------	---------------------------------	---------------------------

According to the comparison table made above, Snort was chosen by the network consultant as the software to be used as it supports Windows which is the main operating system used by EVOTECH. Besides, the software is a type of network intrusion detection system which is suitable for managing network traffic of online business. In addition, Snort provides many features such as packet sniffer, packet logger, threat intelligence, signature blocking, real time updates for security signature as well as the ability detect events such as CGI attacks, stealth port scans and OS fingerprinting. Last but not least, Snort is suitable for small and medium sized business which is suitable for EVOTECH which is a startup company.

3.3.2 Antivirus

Antivirus is a software that helps to look for suspicious unwanted applications that are not originally belonged in the PC or smartphone (Martindale, 2020). They are software designed to protect a user from viruses and malware such as worms, Trojan, spyware, adware, and many more from executing and causes hard to the device. The network consultant is being told to pick an antivirus among the table that is as shown below.

Software Features	AVG	F-Secure	Kaspersky
Ransomware Protection	✓	✓	X
Anti-Banner	✓	X	X
Anti-Spam	✓	X	X
Anti-Phishing	✓	X	X
File Shredder	✓	X	✓
System Booster	✓	X	X

According to the comparison table as made above, AVG is chosen by the network consultant as the software to be used as it has all the features that is listed out in the table as compared to the rest. Anti-Banner, Spam and Phishing is important especially in terms of online business as the clients of EVOTECH requires sending email to customers as part of their daily tasks. With the help of these features as well as a few additional features such as ransomware protection, file shredder and system booster will come in handy and helps to secure protection of the device of employees of EVOTECH.

4.0 Conclusion

Based on the WLAN site survey that has been performed in this assignment, I have concluded that there are many opportunities and problems that can be found in the proposed site survey. One of the few problems include obstacles that causes network interference such as the furniture that is being placed in EVOTECH office. In this assignment, I manage to understand how site survey is being performed in a workplace environment and how different considerations such as design, radio frequency coverage, range, and speed as well as radiation would in the end affect the decision making towards WLAN deployment as compared to the initial study. One of the few interesting findings that I have found in this study is how a signal or wave can be affected differently based on the environmental conditions such as reflection, refraction, diffraction, and absorption depending on the material and surface of an object or building.

5.0 References

AccessAgility (2017) *WiFi Network Design Considerations* [Online]. Available from: <https://www.accessagility.com/blog/wifi-network-design-considerations> [Accessed: 16th August 2020].

Al Agha,K. Pujolle,G. and Ali Yahiya,T.(2016) *Mobile and Wireless Networks (Networks & Telecommunications Series: Advanced Network Set)*. New York:Wiley.ISBN-13: 978-1848217140.

ASUS Malaysia. (2020). *Networking | ASUS Malaysia*. [Online] Available from: <https://www.asus.com/my/Networking/> [Accessed: 4th September 2020].

Bartz,R. J.(2017) *CWTS, CWS, and CWT Complete Study Guide: Exams PW0-071, CWS-2017, CWT-2017* .3rd Edition.New York:Wiley.ISBN-13: 978-1119385035.

CISA (2020) *RADIO FREQUENCY INTERFERENCE BEST PRACTICES GUIDEBOOK*
National Council of Statewide Interoperability Coordinators

Coleman, D.and Westcott, D.(2018) *CWNA Certified Wireless Network Administrator Study Guide: Exam CWNA-107*. 5th Edition. Sybex. ISBN-13: 978-1119425786.

Cook, A., (2015). *5 Phenomena That Impact Wi-Fi Signal | Mirazon*. [Online] Mirazon. Available at: <https://www.mirazon.com/5-phenomena-that-impact-wi-fi-signal/> [Accessed: 5th September 2020].

Dionicio, R., (2016). *Reducing Wifi Channel Interference*. [Online] Network Computing. Available from: <https://www.networkcomputing.com/wireless-infrastructure/reducing-wifi-channel-interference> [Accessed: 12th August 2020].

Dot11AP. (2019). *Reflection, Refraction, Diffraction, And Scattering*. [Online] Available from: <https://dot11ap.wordpress.com/cwna/radio-frequency-rf-technologies/reflection-refraction-diffraction-and-scattering/> [Accessed: 13th August 2020].

Extreme Networks. (2019). *Do You Know The RF Fundamentals - Extreme Networks*. [Online] Available from: <https://www.extremenetworks.com/extreme-networks-blog/do-you-know-the-rf-fundamentals/> [Accessed: 19th August 2020].

Fedorov, N., 2020. *SOHO Servers - Small Office And Home Office*. [Online]. Available from: <https://www.avadirect.com/blog/soho-servers-small-office-and-home-office/> [Accessed: 20th August 2020].

Martindale, J. (2020) *What is antivirus software, and how does it work?* [Online]. Available from: <https://www.digitaltrends.com/computing/what-is-antivirus-software/> [Accessed: 20th August 2020].

Martindale, J., (2020). [Online] Digitaltrends.com. Available from: <https://www.digitaltrends.com/computing/different-types-of-ethernet-cables-explained/> [Accessed: 20th August 2020].

Nik (2019). *Ethernet Vs Fiber Optic Cables: What's The Difference And How Do They Work?*. [Online] Available from: <https://www.techjunkie.com/ethernet-vs-fiber-optic-cables/> [Accessed: 20th August 2020].

Pierce, M. (2018). *What's Included With a Wireless Site Survey?* [Online]. Available from: <https://www.securedgenetworks.com/blog/whats-included-with-a-wireless-site-survey> [Accessed: 20th August 2020].

RouterSwitch (2020) *Ethernet Cable or Fiber Optic Cable? Ethernet vs. Fiber* [Online]. Available from: <https://blog.router-switch.com/2017/12/ethernet-cable-or-fiber-optic-cable-ethernet-vs-fiber/#:~:text=As%20mentioned%2C%20gigabit%20Ethernet%20can,potential%20to%20be%20incredibly%20fast.> [Accessed: 15th August 2020].

Shaw, K., (2018). *What Is MU-MIMO And Why You Need It In Your Wireless Routers*. [Online] Network World. Available from: <https://www.networkworld.com/article/3250268/what-is-mu-mimo-and-why-you-need-it-in-your-wireless-routers.html> [Accessed: 25th August 2020].

Siddesh Patil, Pooja Yadav, Shivneeta Gunjal and Sumit Yenugwar, Rambabu Vatti, (2018) *Wi-Fi Site Survey and Analysis of Dead Zones. International Journal of Engineering Research and*, V7(01), p.153.

Softwaretestinghelp.com. (2020). *Top 10 BEST Intrusion Detection Systems (IDS) [2020 Rankings]*. [Online] Available from: <https://www.softwaretestinghelp.com/intrusion-detection-systems/> [Accessed: 20th August 2020].

SonicWall (2020) *Why Is A Wireless Site Survey Needed?* [Online]. Available from: <https://www.sonicwall.com/support/knowledge-base/why-is-a-wireless-site-survey-needed/170503717715599/> [Accessed: 17th August 2020].

Ubiquiti Inc. (2020). [Online] Available from: <https://www.ui.com/unifi/unifi-ap-ac-pro/> [Accessed: 20th August 2020].

Ubiquiti Inc. (2020). [Online] Available from: [https://www.ui.com/unifi/unifi-ap-ac-lr /](https://www.ui.com/unifi/unifi-ap-ac-lr/) [Accessed: 20th August 2020].

Ubiquiti Inc. (2020). [Online] Available from: [https://www.ui.com/unifi/unifi-ap-ac-lite /](https://www.ui.com/unifi/unifi-ap-ac-lite/) [Accessed: 20th August 2020].