FIT4165 Assignment - Enterprise Network Design

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Executive Summary

A financing enterprise needs to be reachable at all times, a network going offline even for a few minutes affects the clients as much as it affects the business itself. This consequence comes with a weighty cost, thus, the added price of having reliability as the focal point of the designed network is justifiable. Reliability and High performance are the main designing principles for this network, the planned network will consist of dependable access switches on each floor linked to a pair of highly efficient distribution switches that manage the internal network and offer redundancy. Powerful routers to handle the network traffic coming directly from the ISP leased line. Fibre optic and UTP cabling to handle uplink and horizontal flows respectively. High bandwidth with broad ranged access points to support wireless connections on each floor, leaving no dead zones.

Introduction

Having a reliable and tailored network that effectively performs under load is a crucial requirement for every company's success. The design of the network is often an underestimated task and the consequences of a poorly designed network are frequently overlooked.

Fusion Inc is a pioneering IT solutions company established in the early 2000s. We deliver innovative and high performing software oriented networking infrastructures, carefully tailored to our clients needs. Our engineers are trained, licensed, and experienced in designing networks for a wide variety of end users. We have put together this proposal which entails the technicalities of the gathered network requirements, our suggested network design, necessary hardware and cabling, as well as a vague valuation that our design would amount to.

The proposed solution encompasses a comprehensive blueprint, clearly displaying the LAN, wireless LAN, Backbone and WAN layout; accompanied with the justification for each compromise. The scope of this proposal is to design a well suited network for your business that guarantees the following:

- Reliability & fault tolerance
- Quick communication speeds
- High performance & load balancing

Requirements Analysis

1. Client currently has 150 employees and will hire 260 new staff members
2. Acquired 2 new buildings (A and B)
3. Building A and B have 4 floors
4. The floor dimensions of building A are 40m by 40m
5. The floor dimensions of building B are 30m by 30m

6. Both buildings will have a ceiling height of 3m (inclusive of the false ceiling)
7. Building A will hold 160 employees
8. Building B will hold 100 employees
9. Based on point 3 and 5, can be assumed to have 40 employees per floor in building A
10. Based on point 4 and 6, can be assumed to have 25 employees per floor in building B
11. Each employee will have an office space with a wired PC and can be assumed to have one personal device each
12. Average wired traffic is between 15 Mbps to 20 Mbps per employee
13. Peak wired traffic can be assumed to be 30 Mbps per employee
14. Wireless traffic is 20% of wired traffic
15. From point 12, we can assume that average wireless traffic is between 3 Mbps and 4 Mbps per employee. Furthermore, 6 Mbps peak wireless traffic per employee.
16. Each floor has a wiring closet where vertical and horizontal cabling can run through. Same closet can be assumed to hold switches
17. Dedicated server room on the ground floor
18. Reliability and high performance are our main objectives

Wired, Wireless Lan and WAN Design

WAN connectivity

The WAN connectivity is the same for both buildings. We are proposing the usage of a direct leased line from the ISP. By doing so, we ensure a dedicated communication path directly between the ISP and each building. This allows for the maximum traffic capacity to be delivered as the channel is dedicated and not shared. An additional benefit of using a leased line is that it allows for easy tunnelling and VPN creation between buildings to connect and use resources.

By employing a leased line, we ensure high reliability, security and performance. This is guaranteed and protected with the service level agreement between the ISP and client. Obviously, using a leased line comes with a higher premium than simply connecting to a shared channel, but it is definitely worth it to guarantee connectivity and failure tolerance.
In order to connect to the leased line, a powerful router needs to be used that will not bottleneck the bandwidth and performance being paid for. This will be discussed in the next section.

A visual display of this can be seen below in figure 1

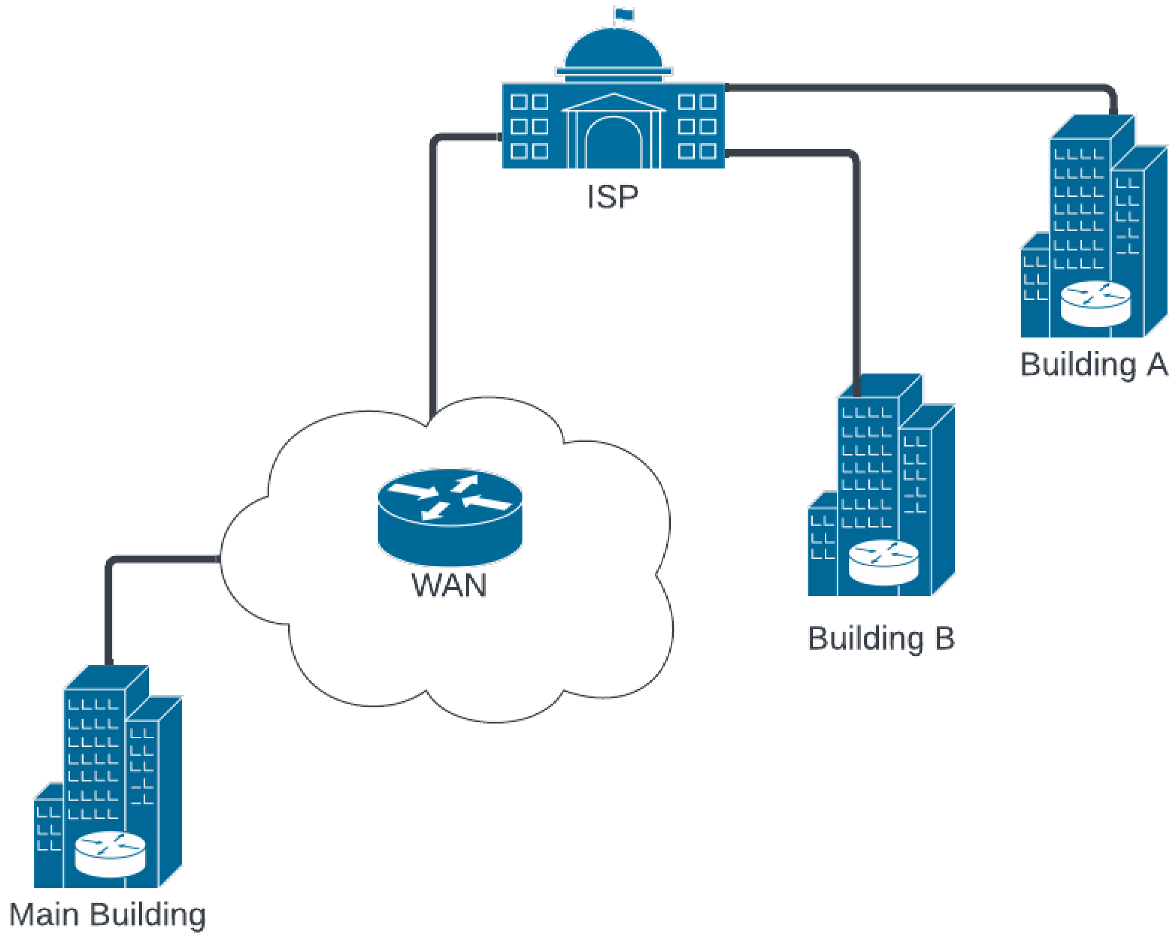


Figure 1

Backbone

The backbone infrastructure is the most pivotal foundation for the entire network. Having a well structured backbone is directly linked to the reliability and performance of the network. Here we have to combine the access switches, distribution switches, server, and router; ensuring connectivity within the building and to the outside world. The general structure of the backbone will be the same for both buildings with only some minor changes.
The network anatomy will be as follows:

Firstly, we will have two distribution switches in each building; with an emphasis on more SFP+ ports than RJ45. All the access switches from each floor will be connected directly to both the distribution switches using multimode fiber OM3 cables for uplink. These fiber cables will be connected through the SFP/SFP+ ports of each switch as this allows for higher bandwidth transmission; handling the entire building traffic. This is great as we can fully utilise the network capacity as well as leave room for future scalability in network traffic without having to upgrade the hardware.

We have two distribution switches for redundancy and load balancing. Protocols will be set up to handle load and equally disperse it between the switches. This is also great as the internal network can communicate with each other without having to go through the router; even if the router fails. Please note that the access switches will not be linked together in a looping manner, as any breakage in the link would cause parts of the network to be unreachable. The only disparity here is that building B employs two switches per floor, so we will connect those two access switches together as an additional transmission path; again making the infrastructure more reliable overall and faster when communicating with the devices from the same floor. In addition to this, since each access switch is directly connected to two distribution switches, if one of the distribution switches fails, the other can still reach all the devices in the network and carry the entire load.

The recommended distribution switch to be used is the D-Link DGS-1210-12TS/ME, a fully managed switch that offers 10 SFP+ ports with an additional 2 10/100/1000BASE-T ports; We are mainly interested in the SFP+ ports. The benefit of a managed distribution switch is that it is generally more secure and oftentimes offers better overall network performance.

For building A, we are currently using a single access switch on each floor, which means 4 sfp+ ports are occupied for them. A single SFP+ port for the router, which leaves us with 5 SFP+ ports and the 2 RJ45 ports allowing for additional access switch stacking in the future; leaving room for scalability.

For building B, we are employing two access switches per floor, this means there are already 8 sfp+ ports being used up in each distribution switch. A single SFP+ port is also used for the router. This leaves us with one SFP+ port and the 2 RJ45 ports for future use. The access switches will be further explained in the LAN design section below.

Secondly, we need to connect the server. The server will simply be connected to the router directly. It is connected to the router instead of the distribution switches for two main reasons: firstly, most servers can only have one connection, and so, connecting to two distribution switches is not possible. Secondly, the server should be more accessible to the WAN more so than the internal network; so by removing the switching layer, we are able to slightly speed up the transmission.

Lastly, the router. Choosing the router is an influential decision on our network design as so much depends on the router and we do not want a bottleneck. Based on the aforementioned points, we are going to need a router with a minimum of 3 SFP+ ports and a single RJ45 port at the moment. The router will be connected to the WAN via a leased line directly from the internet service provider.

The suggested router to be used in each building is the Cisco Meraki MX95. This router offers two 10 GbE SFP+ and two 2.5 GbE RJ45 ports for WAN connectivity. It also offers four GbE RJ45, two 10 GbE SFP+ ports for LAN. We only need one SFP+ port for the leased line connectivity (WAN) and the two LAN sfp+ ports to connect our distribution switches. One RJ45 port will be used for the server. An added advantage of using this router is that it has security features implemented and can easily be managed. This is brought up as it offers better protection from cyber attacks such as DOS; which would bring the network down temporarily.

In this section we will calculate the required length of uplink cabling needed to connect the backbone infrastructure. Please note that we don't take the ISP leased line into consideration. We assume that this will be part of the service level agreement with the ISP. From the building layout, we are told that there are four floors each with a ceiling height of 3m. Multimode fiber OM3 cables will be used for uplink and connections between distribution switches and the router, as it offers higher bandwidth; allowing it to handle the entire building's traffic.

Diving into building A first, we will need a cable from each access switch to each distribution switch. Assuming that each connection would cross heights of 6m, 9m, and 12m from the second floor to the last, respectively. The ground floor is not taken into account for vertical cabling as it is on the same floor as the router and server. Aside from the vertical cabling, we need some horizontal slack to connect the device together. We can give an additional 1m for each connection. This means that the ground floor connection will need 1m only (per switch), putting these together, we formulate (2*1) + (2*7) + (2*10) + (2*13), equating to 62m. Considering that the distribution switches and routers will be very close together, we can assume only 0.5m cable is needed for each connection from each distribution switch; bringing the total to 63m now.

Finally, the server. The server is also assumed to be in the same service well which is relatively close. For this, we can assign 2m of fiber cabling. This means the total length of multimode fiber OM3 cabling needed for building A is 65m.

Building B is very similar but with some additional wiring considering we have two access switches per floor. This will roughly double the vertical portion of the cabling. Assuming that each connection would cross heights of 6m, 9m, and 12m from the second floor to the last, respectively. The ground floor is not taken into account for vertical cabling as it is on the same floor as the router and server. We can give an additional 1m for each connection as horizontal slack. This means that the ground floor connection will need 1m only (per switch), Putting these together, we formulate (4*1) + (4*7) + (4*10) + (4*13), equating to 124m. The connection to the router and server can be assumed to be the same as previously explained. From this, the total length of multimode fiber OM3 cabling needed for building B is 127m. Thus, the total length of multimode fiber OM3 cabling needed for the entire infrastructure equates to 192m.

The backbone infrastructure can be visualised in figure 2 and figure 3 below.

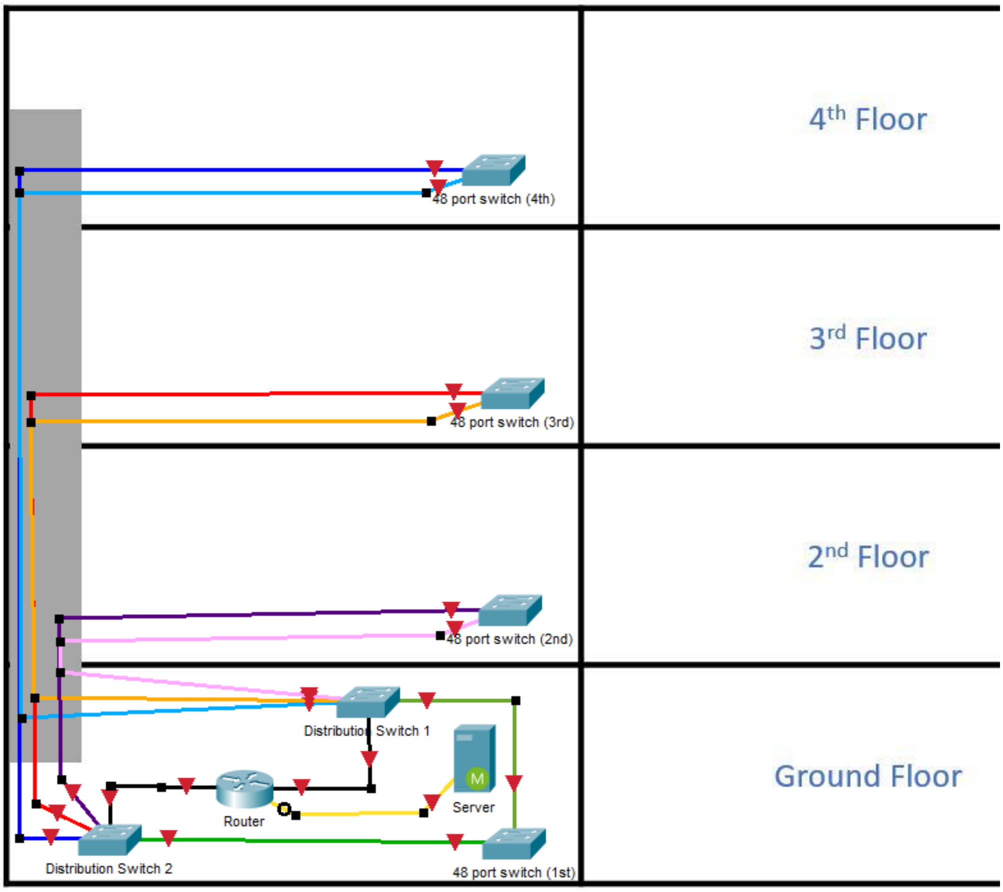


Figure 2: Building A

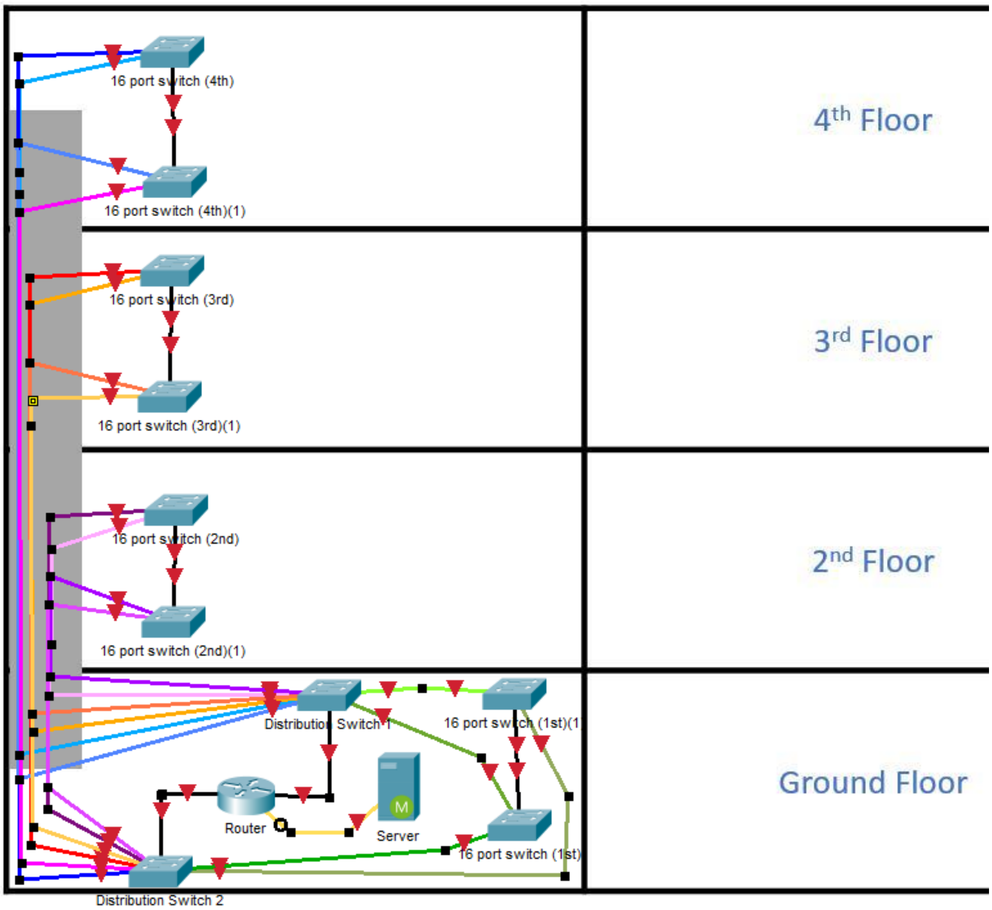


Figure 3: Building B

LAN & WLAN Design

Building A

As obtained from the requirements, building A is the larger of the two newly acquired four storey buildings, holding 160 new employees. From this, we can assume 40 staff members per floor.

In order to handle 40 wired connections, a 48 port switch with additional SFP ports is to be deployed. Forty of the ports will be connected directly to the PCs using UTP CAT6 cabling. Of the remaining 8 RJ45 ports, 2 will be used to connect the pair of access points attached on the ceilings using CAT6 cables as well. The remaining ports can be used to stack more switches in the future or simply wiring additional PCs. The additional sfp ports will be used for uplink, directly connecting to the two distribution switches proposed earlier.
The D-Link DGS-1510-52 switch is a great fit for this scenario as it offers 48 10/100/1000Mbps ports, which means each port can handle up to a 1000 Mbps. It also has the additional SFP ports needed. The SFP ports are ideal for connecting to our distribution switches and transferring the peak traffic from the floor; it also means the switch can handle higher traffic in the future.

We suppose that the average wired traffic for each user is 15-20 Mbps on average, from this, we can further presume that peak traffic would amount to 30 Mbps per user. The total wired traffic for a single floor would add up to 1200 Mbps; not taking into account the traffic to the access points.

Wireless traffic can be estimated as 20% of the wired traffic. Given this, we can deduce that the peak wireless traffic will be around 240 Mbps overall. It is safe to conclude that the total traffic from one floor is around 1500 Mbps and for the entire building is around 6000 Mbps proportionally. The two access points will be attached to the ceiling in strategic locations to ensure connectivity across the entire floor, eliminating any dead zones. We do this by placing the access points 10m in from each wall; doing this will cover the 10m in each direction from one AP, therefore covering the entire floor.
The Netgear WAC510 is a reliable business access point which offers high performance within high density offices. One of these APs is actually enough for one floor, but will have a few dead zones; we do not want this. Therefore, two will be used to ensure the entire floor is in range as well as another form of redundancy in case one AP happens to go down.
It is noteworthy to mention that the Switch and access points are PoE enabled, which allows the access point to be powered simply by connecting to the switch via ethernet (UTP CAT6).

Estimating the length cabling needed is tricky, so we generally round up to give room for some slack. Given the dimensions of one floor is 40m by 40m , we assume that the middle table is in the dead centre of the room. Let's consider the tables farthest away from the switches. The topology being used here is a full duplex star topology. There is going to be 13 m running on either side of the wall to the edges of the office. Following this we will need about 35 m to the centre of the farther table, we add 1m to reach each PC in the cubicle. Combining these

together, we get (13*8) + (35*8) + (1*8) which equates to the current cumulative value of 392m of cabling.
Considering the middle tables farthest from the switches, they also need the 13m on either side of the wall to reach the edge. Followed by 25m to the centre with the 1m extra for each PC. The middle tables only need the 25m to the centre of the cubicle with the additional 1m for each PC. Combining these together, we get (13*8) + (25*16) + (1*16) which equates to 520m of cabling; the cumulative length being 912m.
The middle tables closer to the switches, also need the 13m on either side of the wall to reach the edge. Followed by 15m to the centre with the 1m extra for each PC. The middle tables only need the 15m to the centre of the cubicle with the additional 1m for each PC. Combining these together, we get (13*8) + (15*16) + (1*16) which equates to 360m of cabling; the cumulative length being 1272m.
For the closest cubicles to the switches. 13m on either side of the wall to reach the edge are also needed. Followed by 5 m to reach the midpoint of the cubicle, we add 1m to reach each PC in the cubicle. We also need to take into account the middle row table. For this we only need 6m to reach the table centre, with the additional 1m to reach the PC. Combining these together, we get (13*8) + (5*8) + (1*8) which equates to 152m of cabling. The current cumulative total is 1424m.

Lastly, the cabling to the access points. Assuming the switches are on a 0.5m high rack and the ceiling height is 3m. We will need 2.5m to reach the ceiling followed by 10m to the access point closer to the switch, and another 30m for the access point farther away. Therefore, we need 55m for the WLAN. This means that the entire floor would require a cumulative 1479 m worth of UTP CAT6 cabling. We can further conclude that the total UTP CAT6 cabling required to handle the LAN and WLAN of the entire building amounts to 5916m.

The overall layout, cabling paths and AP locations can be seen below in figure 4.

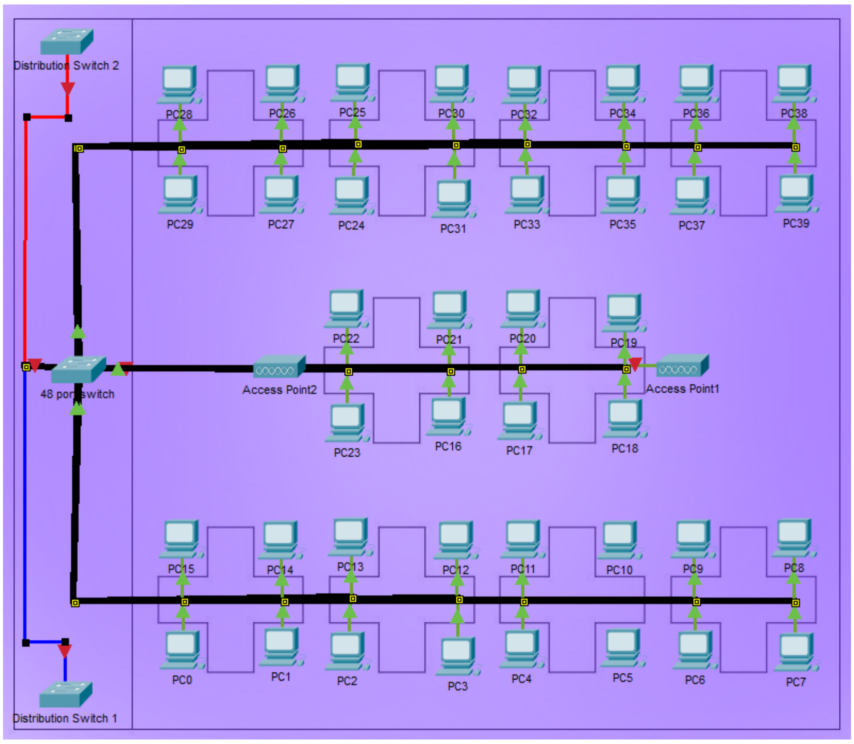


Figure 4

It is noteworthy to mention that the wiring to the PCs will be on the ground while the wiring for the APs will be on the ceiling. In addition to this, the distribution switches are on the ground floor, they are shown in the diagram to provide a different view of the connection.

The purple shading in figure 4 represents the access point coverage, indicating complete coverage of a single floor with dual AP setup. However, we still need to account for the horizontal and vertical overlapping of the AP coverage. For this, we need to plan the transmission channels.

The APs will be mounted on the ceiling with the antennas facing downwards, given this, we can assume a downwards propagation of the coverage. With this in mind, we need to account for the overlap in the floors below as well as the horizontal overlap with the secondary AP on the same floor . The channels being used are sourced from the channels figure listed in the appendix. Figure 5 displays the AP channel and coverage for one floor. To prevent any interference, we will alternate between non overlapping channels for each floor as shown in the figure 6 below. By using such configuration, we are utilising the AP to the maximum capacity and preventing any channel overlap.

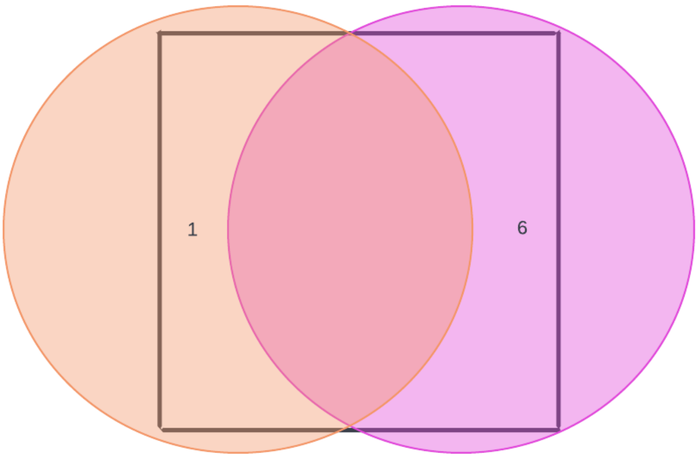


Figure 5: AP channels on one floor

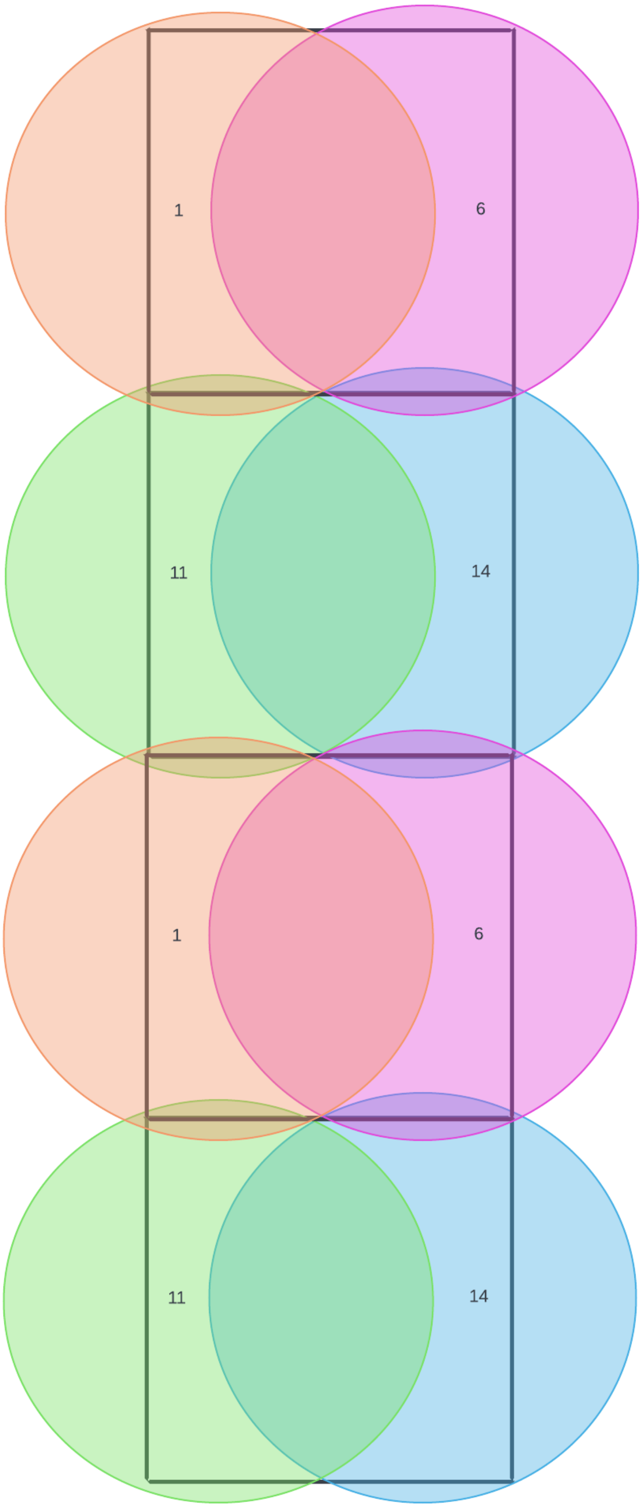


Figure 6: Vertical AP channel configuration

Building B

As obtained from the requirements, building B is the smaller of the two newly acquired four storey buildings, holding 100 new employees. From this, we can assume 25 staff members per floor.

In order to handle 25 wired connections, using a 48 port switch like in building A would be a waste, as a significant proportion is left unused. For this building, 2x 16 port switches are advised, with additional SFP ports. One switch will use 12 ports (switch A), while the other will use 13 ports (switch B) to connect directly to the PCs using UTP CAT6 cabling. Of the remaining RJ45 ports from switch A, 1 will be used to connect the access point attached on the ceilings using CAT6 cables as well. One of the remaining ports from each switch will need to be used to connect the two switches together. Switch A and B are left with 2 usable RJ45 ports, that can be used to stack more switches in the future or simply wiring additional PCs. The additional SFP ports will be used for uplink, directly connecting each switch to the two distribution switches proposed earlier.

We suppose that the average wired traffic for each user is 15-20 Mbps on average, from this, we can further presume that peak traffic would amount to 30 Mbps per user. The total wired traffic for a single floor would add up to 750 Mbps; not taking into account the traffic to the access points.

Wireless traffic can be estimated as 20% of the wired traffic. Given this, we can deduce that the peak wireless traffic will be around 150 Mbps overall. It is safe to conclude that the total traffic from one floor is around 900 Mbps and for the entire building is around 3600 Mbps proportionally.

The access point will be attached to the ceiling in the centre of the floor to ensure connectivity across the entire floor, eliminating any dead zones. We will use the same Access point as the Building A, the Netgear WAC510. It provides coverage to the entire floor and can also be used in the future as it can maintain a large number of users at one time.

The proposed switch for this building is the D-Link DGS-F1018P-E which has 16 10/100/1000Mbps ports which is sufficient for our needs. It has two additional sfp ports which are ideal for uplink traffic to and from distribution switches.

It is noteworthy to mention that the switch and access points are PoE enabled, which allows the access point to be powered simply by connecting to the switch via ethernet (UTP CAT6).

Estimating the length cabling needed is tricky, so we generally round up to give room for some slack. Given the dimensions of each floor is 30m by 30m, we assume that the middle table is in the dead centre of the room. The topology being used here is a full duplex star topology. Firstly, the connection between switches will likely be around 0.5 m (they will be stacked anyways). Now let's consider the tables farthest away from the switches. There is going to be 10 m running on either side of the wall to the edges of the office. Following this we will need about 24 m to the centre of the farther table, we add 1m to reach each PC in the cubicle. Combining these together, we get (10*8) + (24*8) + (1*8) which equates to the current cumulative value of 280m of cabling excluding the switch connection.
Considering the middle tables, they also need the 10m on either side of the wall to reach the edge. Followed by 15m to the centre with the 1m extra for each PC. Combining these together, we get (10*8) + (15*8) + (1*8) which equates to 208m of cabling excluding the switch connection; the cumulative length being 488m.

For the closest cubicles to the switches. 10m on either side of the wall to reach the edge are also needed. Followed by 6 m to reach the midpoint of the cubicle, we add 1m to reach each PC in the cubicle. We also need to take into account the middle row table. For this we only need 6m to reach the table centre, with the additional 1m to reach the PC. Combining these together, we get (10*8) + (6*9) + (1*9) which equates to 143m of cabling excluding the switch connection. The current cumulative total is 631m.

Lastly, the cabling to the access points. Assuming the switches are on a .5m high rack and the ceiling height is 3m. We will need 2.5m to reach the ceiling followed by 15m to the access point as it is in the centre) Therefore, we need 17.5m for the WLAN. This means that the entire floor would require a cumulative 648.5 m worth of UTP CAT6 cabling. We can further conclude that the total UTP CAT6 cabling required to handle the LAN and WLAN of the entire building amounts to 2594m.

The overall layout, cabling paths and AP locations can be seen below in figure 7.

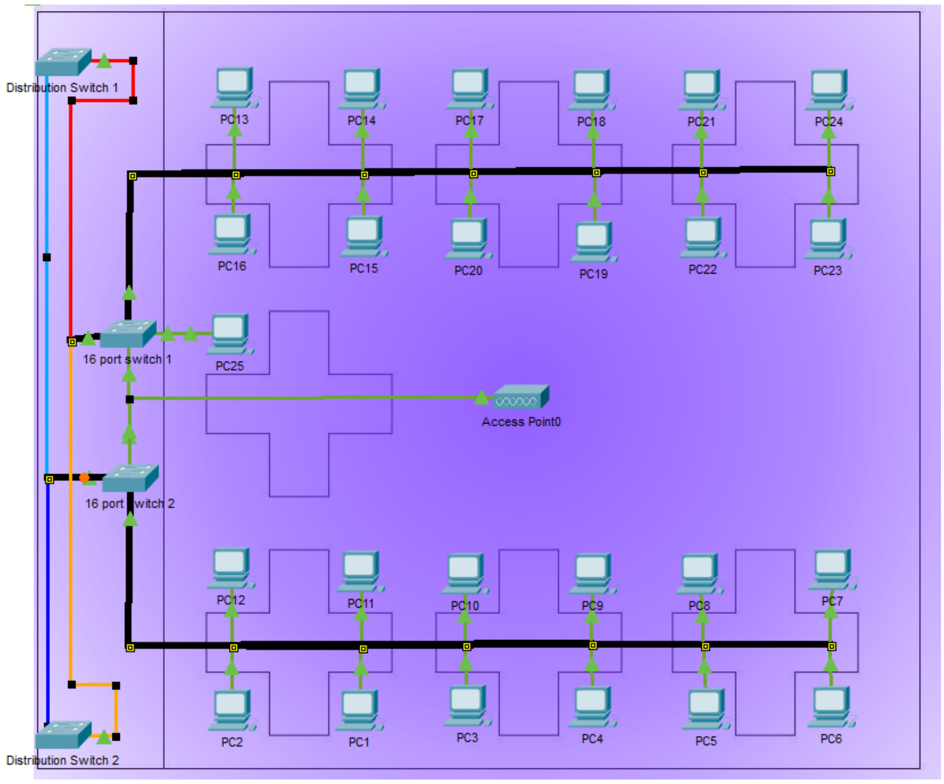


Figure 7

It is noteworthy to mention that the wiring to the PCs will be on the ground while the wiring for the APs will be on the ceiling. In addition to this, the distribution switches are on the ground floor, they are shown in the diagram to provide a different view of the connection.

The purple shading in figure 7 represents the access point coverage, indicating complete coverage of a single floor with a single AP. However, we still need to account for the vertical overlapping of the AP coverage. For this, we need to plan the transmission channels.
The APs will be mounted on the ceiling with the antennas facing downwards, given this, we can assume a downwards propagation of the coverage. With this in mind, we only need to account

for the overlap in the floors below. The channels being used are sourced from the channels figure listed in the appendix. Figure 8 displays the AP channel and coverage for one floor. To prevent any interference, we will alternate between non overlapping channels for each floor as shown in the figure 9 below. By using such configuration, we are utilising the AP to the maximum capacity and preventing any channel overlap.

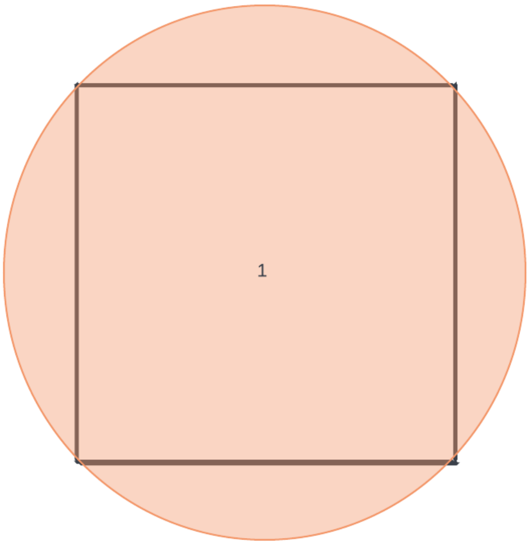


Figure 8: AP channel for one floor

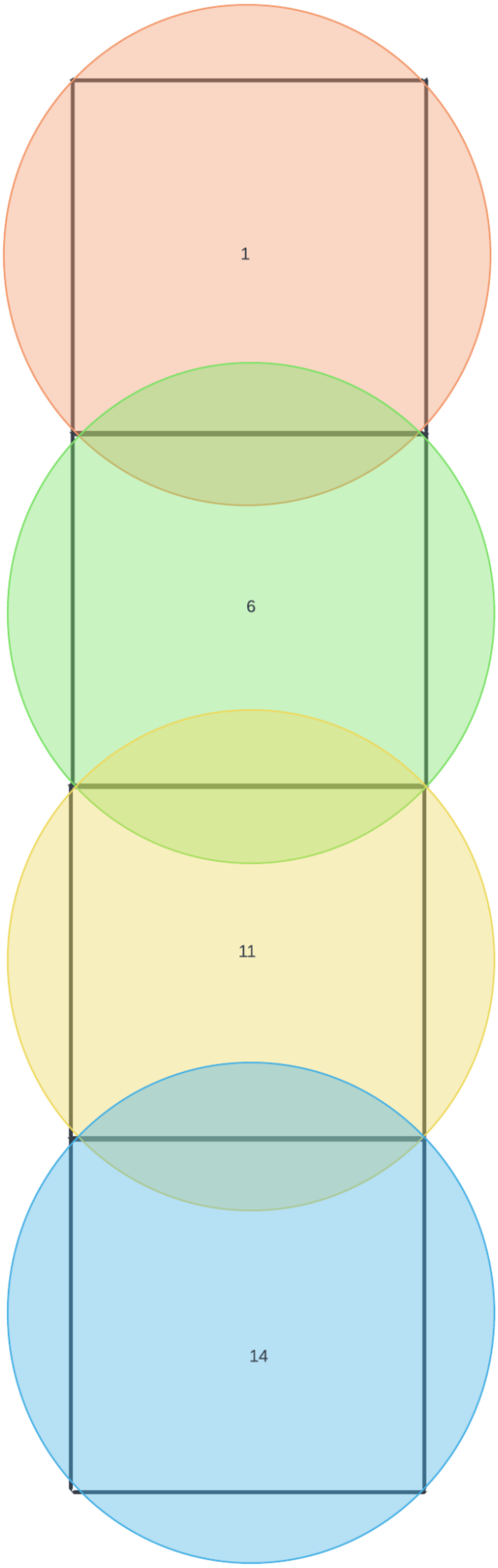


Figure 9: Vertical configuration of AP channels

High level WAN diagram

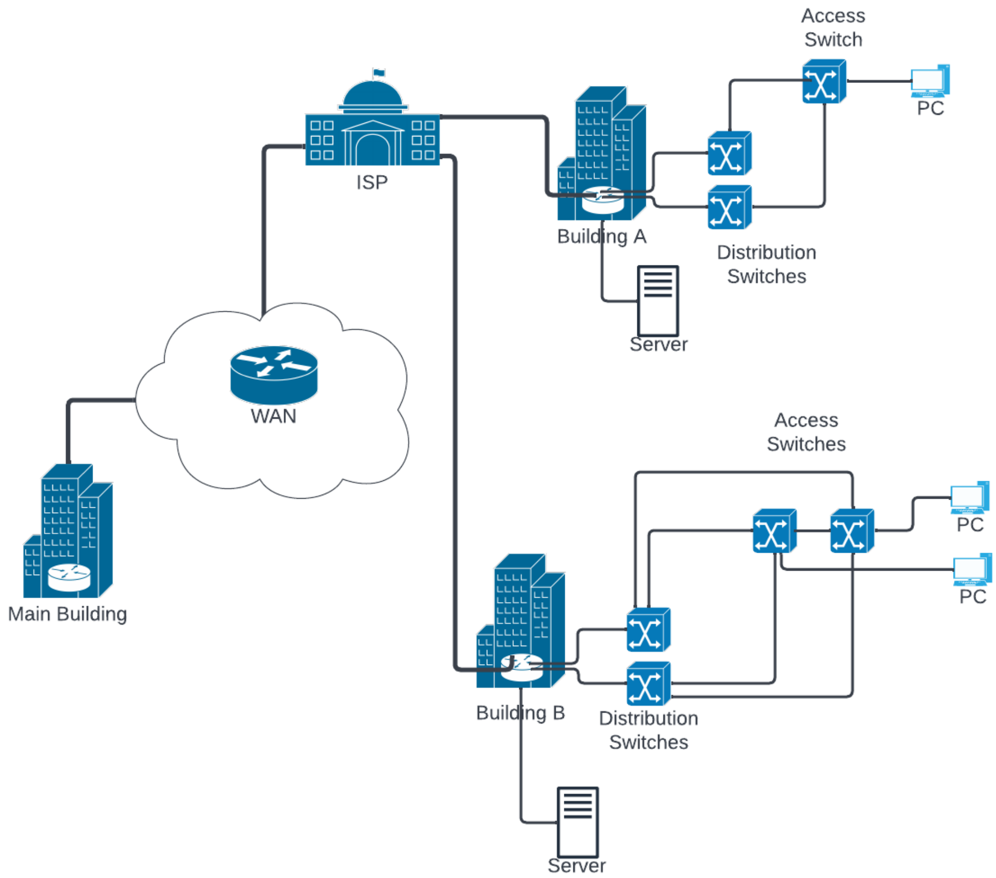


Figure 10

IP Plan

We assume that we have been given an IP block of 192.168.0.0/16

	Subnet	*No. Of devices	IP block	Usable IP Range	Broadcast Address	Network Address
Building A	A	100	128	192.168.0.1 - 192.168.0.126	192.168.0.127	192.168.0.0
	B	100	128	192.168.0.129 - 192.168.0.254	192.168.0.255	192.168.0.128
	C	100	128	192.168.1.1 - 192.168.1.126	192.168.1.127	192.168.1.0
	D	100	128	192.168.1.129 - 192.168.1.254	192.168.1.255	192.168.1.128

Building B	E	60	64	192.168.2.1 - 192.168.2.62	192.168.2.63	192.168.2.0
	F	60	64	192.168.2.65 - 192.168.2.126	192.168.2.127	192.168.2.64
	G	60	64	192.168.2.129 - 192.168.2.190	192.168.2.191	192.168.2.128
	H	60	64	192.168.2.193 - 192.168.2.254	192.168.2.255	192.168.2.192

*It is assumed that each employee has a wired PC and a wireless device, leaving some extra IPs for visitors, new employees or more devices.

Cost Estimate

In this section we aim to briefly give an estimation of the cost breakdown for each individual piece of hardware and from that, the total valuation.

Hardware	Purpose	Quantity	Individual Cost	Total Cost
Multimode fiber OM3 cable	Uplink connection	192 m	RM 22 per 2m	RM 2,122
UTP CAT6 cable	LAN + WLAN	8510 m	RM 459 per 305m	RM 12,582
NETGEAR WAC510	Access Point (WLAN)	12	RM 709	RM 8,508
D-Link DGS-1210-12TS/ME	Distribution Switch	4	RM 2006	RM 8,024
D-Link DGS-F1018P-E	Access Switch (Building B)	8	RM 765	RM 6,120
D-Link DGS-1510-52	Access Switch (Building A)	4	RM 5030	RM 20,120
Cisco Meraki MX95	Router (WAN)	2	RM 25,934	RM 51,868

Note: The calculated value does not include the cost of using a leased line from the service provider.
Total cost roughly equating to: **RM 109,344**

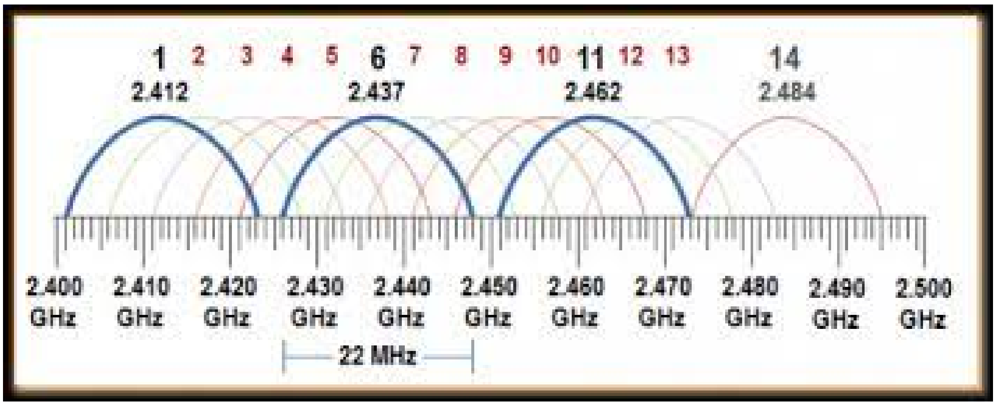
Conclusion

Within this proposal, we outlined the general and specific technicalities involved in our network design and deployment; presenting suggested topologies and hardware to efficiently meet the clients needs with reliability and performance as the primary focus. Overall, a solid network infrastructure is crucial to the operations of any business. For this reason, this network design is tailor made to the clients specific needs with the best interests in mind. The slightly higher cost is a necessity to ensure reliability and constant up time with peak performance; considering the future growth too.

On a final note, this network structure has been simulated on specialist software namely, Cisco packet tracer, CORE network, and Wireshark; to test the focal features and overall operability. Having done so, the network proved to be robust and high yielding; ensuring the best solution.

We, from Fusion Inc, formally extend our gratitude, for this opportunity to become a part of your business success.

Appendix



48 port 10/100/1000Mbps with 2 SFP port + 2 x 10G SFP+ ports Gigabit Smart Pro Switch

DGS-1510-52

DGS-1510 Series includes switches SmartPro 10G ports and is the ideal solution for the deployment of networks of small and medium-sized enterprises (SME / SMB). DGS-1510 Series provides a reliable connection and makes it easy to scale the existing network. The series are equipped with 16, 24 or 48-port 10/100/1000 Mbit / s, as well as 2 or 4-port 10G SFP +, used for stacking or uplink-connection.

PoE switches are ideal for corporate clients in networks that use VoIP-services, wireless access points and network cameras. Switch DGS-1510-28P 24-port PoE supports 802.3at (up to 30 W output power per port) and provides power to the various devices with PoE, allowing you to expand the existing network as your business grows and put to use the latest technology without excessive costs.

10G SFP + ports used for stacking or uplink-connection
Depending on the topology implemented stacking (linear or circular) to create a physical stack users may use one or two ports 10-Gigabit SFP +. Using additional cables can be connected in a stack of up to 6 devices (288 Gigabit ports) and get a wide bandwidth at an affordable price. In addition, in one stack, you can use any series switches DGS-1510 in order to ease of configuration, management, and troubleshooting. Maintaining a speed of 20 Gbit / s in full duplex mode, the Switch DGS-1510 allows you to connect to the core network and servers, while providing high performance.

10. Netgear WAC510

802.11ac 1.2Gbps AC WiFi Business Access Point
with NETGEAR Insight app

Business Features for higher speed, higher coverage and higher density WiFi

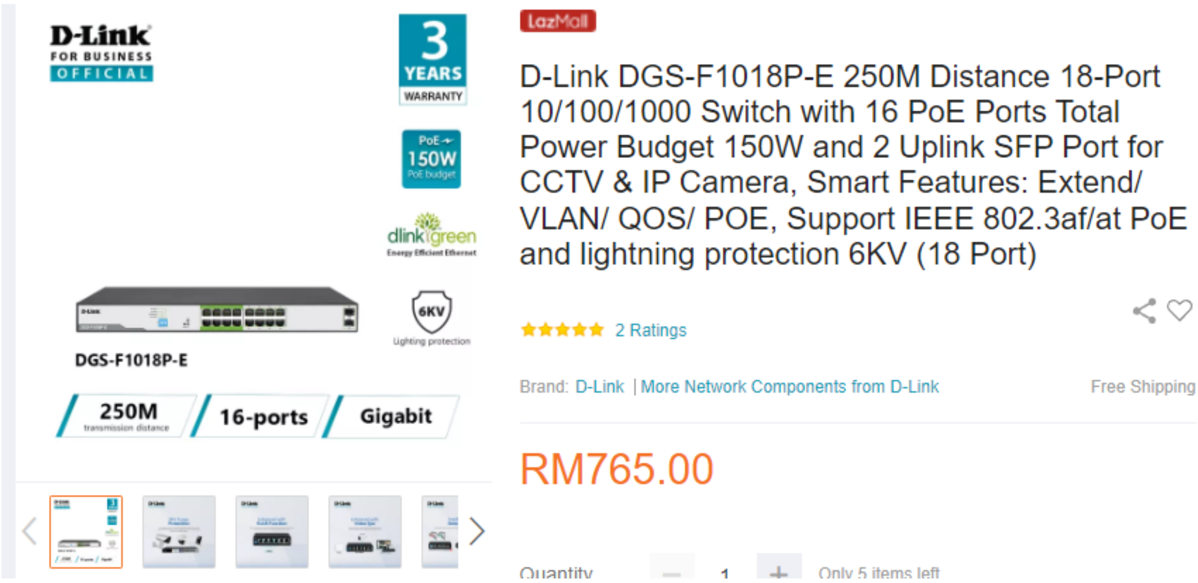
The NETGEAR® AC WiFi Business Access Point WAC510 delivers high performance with high client density for enterprises requiring ubiquitous and reliable wireless for all business applications. The WAC510 is managed by NETGEAR Insight app, for a more intuitive and innovative support, with no need for extra management hardware. The WAC510 features Multi-User MIMO (MU-MIMO) to achieve aggregate speeds up to 1.2 Gbps, option to configure as Router or Access Point modes, and comes with two Ethernet ports, including a Power-over-Ethernet (PoE) 1Gb port. WAC510 comes with lifetime limited warranty, and 24/7 support including lifetime chat.

Features:

- **NETGEAR Insight mobile app managed** for ease of centralised management, no hardware needed
- **High performance, easy to setup, reliable** to handle high numbers of users, WAC510 is the perfect solution for small to mid-size offices
- **Business class** with superior 802.11ac performance (up to 1.2Gbps)
- **2×2 (transmit x receive)** with 2 streams of data for 2.4GHz (300Mbps) and 5GHz (900 Mbps) of reliable data delivery
- **Multi-User Multiple In Multiple Out (MU-MIMO)** enabling maximum client density deployments with no interference
- **Operate** in router or access point modes for flexibility in deployment options
- **Powered by PoE or DC** power inputs (PoE switch and AC/DC power sold separately)
- **Gigabit port** for single wired connection to switch for easy installation
- **Compact and elegant design** stylishly blends into the environment
- **Lifetime limited warranty,** lifetime chat support and 24×7 Support where available

12-Port Gigabit Fiber Metro Ethernet Switch
DGS-1210-12TS/ME

Efficient and resilient Gigabit performance for Metro Ethernet applications.



MX95

A building block for SASE in a rack-mountable form factor

Medium- to large-branch security and SD-WAN appliance for up to 500 users.

Pricing sources:

- https://netgearstore.my/collections/access-points/products/netgear-wireless-access-point-wac510-dual-band-ac1200-wifi-speed-up-to-200-client-devices-1-x-1g-ethernet-lan-port-mu-mimo-insight-remote-management-poe
- https://www.lazada.com.my/products/d-link-dgs-f1018p-e-250m-distance-18-port-101001000-switch-with-16-poe-ports-total-power-budget-150w-and-2-uplink-sfp-port-for-cctv-ip-camera-smart-features-extend-vlan-qos-poe-support-ieee-8023afat-poe-and-lightning-protection-6kv-18-port-i557582276-s1109038835.html?freeshipping=1&search=1&spm=a2o4k.searchlist.list.i13.f64b3b030yyJDF
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- https://www.lazada.com.my/products/ampcom-om3-lc-lc-sc-sc-lc-sc-upc-50125-multimode-duplex-lszh-fiber-optic-patch-cable-fiber-optical-jumper-support-customization-i2539627024-s11257277344.html?

Part 2.1 Calculations

Student ID: 29799260

NET A → 60 PCs
NET B → 99 PCs
NET C → 297 PCs

IP block given → 176.16.0.0/20
IP block binary form: 10110000.00010000.00000000.00000000

From the IP block given, 20 bits are assigned to the network meaning that we have 12 bits left over.

We begin with the biggest subnet, in this case, NET C:

1. NET C requires 297 PCs, the closest IP block (power of 2) that is larger than 297 is 512.
2. 512 written in base 2 is 2^9, meaning that the first 23 bits (32 -9) will be used to identify the network.
3. To find the minimum value of the subnet, we use all zeros for the 9 allocated bits as shown below.
4. Min → 10110000.00010000.00000000.00000000 →176.16.0.0
5. To find the maximum value of the subnet, we use all ones for the 9 allocated bits as shown below.
6. Max → 10110000.00010000.00000001.11111111 → 176.16.1.255
7. Our total range is from 176.16.0.0 to 176.16.1.255.
8. The first IP is used for network address while the last is used for broadcast.
9. All of the IPs in between are the usable range.

We then begin to consider our next largest subnet, in this case, NET B:

1. Earlier, we broke down the given IP block into blocks of 512 addresses. The first block of 512 is completely reserved for NET C. For this reason, we take the next 512 ip block starting at 176.16.2.0 and use it to create the splits for the other subnets.
2. We want to set up 99 PCs, so the closest IP block (power of 2) for that would be 128. 128 written in base 2 would be 2^7, meaning that the first 25 bits (32-7) will be used to identify the network. This means that we will take the next 512 block and split it into 4x 128 blocks. The first 128 block will be used for NET B.
3. The binary form of 176.16.2.0 is 10110000.00010000.00000010.00000000
4. To find the minimum value of the subnet, we use all zeros for the 7 allocated bits as shown below.
5. Min → 10110000.00010000.00000010.00000000→ 176.16.2.0

6. To find the maximum value of the subnet, we use all ones for the 7 allocated bits as shown below.
7. Max → 10110000.00010000.00000010.01111111 → 176.16.2.127
8. Our total range is from 176.16.2.0 to 176.16.2.127
9. The first IP is used for network address while the last is used for broadcast.
10. All of the IPs in between are the usable range.

Lastly, we consider our smallest and last subnet, NET A:

1. From the previous subnet breakdown, we can see that only 3x 128 blocks remain in the second 512 block.
2. We take the next 128 ip block starting at 176.16.2.128 and use it to create splits for our last subnet.
3. We want to set up 60 Pcs, so the closest IP block (power of 2) for that would be 64. 64 written in base 2 is 2^6, meaning that the first 26 bits (32-6) will be used to identify the network.
4. The binary form of 176.16.2.128 is 10110000.00010000.00000010.10000000
5. To find the minimum value of the subnet, we use all zeros for the 6 allocated bits as shown below.
6. Min → 10110000.00010000.00000010.10000000
7. To find the maximum value of the subnet, we use all ones for the 6 allocated bits as shown below.
8. Max → 10110000.00010000.00000010.10111111
9. Our total range is from 176.16.2.128 to 176.16.2.191
10. The first IP is used for network address while the last is used for broadcast.
11. All of the IPs in between are the usable range.

This table below shows the overall IP plan for subnets A, B and C:

SUBNET	No. Of PCs	IP block	Usable IP Range	Broadcast	Network	Subnet Mask
A	60	64	176.16.2.129 - 176.16.2.190	176.16.2.191	176.16.2.128	/26
B	99	128	176.16.2.1 - 176.16.2.126	176.16.2.127	176.16.2.0	/25
C	297	512	176.16.0.1 - 176.16.1.254	176.16.1.255	176.16.0.0	/23