An Enterprise Network Design Proposal on

Local Area Network (LAN), Wireless Local Area Network (WLAN) and Wide Area Network (WAN)

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1. Executive Summary

This report is an overview of the network design for the new office buildings. Our proposal has considered important functional and non-functional requirements such as flexibility, scalability, affordability, reliability, security when designing the Local Area Network, Wireless Local Area Network, and Backbone Wide Area Network. The report will present the analysis and address each of these requirements respectively in detail. All design choices are supported with clear and factual justifications. This proposal also outlines a list of recommended hardware and their specification and model. The latest technology is also utilised as part of the network design. The report summarises and analyses these resources.

2. Introduction

This report is our company response, NetDesigner, to the public transport company Request For Proposal (RFP). As a medium-sized company with 200 experienced employees, the company has managed projects of various sizes successfully. The company is confident our proposal fulfils all requirements. Our proposal is the solution to the RFP. The proposal outlines the project requirements taken from the RFP and the high-level network design choices on the Local Area Network, Wireless Local Area Network, and Backbone Wide Area Network. The design choices proposed are supported by factual justification and the company's knowledge of the latest technology. The high-level conceptual diagram on the designed network is attached to the proposal. Visualization of the floor plans, backbone connection diagram, WAN design diagram was also attached for references. There is an appendix that includes a list of equipment, the specification, technical data and the cabling specification.

3. Requirement Brief

1. A new network design to accommodate two new buildings with four-storey buildings due to the increase in the number of new employees.
    a. Building A: 160 new staff, 40 staff each floor
    b. Building B: 80 new staff, 20 staff each floor
    c. A total number of 240 new employees in Melbourne
2. Each employee will need an office space or cubicle with a desktop wired to network LAN connection.
3. New buildings need to be wired for network connections
4. The network needs to be able to support both LAN and wireless connection
5. Design LAN and Wireless connection.
6. Switches need to be installed to connect the LAN.
7. Access points need to be mounted to provide Wireless Connection that has enough speed and coverage.
8. The layout of horizontal cabling and vertical cabling for both new buildings and backbone cabling plan (Paths and length)
9. A Wide Area Network (WAN) connectivity for the new buildings and the main office network located across the road with a width 100 m wide.
10. Calculate current network load analysis for 240 new users and estimate for future network load analysis.

4. Proposed Equipment

Building A	Floor				Total
	1	2	3	4	
Routers	1	-	-	-	1
Switches	2	2	2	2	8
Access points	4	4	4	4	16
DHCP Server	1	-	-	-	1
DNS Relay	1	-	-	-	1
Building B	Floor				Total
	1	2	3	4	
Routers	1	-	-	-	1
Switches	2	2	2	2	8
Access points	2	2	2	2	8
DHCP Server	1	-	-	-	1
DNS Relay	1	-	-	-	1

Equipments	Routers	Switches	Access points	DHCP Server	DNS Relay
Building A	1	32	64	1	1
Building B	1	32	32	1	1
Total	2	64	96	2	2

5. Floor Plan

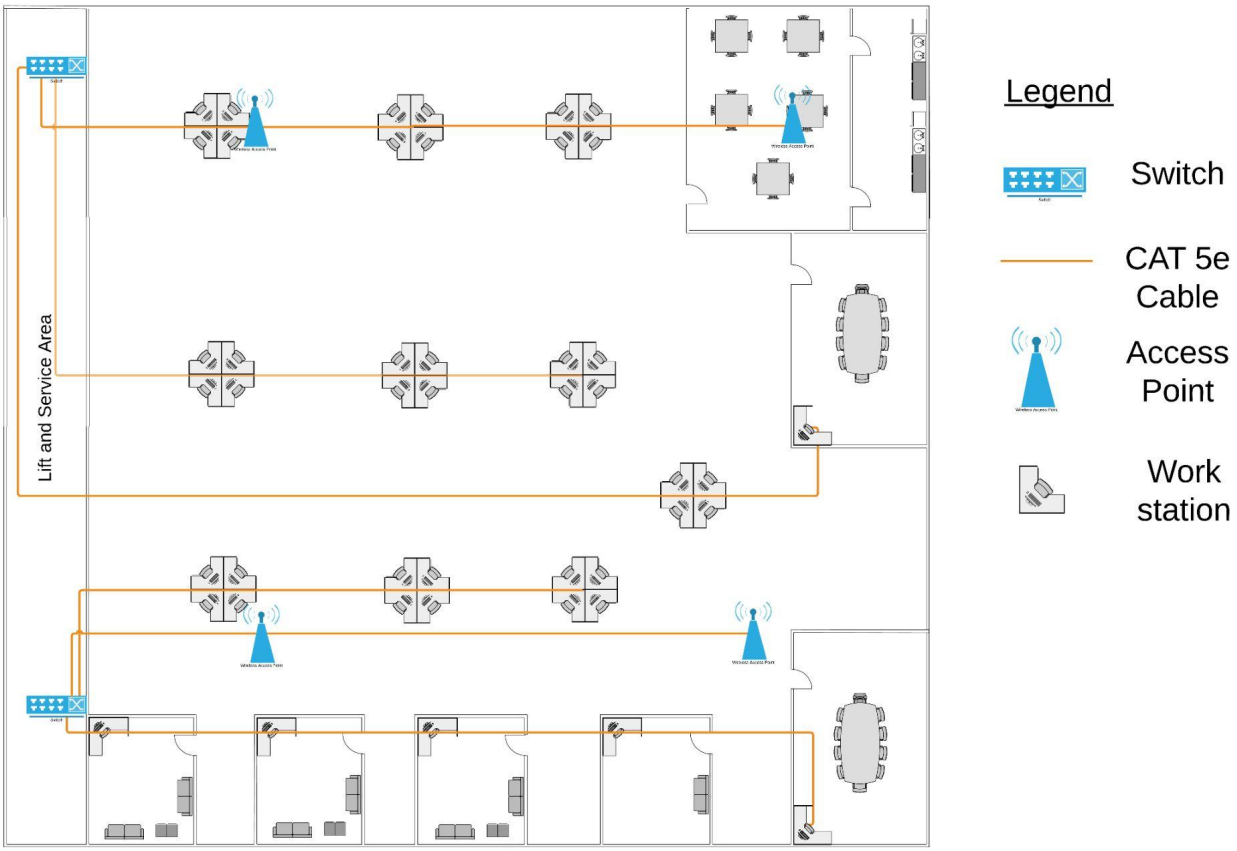


Figure 1: Floor Plan of Building A

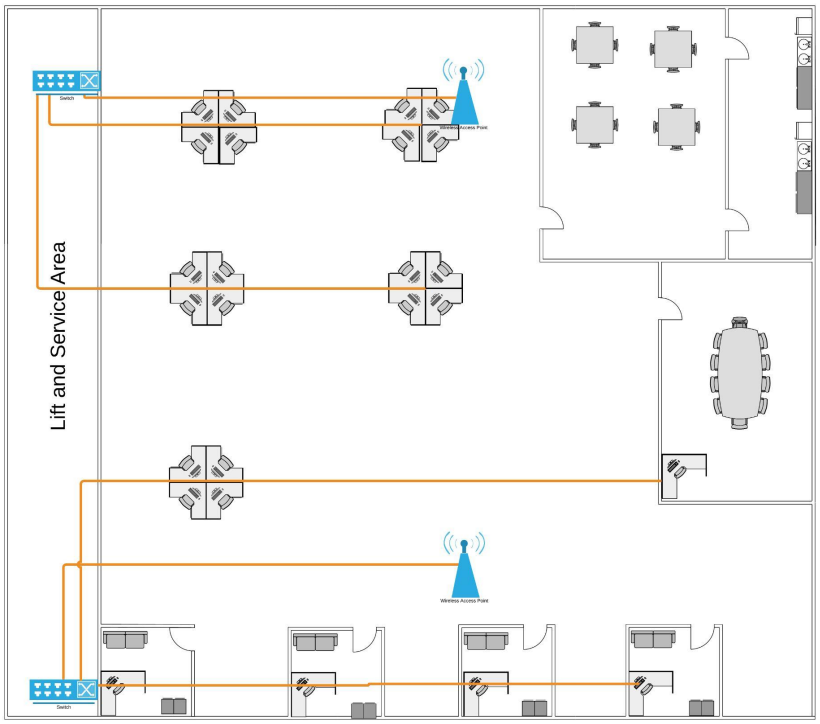


Figure 2: Floor Plan of Building B

Floor Network Architecture

Switch

There will be two switches set up on each floor. The LAN on that floor will be connected to these switches to provide a wired and direct connection or wireless connection network to the staff computer and several office rooms. Usage of two switches will prevent the issue of a single point of failure. In the event of one switch malfunctioning, the other switch can still function and transmit the data from the router. This increases the reliability of the network. There will also be load balancing between the two switches.

For building A, there will be 40 users on each floor. Two Ethernet switches with 48 ports will be enough for each floor to connect the LAN. We recommend the *Cisco Business 250 Series Smart Switches, with model CBS250-48P-4X*. For building B, there will be 20 users on each floor. Two Ethernet switches with 24 ports will be sufficient. We recommend the Cisco Business 250 Series Smart Switches, with model CBS250-24P-4X. The reason we have suggested a switch with more ports than the number of users is also to take into account potential new users such as guests or new staff on each floor in the future. Cisco Business 250 Series Smart Switch is recommended because of their ease of configuration and management, high reliability and performance, good security and energy efficiency.

Network Traffic Load Analysis

There are two related steps and calculations we can take to plan and design the LAN.

1) *Current Load Analysis*

For **building A**, there will be 160 new staff with 40 staff on each floor. For **building B**, there will be 80 new staff with 20 staff on each floor. It is anticipated that each staff that uses the network will generate average network traffic of 15-20 Mbps. We can use this information to calculate the network effective throughput. We have tabulated the result below.

Network throughput	Floor	Building
Building A	40 users x 20MBps = **800 Mbps**	800Mbps x 4 **= 3200 Mbps**
Building B	20 users x 20Mpbs = **400 MBps**	400Mbps x 4 = **1600 Mbps**

In conclusion, the total **effective throughput of building A and B is *3200Mbps + 1600Mbps = 4800Mbps* during peak hours.**

2) *Estimation of future loads*

The growth of the organization is also something we have taken into consideration. Hence, we will estimate the future network traffic load for each building here. The future network traffic load can be calculated by scaling up the estimated throughput calculated above by 20%.

Network throughput	Floor	Building
Building A	800 x1.2= 960MBps ~ **1GBps**	3200Mbps x 1.2 = 3840 MBps ~ **4Gbps**
Building B	400 x1.2= 480MBps ~ **500MBps**	1600Mbps x 1.2 = 1920 MBps ~ **2Gbps**

LAN Architecture and Design

Local Area Network, or LAN, will be set up in the new buildings to allow different workstations in the LAN to communicate with each other. We suggest each floor in both buildings A and B have a LAN dedicated to it. Hence, there will be four LANs connected to their respective switches in each building. Below we have stated the benefits of this implementation.

1. Assuming that each floor is dedicated to one department for the organization, LAN will isolate the traffic within the department, preventing external access from other floors or departments.
2. Isolation of traffic will also improve the security of the network. In the event of breaches, it will be isolated within the LAN of the specific department.
3. Each building will need to support at least 80 users worth of traffic. Having multiple LANs in each building can help spread the heavy load across the network in the building.
4. This architecture also prevents a single point of failure, whereby one LAN down in a department or floor, will not impact the other departments in the building.

LAN Network Topology - Star

We recommend the usage of *Star* type for the LAN network topology. The main advantage of star topology is its reliability due to its fault tolerance. All workstations on each floor will be connected to the switch individually, not to each other. In the event of a cable malfunctioning, the other workstations in the network will not be affected as they are part of different cables. Star topology is also flexible in scalability. A new workstation can be set up just by connecting it to the switch and it will have access to the data in the LAN. The only downside is that more costs are required to scale up the network because of the individual connection to the switch.

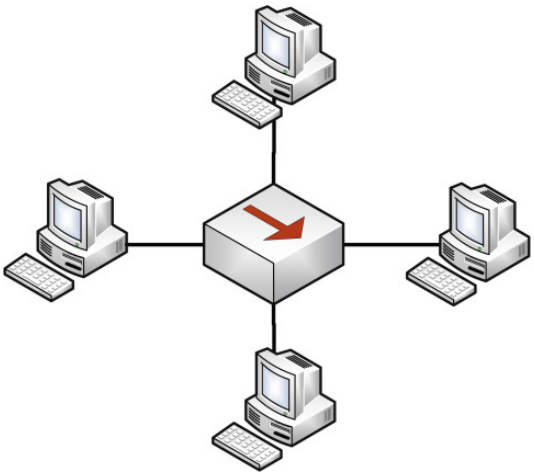


Figure 3: Star Network Topology

LAN Host Operating System

We recommend the LAN Host Operating Systems to be the Microsoft Server. Microsoft server offers an affordable and usable suite of applications and tools. The company and the business will be highly benefited by its ease of use and the range of services Window Server provides.

The client-server architecture will also be a better choice to be implemented in conjunction with the usage of Star topology. This is because all workstations are connected to the switch directly. Hence, the switches play the role of a centralised point to manage all the communications in the LAN, which is the function the client-server architecture offers.

Wireless LAN Design

1) Wireless Access Point Design and Placement

We recommend *Cisco Catalyst 9105AXI*, for the access point hardware. It utilizes IEEE 802.11ax, or Wi-fi 6, which is the latest technology that has improved coverage and speed compared to IEEE 802.11ac. The Wireless Access Points will be installed on the ceilings of each floor. This configuration will provide the best signal performance and full wireless coverage to the whole floor. This will indirectly also allow each AP to be connected to the switch through cabling over the ceiling. In addition, a direct connection to the Ethernet switch will give each AP a bandwidth of up to 1.4 Gbps to support the peak traffic.

Each AP will be configured with a 5GHz channel because it is faster than old technology 2.4 GHz. Devices nowadays are compatible with 5GHz. We assume here that our chosen AP each gives wide coverage. However, we proposed to scale the range down to a radius of 20 m. This is to decrease the power needed to maintain the wide coverage provided by the AP with the trade-off to increase the number of APs in the network. However, the usage of more APs will ensure that the entire floor can access the wireless network as the walls, obstructions and inference may weaken the 5Ghz signals. We can calculate the number of APs for each building as below.

Number of APs	Theoretical	Real world (scale up)
Building A (40 m x 40 m)	*(40x40)/(pi(20^2) = 1.27 ~ 2*	4
Building B (30 m x 30 m)	*(30x30)/(pi(20^2) = 0.07 ~ 1*	2

According to the calculated maximum traffic produced from the previous section, we know that building A and building B will have estimated traffic of 1000 Mbps and 500 Mbps on each floor respectively. We recommended using Wireless Standard of 802.11ax, which can give a maximum speed of 14 GBps, and also support the MU-MIMO, or “Multi-User Multiple-In and Multiple-Out function”, closed-loop beamforming and backwards compatible. This technology will be able to help the system to meet the requirements for 5GHz channels, high-resolution video streaming and the speed and performance for the potential usage of the network.

2) Channel selection

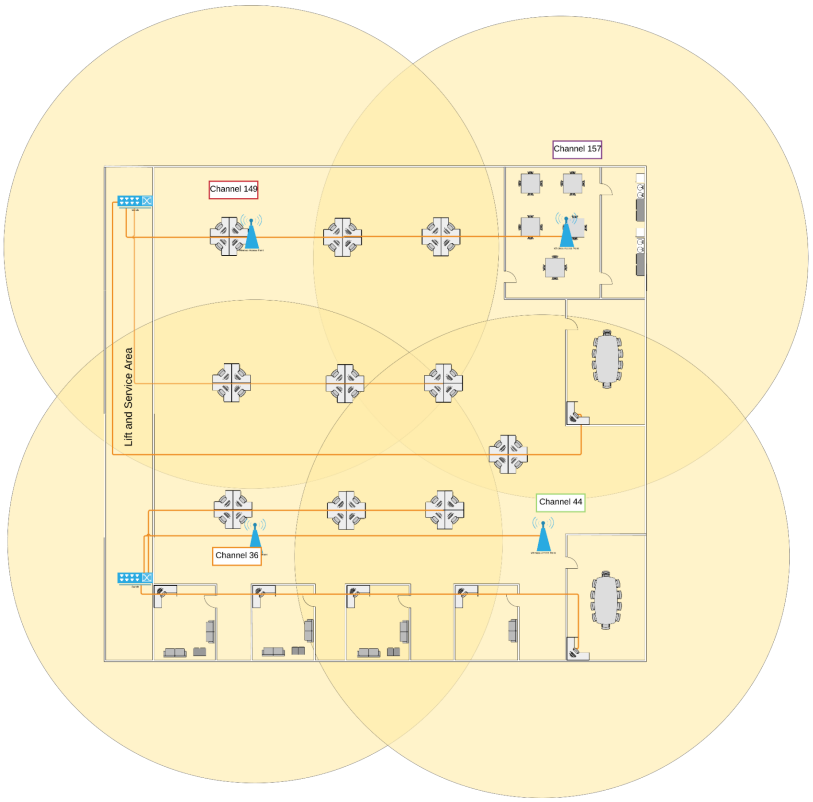
Since the AP chosen will provide enough speed to all the users for each floor, we recommend using 20 MHz channels to accommodate the non-overlapping channels. Hence, non-overlapping channels 36, 44, 149, 157 are chosen for each floor respectively in Building A and channels 44 and 157 for Building B. Each combination of the channel on each floor should be different to reduce inference and maximise the performance. There will be full coverage with minimal overlapping of each AP. The interference produced by the overlaps will not have a significant impact on the performance of the network.

Configuration of Channels for each building is shown below:

Combination of 5GHz Channels	Floor			
	1	2	3	4
Building A	**149, 157** **36, 44**	**157,44** **149,36**	**44,36** **157,149**	**36, 149** **44, 157**
Building B	**44** **157**	**157** **44**	**44** **157**	**157** **44**

The figure below shows the channels selected and coverage provided by the Access Points on the first floor of building A and B.

Figure 4: Channel selection and AP coverage on first floor of Building A



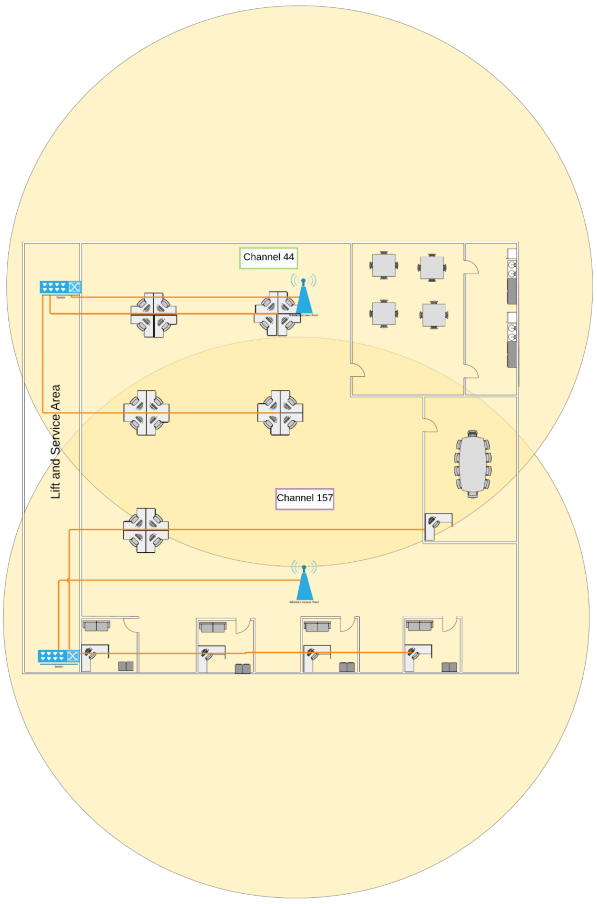


Figure 5: Channel selection and AP coverage on first floor of Building B

Horizontal Cabling

We have chosen the Twisted Pair Cable of type Unshielded Twisted Pair Category 5e For the horizontal cabling. The *Cat5e Snagless Unshielded (UTP) PVC CM Ethernet Patch Cable* is recommended for the specific cable model. However, any type of CAT 5e will be suitable because CAT 5e cable has an effective performance range of 100m, which is enough for the floor size of 40m and 30 m length for the two buildings. CAT 5e cable also provides a transfer rate of up to 1 GBs, which is sufficient for each floor. They are one of the popular choices in the market because they are affordable, easy to install and more durable compared to optic fibres. For building A, the cable will need to be around 40m long to connect the workstations and Wireless access points horizontally. For building B, the cable will need to be around 30 m long.

6. Backbone Plan

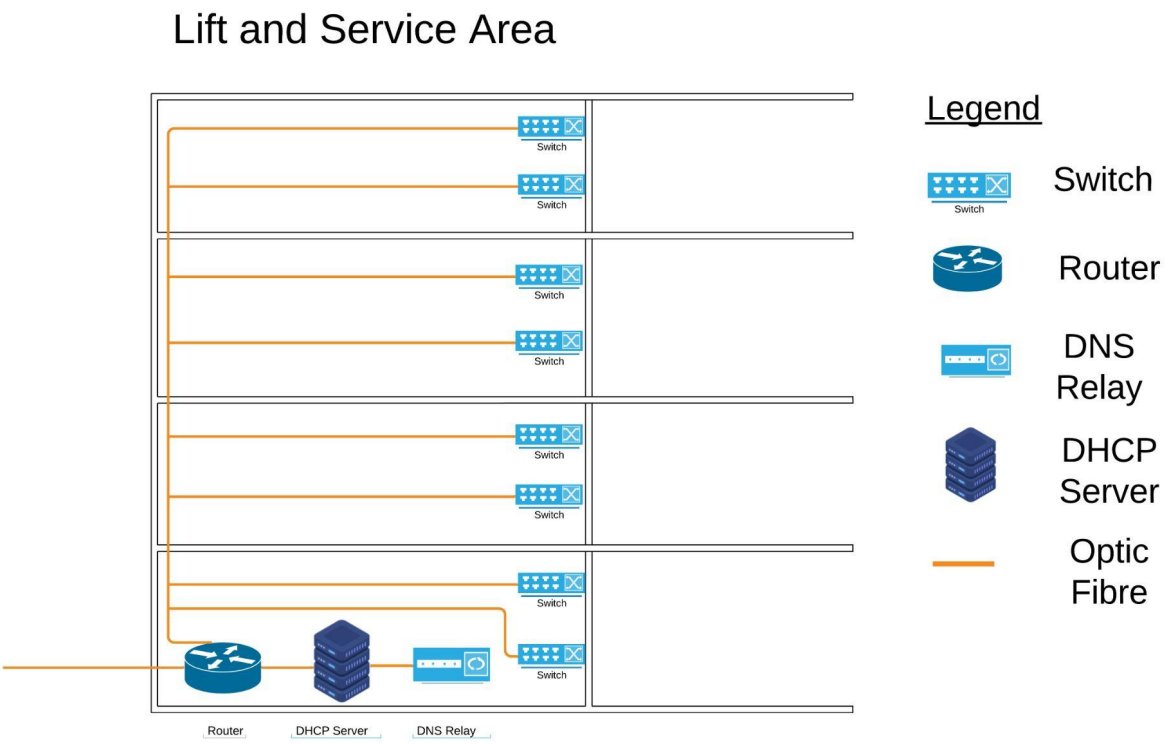


Figure 6: Backbone Plan Diagram

Backbone Design

1) Router

All the switches in the new buildings will be connected to the router located on the first floor. Meaning that the router will connect multiple LANs. It will be in charge of forwarding and routing data throughout the network in the building efficiently and securely. The router should also be connected to the Wide Area Network through the backbone to access the internet. We also encourage building a connection between routers in building A and B for internal

communication. To support the estimated maximum network load of 4 Gbps, we recommend *Cisco 4461 Aggregate CEF only Throughput (Boost License)* that can support up to 7 Gbps.

2) DHCP server

A DHCP server will be set up on the first floor. This network server will manage IP addresses dynamically and assign them to the workstations or clients in the subnet range. The DHCP server will also configure the IP subnetting needed for each floor. This eliminates the need of configuring the subnetting manually.

3) IP address version 4 strategy

The IP address will define the connection of a router to the internet. Hence, it is important to have a good IP address version 4 strategy. We have planned out a way to deal with this strategically, by implementing the Classless addressing. The strategy is as follows.

Building A:

Floor	Subnet Mask (CIDR)	Network Address	Broadcast Address	Address Range	Available Number of Hosts	Reserve Number of Hosts
1	/25 (255.255.255.128)	192.168.1.0/25	192.168.1.127	192.168.1.1-192.168.1.126	90	36
2		192.168.1.128/25	192.168.1.255	192.168.1.128-192.168.1.254	90	36
3		192.168.2.0/25	192.168.2.127	192.168.2.1-192.168.2.126	90	36
4		192.168.2.128/25	192.168.2.255	192.168.2.128-192.168.2.254	90	36

Building B:

Floor	Subnet Mask (CIDR)	Network Address	Broadcast Address	Address Range	Available Number of Hosts	Reserve Number of Hosts
1	/25 (255.255.255.128)	192.168.1.0/25	192.168.1.63	192.168.1.1-192.168.1.62	42	20
2		192.168.1.64/25	192.168.1.127	192.168.1.65-192.168.1.126	42	20
3		192.168.1.128/25	192.168.2.191	192.168.2.129-192.168.2.190	42	20
4		192.168.1.192/25	192.168.1.255	192.168.2.193-192.168.2.254	42	20

There is one subnet on each floor. The private network address starts with 192.168.1.0. We allocated 512 IP addresses to accommodate the new 160 users for Building A and 256 IP addresses for 80 users in Building B. Available hosts of each floor are scaled up to twice the number of users to take into account future increase in numbers of users and also extra devices. Reserve hosts are for services such as printer, file, database, mail and so on.

4) DNS Relay

A DNS relay will also be set up on the first floor. When a request by DNS Client or workstation is received, the DNS Relay will relay the DNS request to the DNS server located in the main building. The DNS server will then translate the domain name of the request to an IP address and return it to the client.

5) Backbone Cabling

We have chosen Multimode Optical fibre, specifically *OM3 50/125 Multimode LC/UPC to LC/UPC Duplex Indoor Armored Fiber Optic Cable* for vertical cabling. Each floor has a height of 3m. Hence, the length of each cable will vary from 3m, 6 m, 9 m and 12 m to connect the switches located on floor 1,2,3,4, respectively, to the router.

For WAN cabling, we will be using the same type of cable but with a different specification that is suitable for underground cabling. We have chosen *M4 Multimode PVC (OFNR) 2.0mm Fiber Optic Patch Cable* to connect the new buildings to the main building for WAN connection. It is more bendable and durable compared to the cable above.

The main reason we have chosen Multimode optical fibre cable is that it provides high transmission of data. It also can support distances up to 300 meters without performance loss, which meet the requirement of our 100 m wide road that separates the main and new buildings for WAN cabling.

7. Wide Area Network Plan

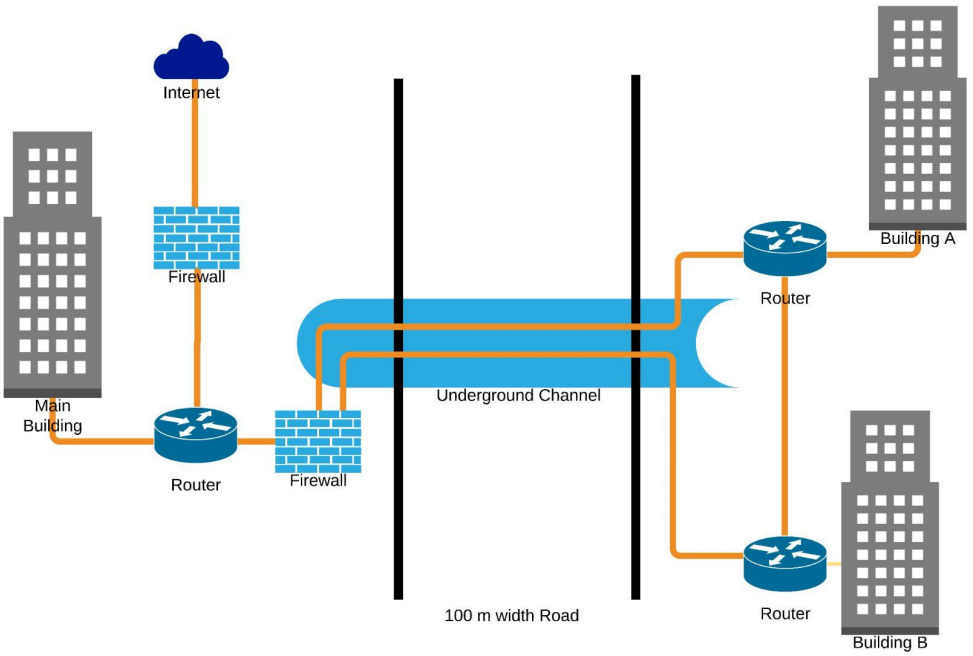


Figure 7: Wide Area Network Plan Diagram

WAN Architecture and Design

Wide Area Network connection will be used to form a network that has coverage over the new buildings and the main building. This will be achieved using a 10 Gigabit Multimode Ethernet fibre optical cable, which supports a distance up to 300 m, enough to connect the new buildings into the WAN. We recommend placing the firewall between the connection of the routers and the DNS server. This is because the DNS server is in the main building. Hence the main office will be the one connected to the internet while also accepting DNS requests. This will provide a layer of security to filter traffic and block any unauthorised access to the LANs or WAN. There will also be a dedicated router connection between the two new buildings for internal communication.

8. Recommendation and Justification

The network above is designed with consideration of the potential growth of the organisation. The proposed network design is highly extensible and easy to maintain. The usage of Star topology has allowed a new workstation to be set up quickly just by connecting a cable. The switches can still host a large amount of new staff before it reaches the maximum capacity. There is only minimal configuration to the access points to configure the coverage. The number of IP addresses can easily be scaled up using the classless strategy to perform IP subnetting. A new building can also be connected to the WAN via the router and backbone. Cabling also can be added easily.

9. Conclusion

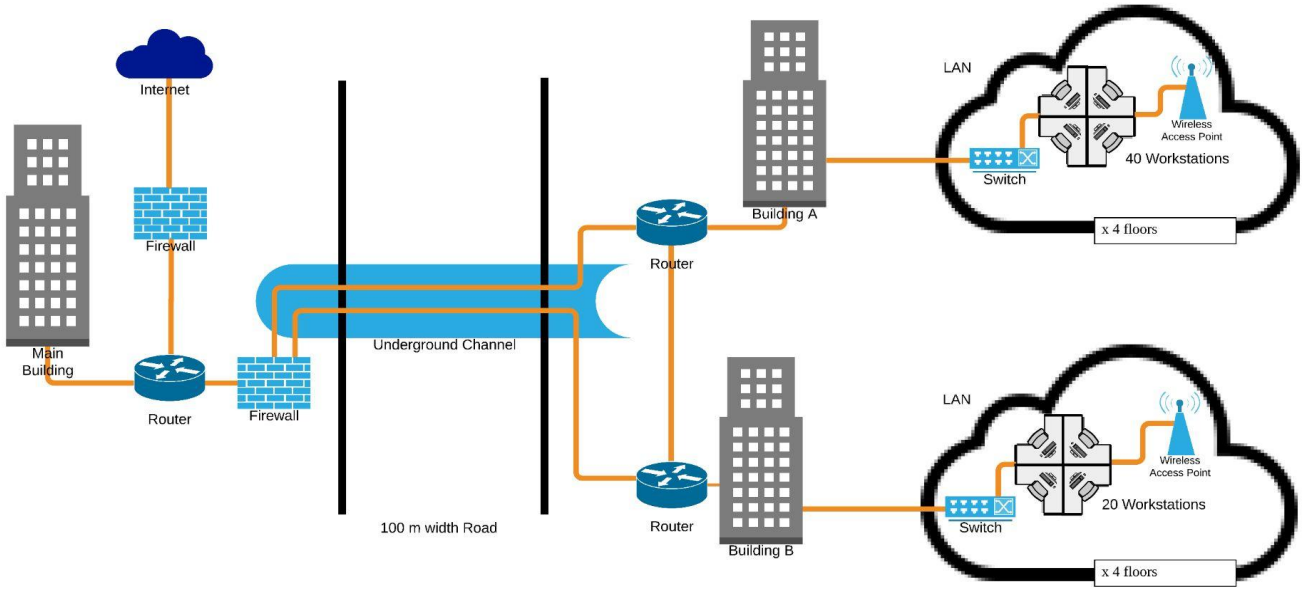


Figure 8: Overview Network Diagram

The diagram above is the overview of the network that our company had designed. It includes the four LANs in each building, the access points to provide wireless connectivity, new routers to connect the new buildings to the main building for WAN connection, backbone design and two firewalls for security. The recommendations given are backed up by scientific reasoning and the latest technology. We are confident that the proposed network will hugely benefit your business.

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11. Appendix

Hardware	Model	Configuration
Switch, Cisco Business 250 Series Smart Switches		
Building A	CBS250-48P-4X	Number of ports: 48 Port type: GB Speed: GB
Building B	CBS250-24P-4X	Number of ports: 24 Port type: GB Speed: 1GB
Access Point		
Both Buildings	Cisco Catalyst 9105AXI	Protocol: 802.11ax Port:1x 10/100/1000 Base-T (Ethernet) Maximum data rates: 1.488 GBps Frequency: 5GHz Max clients: 200 per radio
Category 5E cable		
Building A	Cat5e Snagless Unshielded (UTP) PVC CM Ethernet Patch Cable	Bandwidth: 100 MHz Max Cable length: 40 m Speed: 1000 MBps
Building B	Cat5e Snagless Unshielded (UTP) PVC CM Ethernet Patch Cable	Bandwidth: 100 MHz Max cable length: 30m Speed:1000 MBps
Router		
Both Building	Cisco 4461 Aggregate CEF only Throughput (Boost License)	Speed: Over 7Gbps
Multi-Mode Fibre		
Indoor	OM3 50/125 Multimode LC/UPC to LC/UPC Duplex Indoor Armored Fiber Optic Cable	Speed: 10Gbit/s Maximum Distance: 300m
Outdoor/ underground	OM4 Multimode PVC (OFNR) 2.0mm Fiber Optic Patch Cable	Speed: 10Gbit/s Maximum Distance: 300m

*There are only 10 pages without the diagrams, table of content and cover page