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Network Design for Faculty of Computing Block N28B

by SURVIVOR

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ABSTRACT

This report details the comprehensive network design for the new N28B Faculty of Computing building. The project aims to establish a robust, scalable, and secure Local Area Network (LAN) that supports modern digital learning environments. We utilized a top-down design methodology to align the infrastructure with specific academic and administrative requirements. The proposed architecture features a hierarchical model using Cisco Catalyst 9200 switches with StackWise technology, which simplifies management and ensures high availability.

To address the constraints of the limited /23 IP address block, we implemented Variable Length Subnet Masking (VLSM) to maximize address efficiency. Furthermore, we applied Network Address Translation (NAT) for the wireless network. This strategy isolates the high density of student BYOD traffic from critical internal resources, preserving valuable IP space. The physical topology integrates essential smart technologies, including PoE-powered ceiling speakers and cameras, and Samsung interactive displays, within a total budget of RM 900,000. Logically, the design enforces strict security boundaries through VLAN segmentation and optimized DHCP policies. In conclusion, this blueprint delivers a cost-effective, enterprise-grade infrastructure that satisfies current connectivity needs while ensuring future network reliability for the faculty.

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INTRODUCTION

This report serves as a comprehensive guide for the design and implementation of a new Local Area Network (LAN) for the Faculty of Computing. The primary purpose of this document is to present a complete technical blueprint that transforms the faculty's operational requirements into a fully functional and reliable infrastructure. As the foundation for all digital activities within the building, this design is critical for supporting the daily tasks of students, lecturers, and administrative staff.

The report begins by establishing the scope and specific needs of the project. In the initial phase, we conducted a thorough analysis of the building's layout to identify distinct user groups and their unique connectivity requirements. This step was essential to ensure that every room, from large computer laboratories to private offices receives the appropriate level of service and equipment.

Following the needs analysis, the report details the physical design of the network. This section focuses on the tangible components of the infrastructure. We describe the process of selecting the necessary hardware, including high-performance computers for students, modern interactive displays for smart classrooms, and the underlying cabling systems that connect them all. Special attention was given to choosing equipment that balances modern features with durability and cost-efficiency.

Subsequent sections address the logical design, which serves as the "brain" of the network. Here, we outline the strategy for organizing the network behind the scenes. This includes the methods used to assign unique addresses to hundreds of devices and the creation of separate digital groups to keep student and staff traffic isolated from one another. This logical structure is vital for maintaining security and ensuring that the network runs smoothly without congestion.

Finally, the report presents a detailed financial breakdown. We have compiled a comprehensive list of all required materials and their associated costs to demonstrate the economic feasibility of the proposed solution. By combining physical planning, logical organization, and financial analysis, this report provides a finalized roadmap for deploying a network that is secure, scalable, and ready for the future.

PROJECT BACKGROUND & OVERVIEW

The Faculty of Computing (FC) presently serves a large academic community comprising 1,800 undergraduate and postgraduate students, along with 140 academic and support staff. Strategic forecasting indicates a 15% increase in this population over the next four years, necessitating immediate infrastructure expansion to avoid overcrowding and resource bottlenecks. To facilitate this growth, the Faculty has commissioned the construction of a new two-storey building designed to provide advanced educational facilities and relieve pressure on the existing buildings.

The new facility is specifically designed to house high-tech learning environments essential for the Fourth Industrial Revolution (4IR). The floor plan includes four specialized computer laboratories which are two General Purpose Labs for standard computing needs, one Cisco Network Lab for infrastructure training, and one Embedded Lab focused on IoT and technology. Each laboratory is sized at 140 square meters and is equipped to support 30 high performance workstations. Additionally, the building will feature a Video Conferencing Room for virtual collaboration, a Hybrid Smart Classroom optimized for modern teaching methods, and a Student Lounge designed as a flexible, Wi-Fi-enabled space for student collaboration and relaxation.

From a technical perspective, the primary goal is to establish a network that is ready for anything, balancing cutting edge performance with long-term cost effectiveness. The Faculty administration demands a system that is highly reliable, easy to manage, and secure against modern cyber threats such as Denial-of-Service (DoS) attacks and internet worms. Crucially, the network infrastructure must also be scalable as it needs to support the immediate high-bandwidth requirements of the core backbone while retaining the capacity for future wireless expansion and user growth without requiring expensive hardware replacements. The design must also ensure a seamless transition, integrating with existing systems to guarantee uninterrupted access for all stakeholders during the migration.

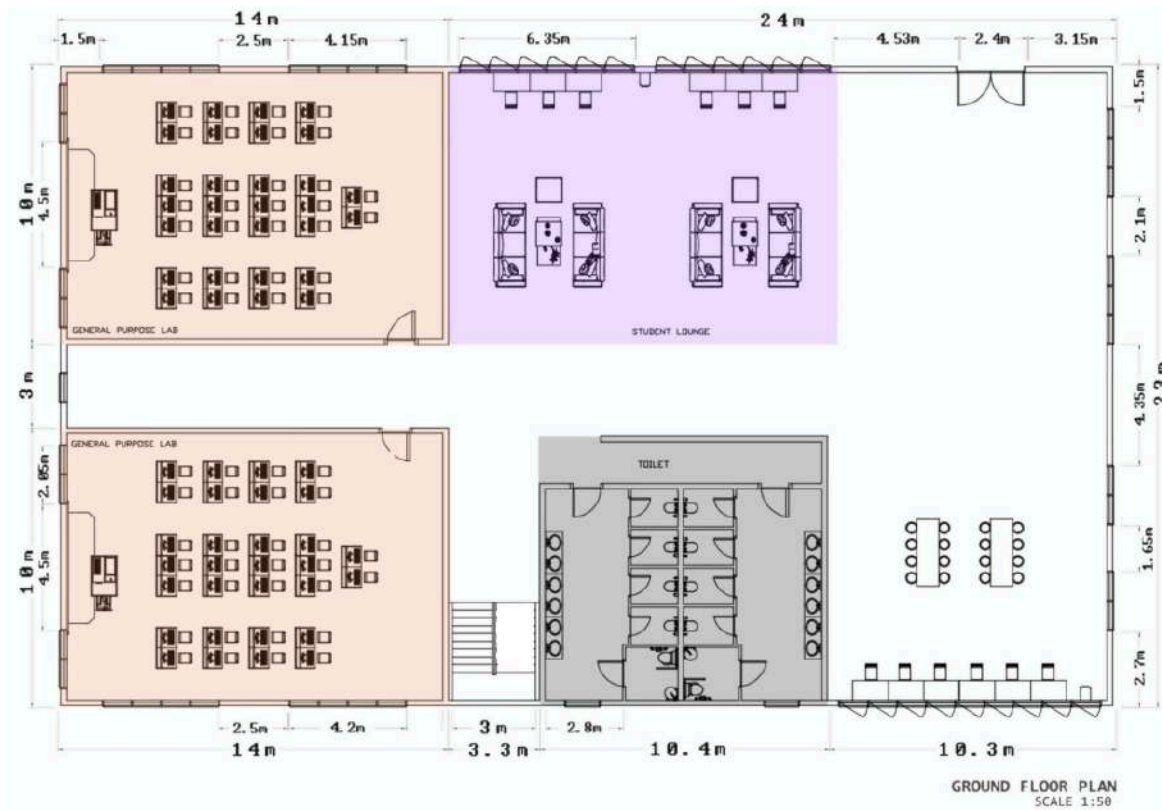
TASK 1: Project Setup

Overview

In this phase, we come out with the physical foundation for the new N28B building's network infrastructure. We developed 2D floor plans for both the Ground and First Floors with detailed layouts for all seven key functional areas. This includes the four specialized laboratories, the Hybrid Classroom, the Video Conference Room, and the Student Lounge, ensuring the physical space is optimized for both academic activities and network cable routing.

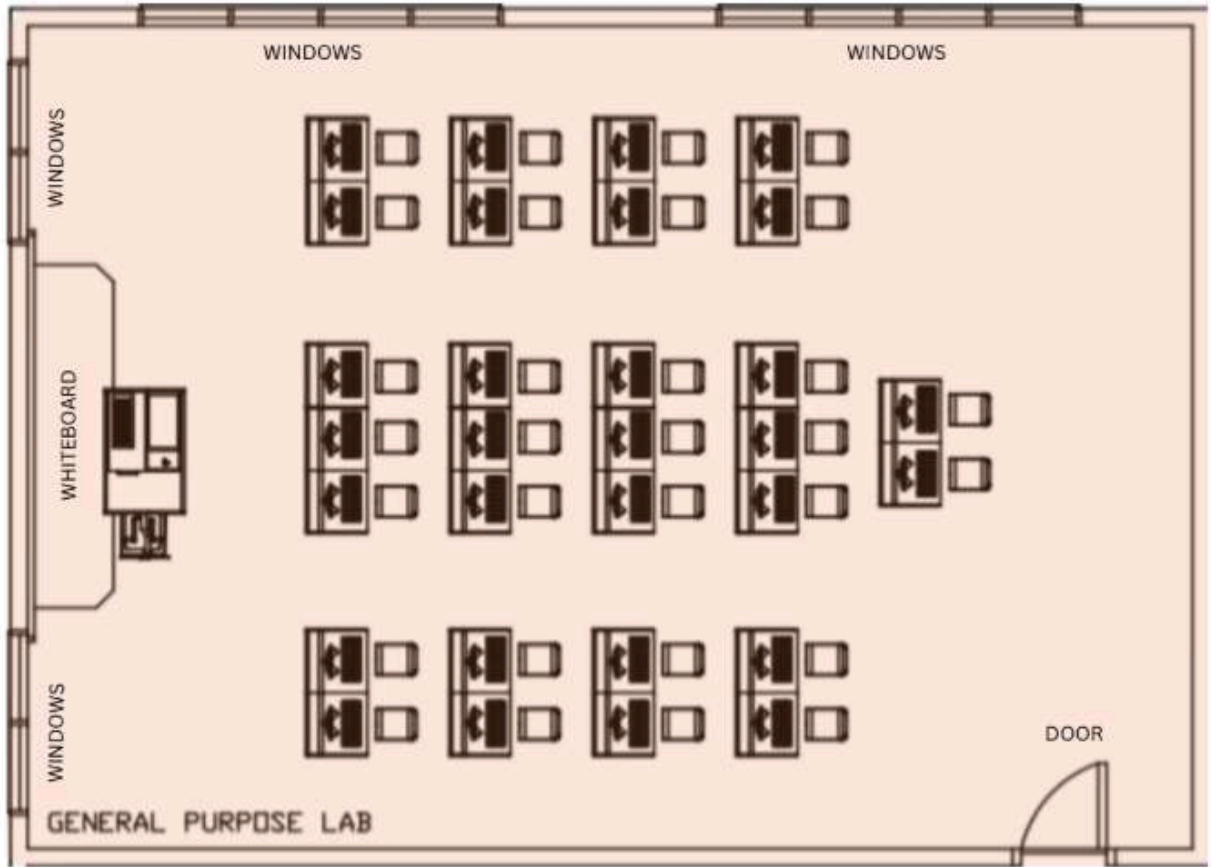
Floor Plan

Ground Floor



[PDF GROUND_FLOOR.pdf](#)

Figure 1.1 Ground floor

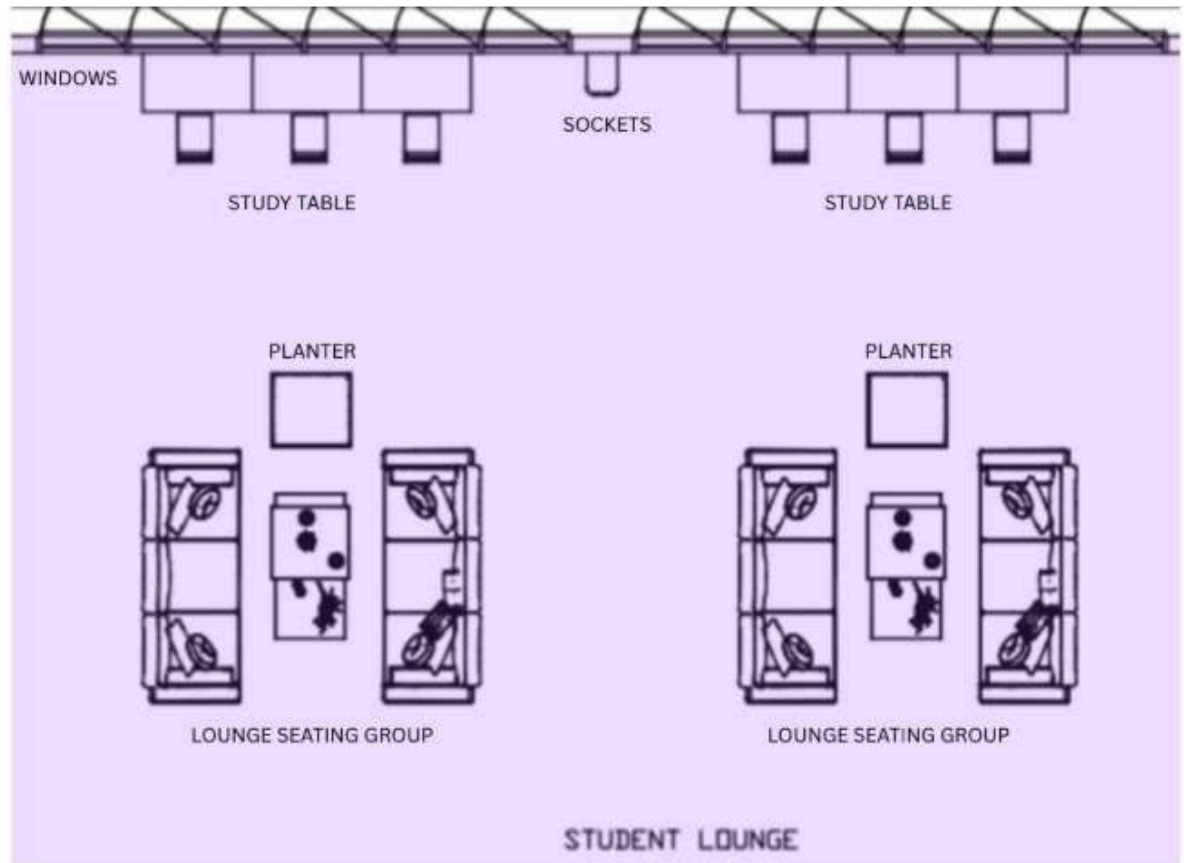


 GENERAL_PURPOSE LAB.pdf

Figure 1.1.1 General purpose lab 1 & 2

- **Two General Purpose Labs**

Each of the four new labs, including the general-purpose labs, is 14x10m in size, and each lab is to be equipped with a total of 30 workstations, following the given requirements requested in the project.

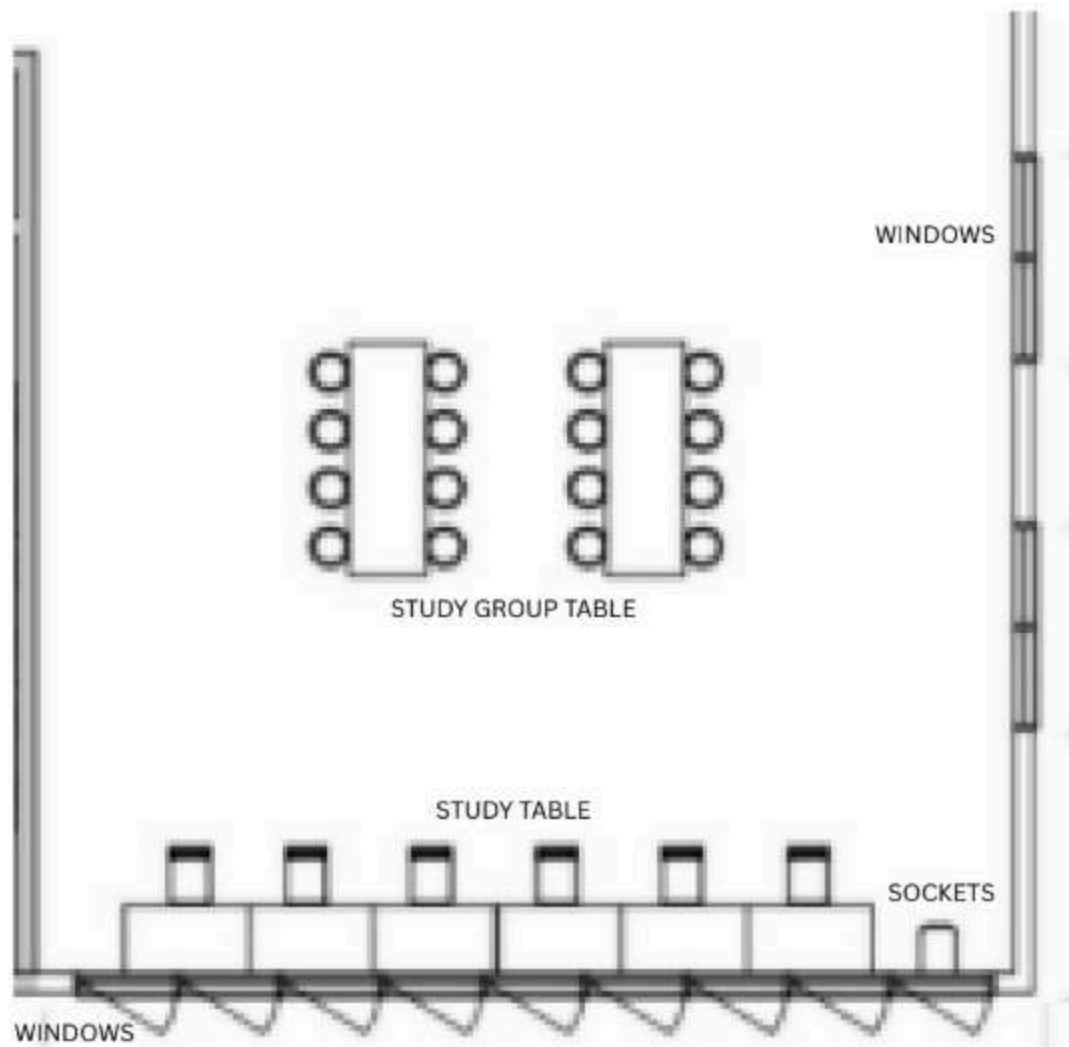


 STUDENT_LOUNGE.pdf

Figure 1.1.2 Student lounge

- **Student Lounge**

Designed to give students an area to work and relax while connected to the network via Wi-Fi. The project specifies that the student lounge is also 14x10m in size. The student lounge has no walls, as it is an open space, yet it still ranges 14x10m regardless.



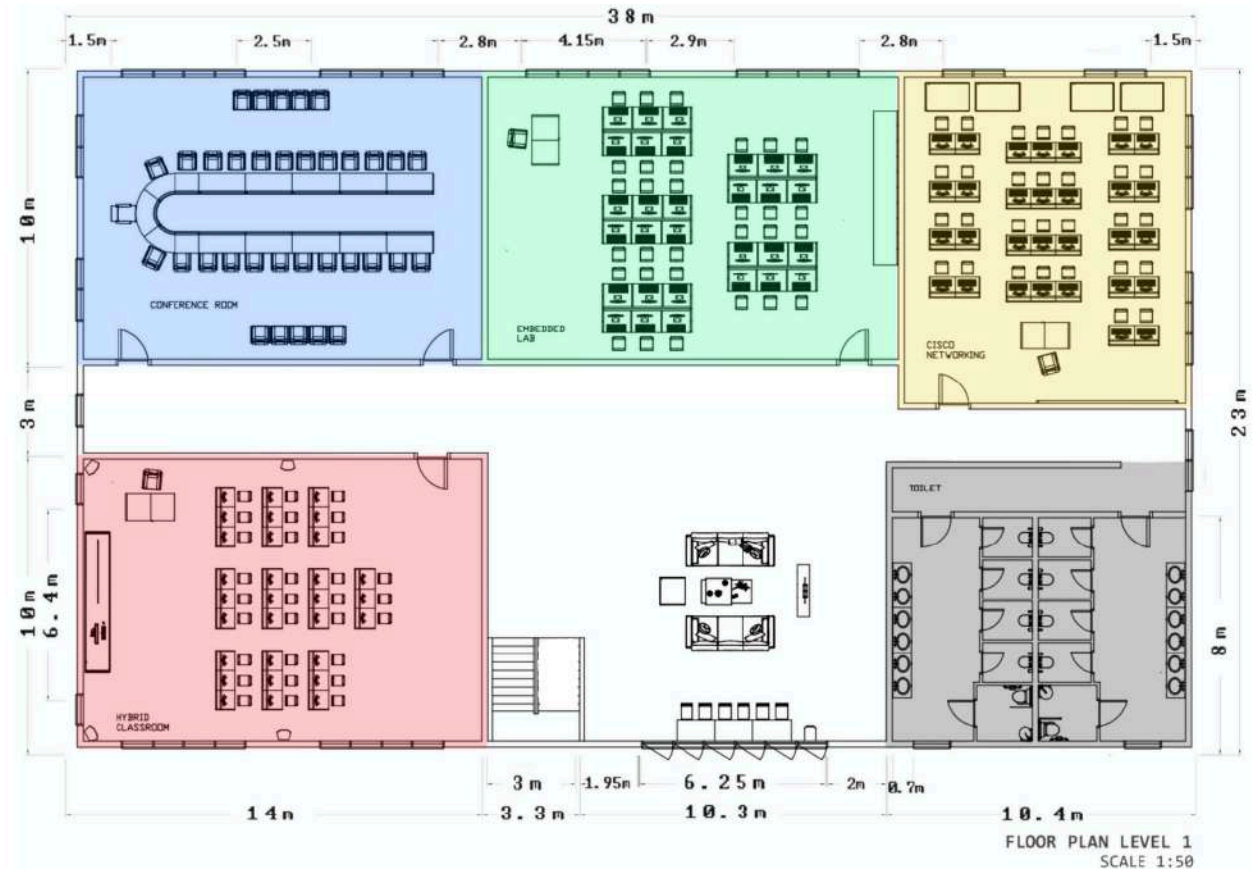
 ADDITIONAL_SPACE.pdf

Figure 1.1.3 Additional space

- **Additional Spaces**

The ground floor also includes a large area with tables and chairs near the bottom right, and a separate set of restroom/toilet facilities.

Floor Level 1

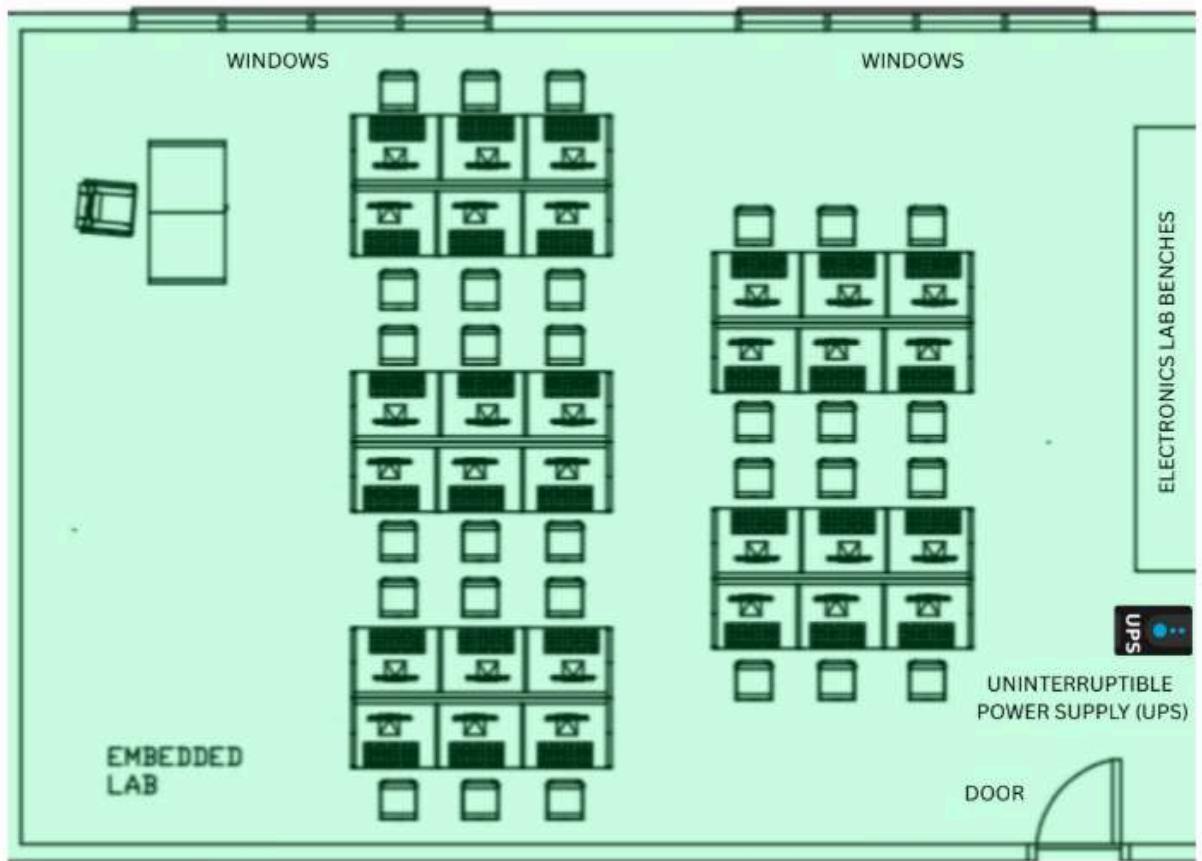


 FLOOR_LEVEL_ONE.pdf

Figure 1.2 Ground floor

- **Specialized Labs:**

This floor houses the remaining two new labs, which are specialized. Each of these labs must also be equipped with 30 workstations.

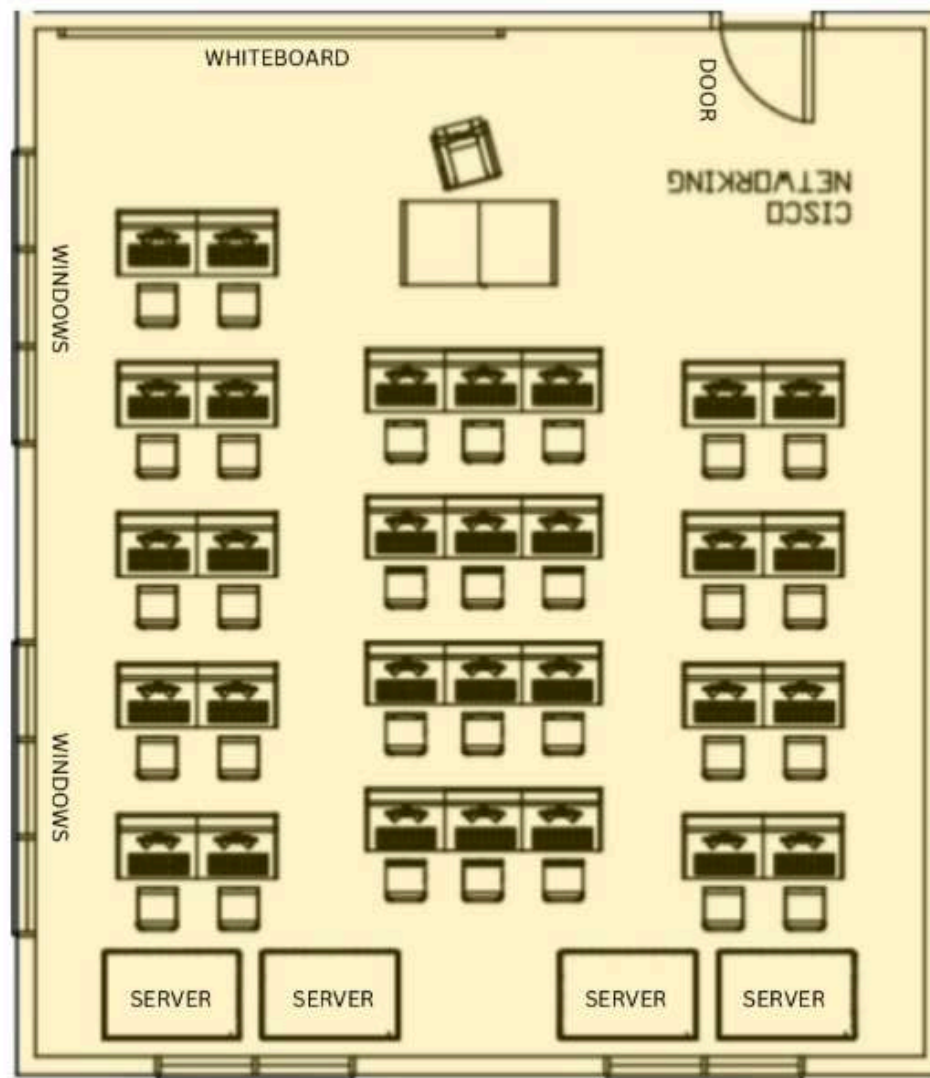


[PDF EMBEDDED_LAB.pdf](#)

Figure 1.2.1 Embedded lab

- **Embedded Lab**

One lab is dedicated as an Embedded Lab (for IOT, Digital, sensors, etc.). The project also specifies that the Embedded Lab is 14x10m, as mentioned earlier, the same is said for all labs.

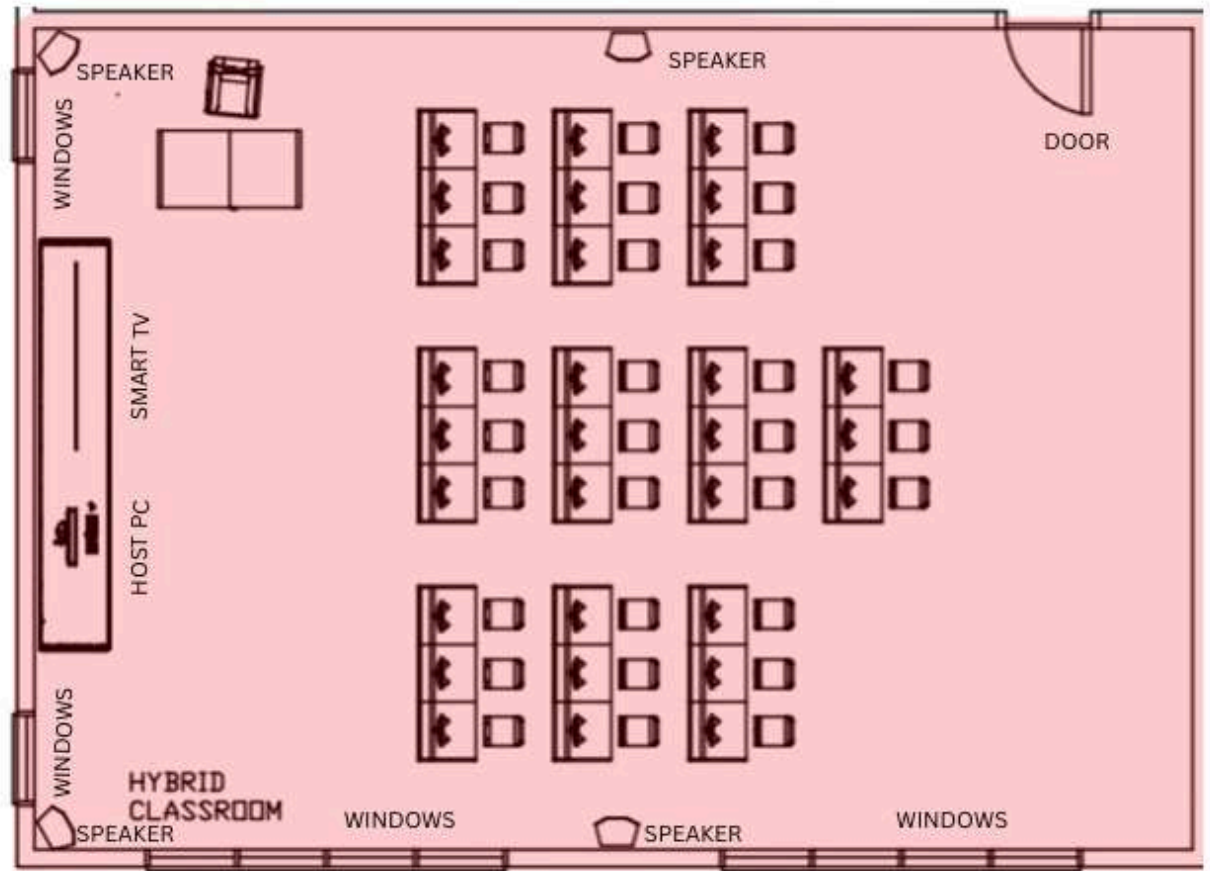


 CISCO_NETWORKING.pdf

Figure 1.2.2 Cisco networking lab

- **Cisco Networking Lab**

The other lab is a Cisco Network Lab (for learning network implementation). The project specifies that the Cisco Network Lab is 14x10m.

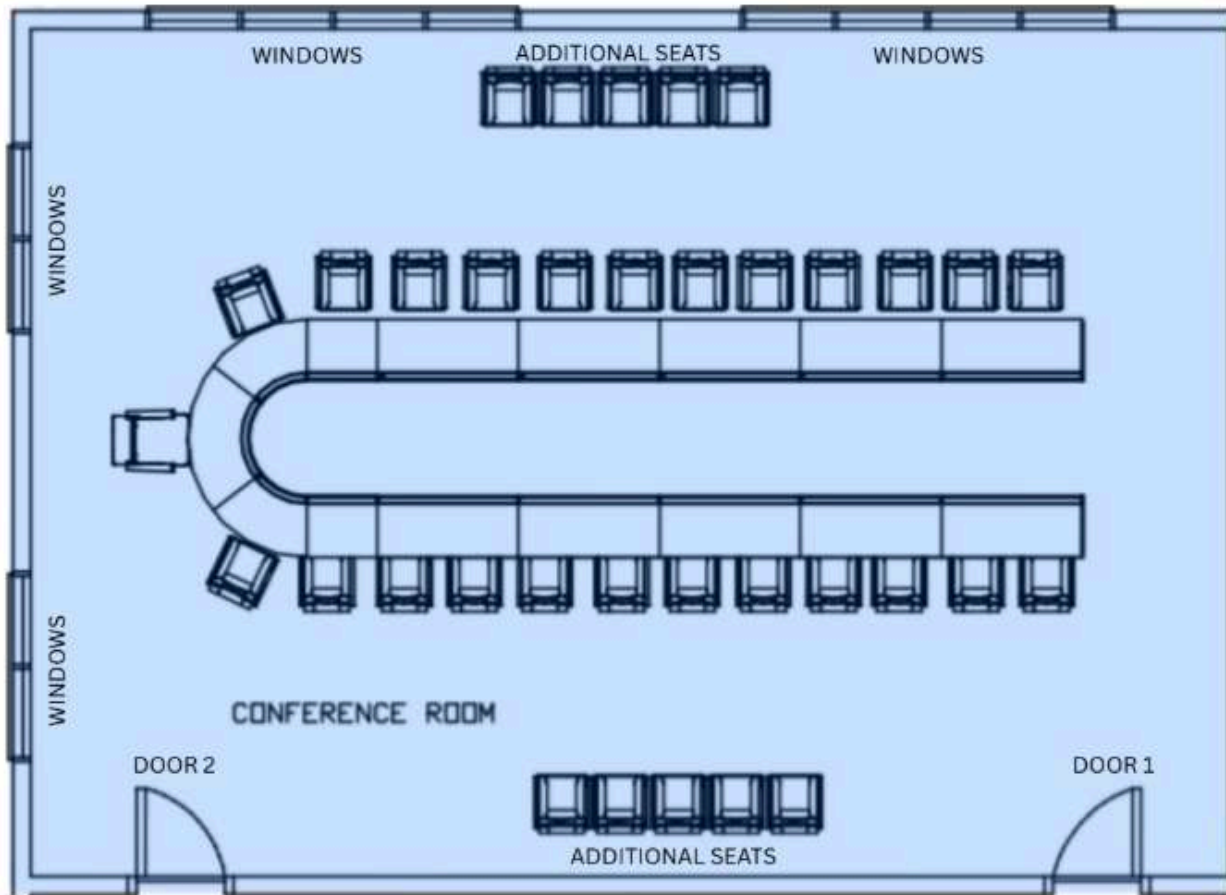


 HYBRID_CLASSROOM.pdf

Figure 1.2.3 Hybrid classroom

- **Hybrid Classroom**

The Hybrid Classroom features a layout centered around a Smart TV and Host PC on the left wall, with approximately 30 student workstations facing the screen. The room is equipped with a multi-speaker system and windows along two walls, creating an environment optimized for digital and hybrid instruction.

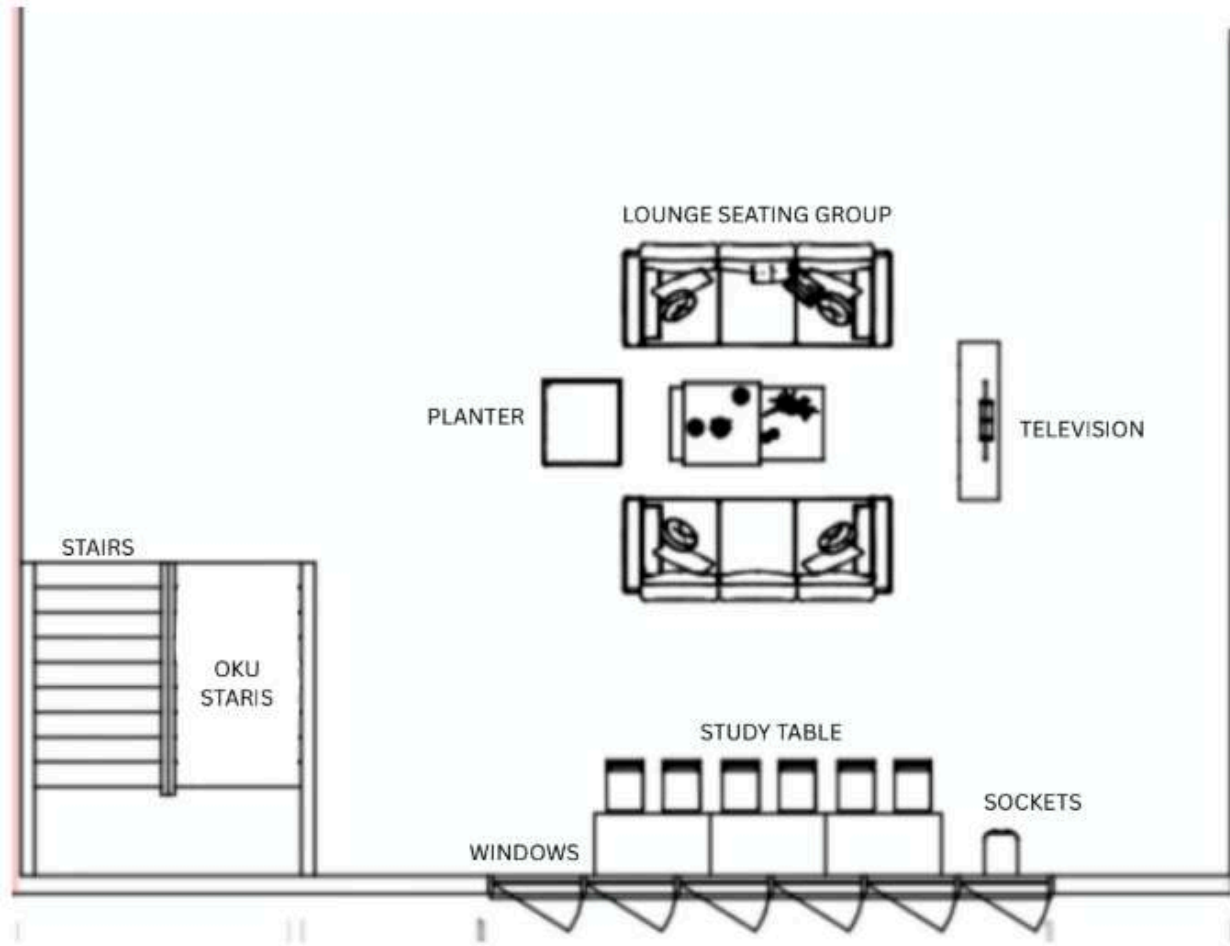


 CONFERENCE_ROOM.pdf

Figure 1.2.4 Conference room

- **Teaching/Meeting Rooms:**

- **Hybrid Classroom:** This classroom must be set up for best performance and efficiency for teaching and learning.
- **Video Conferencing Room:** A room for project meetings is included.



 LOUNGE ROOM.pdf

Figure 1.2.5 Open space

- **Other Spaces:** A rest/waiting area by the stairwell, as well as more restrooms, with the inclusion of the OKU stairwell.

TASK 2: Initial Design - Preliminary Analysis

Overview

This phase focused on gathering the foundational requirements for the project through a preliminary analysis. We conducted interviews with key stakeholders to understand their specific expectations for the new building and to identify the operational problems they faced with the previous infrastructure. This qualitative data served as the baseline for our subsequent technical decisions.

List of questions and answers

1. How do you currently use the existing labs or classrooms for teaching and learning?
 - Current labs are mainly used for face-to-face teaching and lab-based activities such as programming, networking, and project work.
 - Not all labs are hybrid yet, but the faculty is gradually transitioning toward hybrid setups to support both **physical and online learning**.
 - The future goal is to achieve **fully hybrid classrooms**, in line with modern university teaching trends and **4IR (Fourth Industrial Revolution)** education initiatives.
 - Source: **Lecturer Interview**
2. What are the main challenges or issues you face in the current labs or facilities?
 - The lecturer reported **network congestion** during peak hours, especially during final exams or assignment submissions when many users access the network simultaneously.
 - This high traffic causes **significant delays and reduced performance** for both staff and students.
 - Indicates a need for **bandwidth management, load balancing**, and possibly **upgraded switches and routers** that can handle concurrent connections efficiently.
 - Source: **Lecturer Interview**
3. How many students usually attend each lab session or class?
 - Each new lab is expected to accommodate **a maximum of 30 students**.
 - This aligns with the case study requirement and allows sufficient workspace and network capacity for group activities or equipment use.
 - Source: **Lecturer Interview, case study**

4. Do you think the current network and internet connection are sufficient for your teaching activities?
 - Current network performance is **adequate for normal operations**, but struggles during **sudden spikes in user traffic**.
 - Suggests that the new network should incorporate **redundancy, scalable bandwidth allocation**, and **traffic shaping** techniques to handle high-load scenarios.
 - Source: **Lecturer Interview**
5. What type of activities or learning tools (like online platforms, software, or virtual labs) do you often use during your classes?
 - The faculty primarily uses **Webex** for hybrid classes and video conferencing.
 - Some courses (e.g., computer graphics) require **high-bandwidth applications** such as rendering or simulation tools.
 - Future network design must support **consistent high throughput and low latency**, suitable for multimedia and real-time collaboration tools.
 - Source: **Lecturer Interview, online research**
6. What new features or improvements would you like to have in the new labs or classrooms?
 - Improvements should focus on **handling anticipated network requirements and scalability**.
 - The lecturer emphasized the importance of **future-proofing** the network — meaning equipment and configurations should allow easy upgrades for newer technologies (e.g., Wi-Fi 6E, 10GbE switches).
 - Source: **Lecturer Interview**
7. How important is it for you to have wireless connectivity (Wi-Fi) in all areas such as labs, lounges, and classrooms?
 - Wi-Fi connectivity is **critical** for teaching and learning.
 - Each student typically connects **3 to 4 personal devices** (laptop, smartphone, tablet, etc.).
 - With an estimated **1,500 students**, the network must support at least **4,500–6,000 concurrent device connections**.
 - This requires **enterprise-grade access points (APs)** with high client density, proper **channel planning**, and **load balancing** across bands (2.4 GHz, 5 GHz, and possibly 6 GHz for Wi-Fi 6E).
 - Source: **Lecturer Interview, online research, case study**

8. What kind of environment do you think would help students learn and collaborate better in the new building?
- Most collaborative student activities are held in the **student lounge**.
 - The lecturer suggested ensuring the **lounge area has strong, accessible Wi-Fi coverage** to encourage group discussions, project work, and peer learning.
 - The lounge should include sufficient **power outlets**, comfortable seating, and **access to cloud-based learning tools** via the network.
 - Source: **Lecturer Interview**
9. Do you have any suggestions on how the new hybrid classroom or video conferencing room should be set up?
- The current setup is already functioning well but can be improved.
 - Possible enhancements include:
 - **Dual high-resolution displays or smartboards** for in-room and remote participants.
 - **High-quality PTZ (pan-tilt-zoom) cameras** and **noise-cancelling microphones** for clear audio and visuals.
 - **Dedicated network VLAN** for hybrid classroom equipment to ensure stable and prioritized connections.
 - Source: **Lecturer Interview, online research**
10. From a networking perspective, what improvements or features do you expect in the new building's network (e.g., faster internet, better coverage, reliable connections, or more ports)?
- All networking features — **speed, coverage, reliability, and port availability** — are equally important and must be prioritized.
 - Lecturer emphasized that as network consultants, the team should focus on **advanced technology** integration such as:
 - Wi-Fi 6 or Wi-Fi 6E access points for high-density environments.
 - Gigabit or 10-Gigabit Ethernet backbone.
 - Network segmentation via **VLANs** for labs, staff, and students.
 - Centralized **network monitoring system (NMS)** for performance tracking and quick troubleshooting.
 - Source: **Lecturer Interview, online research**

11. What are the main problems or challenges that you often face in maintaining the existing lab network?

- **Lack of real-time monitoring tools** – Current setup doesn't have a centralized system to monitor network performance, uptime, or device health, making troubleshooting slower.
- **Power related problems** – Occasional power trips or unstable power supply affect switches and cause temporary disconnections.
- Source: **Technician Interview**

12. What kind of additional support or facilities would help you manage and maintain the network more effectively in the future?

- **Centralized network management system (NMS)** – A monitoring tool (like Cisco DNA Center or PRTG) to view all devices, detect faults, and manage bandwidth usage efficiently.
- **Dedicated maintenance workstation** – A secure PC connected to all lab networks for quick testing, firmware updates, and configuration backups.
- Source: Technician Interview, online research

Feasibility Analysis and Reasoning

Based on the preliminary analysis, interviews, and project constraints, the proposed network upgrade project is deemed feasible. This conclusion is supported by strong evidence across economic, technical, and operational dimensions.

1. Economic Feasibility

The project is economically viable, SURVIVOR has been given a significant budget of RM 0.9 million. This budget is sufficient to acquire the high-end equipment required by the client, including Wi-Fi 6 or Wi-Fi 6E Access Points, Gigabit/10-Gigabit Ethernet backbone switches, and necessary software licensing for a Centralized Network Management System (NMS). After analysing the initial cost, this confirms that the required infrastructure can be implemented within our financial limits.

2. Technical Feasibility

The technical requirements gathered, specifically the need to support more than 4,500 or less than 6,000 concurrent devices, around that range, and the use of technologies like VLANs for network segmentation, QoS for real-time traffic, and a 10GbE backbone, are all based on *modern, commercially available, and proven* networking standards. Since these technologies are fully compatible with existing university standards and readily available from major vendors, the project poses no difficult and dragging technical challenges.

3. Operational Feasibility

Operationally, the project is highly feasible because the new design directly resolves existing challenges, problems, and mishaps faced by the faculty and technical staff. The implementation of a new network that includes a centralized NMS and dedicated maintenance workstations will eliminate issues like network congestion and the lack of real-time monitoring, leading to easier maintenance, quicker troubleshooting, and overall improved network reliability and uptime for teaching and learning activities.

TASK 3: Choosing the Appropriate LAN Devices

Overview

This section details the selection of network and end-user hardware required to meet the operational needs of the faculty. We have shortlisted network devices with enterprise-grade reliability and cost-efficiency, selecting devices such as Cisco Catalyst 9200 switches for the network backbone and high-performance workstations for labs. Each choice is justified based on technical specifications, power requirements (PoE), and compatibility with the building's infrastructure

Devices Comparisons

1. Router/Firewall




		
Cisco Firepower 1010 (FPR1010-NGFW-K9)	Ubiquiti UniFi Dream Machine Special Edition (UDM-SE)	Fortinet FortiGate 80F
RM3,841.00	RM2,733.00	RM4,617.43
<ul style="list-style-type: none"> ● Performance: 10 Gbps firewall, 1.4 Gbps threat protection (IPS, anti-malware, web filtering) ● Ports: 2 WAN (Gigabit SFP/RJ45), 8 LAN (Gigabit RJ45) ● Security: Next-gen firewall with IPS, anti-malware, web filtering, and network segmentation ● Networking: Secure SD-WAN for reliable Internet and cloud/LMS access 	<ul style="list-style-type: none"> ● 1× 2.5 GbE RJ45 WAN, 1× 10 Gbps SFP+ WAN ● 8× 1 GbE LAN with PoE/PoE+ (6× 802.3af, 2× 802.3at) ● 1× 10 Gbps SFP+ LAN uplink ● Performance: ~3.5 Gbps routing + IDS/IPS throughput ● Features: All-in-one gateway/router/firewall with UniFi OS, IDS/IPS, DPI, PoE/PoE+ switch, 128 GB SSD + HDD bay, 1.3" touchscreen 	<ul style="list-style-type: none"> ● Performance: Firewall 10 Gbps, Threat Protection 1.4 Gbps ● Ports: 2 WAN (Gigabit SFP/RJ45), 8 LAN (Gigabit RJ45) ● Features: Next-gen firewall with IPS, anti-malware, web filtering; Secure SD-WAN ● Design: Fanless, silent, suitable for lab or office rack deployment
Summary <p>The Fortinet FortiGate 80F was chosen because it provides much higher security performance compared to both the Cisco Firepower 1010 and the Ubiquiti UniFi Dream Machine Special Edition. The FortiGate 80F supports up to 10 Gbps firewall throughput and 1.4 Gbps threat protection, making it more suitable for a faculty network with high Internet usage. In comparison, the Cisco Firepower 1010 has lower throughput and limited scalability, which may become a bottleneck as network traffic grows. While the UDM-SE is a good all-in-one device with routing and basic security features. Therefore, the FortiGate 80F offers the best balance of performance, security, and future scalability for the faculty network.</p>		

Table 1.1: Router/Firewall comparison table

2. Core Switch




		
Huawei CloudEngine S6730-H24X6C	FS-S5850-48B8C-PE 48×25Gb + 8×100Gb L3	HPE JL624A – Aruba 8325 – 48x25GbE + 8x100GbE
RM12,484.47	RM22,874.00	RM35,702.25
<ul style="list-style-type: none"> ● Ports: 24 x 10G SFP+, 6 x 100G QSFP28 ● Capacity: 2.4 Tbit/s Switching, 490 Mbps Forwarding ● WLAN: Native AC Built-in (Manage up to 1K APs) ● Feature: Supports VXLAN, Telemetry & BGP-EVPN ● Power: Dual Modular Power Supply (1+1 Redundancy) 	<ul style="list-style-type: none"> ● Ports: 48×10/25G SFP28, 8×40/100G QSFP28 (breakout support) ● Performance: 4 Tbps, 2976 Mpps, 0.7 μs latency ● Power & Cooling: 2 PSUs (1+1), 4 fans (2+2), hot-swappable ● Memory & Buffer: 2 GB DRAM, 8 GB flash, 36 MB buffer ● Other Specs: Jumbo frame 9600, 120K MAC, 60K IPv4 / 4K IPv6 routes, 4K VLANs, 160 W max 	<ul style="list-style-type: none"> ● Ports: 48×25 GbE + 8×100 GbE ● Layer: Fully Layer 3, ArubaOS-CX ● Performance: 6.4 Tbps, ~2000 Mpps ● Redundancy: 2 PSUs, 6 fans ● Protocols: BGP, OSPF, VRF, VXLAN
<p>Summary</p> <p>The Huawei CloudEngine S6730-H24X6C is the most feature-rich choice for converged networks, offering unmatched value for wireless-heavy environments. It serves as a budget-friendly alternative to the higher-capacity FS-S5850-48B8C-PE and the premium HPE Aruba 8325. The S6730-H24X6C features 24×10G SFP+ ports and 6×100G QSFP28 uplinks, with a unique built-in Native AC capable of managing up to 1,000 APs. Supporting VXLAN, BGP-EVPN, and dual modular power redundancy, it is a practical and efficient solution for campus aggregation and core roles, with integrated management.</p>		

Table 1.2: Core Switch comparison table

3. Access Switch (PoE)




		
Cisco Catalyst 9200L-24P-4X-E	USW-Enterprise-24-PoE	FS S3270-24TM-P
RM5,234.87	RM3,118.84	RM2,311.00
<ul style="list-style-type: none"> • Ports: 24× 1 Gbps PoE+ RJ-45 downlinks, 4× 10 Gbps SFP+ uplinks • Performance: 128 Gbps switching, ~190.4 Mbps forwarding • Power & PoE: 600 W AC PSU, fixed redundant fans, up to ~370 W PoE budget (expandable with second PSU) • Software & Stack: Cisco IOS XE with Network Essentials, StackWise-80 stacking support 	<ul style="list-style-type: none"> • Ports: 12× 2.5 GbE PoE+ + 12× 1 GbE PoE+ + 2× 10 Gbps SFP+ uplinks • PoE Power: Up to 400 W total PoE budget, all PoE+ ports • Performance: 124 Gbps switching, ~92 Mbps forwarding • Layer: Managed Layer 3 switch with routing & VLAN support • Extras: Integrated 1.3" touchscreen, rack-mountable, UniFi controller management 	<ul style="list-style-type: none"> • Ports: 24× Gigabit PoE+ RJ45 + 4× 1/2.5 Gb SFP uplinks • Switching: 68 Gbps capacity, ~50.6 MPPS forwarding • PoE: 370 W total PoE budget (IEEE 802.3af/at) • Power & Cooling: Built-in PSU, 2 internal fans • Other: PicOS® OS (managed L2+), jumbo frames, QoS, OSPF, MLAG support
<p>Summary</p> <p>The Cisco Catalyst 9200L-24P-4X-E is the premier choice for mission-critical networks, prioritizing unmatched reliability and performance. It outperforms the Ubiquiti USW-Enterprise-24-PoE and FS S3270-24TM-P by offering a superior 190.4 Mbps forwarding rate, 4× 10Gbps uplinks, and StackWise-80 hardware stacking. With 24× PoE+ ports and advanced IOS XE Layer 3 features, it provides a highly secure, resilient, and scalable solution for enterprise-grade faculty environments.</p>		

Table 1.3: Access Switch (PoE) comparison table

4. Access Switch (non-PoE)




		
Cisco Catalyst 9200L-24T-4X-E	NETGEAR GS524v3 24-Port Gigabit Ethernet Unmanaged Switch	REYEE 24-Port Gigabit Smart Non-PoE Switch Cloud Managed
RM4,059.05	RM889.00	RM833.31
<ul style="list-style-type: none"> ● Ports: 24× 1Gbps data ports and 4× 10G SFP+ uplinks. ● Performance: 128 Gbps switching and 190.4 MPPS forwarding. ● Power: 125W AC PSU with fixed redundant fans (Data-only). ● Stacking: Supports StackWise-80 for hardware resiliency. ● Software: Cisco IOS XE with Layer 2 and basic Layer 3 features. 	<ul style="list-style-type: none"> ● Ports: 24× 10/100/1000 Mbps Gigabit RJ-45 ports (unmanaged) ● Switching Capacity: 48 Gbps non-blocking bandwidth ● Forwarding: Up to ~1,488,000 fps at 1 Gbps per port ● Features: Auto-MDI/MDI-X, 802.1p QoS, jumbo frames up to 9 KB ● Design: Fanless (silent), Energy Efficient Ethernet (IEEE 802.3az), desktop/wall/rack mount 	<ul style="list-style-type: none"> ● Ports: 24 x Gigabit Ethernet ports (10/100/1000 Mbps) ● Switching Capacity: 48 Gbps ● MAC Address Table: 8K entries ● VLAN Support: Up to 4,094 VLANs ● QoS: Traffic prioritization based on port, 802.1p, and DSCP ● Security: Includes features like port security, ACLs, and storm control ● Management: Cloud-based management with SNMP support
<p>Summary</p> <p>The Cisco Catalyst 9200L-24T-4X-E is the premier access switch, balancing enterprise security with high-speed connectivity. It surpasses the unmanaged NETGEAR GS524v3 and the limited REYEE Smart Switch by providing 24× PoE+ ports, 4× 10Gbps uplinks, and StackWise-80 redundancy. This makes it a resilient, secure, and future-proof solution for mission-critical faculty networks requiring maximum performance and manageability.</p>		

Table 1.4: Access Switch (non-PoE) comparison table

5. Wireless Access Point (Student Lounge, Labs)




		
Ubiquiti U6-Enterprise AP Wi-Fi 6E 1x2.5GbE Multiband	TP-Link Omada EAP245 AC1750 Wireless AP	Ubiquiti UniFi AC Mesh UAP-AC-M
RM1,131.35	RM670.00	RM570.00
<ul style="list-style-type: none"> • Wi-Fi 6E (802.11ax) • 2.4 GHz / 5 GHz / 6 GHz (Tri-Band) • Performance: Up to ~1.5 Gbps combined speed • OFDMA and MU-MIMO Technologies • WPA3 Security • Up to 10.2 Gb/s Throughput • 2.5G Ethernet PoE+ Port • Includes Wall & Ceiling Mounting Kit 	<ul style="list-style-type: none"> • Wi-Fi Standard: AC1750 (802.11ac) • Ports: 2× Gigabit RJ45 (PoE support) • Performance: Up to ~1.75 Gbps combined speed • Features: <ul style="list-style-type: none"> ◦ Cloud/Omada controller management ◦ Seamless roaming, band steering, and guest portal ◦ Designed for stable business Wi-Fi • Use Case: Labs, offices, and areas with many users 	<ul style="list-style-type: none"> • Wi-Fi Standard: Wi-Fi 5 (802.11ac) • Ports: 1× Gigabit RJ45 (PoE) • Performance: Good coverage and stable throughput • Features: Mesh support for wide coverage • Use Case: Large halls, outdoor/mesh areas
<p>Summary</p> <p>The Ubiquiti U6-Enterprise is the premier high-density wireless solution, delivering cutting-edge Wi-Fi 6E technology for superior performance. It surpasses the TP-Link Omada EAP245 and UniFi AC Mesh by offering tri-band connectivity, a 2.5 GbE uplink, and a massive 10.2 Gbps aggregate throughput. With support for 600+ concurrent clients and advanced WPA3 security, it provides a future-proof and robust solution for demanding environments requiring maximum reliability and speed.</p>		

Table 1.5: WAP (Student Lounge, Labs) comparison table

6. Wireless Access Point (Hybrid Classroom, Video Conference Room)




		
Huawei AirEngine 6760-X1 Indoor WiFi 6 AP	TP-Link Omada EAP245 AC1750 Wireless AP	Ubiquiti UniFi AC Mesh UAP-AC-M
RM2,319.46	RM670.00	RM570.00
<ul style="list-style-type: none"> ● Wi-Fi Standard: Wi-Fi 6 (802.11ax) ● Ports: 1× 10 GE RJ45, 1× GE RJ45, and 1× 10 GE SFP+ ● Performance: Up to 10.75 Gbps aggregate throughput (with RTU license) ● Features: Built-in Smart Antennas, integrated IoT slots, and 802.3bt PoE support 	<ul style="list-style-type: none"> ● Wi-Fi Standard: AC1750 (802.11ac) ● Ports: 2× Gigabit RJ45 (PoE support) ● Performance: Up to ~1.75 Gbps combined speed ● Features: <ul style="list-style-type: none"> ○ Cloud/Omada controller management ○ Seamless roaming, band steering, and guest portal ○ Designed for stable business Wi-Fi ● Use Case: Labs, offices, and areas with many users 	<ul style="list-style-type: none"> ● Wi-Fi Standard: Wi-Fi 5 (802.11ac) ● Ports: 1× Gigabit RJ45 (PoE) ● Performance: Good coverage and stable throughput ● Features: Mesh support for wide coverage ● Use Case: Large halls, outdoor/mesh areas
<p>Summary</p> <p>The Huawei AirEngine 6760-X1 is the ultimate high-performance wireless solution, outclassing the TP-Link Omada EAP245 and Ubiquiti AC Mesh with its massive 10.75 Gbps throughput and Wi-Fi 6 technology. It features advanced 10 GE and SFP+ uplinks to eliminate bottlenecks, alongside Smart Antennas and IoT support for superior coverage and future-proof scalability. Supporting over 1,000 concurrent users, it is the most robust and reliable choice for high-density environments like large lecture halls or busy faculty centers.</p>		

Table 1.6: WAP (Hybrid, Conference room) comparison table

7. Server




		
Dell PowerEdge T150 Tower Server	HPE ProLiant ML30 Gen10 Plus Server	DELL PowerEdge T350 Tower Server (Basic Variant)
RM4,507.00	RM8,440.00	RM8,200.00
<ul style="list-style-type: none"> ● CPU: Intel Xeon E-2314 ● RAM: 16 GB ECC ● Storage: 2 TB HDD ● Network: Dual 1 Gb Ethernet ● Use Case: File server, small applications, basic virtualization server, listing above 	<ul style="list-style-type: none"> ● CPU: Intel Xeon E-2124 ● RAM: 16 GB ECC ● Storage: Expandable (multiple drive bays) ● Network: 1 Gb Ethernet ● Use Case: Business applications, database, light to medium virtualization 	<ul style="list-style-type: none"> ● CPU: Intel Xeon E-2324G ● RAM: 8 GB ECC (upgradeable) ● Storage: Highly expandable ● Network: Dual 1 Gb Ethernet ● Use Case: Larger workloads, future expansion, multiple service hardware
<p>Summary</p> <p>The HPE ProLiant ML30 Gen10 Plus is the superior choice for businesses requiring a reliable foundation for databases and virtualization. While the Dell PowerEdge T150 is the most affordable option (RM4,507), it is limited to basic file server tasks. The HPE model justifies its RM8,440 price point by offering 16 GB of ECC RAM straight out of the box—double the memory of the similarly priced Dell PowerEdge T350 (8 GB). This immediate performance advantage, combined with its proven stability for business applications, makes HPE the most complete and dependable solution for professional workloads.</p>		

Table 1.7: Server comparison table

8. Desktop (Standard)


		
DELL OptiPlex Tower	HP Pro Tower 400 G9 PCI Desktop PC	ACER ASPIRE XC-1785-14400W11S
RM3,255.00	RM3,137.00	RM2,452.20
<ul style="list-style-type: none"> ● Processor: 14th Generation Intel® Core™ i5-14400 Processor ● Operating System: Windows 11, Home 64 ● Graphic Card: Integrated Graphics ● Memory: 8 GB DDR5-4800MT/s (UDIMM) ● Storage: 256 GB SSD M.2 2280 PCIe Gen4 TLC Opal 	<ul style="list-style-type: none"> ● CPU: Intel® Core™ i5-14500 (14th Gen, up to 5.0 GHz) ● Memory: 8 GB DDR5-4800 MHz RAM ● Storage: 512 GB PCIe® NVMe SSD ● Graphics: Intel® UHD Graphics 770 ● OS & Extras: Windows 11 Pro, includes wired keyboard & mouse 	<ul style="list-style-type: none"> ● OS: Windows 11 Home 64-bit ● Processor: Intel® Core™ i5-14400 ● Memory: 8GB DDR5 5600 MHz UDIMM (upgradable to 16GB*2) ● Storage: 512 GB M.2 2280 PCI-e Gen4 SSD ● Network Interface: 802.11ax/ac/a/b/g/n, Wi-Fi 6 and Bluetooth® 5 ● Provide: Acer Wired keyboard and mouse
<p>Summary</p> <p>The ACER ASPIRE XC-1785-14400W11S is the clear winner for standard desktop deployments, offering unbeatable value without sacrificing performance. At just RM2,452.20, it provides the same 14th Gen Intel Core i5-14400 processing power as the Dell OptiPlex Tower but costs approximately RM800 less. Furthermore, it outclasses the more expensive Dell model by doubling the storage capacity (512 GB vs. 256 GB) and providing faster RAM speeds (5600 MHz vs. 4800 MHz). By delivering superior specifications at the lowest price point among the three, Acer is the smartest investment for maximizing budget efficiency while ensuring high-speed daily productivity.</p>		

Table 1.8: Desktop (Standard) comparison table

9. Desktop (Pro)

		
HP Pro Mini 400 G9	ROG NUC (2025) Gaming Mini PC	Lenovo Legion Tower 5i
RM3,255.00	RM12,986	RM5,517.01
<ul style="list-style-type: none"> ● Processor: Intel® Core™ i5-14500T (up to 4.8 GHz with Intel® Turbo Boost Technology) ● Operating System: Windows 11 Pro ● Graphic Card: Integrated Intel® UHD Graphics 770 ● Memory: 8 GB DDR5-4800 MHz RAM (1 x 8 GB) ● Storage: 512 GB PCIe® NVMe™ SSD 	<ul style="list-style-type: none"> ● CPU: 2.7 GHz intel_core_ultra_9 ● Memory: 32GB DDR5 RAM ● Storage: 2 TB SSD ● Graphics: Nvidia GeForce RTX USB 3.2 Gen2 ● OS & Extras: Windows 11 Home 	<ul style="list-style-type: none"> ● Processor: Intel® Core Ultra 7 265F Processor (AI-Powered) ● Operating System: Windows 11 Home ● Graphic Card: NVIDIA® GeForce RTX™ 5060 Ti ● Memory: 16 GB DDR5 ● Storage: 1 TB SSD M.2 PCIe Gen4
<p>Summary</p> <p>The Lenovo Legion Tower 5i is the definitive choice for high-duty performance on a budget, delivering the best value among the three options. At RM5,517.01, it vastly outperforms the HP Pro Mini by offering a dedicated RTX 5060 Ti GPU and AI-powered Core Ultra 7 processor, making it capable of handling heavy rendering and gaming tasks that the HP cannot touch. Crucially, it provides this workstation-grade power at less than half the price of the ROG NUC (RM12,986), proving that you do not need to overspend to get a high-performance, future-proof machine.</p>		

Table 1.9: Desktop (Advanced) comparison table

10. Keyboard & Mouse




		
HP 225 Wired Mouse and Keyboard Combo	Dell KB216 Multimedia USB Chiclet Keyboard + MS116 USB Optical Mouse	Lenovo Essential Wired Combo Keyboard and Mouse
RM93.00	RM43.90	RM88.20
<ul style="list-style-type: none"> • Price: ~RM 93 (Discounted from RM 116). • Keyboard: Full-size 3-zone layout with adjustable feet (0-6 degrees) and a dedicated Copilot AI Key. • Mouse: Ambidextrous design with 3 buttons and a scroll wheel (Red optical tracking). • Connection: Wired USB (1.8m cables for both). • Durability: Designed to withstand daily cleaning with disinfecting wipes. 	<ul style="list-style-type: none"> • Price: ~RM 44 – RM 47 • Keyboard: Quiet "chiclet" keys with dedicated media buttons (volume/play/pause). • Mouse: 1000 DPI optical sensor (standard speed/precision). • Connection: Wired USB (1.8m cable), plug-and-play. • Colors: Available in Black or White. • Warranty: 1-Year Local Manufacturer Warranty (Dell). 	<ul style="list-style-type: none"> • Keyboard: Low-profile "island-style" keys, spill-resistant, and includes a dedicated Microsoft Copilot AI Key. • Mouse: Ambidextrous full-size mouse with a 1600 DPI optical sensor. • Connection: Wired USB (1.8m cables for both). • Durability: Keyboard handles up to 10 million clicks; Mouse up to 1 million clicks.
<p>Summary</p> <p>The Lenovo Essential Wired Combo (Gen 2) stands out as the best overall choice, offering the ideal balance of performance and durability for modern productivity. Priced at RM88.20, it outperforms the budget-friendly Dell KB216 (RM43.90) by providing a superior 1600 DPI mouse for precise tracking and adding valuable spill resistance to protect against accidents. Furthermore, it offers better value than the HP 225 (RM93.00) by matching key features like the Copilot AI key and offering better liquid protection at a lower price point, making it the most practical investment for daily heavy usage.</p>		

Table 1.10: Keyboard & Mouse comparison table

11. Monitor




		
ThinkVision S22i-30 21.5" Monitor	Dell E2222HS	HP V22v G5
RM534.00	RM339.00	RM440.00
<ul style="list-style-type: none"> • Ports: 1x HDMI 1.4, 1x VGA, 1x Audio-out (3.5 mm) • Design: 21.5" IPS panel; 3-side NearEdgeless bezel; includes tilt stand with integrated phone holder and VESA mount support (100x100mm) • Modularity: Fixed stand, standard VESA mounting • Use Case: Best for university labs requiring high color accuracy (99% sRGB) and eye protection (Natural Low Blue Light) for long coding sessions 	<ul style="list-style-type: none"> • Ports: 1x HDMI 1.4, 1x VGA, 1x DisplayPort 1.2 • Design: 21.5" VA panel; traditional thick bezels; height-adjustable stand with built-in speakers • Modularity: Height-adjustable stand included; VESA compatible (100x100mm) • Use Case: Ideal for office environments requiring legacy connectivity (DisplayPort) and built-in audio 	<ul style="list-style-type: none"> • Ports: 1x HDMI 1.4, 1x VGA • Design: 21.45" VA panel, 3-side micro-edge design, compact tilt-adjustable stand • Modularity: Basic tilt stand, VESA mountable (100x100mm). • Use Case: A budget-friendly option for general administrative tasks and basic student use
<p>Summary</p> <p>We chose the ThinkVision S22i-30 because it is the only monitor in this budget that offers 99% sRGB color coverage. For a computing faculty, this accuracy is vital for students working on UI/UX design or web development. Additionally, its 75Hz refresh rate provides a much smoother experience than the 60Hz alternatives, all while being the most affordable option.</p>		

Table 1.11: Monitor comparison table

12. IP Webcam



		
TENVEO VL12U	ROCWARE RC840	OBSBOT Tail Air
RM2,530.24	RM6,608.19	RM3,405.75
<ul style="list-style-type: none"> • 12X optical zoom; 4K video resolution; • Sleek and intelligent design • AI function is optional and available for purchase separately • Preset: 10 via IR remote setting (255 via PELCO-P/D/64 via VISCA) • USB3.0, HDMI, RJ45, support POE 	<ul style="list-style-type: none"> • Resolution: 4K Ultra HD @ 60fps (Panasonic Sensor). • Zoom: 20x Optical Zoom • Ports: HDMI 2.0, USB 3.0, 3G-SDI, and RJ45 (LAN). • Network Video: Supports NDI HX for high-quality video over standard networks. 	<ul style="list-style-type: none"> • Advanced AI Auto Tracking • UHD Resolutions up to 4K@30fps / 1080P@60fps • Seamless NDI Connectivity • Multi-port Connections • Exclusive App Support: Obsbot Start & Obsbot Live • PowerUp Combo - NDI Activated
<p>Summary</p> <p>We have selected the Tenveo VL12U because it offers the most practical balance of optical clarity and installation reliability for a hybrid classroom. Unlike the OBSBOT Tail Air, which relies on digital cropping and external adapters, the Tenveo features a true 12x Optical Zoom and a native RJ45 port with PoE. This ensures remote students can clearly read handwritten whiteboard text and that the installation is stable without loose dongles. Furthermore, it provides the same critical professional connectivity (HDMI, USB 3.0, LAN) as the Rocware RC840, delivering all the necessary classroom functionality without the "overkill" specifications that drive the price up.</p>		

Table 1.12: IP Webcam comparison table

13. IP Speaker



		
AXIS C1210-E Network Ceiling Speaker	BenQ MH733	Grandstream GSC3510
RM2,142.45	RM5,332.32	RM1,076.85
<ul style="list-style-type: none"> • All-in-one speaker system • Connects to a standard network • Easy installation with just one network cable (PoE) • MaximumAudio Output: 105 dB Maximum Sound Pressure Level (SPL) • Scalable and easy to integrate • Remote health testing 	<ul style="list-style-type: none"> • 3-in-1 Design: Combines a PA speaker. • Smart Volume: Ambient Noise Compensation automatically adjusts the volume based on room noise. • Relay I/O: Terminal block for external call buttons or door control. 	<ul style="list-style-type: none"> • Wireless Hybrid: A unique built-in Dual-Band Wi-Fi and Bluetooth allow for installation without running network cables. • Superior Intercom: Uses 3 directional microphones with a 4.2-meter (15ft) pickup range for very clear 2-way voice communication.
<p>Summary</p> <p>We have selected the AXIS C1210-E (RM2,142.45) for its superior audio power and enterprise reliability compared to the Grandstream model. With a high 105 dB output, it ensures announcements are clearly heard, while its unique remote health testing feature automatically verifies functionality to minimize maintenance. The unit simplifies infrastructure with a single-cable PoE connection, offering a robust, professional-grade solution for our facility.</p>		

Table 1.13: IP Speaker comparison table

14. Projector

		
Epson EB-FH52	BenQ MH733	Optoma EH412
RM4,189.00	RM4,750.00	RM5,335.00
<ul style="list-style-type: none"> ● Projection Technology: 3LCD (3-chip technology) ● Native Resolution: Full HD 1080p (1920 x 1080) ● Brightness: 4,000 Lumens ● Wireless Connectivity: Built-in Wi-Fi and Screen Mirroring ● Wired Inputs: 2 x HDMI, 1 x VGA (D-Sub 15-pin), 1 x Composite (RCA), 1 x Audio In (2 x RCA Red/White) 	<ul style="list-style-type: none"> ● Projection Technology: DLP (Single chip) ● Native Resolution: Full HD 1080p (1920 x 1080) ● Brightness: 4,000 Lumens ● Contrast Ratio: 16,000:1 ● Wireless: Requires optional QCast dongle ● Wired Inputs: 2 x HDMI (one supports MHL), USB Type-A (Reader), VGA, RS232 	<ul style="list-style-type: none"> ● Projection Technology: DLP ● Native Resolution: Full HD 1080p (1920 x 1080) ● Brightness: 4,500 Lumens ● Contrast Ratio: 50,000:1 (Dynamic) ● Wireless Connectivity: Strictly cabled or requires 3rd party dongle ● Wired Inputs: 1 x HDMI 2.0 (4K Input Compatible), 1 x HDMI 1.4, VGA, Audio In/Out
<p>Summary</p> <p>We have selected the Epson EB-FH52 because it offers the best overall value at RM4,189.00, saving significantly compared to the BenQ (RM4,750) and Optoma (RM5,335) alternatives. Unlike its competitors, the Epson features built-in Wi-Fi and screen mirroring, which eliminates the need to purchase and manage separate, easily lost wireless dongles. Additionally, its 3LCD technology ensures superior colour accuracy and image stability compared to the single-chip DLP systems found in the rival models. Ultimately, the Epson provides a complete, "ready-to-use" solution for our 25-person conference room without requiring any additional hardware investments.</p>		

Table 1.14: Projector comparison table

15. Smart TV




		
Sharp AQUOS 75" 4K UHD Google TV (Model: 4TC75FK1X)	75" Crystal UHD UE100F 4K Smart TV (2025)	LG 75" 75UR640S UHD TV Signage
RM4,434.00	RM3,549.00	RM9,799.00
<ul style="list-style-type: none"> ● Google TV: Native support for classroom apps (Meet, Slides) and Android ecosystem. ● Hands-Free Voice: Teacher can control the TV ("Hey Google") without the remote. ● Eye Comfort: TUV-certified mode to reduce eye strain during long lessons. ● Reliability: Known for durable build quality in educational settings. 	<ul style="list-style-type: none"> ● Screen Size 75-Inch (Massive display, suitable for 20-30 pax viewing) ● Resolution 4K UHD (3,840 x 2,160) — <i>4x the pixels of Full HD for sharp text.</i> ● PC on TV (Workspace) AudioQ-Symphony (Syncs with soundbars for better room audio) 	<ul style="list-style-type: none"> ● PC-Free Management: Built-in tools to schedule and play content directly on the TV. ● Mobile Ready: Create and update display info instantly via the LG Promota app. ● AV Integrated: Certified Crestron Connected® for automated room control. ● Commercial OS: Runs on webOS 6.0 for reliable, smooth multitasking. ● Slim Profile: Professional, thinner design
Summary For a hybrid classroom, the Samsung 75" Crystal UHD UE100F (RM3,549) is the best choice because it offers the lowest price (saving RM6,250 over the LG) while delivering essential hybrid features like PC on TV (Workspace) for remote desktop access and Q-Symphony for better classroom audio, giving you high-value 4K performance without the extra cost of commercial signage or voice control features found in the Sharp and LG models.		

Table 1.15: Smart TV comparison table

16. Smart Board

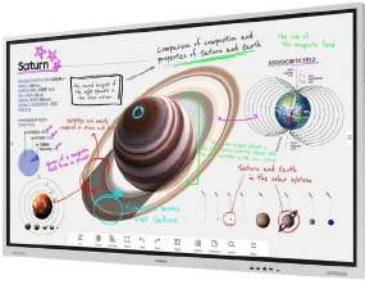

		
<p>Samsung Flip Pro 65" (WM65B)</p>	<p>ViewBoard IFP6552-1C ViewBoard® 65" 4K Interactive Display</p>	<p>BenQ Board Pro RP04 (Pre Order)</p>
<p>RM14,999.00</p>	<p>RM8,642.00</p>	<p>RM16,800.00</p>
<ul style="list-style-type: none"> ● 65" 4K UHD: Interactive anti-glare display for clear visuals. ● Natural Writing: Fast 26ms latency for a smooth, pen-on-paper feel. ● USB-C Ready: Single-cable connection for video, touch, and power. ● Easy Sharing: Supports Apple AirPlay 2 and wireless casting. ● Smart Features: Tizen 6.5 OS with built-in video conferencing support. 	<ul style="list-style-type: none"> ● Google Certified: EDLA support for native Play Store & Google apps on Android 14. ● AI Camera: Built-in 50MP lens with voice tracking and 4x zoom. ● Pro Audio: 8-microphone array ensures clear voice pickup. ● USB-C: Single-cable connection for video, data, and power. ● 4K Touch: 65" UHD interactive display for engaging visuals. 	<ul style="list-style-type: none"> ● Google Certified: Official integration with Play Store and Google Workspace. ● Fast Performance: Runs on Android 13 with an 8-core processor for smooth use. ● Smart Whiteboard: EZWrite 6 enables live cloud sharing and collaboration. ● Quick Login: NFC tap instantly loads personal files and settings. ● Voice Control: Hands-free "Hey Google" support via remote.
<p>Summary</p> <p>The Samsung Flip Pro (RM14,999) offers the best paper-like writing but is priced uniquely. It's much costlier than the ViewSonic (RM8,642) and lacks its 50MP camera and 8-mic array. Unlike the pricier BenQ Board Pro (RM16,800), the Samsung omits complex Google EDLA and NFC login, positioning itself as an easy-to-use creative tool rather than an all-in-one classroom system.</p>		

Table 1.16: Smart Board comparison table

17. Uninterruptible Power Supply (UPS)




		
Right Power Powertank F800P	APC BVX1200LI-MS APC	Prolink PRO1201SFCU 1200VA
RM251.00	RM539.00	RM325.00
<ul style="list-style-type: none"> • Capacity: 800VA (approx. 480 Watts) – Suitable for office PCs or low-power devices. • Protection: Built-in AVR (stabilizes voltage fluctuations) + Lightning, Spike & Surge Protection. • Display: Digital LCD screen (Shows battery level, input/output voltage). • Backup Time: Approx. 20–30 minutes (depending on how heavy the load is). 	<ul style="list-style-type: none"> • Provides 1200VA / 650 Watts of power, suitable for handling the Lenovo Legion Tower. • Includes Automatic Voltage Regulation (AVR) to stabilize voltage fluctuations instantly. • Offers about 5 minutes of backup runtime at half load for safe shutdowns. 	<ul style="list-style-type: none"> • Delivers 1200VA / 720 Watts of power, offering a higher wattage capacity than the APC model. • Features Super Fast Charging, recharging the battery to 90% in just 2-4 hours. • Equipped with Universal sockets compatible with Malaysian plugs and built-in AVR for voltage stability. • Covered by a 2-year warranty for both the unit and the battery.
<p>Summary</p> <p>The Prolink PRO1201SFCU is the best choice for the lab room, offering the superior balance of power capacity and value. At RM325, it provides the highest power output (720 Watts), which is critical for supporting high-performance workstations like the Lenovo Legion Tower, giving it a distinct advantage over the APC model (650 Watts), which costs significantly more at RM539. Additionally, its USB connection for battery management makes it more practical for a lab environment compared to the Right Power F800P, which lacks the necessary wattage (480 Watts) to safely handle heavy computing loads.</p>		

Table 1.17: UPS comparison table

18. Cable (Fiber)




		
FOB-MFD-24FM4R-M OM4 Multi-Mode Fiber Optic 24 Fibres	OPTI-CORE OUTSIDE PLANT ARMORED CABLE 250UM OM3 6 FIBER	Customized 24 Fibers OM4 Multimode LC/SC/FC/ST/LSH Indoor Tight-Buffered Multi-Fiber Breakout Cable
RM139.01	RM10.00	RM298.04
<ul style="list-style-type: none"> ● OM4 Multinode ● 50µm / 125µm ● 24 Fibres ● 7.8mm ● Manufacture: L- COM 	<ul style="list-style-type: none"> ● Brand: PANDUIT ● Cable Geometry: Round ● Material Armouring: Steel ● Tube: Loose Tube 	<ul style="list-style-type: none"> ● Fibers count: 24 Fibers ● Length: 1m ● Cable Jacket: Riser (OFNR) ● Breakout Type (A to B): Fan-out in line 0.3m to Fan-out in line 0.3m ● Breakout Diameter: 2.0mm
<p>Summary</p> <p>The L-COM (RM139) offers a balanced, high-capacity solution with 24 OM4 fibers, ideal for standard backbones. The Panduit (RM10) is a budget-friendly, armored outdoor option, but is limited to just 6 OM3 fibers and requires splicing. The Customized Breakout (RM298) is the premium choice, providing 24 OM4 fibers in a tight-buffered, plug-and-play design that simplifies indoor installation significantly.</p>		

Table 1.18: Fiber cable comparison table

19. Cable (Copper)




		
RS PRO Cat6a Ethernet Cable (100m)	RS PRO Cat6 Ethernet Cable (305m)	RS PRO Cat8 Ethernet Cable (100m)
RM635.91	RM730.00	RM1,034.60
<ul style="list-style-type: none"> ● Type & Category: RS PRO Cat6a Ethernet cable, shielded (F/FTP) for high-speed networks. ● Length & Color: 100 m reel, white LSZH outer jacket. ● Construction: 4 twisted pairs, solid bare copper cores, foam PE insulation. ● Performance: Supports 10 Gbps Ethernet up to 100 m with reduced crosstalk. ● Durability: Voltage rated 300 V, operating temperature -20 °C to +75 °C. 	<ul style="list-style-type: none"> ● Type & Category: Unshielded Cat6 Ethernet cable (U/UTP) on a bulk reel. ● Length & Color: 305 m, white jacket ● Construction: 4 twisted pairs of solid copper conductors. ● Sheath: Low Smoke Zero Halogen (LSZH) outer jacket. ● Performance: Cat6 standard supports up to ~250 MHz data bandwidth. 	<ul style="list-style-type: none"> ● Category & Type: Cat 8 Ethernet cable with S/FTP shielding for high-speed network performance. ● Length & Jacket: 100 m reel with white Low Smoke Zero Halogen (LSZH) outer jacket. ● Construction: 4 shielded twisted pairs (S/FTP) with stranded 26 AWG copper conductors. ● Performance: Designed for next-gen Ethernet (high frequency, up to 2000 MHz typical Cat8 spec). ● Termination: Underterminated
<p>Summary</p> <p>We'd choose the RS PRO Cat6 Ethernet Cable (305m) at RM730.00 because it strikes the best balance between price and reliable performance for standard infrastructure. As a Unshielded (U/UTP) cable featuring 4 twisted pairs of solid copper conductors, it ensures robust connectivity without the added cost or bulk of shielding. It meets the Cat6 standard with support for ~250 MHz data bandwidth, making it perfectly capable of handling Gigabit speeds for typical office or faculty use. Additionally, the Low Smoke Zero Halogen (LSZH) white jacket adds a critical layer of safety and durability. It avoids the overkill pricing of Cat8 while providing the exact specifications needed for a professional, high-quality installation.</p>		

Table 1.19: Copper cable comparison table

20. Patch Panel




		
Pro Signal 24-Port Cat6 Patch Panel	CommScope SL Series 24-Port Panel	24-Port Shielded Keystone Patch Panel
RM172.00	RM300.00	RM75.00
<ul style="list-style-type: none"> ● Ports: 24 RJ45 (Cat6 unshielded) ● Design: 1U, 19" rack-mount steel panel, supports T568A/B wiring standards ● Modularity: Uses CommScope SL modular jack system; modules can be replaced or reconfigured if needed ● Use Case: Best for clean, organized structured cabling in office/lab racks; meets Cat6 performance standards (Gigabit Ethernet) 	<ul style="list-style-type: none"> ● Ports: 24 RJ45 Cat6 ● Design: 1U, 19" rack mount with IDC punch-down terminations ● Performance: Cat6 support for up to Gigabit Ethernet (1 Gbps) ● Use Case: Simple, reliable panel ideal for most campus/office cabling where shielded cables aren't required 	<ul style="list-style-type: none"> ● Ports: 24 shielded keystone openings for adapter jacks ● Design: 1U rack-mount panel with shielded metal housing ● Flexibility: You add your own Cat6/6A keystone jacks (great for mixed environment or shielded cables) ● Use Case: Good if you plan to terminate various cable types or want shielded termination for EMI-noisy areas
<p>Summary</p> <p>The CommScope SL Series 24-Port Patch Panel is the preferred choice because it combines high-quality Cat6 performance, modular flexibility, and professional-grade durability. Unlike fixed punch-down panels, its replaceable modules allow easy upgrades to Cat6a or special connectors, supporting future network growth. CommScope's reputation ensures robust build quality and easier long-term maintenance. While the Pro Signal panel is cheaper with fixed terminations and the shielded keystone panel requires extra parts, the SL Series offers the best balance of reliability, flexibility, and ease of installation for a faculty network rack.</p>		

Table 1.20: Patch panel comparison table

List of Selected Devices

Purpose	Model Name	Price x Quantity	Subtotal
Router/Firewall	Fortinet FortiGate 80F	4,617.43 x 1	4,617.43
Core Switch	Huawei CloudEngine S6730-H24X6C	12,484.47 x 2	24,968.94
Access Switch (PoE)	Cisco Catalyst 9200L-24P-4X-E	5,234.87 x 2	10,469.74
Access Switch (non-PoE)	Cisco Catalyst 9200L-24T-4X-E	4,059.05 x 8	32,472.40
Wireless Access Point (Student Lounge, Labs)	Ubiquiti UniFi 6 Enterprise	1,131.35 x 6	6,788.10
Wireless Access Point (Hybrid, Smart Classroom)	Huawei AirEngine 6760-X1	2,319.46 x 2	4,638.92
Server	HPE ProLiant ML30 Gen10 Plus Server	8,440 x 1	8,440
Desktop (standard)	ACER ASPIRE XC-1785-14400W11S	2,452.20 x 60	147,132
Desktop (Advanced)	Lenovo Legion Tower 5i	5,517.01 x 60	331,020.60
Keyboard & Mouse	Lenovo Essential Wired Combo	88.20 x 60	5,292
Monitor	ThinkVision S22i-30	534 x 120	64,080
IP Webcam	TENVEO VL12U (4K AI PTZ Camera)	2,530.24 x 2	5,060.48
IP Speaker	AXIS C1210-E	2,142.45 x 3	6,427.35
Projector	Epson EB-FH52	4,189 x 4	16,756
Smart TV	Samsung 75" Crystal UHD UE100F	3,549 x 1	3,549
Smart Board	Samsung Flip Pro 65" (WM65B)	14,999 x 1	14,999

UPS	HPE ProLiant ML30 Gen10 Plus	8,440 x 1	8,440
Cable (Copper)	CommScope CS30CM Cat6 (100m)	372.00 (per 100 meter) x 4	1,488
Cable (Fiber)	OM4 Multi-Mode Fiber Optic	133.51 (per meter) x 90	12,015.90
Patch Panel	CommScope SL Series 24-Port	300.00 x 2	600
Total			RM 709,255.86

Table 1.21: List of selected devices

TASK 4: Making the Connections

Overview

This task established the physical and logical connectivity logic for the network. Using our floor plans and the selected hardware from the previous tasks, we designed the complete Network Topology and defined the cabling infrastructure. This includes the planning of **Vertical Cabling** (backbone connections) and **Horizontal Cabling** to ensure every room and device is correctly linked to the central network.

Connectivity Logic

For this network design, we have implemented a **Hierarchical Star Topology** utilizing a collapsed core architecture. We organize devices into a logical tree structure consisting of two main layers, which are the **Core Layer** and the **Access Layer**.

The topology is physically distributed across two floors (Ground Floor and Level 1). The design centers around a high-availability Core Switch stack on Level 1, which acts as the central backbone connecting the Internet Gateway (Firewall), local servers, and the Access Switches located in various labs and rooms to ensure efficient traffic management.

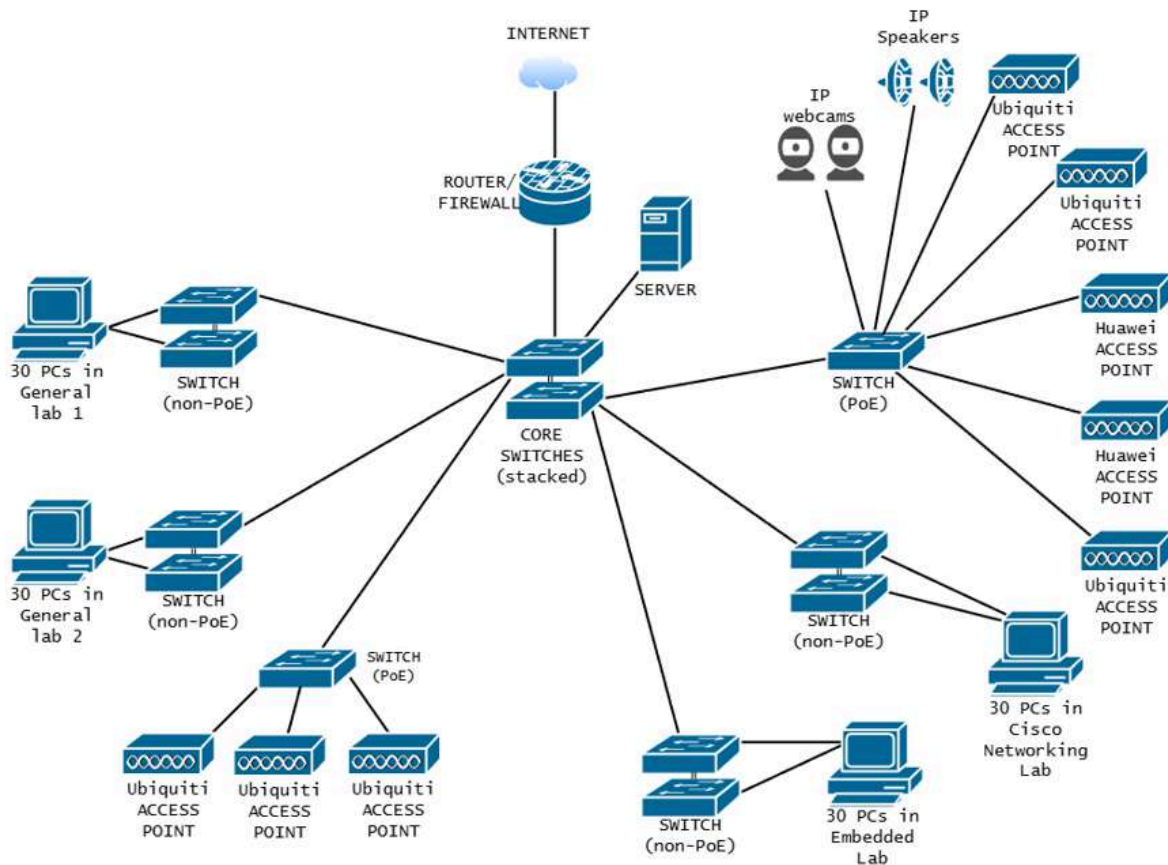


Figure 2.0 N28B Network topology

Connectivity Breakdown

A. Core Layer: Huawei S6730 Traffic Handling

The heart of the network consists of two Huawei S6730-H switches configured in a stack. This Core Layer performs several critical functions:

- **Inter-VLAN Routing:** Instead of sending internal traffic all the way to a router, the Huawei Core switches perform Layer 3 switching. They route traffic locally between different labs at wire speed to minimize latency.
- **Traffic Aggregation:** All uplinks from the Access Switches (Cisco C9200L) terminate here. The Core aggregates data from the heavy-traffic labs and classrooms on Level 1 efficiently towards the servers or the internet.
- **Redundancy:** By stacking two units of the core switch, if one physical Core switch fails, the other immediately takes over traffic forwarding to ensure zero downtime for the building.

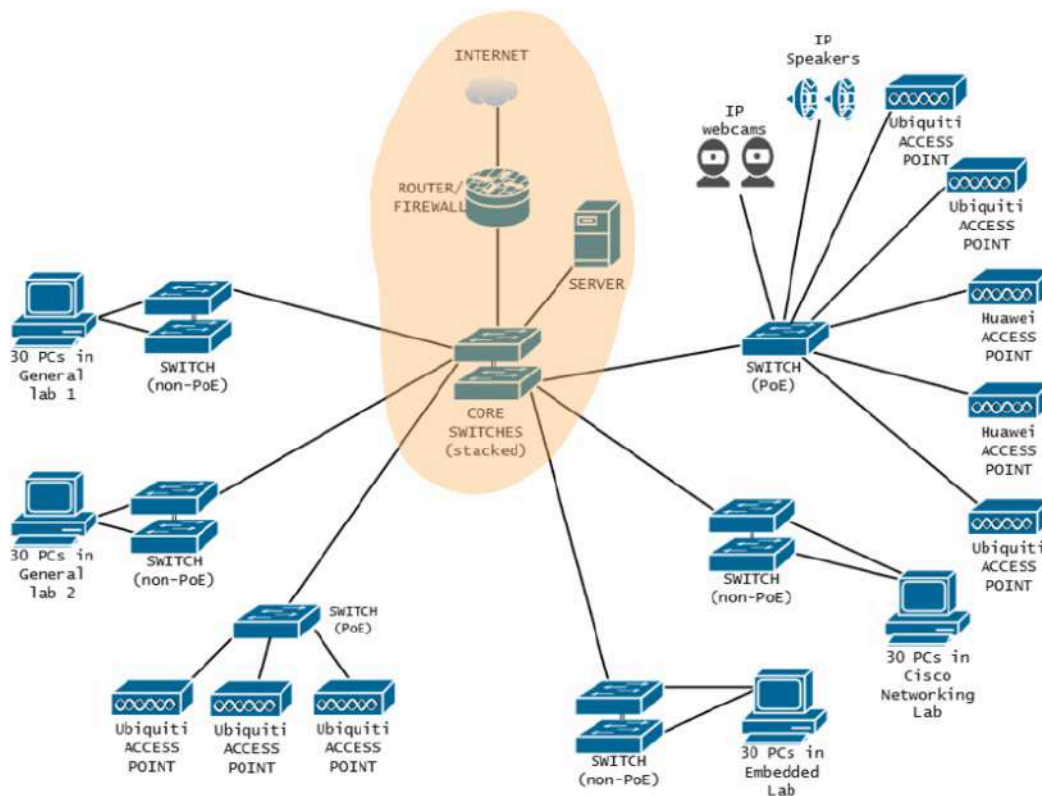


Figure 2.1 Connectivity Breakdown (Core Layer)

B. Access Layer: Cisco C9200L End-User Connection

The Access Layer is built using Cisco Catalyst 9200L switches, which serve as the direct connection point for end devices. We have categorized these connections based on power requirements:

- **Data Connectivity (Non-PoE):** Standard workstations, such as the 30 PCs in the General Labs and the Network Lab, connect to the Non-PoE switch stacks. These switches provide Gigabit Ethernet connectivity for high-speed data transfer during lab exercises.
- **Power over Ethernet (PoE):** Wireless Access Points (Ubiquiti/Huawei) and IP devices (speakers & webcams) connect exclusively to the designated PoE Switches on each floor. This ensures these devices receive both data and electrical power through a single Ethernet cable, eliminating the need for separate power adapters in the ceiling or on desks.

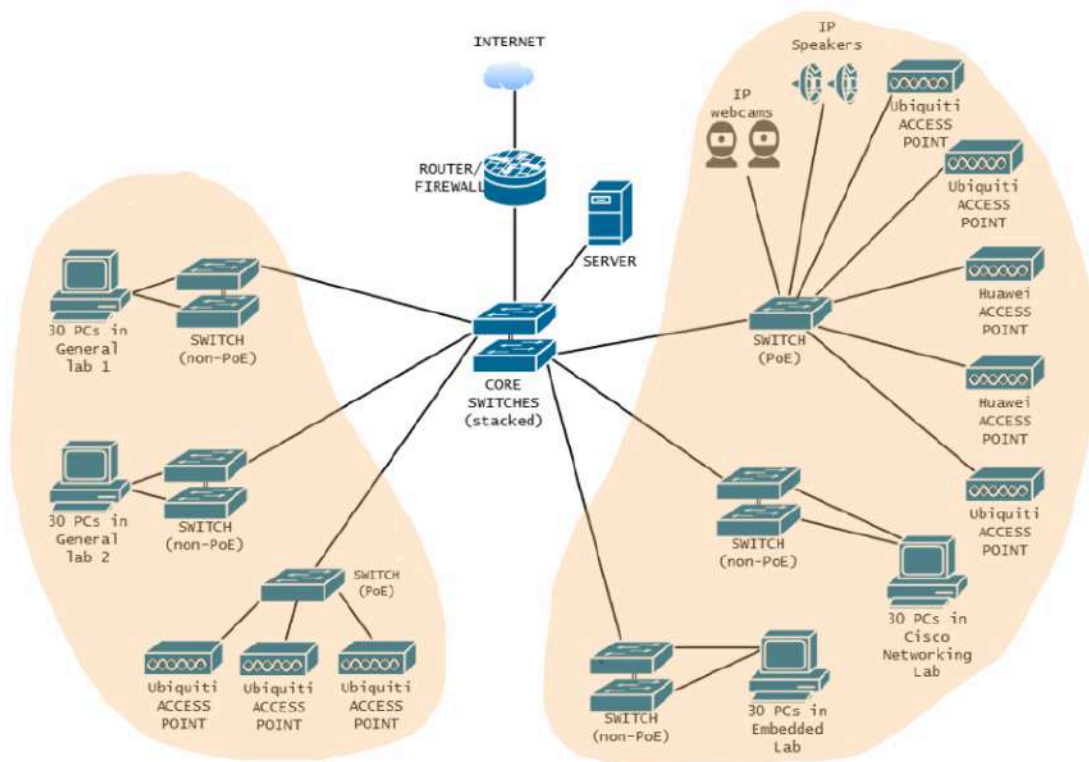


Figure 2.2 Connectivity Breakdown (Access Layer)

C. Security Perimeter: Fortinet Firewall Connection

The network entrance is guarded by a FortiGate 80F Next-Generation Firewall (NGFW).

- **The Gateway Link:** The Firewall connects directly to the Huawei Core Switch via a secure uplink. It is the only path in and out of the network to the ISP (Internet).
- **Security Enforcement:** Before any traffic from the labs reaches the internet (or vice versa), it must pass through the FortiGate. The firewall performs Network Address Translation (NAT) and Deep Packet Inspection (DPI) to block malicious external threats and prevent students from accessing restricted external sites.

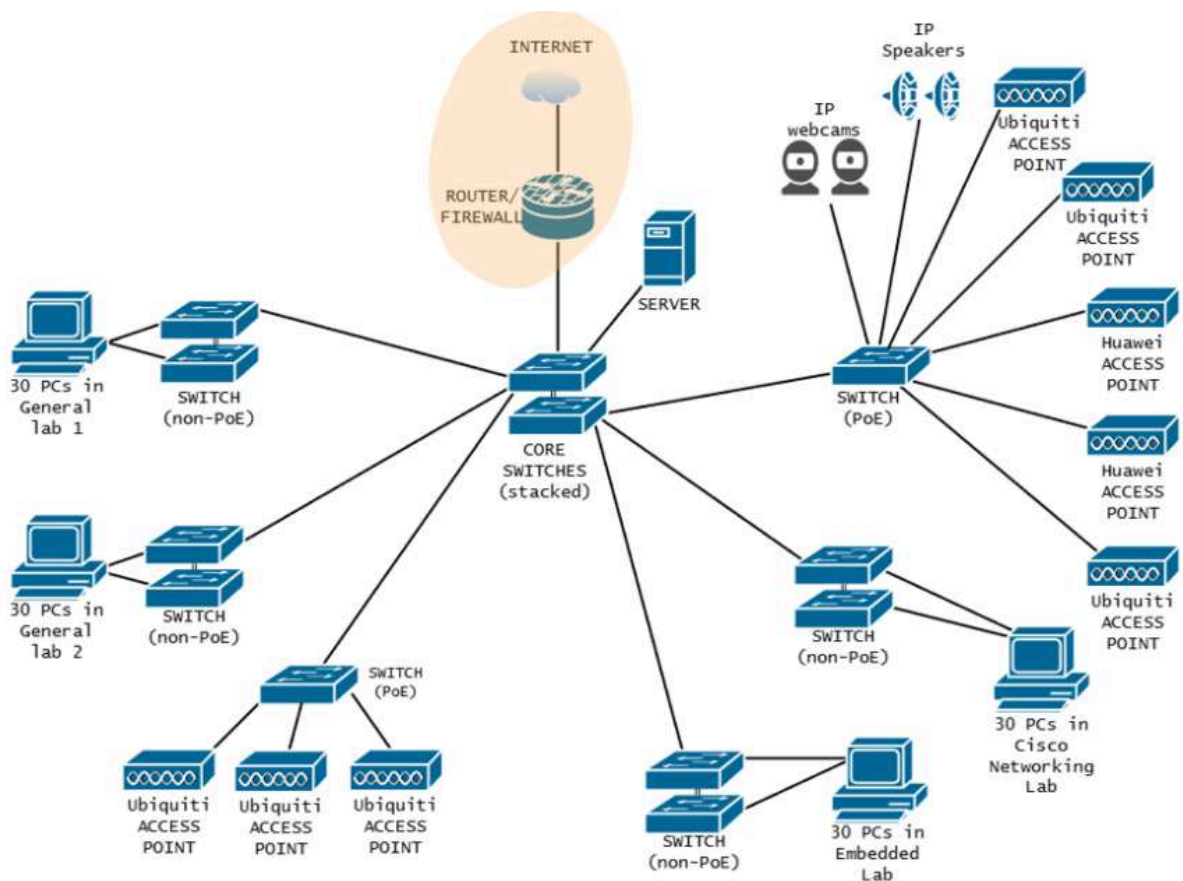


Figure 2.3 Connectivity Breakdown (Security Perimeter)

D. Physical Placement

The physical infrastructure is organized into two primary zones: the Ground Floor and Level 1, interconnected by a vertical fiber backbone running through the building's secure riser. The network design centers around the Main Distribution Facility (MDF) located in the Level 1 Cisco Networking Lab, which houses the high-availability Core Switch stack and the Fortinet security gateway.

On the Ground Floor, we utilize a distributed approach where Access Switches are placed inside the labs themselves (General Purpose Labs 1 & 2) rather than in a separate utility room. This layout allows for shorter Cat6 cable runs to the 120 workstations, ensuring all connections remain well within standard Ethernet distance limitations while connecting back to the Level 1 core via high-speed vertical fiber optics.

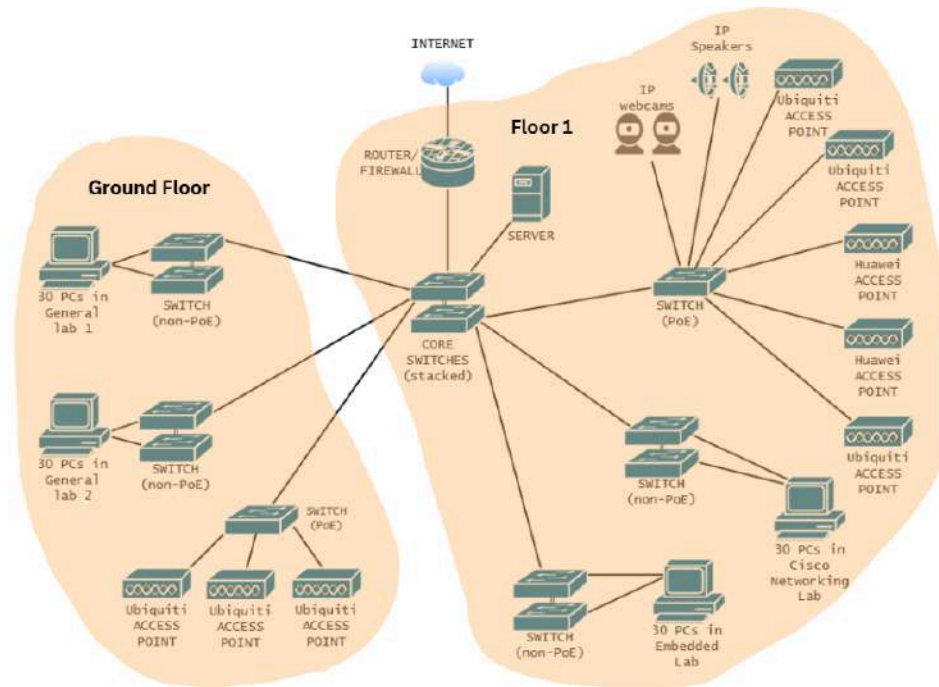


Figure 2.4 Connectivity Breakdown (by level)

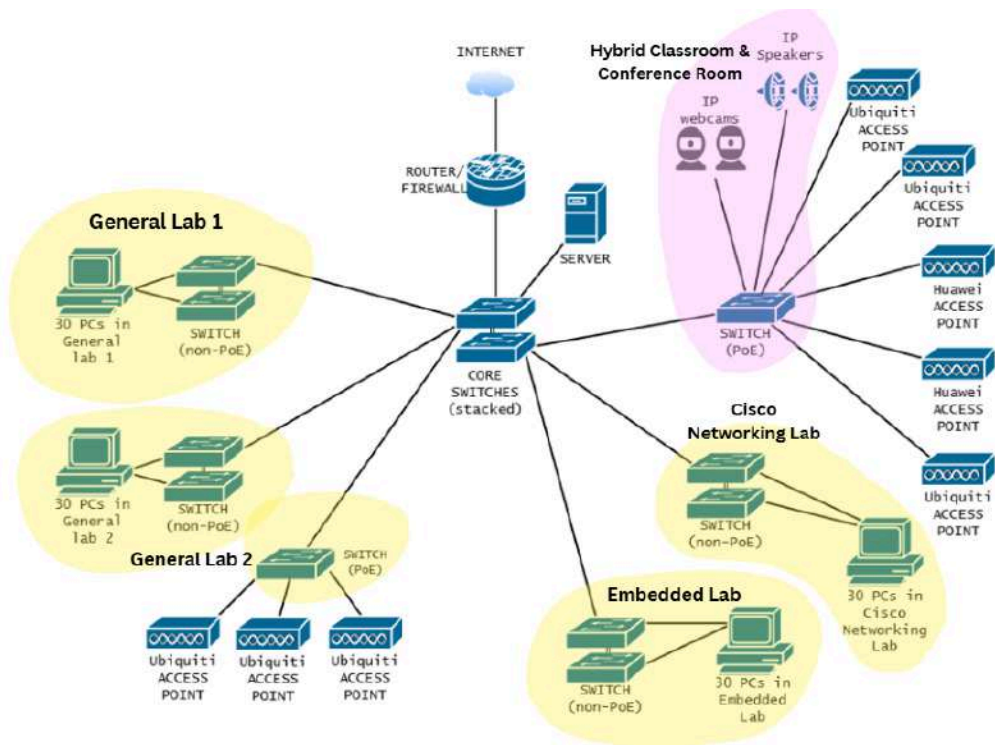


Figure 2.5 Connectivity Breakdown (by area)

E. Logical Segmentation: VLAN Strategy

To optimize performance and security, the network is logically divided into Virtual Local Area Networks (VLANs).

- **Broadcast Domain Reduction:** Each distinct room or function (e.g., General Lab 1, Cisco Network Lab, Staff Office) is assigned its own unique VLAN ID and subnet.
- **Traffic Isolation:** This ensures that broadcast traffic, such as a PC searching for a connection, is contained within a specific lab. For example, a broadcast storm caused by a student error in the Embedded Lab will not slow down other networks. This is crucial for maintaining network stability in a high-density student environment.

Transmission media (Cabling Standards)

To support high-speed data transfer and future scalability, two distinct cabling standards were implemented:

- **Vertical Cabling (Backbone):** We implement OM4 Multi-Mode Fiber Optic cables to connect the Floor 1 Huawei Core Switch to the Cisco Access Switches on the Ground Floor. Fiber was chosen for this riser link because it is immune to electromagnetic interference (EMI) and supports 10Gbps speeds over the distance between floors, which can reduce possible bottlenecks.
- **Horizontal Cabling:** For connections between the Access Switches and end devices (Workstations, WAPs), we are utilizing the CommScope CS30CM Category 6 (Cat6) U/UTP cable.

Wireless connectivity (SSIDs)

Although the Access Points are physically connected to the PoE switches, the wireless network is logically divided into specific Service Set Identifiers (SSIDs) to maintain security:

- **"Campus_Student":** Broadcasted by the Ubiquiti APs in the labs and lounge. This network provides internet access but is isolated from the secure Staff VLANs to prevent unauthorized access to sensitive exam data or admin files.
- **"Campus_Staff_Secure":** Broadcasted by the Huawei AirEngines in the offices. This hidden or encrypted network provides full access to internal servers and printers, strictly authenticated via WPA3-Enterprise to ensure only authorized personnel can connect.

Work Area Mapping

Horizontal cabling

Connects the wiring closets (Access Switches) to end user wall outlets (PCs, WAPs) on the same floor. We use CommScope CS30CM Cat6 copper cabling routed through ceiling trays. Strict adherence to the 90-meter limit is enforced for every run to guarantee stable 1 Gbps Gigabit Ethernet performance.

Vertical cabling (backbone)

Connecting the Main Distribution Facility (MDF) on Level 1 to the Ground Floor cabinets. To ensure that we achieve the 4th goal of the new system which is “Capability to support high-performance to the core backbone”, we use OM4 Multi-Mode Fiber Optic cabling running through the secure building riser, it is chosen for its 10 Gbps capacity and immunity to electromagnetic interference between floors.

Floor Plan

Legends:












Label	Description
	Wireless Access Point (Ubiquiti)
	Wireless Access Point (Huawei)
	Switch (PoE)
	Switch (Non-PoE)
	Server
	Core Switch
	Cable Entrance
	Firewall / Router
	Cable (Fiber)
	Cable (Copper, Non-WAP)
	Cable (Copper, WAP)

Table 2.1 Legends

Ground Floor:

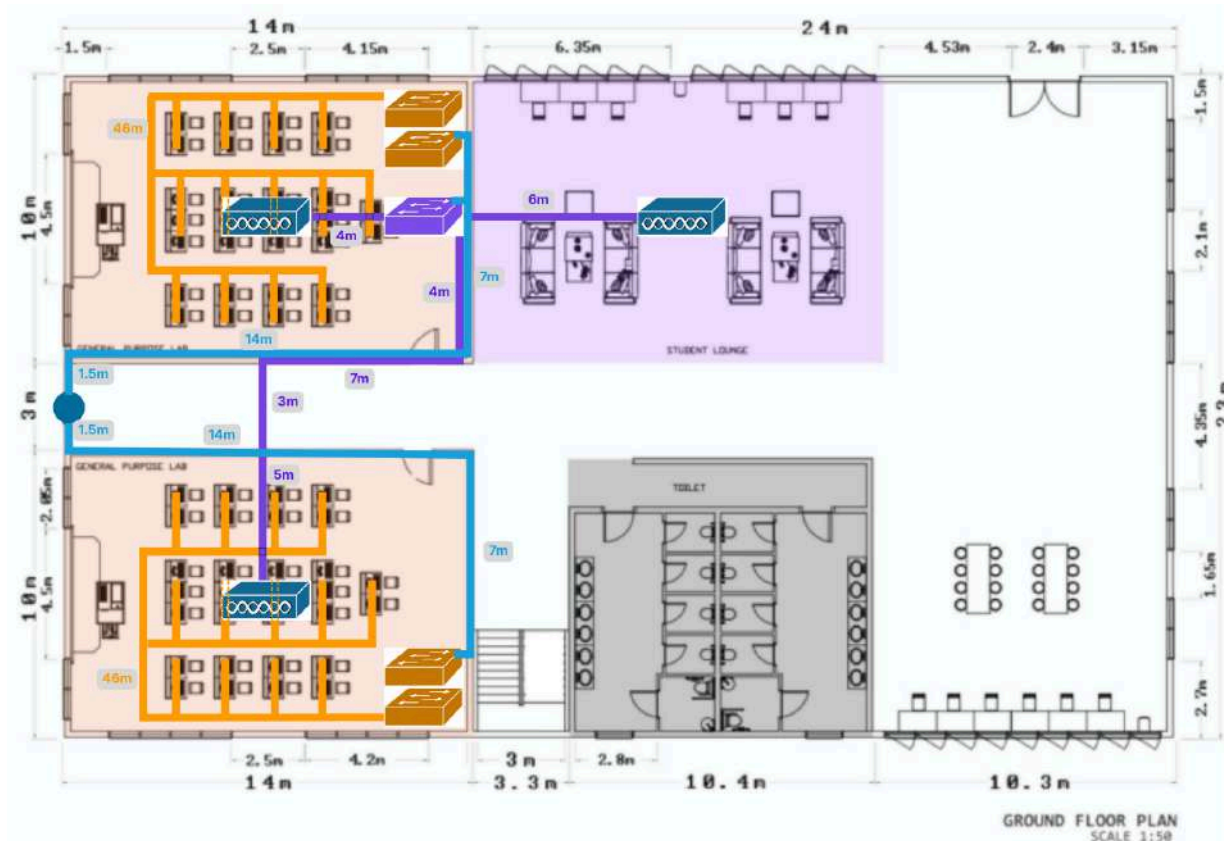


Figure 2.6 Ground Floor layout

A. Room by room device placement (Ground Floor)

1. General Purpose Lab 1:

- **Cabinet:** 6U Wall Mount Rack.
- **Switches:** 2x Cisco C9200L (Non-PoE) for the 30+ PCs that is connected to Level 1 MDF via Fiber cable.
- **WAP:** 1x Ubiquiti UniFi 6 Enterprise (Ceiling Center).
- **Cabling:** Fiber uplink goes from this cabinet UP to the Level 1 MDF.

2. General Purpose Lab 2:

- **Cabinet:** 6U Wall Mount Rack.
- **Switches:** 2x Cisco C9200L (Non-PoE) connected to Level 1 MDF via Fiber cable.
- **WAP:** 1x Ubiquiti UniFi 6 Enterprise (Ceiling Center).

3. Student Lounge:

- **Devices:** 1x Ubiquiti UniFi 6 Enterprise (Ceiling Center).
- **Connection:** Uses a Cat6 cable running through the ceiling to the **Ground Floor PoE Switch** (located in General Lab 1 or Utility Closet).

Floor Plan Level 1:

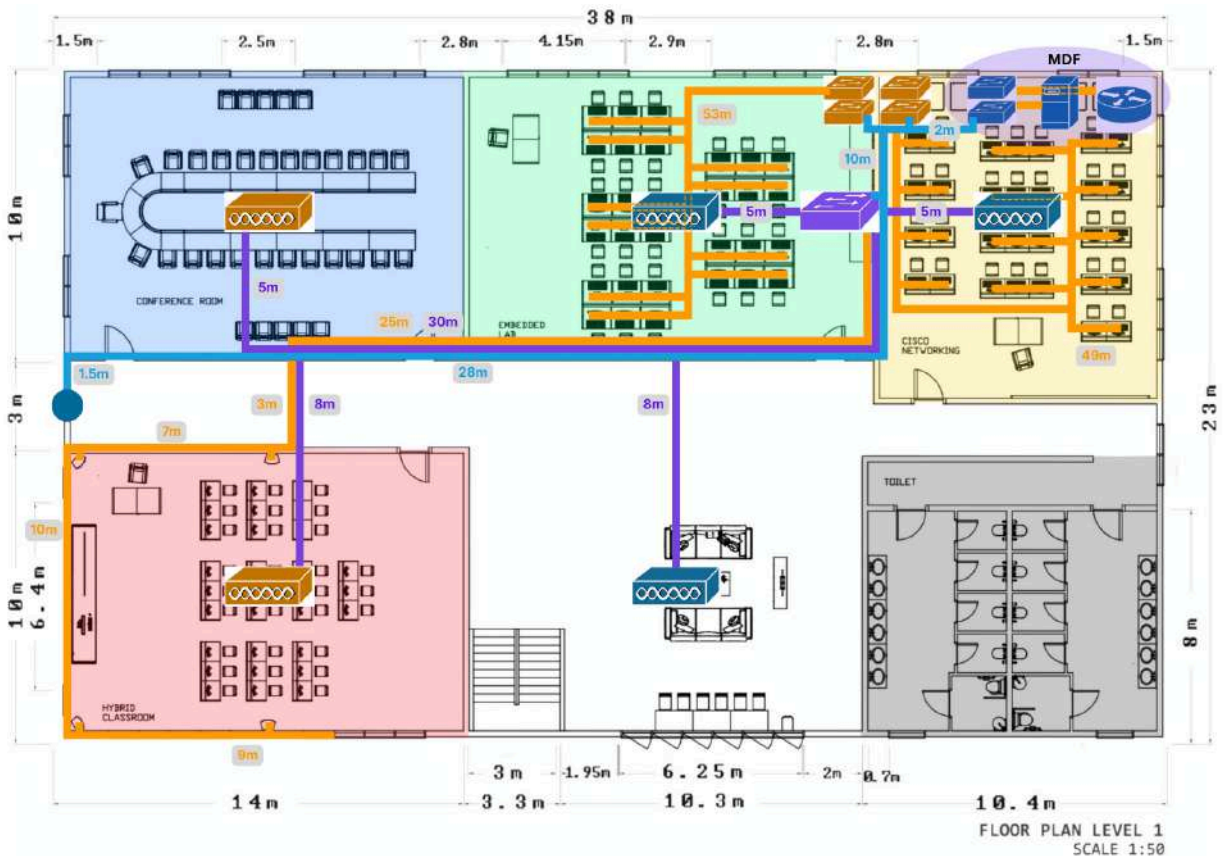


Figure 2.7 Level 1 layout

A. The MDF area

Since the Core Switch is here, this is the most critical area. We have designated a secure, partitioned area at the back of the Cisco Lab to serve as the Main Distribution Facility (MDF) which also houses the Firewall & the Server.

B. Room by room device placement (Level 1)

Since we are using a Distributed Switching Model (placing switches inside the labs), each room will have a small 6U Wall-Mounted Cabinet to house its specific equipment.

1. Cisco Networking Lab (Contains MDF):

- **Cabinet:** The main MDF Rack.
- **Switches:** 2x Cisco C9200L (Non-PoE) for student PCs.
- **WAP:** 1x Ubiquiti UniFi 6 Enterprise (Ceiling Center).

2. **Embedded Lab:**

- **Cabinet:** 6U Wall Mount Rack.
- **Switches:** 2x Cisco C9200L (Non-PoE) connected to core switch.
- **WAP:** 1x Ubiquiti UniFi 6 Enterprise (Ceiling Center).

3. **Hybrid Classroom:**

- **WAP:** 1x Huawei AirEngine 6760-X1 (Ceiling Center).
- **Connection:** Cabling runs through the ceiling tray back to the PoE Switch.

4. **Conference Room:**

- **WAP:** 1x Huawei AirEngine 6760-X1 (Ceiling Center).
- **Connection:** Cabling runs through the ceiling tray back to the PoE Switch.

General Purpose Lab 2:

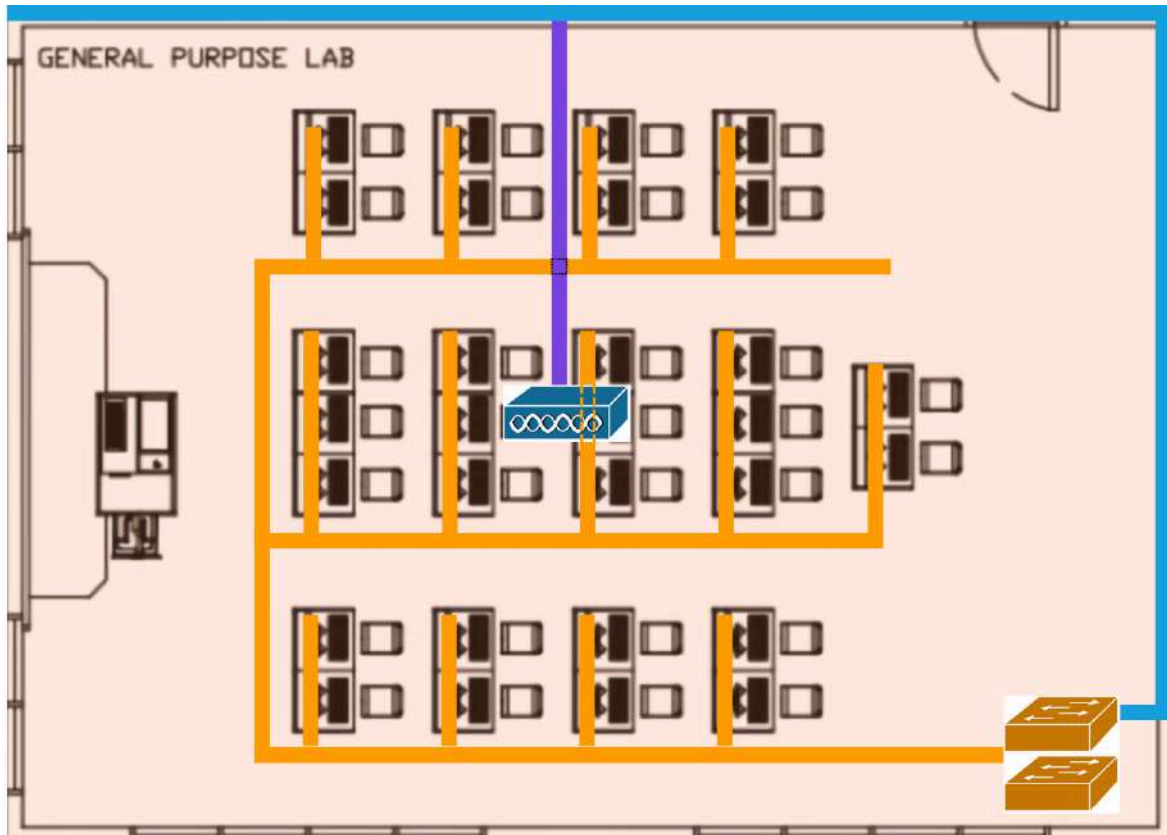


Figure 2.8.1 General Purpose Lab 2

Student Lounge:

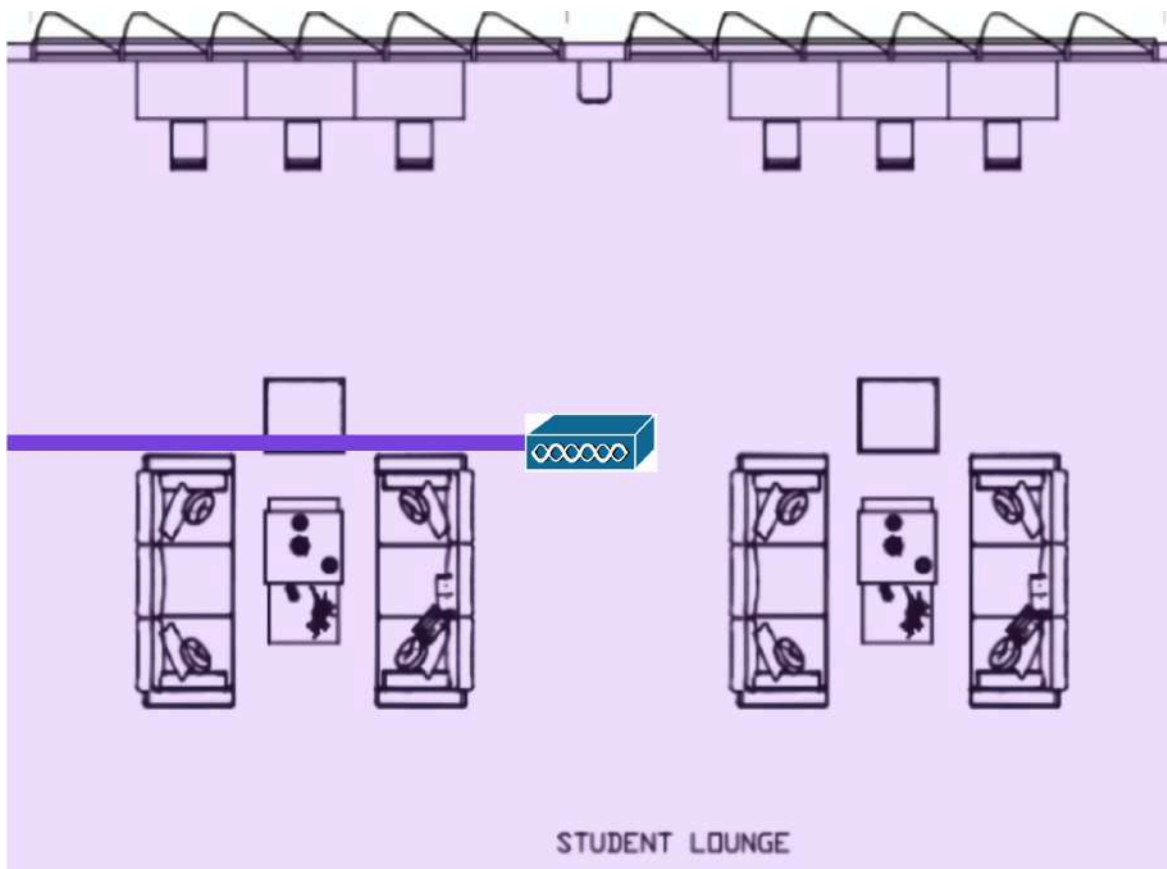


Figure 2.8.2 Student Lounge

Level 1

Cisco Networking Lab:

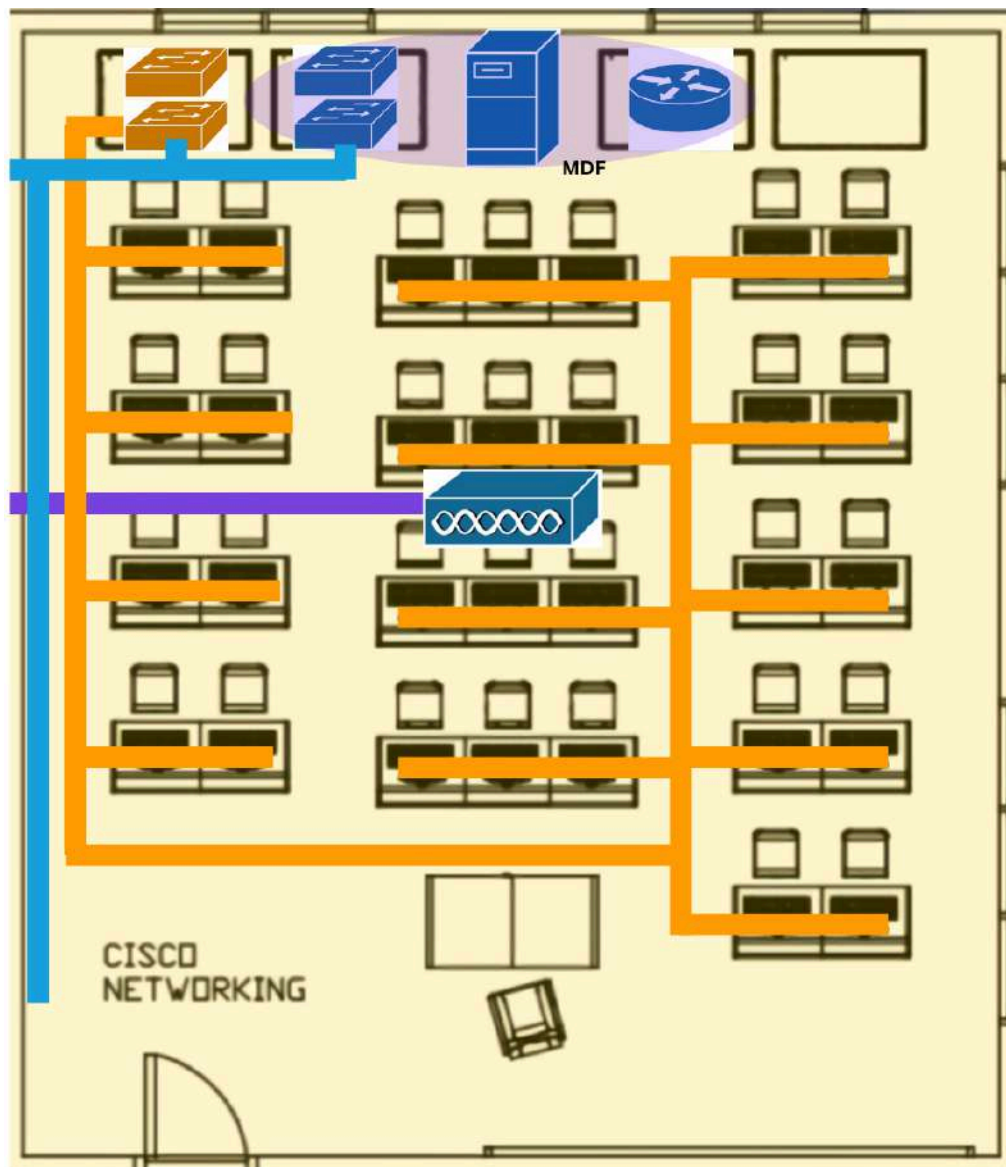


Figure 2.9.0 Cisco Networking Lab layout

Conference Room:

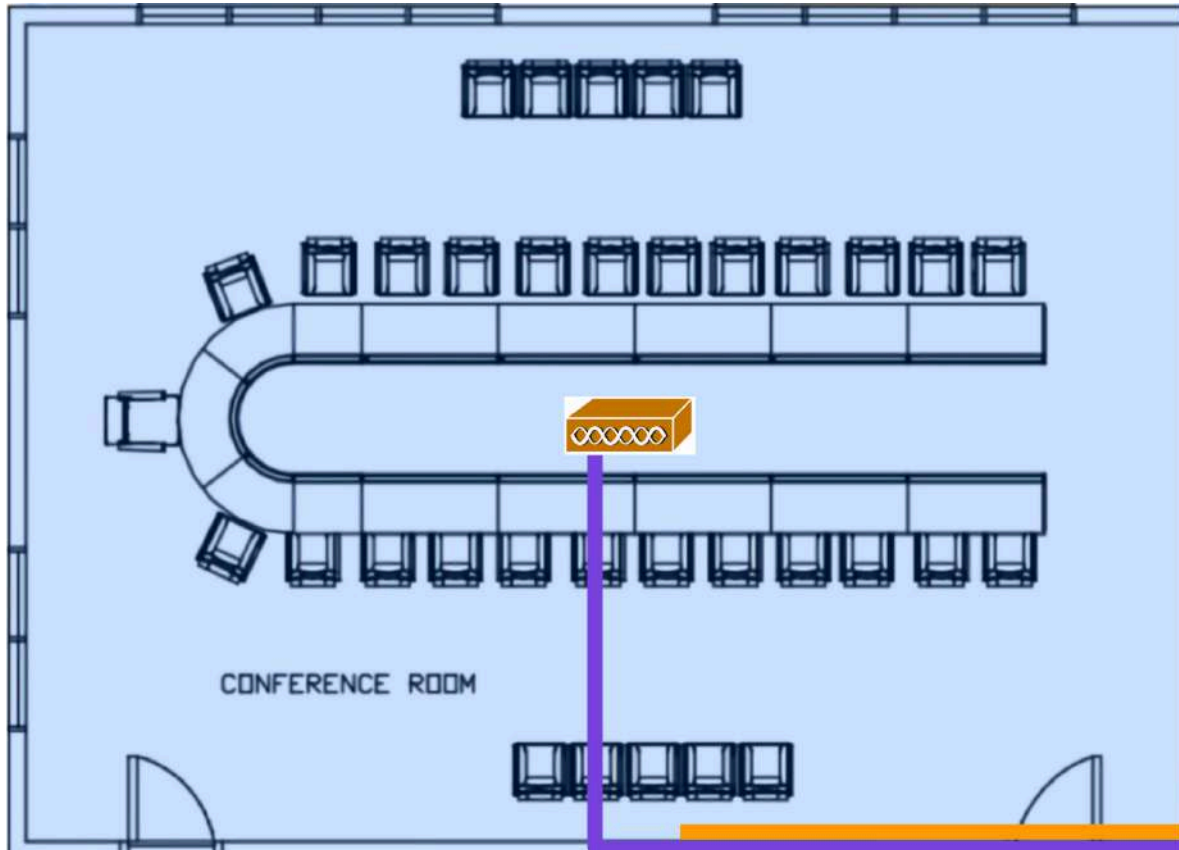


Figure 2.9.1 Conference Room layout

Embedded Lab:

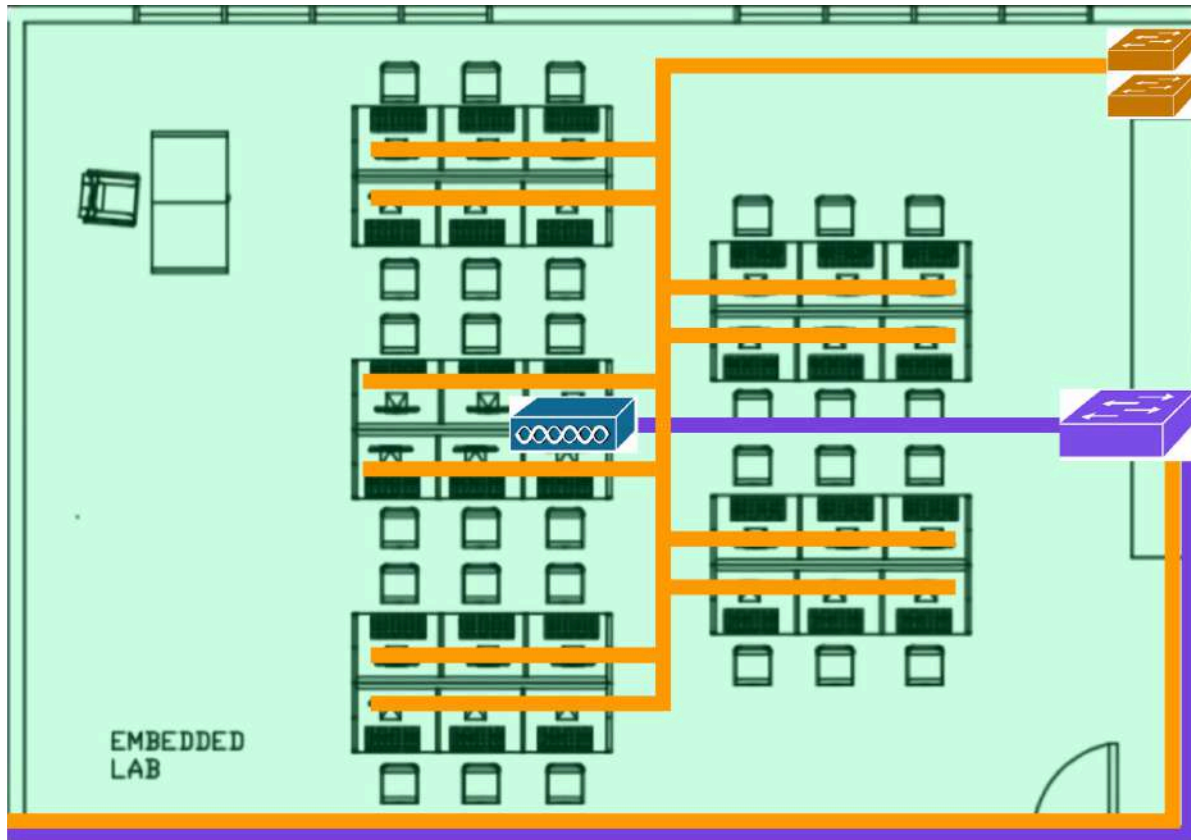


Figure 2.9.2 Embedded Lab layout

Hybrid Classroom:

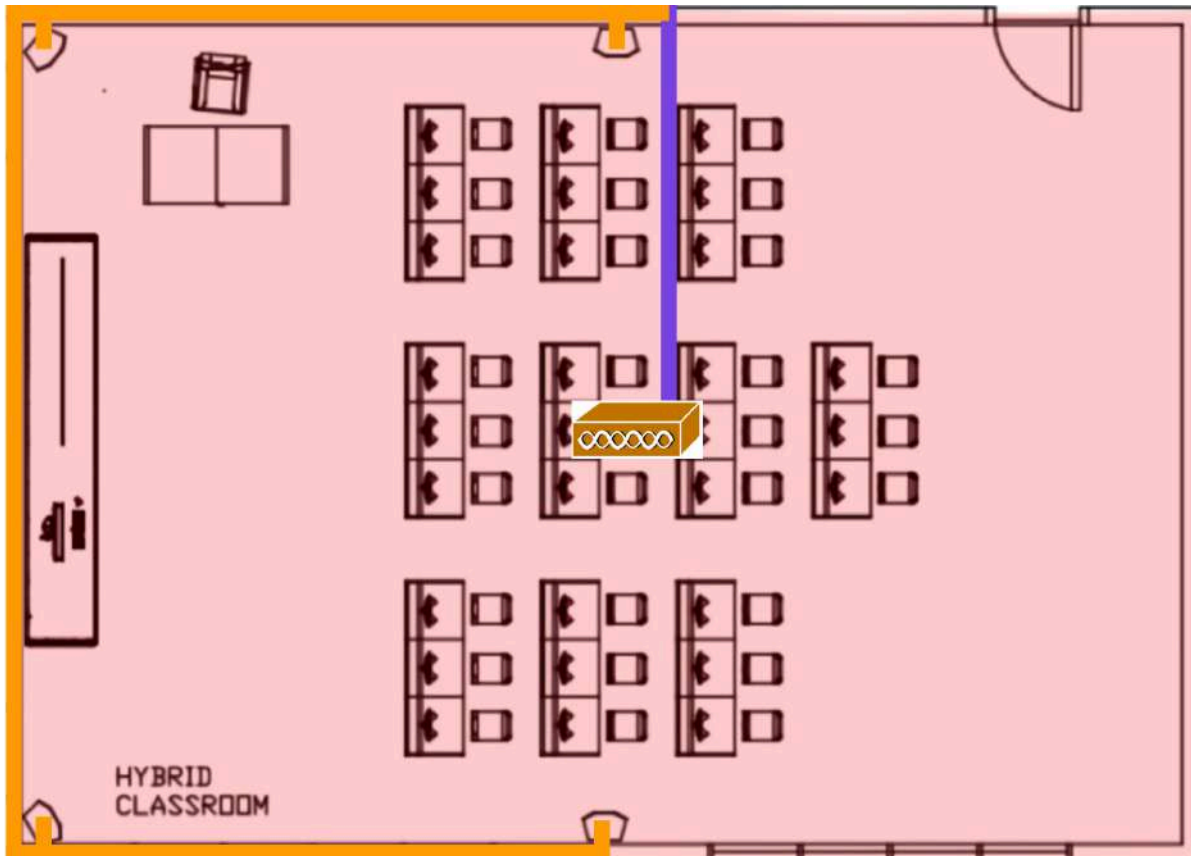


Figure 2.9.3 Hybrid Classroom layout

Connectivity

Ground Floor Connectivity

Item	Model	Function	Total Needed
Access Switch (PoE)	Cisco Catalyst 9200L-24P-4X-E	Power & connect APs	1
Access Switch (Non-PoE)	Cisco Catalyst 9200L-24T-4X-E	PCs & wired devices	4
Wireless AP (Ubiquiti)	Ubiquiti UniFi 6 Enterprise	High-density Wi-Fi	3
Patch Panel	CommScope 24-Port	Cable termination	1

Table 3.1 Ground Floor Connectivity

Level 1 Connectivity

Item	Model	Function	Total Needed
Core Switch	Huawei CloudEngine S6730-H24X6C	Core & aggregation	2
Access Switch (PoE)	Cisco Catalyst 9200L-24P	AP connectivity	1
Access Switch (Non-PoE)	Cisco Catalyst 9200L-24T	PCs & devices	4
Wireless AP (Ubiquiti)	Ubiquiti UniFi 6 Enterprise	Student areas	3
Wireless AP (Huawei)	Huawei AirEngine 6760-X1	Smart classroom	2
Server	Right Power F1000E	Central services	1
Firewall / Router	Fortinet FortiGate 80F	Gateway to the Internet	1
Patch Panel	CommScope 24-Port	Cable termination	1

Table 3.2 Level 1 Connectivity

Media Measurements & Specifications

Cable Estimation – Ground Floor

Media Type	Specification	Usage	Total
Ethernet	Cat6	PC → Access Switch	121m
Fiber Optic Cable	Cat6	MDF→ IDF	45 m
Subtotal (Ground Floor)			166 m

Table 4.1 Cable Estimation – Ground Floor

Cable Estimation – Level 1

Media Type	Specification	Usage	Total
Ethernet	Cat6	PC → Access Switch, Speakers → PoE Switch	217m
Fiber Optic Cable	Cat6	MDF→ IDF	41.5m
Subtotal (Level 1)			258.5m

Table 4.2 Cable Estimation – Level 1

Final Cable Summary

Description	Length
Ground Floor Total	166 m
Level 1 Total	258.5m
Riser Backbone	4m
Subtotal	428.5m
Extra Allowance (12.55%)	61.5m
Final Required	≈ 490m

Table 4.3 Final Cable Summary

TASK 5: IP Addressing Scheme

Overview

The final task addresses the logical addressing scheme required to manage network traffic. We implemented a Variable Length Subnet Masking (VLSM) strategy to segment the network into optimized subnets for students, Wi-Fi users, and management. This section presents the complete IP addressing table and detailed DHCP scope assignments, ensuring conflict-free connectivity for every room.

Requirement Analysis

Before allocating resources to specific departments, we first analyzed the properties of the network block assigned to our group. The following parameters show the strict boundaries and total capacity of our network infrastructure.

Network Parameter	Value
Assigned IP Address	172.22.56.0
CIDR Prefix	/23
Subnet Mask	255.255.254.0
Total Capacity	512 IP Addresses (2^9)
Usable Host Range	172.22.56.1 – 172.22.57.254
Broadcast Address	172.22.57.255

Table 5.1: Network Parameter

User Group	Host Count	Requirement	Justification
Student Group (VLAN 10)	120	/24	Includes all wired PCs in the 4 Labs
Student Wi-Fi (VLAN 20)	~100	/25	High density BYOD area. Needs 126 usable IPs
IP Devices (VLAN 30)	~16	/27	Includes Webcams, Speakers, Network Printers, and Wireless Access Point management IPs
Management (VLAN 90)	~20	/27	Servers, Admin PCs, & Network Switches

Table 5.2: User Group analysis

VLAN 10: Student Group (Laboratories & Hybrid Classroom)

- **Subnet Assignment:** 172.22.56.0/24 (254 Usable IPs)
- **Justification:** This VLAN serves the faculty's core educational facilities which are the four computer laboratories. With a requirement of 120 wired workstations, a /25 subnet (126 IPs) would be sufficient but not recommended. Therefore, we assigned the entire Lower Half of the available address block to this group to ensure all lab computers reside in a contiguous range.
- **Policy Integration:**
 - **DHCP:** Since these are fixed desktop PCs that will not move around, we apply a Long Lease (7 Days). This reduces network broadcast traffic ("chatter") by minimizing frequent renewal requests
 - **NAT:** Traffic from these 120 hosts is multiplexed via NAT Overload (PAT) at the router that allows the entire lab infrastructure to share the single ISP public IP address.

VLAN 20: Student Wi-Fi (Lounge & BYOD)

- **Subnet Assignment:** 172.22.57.0/25 (126 Usable IPs)
- **Justification:** This subnet covers the high density Student Lounge and Hybrid Classroom areas. We estimated up to 100 concurrent wireless users. A /25 subnet provides 126 IPs
- **Policy Integration:**
 - **DHCP:** To prevent "IP Exhaustion" in this limited pool, we enforce a Short Lease (2 Hours). This ensures that when a student leaves the lounge, their IP address is immediately recycled and made available for the next user.
 - **NAT (Scalability):** This VLAN relies on NAT Overload (Port Address Translation). By tracking unique source ports, NAT allows these concurrent mobile users to share the single ISP connection simultaneously without causing IP conflicts or requiring extra public addresses.

VLAN 30: IP Devices (Infrastructure)

- **Subnet Assignment:** 172.22.57.128/27 (30 Usable IPs)
- **Justification:** Connects critical hardware, including Webcams, Network Speakers, Printers, and Wireless Access Points (WAPs). The /27 subnet supports 30 devices, which accommodates the current estimated hardware while leaving space for future.
- **Policy Integration:**
 - **Static Addressing:** Unlike student devices, this hardware is assigned Static IPs or DHCP Reservations. This guarantees service continuity, for example, a lecturer can always connect to a network printer at the same IP address without it changing after a reboot.

VLAN 90: Management (Admin & Servers)

- **Subnet Assignment:** 172.22.57.160/27 (30 Usable IPs)
- **Justification:** This subnet houses the core equipment, the Servers, Admin PCs, and Network Switch management interfaces. A /27 block is sufficient for the ~20 critical devices required for network administration.
- **Policy Integration:**
 - **Remote Management (SSH):** This is the only VLAN authorized to initiate remote connections. We enforce SSH v2 to encrypt all management sessions, protecting administrative credentials from potential sniffing attacks.
 - **ACL Enforcement:** The router and switches are configured to drop any management traffic that does not originate from this specific subnet range, ensuring students cannot access the network backbone.

Reserved (Future Growth)

- **Subnet Assignment:** 172.22.57.192/26 (62 Usable IPs)
- **Justification:** By efficiently sizing the previous VLANs using VLSM, we successfully preserved a contiguous block of 62 IP addresses at the end of the range. This "spare" capacity allows the faculty to add new labs or offices in the future without disrupting the existing network addressing scheme

Subnetting Strategy

The primary challenge of this design was fitting a large user base into the limited 172.22.56.0/23 address space, which provides a total of 512 IP addresses. A standard fixed length strategy would have failed because all the user groups are not equal in size (e.g., the Students Group is five times larger than the Management group).

To solve this, we used **Variable Length Subnet Masking (VLSM)** to create a hierarchical structure.

Phase 1: Primary Segmentation

The main network block (172.22.56.0/23) provides a total of 512 IP addresses. The first step is to divide this block into two equal halves of 256 IPs each (two /24 subnets):

- **Lower Half (172.22.56.0/24):** Dedicated entirely to VLAN 10 (Student Group).
 - With a requirement of 120 wired hosts in student labs, a /25 subnet (126 IPs) is insufficient. Assigning the full /24 ensures contiguous addressing for all lab PCs and provides ~100 spare IPs for future lab expansion.
- **Upper Half (172.22.57.0/24):** Reserved for all other services (Wi-Fi, IP Devices, Management).

Phase 2: Secondary Segmentation (The Upper Half)

The remaining 256 IPs in the Upper Half (172.22.57.x) were divided using VLSM to match these specific requirements:

1. **Student Wi-Fi (VLAN 20):** We allocated the first 128 IPs (172.22.57.0/25) to this group to support high-density BYOD traffic in the student lounge.
2. **Remaining Space:** The remaining 128 IPs (172.22.57.128/25) were split again to accommodate smaller infrastructure groups:
 - **IP Devices (VLAN 30):** Allocated a /27 block (30 IPs) for cameras, printers, and speakers.
 - **Management (VLAN 90):** Allocated a /27 block (30 IPs) for servers and admin switches.
 - **Reserve:** The final block is left unassigned to provide a buffer for future organizational growth.

Subnetting Calculations

These calculations are performed to determine the exact subnet masks required for each user group based on the formula $2^n - 2 \geq \text{Required Hosts}$, where n represents the number of host bits.

Base Network

- **Assigned Block:** 172.22.56.0/23
- **Total Host Bits:** $32 - 23 = 9$ bits
- **Total Available IPs:** $2^9 = 512$ addresses (Range: 172.22.56.0 to 172.22.57.255)

VLAN 10: Student Group

- **Requirement:** 120 Hosts
- **Calculation:**
 - $n=8$:
 - $2^8 - 2 = 254$ usable IPs (sufficient)
- **New Subnet Mask:** $32 - 8 = /24$
- **Result:**
 - Network Address: 172.22.56.0
 - Broadcast Address: 172.22.56.255

VLAN 20: Student Wi-Fi

- **Requirement:** ~100 Hosts
- **Calculation:**
 - $n=7$
 - $2^7 - 2 = 126$ usable IPs (sufficient)
- **New Subnet Mask:** $32 - 7 = /25$
- **Result:**
 - Network Address: 172.22.57.0
 - Broadcast Address: 172.22.57.127

VLAN 30 & 90: IP Devices & Management

- **Requirement:** ~16 Hosts (for Devices/Admin)
- **Calculation:**
 - $n=5$
 - $2^5 - 2 = 30$ usable IPs (sufficient)
- **New Subnet Mask:** $32 - 5 = /27$
- **Results:**
 - VLAN 30 Network: 172.22.57.128 (Range: .129 – .158)
 - VLAN 90 Network: 172.22.57.160 (Range: .161 – .190)

IP Addressing Table (SUBNET)

The Final IP Addressing Table (Table 3) below demonstrates the successful implementation of the VLSM hierarchy proposed in the subnetting strategy.

VLAN ID	Subnet Name	Prefix	Usable IPs	Network Address	Usable Range	Broadcast Address
VLAN 10	Student Group	/24	254	172.22.56.0	.56.1 – .56.254	.56.255
VLAN 20	Student Wi-Fi	/25	126	172.22.57.0	.57.1 – .57.126	.57.127
VLAN 30	IP Devices	/27	30	172.22.57.128	.57.129 – .57.158	.57.159
VLAN 90	Management	/27	30	172.22.57.160	.57.161 – .57.190	.57.191
Reserved	Future Growth	/26	62	172.22.57.192	.57.193 – .57.254	.57.255

Table 5.3: IP addresses allocation (SUBNET)

Logical Segmentation

Our design splits the network into two distinct halves to make management easier. The entire first half of the address block (172.22.56.x) is dedicated to the wired Student Labs, while the second half (172.22.57.x) handles the Wireless network and Management devices. This separation creates a simple rule for the IT team: if an IP address starts with .56, it is definitely a Lab PC, if it starts with .57, it is a wireless or infrastructure device. This clarity is proposed to reduce confusion during troubleshooting.

Zero-Gap Contiguity

We have arranged the subnets so they fit together perfectly without any gaps. As shown in the table, the Lab network fills the address space exactly up to the halfway point (.56.255), and the Student Wi-Fi picks up the very next number (.57.0). By lining up the subnets like this, we ensure that not a single IP address is lost or wasted in the space between different user groups.

Efficiency and Reservation

By assigning smaller blocks of IP addresses to the IP Devices and Management groups instead of giving them large blocks they don't need, we saved a significant amount of space. This planning allowed us to consolidate all the leftover addresses into a single Reserved group at the end of the list. We successfully saved 62 IP addresses, guaranteeing that the faculty has enough room to build new labs or offices in the future without having to redesign the entire network.

IP Assignment by Room (DHCP Scope)

Room Name	VLAN ID	Device Description	Assigned IP Range
General Lab 1	VLAN 10	30 Student Workstations	172.22.56.10 – 172.22.56.39
	VLAN 30	Wireless Access Point	172.22.57.135 (Static)
General Lab 2	VLAN 10	30 Student Workstations	172.22.56.40 – 172.22.56.69
	VLAN 30	Wireless Access Point	172.22.57.136 (Static)
Cisco Networking Lab	VLAN 10	30 Student Workstations	172.22.56.70 – 172.22.56.99
	VLAN 30	Wireless Access Point	172.22.57.137 (Static)
Embedded Lab	VLAN 10	30 Student Workstations	172.22.56.100 – 172.22.56.129
	VLAN 30	Wireless Access Point	172.22.57.138 (Static)
Hybrid Classroom	VLAN 30	Webcam & Speakers	172.22.57.132 – 172.22.57.134
	VLAN 30	Wireless Access Point	172.22.57.139 (Static)
Video Conference Room	VLAN 30	Webcam & Speaker	172.22.57.130 – 172.22.57.131
	VLAN 30	Wireless Access Point	172.22.57.140 (Static)
Student Lounge	VLAN 20	BYOD (Wi-Fi Users)	172.22.57.2 – 172.22.57.126
	VLAN 30	Wireless Access Point	172.22.57.141 (Static)
Admin	VLAN 90	Admin PCs & Servers	172.22.57.162 – 172.22.57.190
	VLAN 30	Wireless Access Point	172.22.57.142 (Static)

Table 5.4: IP addresses allocation by area

Note: refer to **Table 3 (Final IP Addressing Table) in the previous section for the complete technical specifications, including the Subnet Name, Network Address, and Broadcast Address corresponding to each VLAN ID.*

Analysis of Room-Level Allocation

Table above provides a breakdown of how the available IP address space is distributed across different physical locations.

Network Address Allocation (Buffer Strategy)

We organized the Student Group subnet (172.22.56.0/24) by giving each laboratory an exact range of 30 IP addresses for its workstations (e.g., General Lab 1 uses .10 through .39). We decided a Centralized Buffer Strategy was more efficient for the faculty's long term needs. By leaving approximately 134 IP addresses as a single, large pool starting at .130, we created a massive "safety net" for the network. This allows the technical team to connect troubleshooting gear or temporary PCs anywhere in the building. Additionally, it will also keep the Hybrid Classroom ready for expansion, as we can add wired stations there later using this central pool without having to modify the current lab configurations.

Infrastructure Management (VLAN 30)

As detailed in the table, every room equipped with a Wireless Access Point (WAP) includes a specific entry for VLAN 30. While the students in the room utilize VLAN 10 or 20 for their data traffic, the WAP hardware itself is assigned a Static IP in the infrastructure range. This ensures that the management interface used for configuring the device is isolated from the student network for more security.

IP Addressing Policy

Dynamic Host Configuration Protocol (DHCP)

DHCP is applied to optimize the usage of the limited IP pool. The lease time, which is the duration a device holds an IP address will vary based on the user behavior in each VLAN.

- **VLAN 20 (Student Wi-Fi): Short Lease (2 Hours)**
 - **Context:** This network services transient student devices in the Student Lounge. Students typically stay for short durations between classes.
 - **Policy:** The lease time is set to 2 hours.
 - **Justification:** This short lease time ensures that addresses released by departing students are immediately made available for new users. Without this policy, the pool of 126 IPs could be exhausted by midday, preventing new students from connecting.
- **VLAN 10 (Student Group): Long Lease (7 Days)**
 - **Context:** This network services 120 fixed desktop computers in the laboratories. These devices never leave the building.
 - **Policy:** The lease time is set to 7 days.
 - **Justification:** Since these devices are permanent, there is no need for them to request a new IP address every few hours which will minimize DHCP broadcast traffic, leaving more bandwidth for other educational purposes.
- **VLAN 30 (IP Devices): Static Reservations**
 - **Policy:** Infrastructure devices (Network Printers, Wireless Access Points, Webcams, Speakers) are assigned **Static IPs** or **DHCP Reservations**.
 - **Justification:** Service continuity. Staff members must be able to map a printer or access a camera using a consistent IP address that does not change after a reboot.

Network Address Translation (NAT) Policy

Since the entire faculty network operates on private IP addresses (RFC 1918), a translation mechanism is required for internet access.

- **Mode: NAT Overload (Port Address Translation - PAT).**
- **Configuration:** The Edge Router is configured to translate the source addresses of all internal VLANs (10, 20, 30, 90) to the single public IP address provided by the ISP.
- **Mechanism:** The router distinguishes between simultaneous connections from different students by assigning unique **Source Port numbers** to each session. This allows internal devices to share one public IP simultaneously without conflict.

Remote Management Policy via Secure Shell (SSH)

To fulfill the requirement for Easy Management while maintaining security, the following access protocols are implemented:

- **Protocol: Secure Shell (SSH v2)**
 - **Justification:** Telnet transmits passwords in plain text. In a learning environment where students in the Cisco Network Lab may be learning packet sniffing (Wireshark), using Telnet would expose administrative credentials. SSH encrypts the session, mitigating this risk.
- **Access Control List (ACL):**
 - **Policy:** Remote management is strictly limited to the **Management Subnet** (VLAN 90).
 - **Implementation:** An Access Control List (ACL) is applied to the VTY (Virtual Teletype) lines of the switches. Any SSH connection attempt originating from Student VLANs (10 or 20) is automatically dropped, ensuring only the Admin VLAN can access the device CLI.

CONCLUSION

The network design for the N28B building successfully delivers a robust network design that balances high performance with cost effectiveness. By implementing a top-down methodology, our team managed to implement a secure infrastructure for RM 709,255.86, leaving a substantial budget surplus of RM190,744.14.

Our greatest strength during this project was our proactive approach to learning despite our initial inexperience with large scale network deployments. We were highly passionate and committed to accuracy, which led us to constantly seek out information through consultations and interviews with our lecturer, Dr. Zafran, and technical staff. This collaborative effort allowed us to successfully implement complex strategies like Variable Length Subnet Masking (VLSM), which optimized our limited /23 IP block to support over 4,500 devices while reserving space for future growth.

Apart from that, we also faced a lot of challenges. As students, we faced a significant lack of primary sources and specialized networking data early on, forcing us to rely heavily on intensive online research to justify our hardware choices. Furthermore, limited time made it difficult to conduct as deep a feasibility study as we initially intended. These constraints, combined with our collective inexperience, meant that we had to spend extra time verifying technical compatibility, such as ensuring our Cisco switches supported the necessary StackWise and PoE requirements for the faculty.

For future projects, we suggest providing a more structured research timeline to better manage time constraints. Additionally, securing earlier access to specialized network monitoring tools obviously would help bridge the gap between theoretical design and practical troubleshooting. Overall, this project has been a great learning experience, it proves that passion and active consultation can overcome technical inexperience to come out with a good result.

TEAM MEMBERS & RESPONSIBILITIES

No.	NAME	RESPONSIBILITIES	PERCENTAGE
1	AHMAD MUNIF BIN BAHARUM	<p>Core Logic: Developed key strategies for VLSM and NAT to manage the /23 IP block.</p> <p>Device Research: Led research and selection for enterprise hardware like Cisco Catalyst and FortiGate.</p> <p>Project Goals: Set the technical direction to ensure 4IR compatibility and high density support.</p> <p>Economic Lead: Matched high-end requirements with the RM 900,000 budget and performed hardware benchmarking.</p> <p>Stakeholder Support: Aided qualitative data gathering by documenting interviews with staff and lecturers.</p>	30%
2	DANIEL IMAN HAQIMIE BIN YUSOFF	<p>Cabling Lead: Planned horizontal and vertical cabling routes for complete building connectivity.</p> <p>Physical Designer: Developed 2D floor plans and mapped layouts for specialized labs and the student lounge.</p> <p>Logical Connections: Established the physical-to-logical links to ensure every device was correctly connected.</p> <p>Smart Placement: Plotted physical locations for PoE speakers, IP cameras, and smart displays.</p>	30%

		<p>Space Optimization: Analyzed lab requirements to ensure optimal workstation placement for network routing.</p> <p>Backbone Design: Focused on maintaining high-speed throughput between floor levels.</p>	
3	ABDURRAFIQ BIN ZAKARIA	<p>Documentation Lead: Managed the overall structure, formatting, and organization of the final report.</p> <p>Admin Coordinator: Documented meeting minutes and tracked team tasks throughout the project.</p> <p>Workstation Strategy: Analyzed performance specs to select Acer and Lenovo units for lab use.</p> <p>IP Addressing Table: Finalized technical tables for IP addressing and subnet allocation.</p> <p>Reviewer: Assisted the technical lead in proofreading the feasibility analysis and reasoning.</p> <p>Meeting Lead: Moderated project setup phases to ensure the team adhered to the timeline.</p>	30%
4	NAJMUDDIN BIN KAMARUDIN	<p>Information Gathering: Assisted in collecting basic faculty background and population data.</p> <p>Drafting Support: Provided light assistance in writing the project background and intro.</p> <p>Reference Management: Compiled the list of sources and external links used during research.</p>	10%

		<p>Attendance: Participated in scheduled group meetings at KDSE to maintain project awareness.</p> <p>Data Entry: Helped enter device names and basic price points during early budget drafts.</p> <p>Appendices: Assisted in organizing recordings and pictures for the final section.</p>	
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Table 6.1: Team Members & Responsibilities

REFERENCES

BIL .	ITEMS	LINKS
1	CORE SWITCH	<p>Huawei CloudEngine S6730-H24X6C switch. (n.d.). <i>Router-Switch.com</i>. Retrieved January 18, 2026, from https://www.router-switch.com/s6730-h24x6c.html</p> <p>FS S5850-48B8C-PE switch (Product No. 174492). (n.d.). <i>FS.com</i>. Retrieved January 18, 2026, from https://www.fs.com/sg/products/174492.html</p> <p>HPE Aruba 8325-48Y8C switch. (n.d.). <i>SteelCityConsulting.co.uk</i>. Retrieved January 18, 2026, from https://steelcityconsulting.co.uk/product/hewlett-packard-enterprise-aruba-8325-48y8c-none-2/</p>
2	ACCESS SWITCH (PoE)	<p>Cisco C9200L-24P-4X-E switch. (n.d.). <i>Router-Switch.com</i>. Retrieved January 18, 2026, from https://www.router-switch.com/c9200l-24p-4x-e.html</p> <p>Ubiquiti UniFi Switch Enterprise 24 PoE (USW-Enterprise-24-PoE). (n.d.). <i>4Gon.co.uk</i>. Retrieved January 18, 2026, from https://www.4gon.co.uk/ubiquiti-unifi-switch-enterprise-24-poe-p-9469.html</p> <p>FS S3270-24TM-P 1G PoE+ switch (Product No. 166643). (n.d.). <i>FS.com</i>. Retrieved January 18, 2026, from https://www.fs.com/sg/products/166643.html</p>

3	ACCESS SWITCH (non-PoE)	<p>FS S3700-24T4F 24-Port Gigabit Ethernet L2+ Switch (Product No. 84912). (n.d.). <i>FS.com</i>. Retrieved January 18, 2026, from https://www.fs.com/sg/products/84912.html</p> <p>NETGEAR GS524v3 24-Port Gigabit Ethernet Unmanaged Switch. (n.d.). <i>NETGEARstore.my</i>. Retrieved January 18, 2026, from https://netgearstore.my/products/netgear-gs524v3-24-port-gigabit-ethernet-unmanaged-switch?variant=43922051236020&country=MY&currency=MYR</p> <p>REYEE 24-Port Gigabit Smart Non-PoE Switch Cloud Managed. (n.d.). <i>IPD.net.au</i>. Retrieved January 18, 2026, from https://1pd.net.au/products/rejee-24-port-gigabit-smart-non-poe-switch-cloud-managed?variant=44449645265081&country=AE&currency=AUD</p>
4	WIRELESS ACCESS POINT (STUDENT LOUNGE, LABS)	<p>Tech Specs UniFi U6 Enterprise Wi-Fi 6E Access Point. (n.d.). <i>Ubiquiti</i>. Retrieved January 18, 2026, from https://techspecs.ui.com/unifi/wifi/u6-enterprise</p> <p>AC1750 Wireless MU-MIMO Gigabit Ceiling Mount Access Point (EAP245). (n.d.). <i>Omada Networks</i>. Retrieved January 18, 2026, from https://www.omadanetworks.com/my/business-networking/omada-wifi-ceiling-mount/eap245/</p> <p>Tech Specs UniFi UAP-AC-Mesh Wi-Fi 5 Access Point. (n.d.). <i>Ubiquiti</i>. Retrieved January 18, 2026, from https://techspecs.ui.com/unifi/wifi/uap-ac-mesh</p>

5	WIRELESS ACCESS POINT (HYBRID, SMART CLASSROOM)	<p>Huawei AirEngine 6760-X1 indoor Wi-Fi 6 access point. (n.d.). <i>Huawei</i>. Retrieved January 18, 2026, from https://e.huawei.com/en/products/wlan/indoor-access-points/airengine-6760-x1-6760-x1e</p> <p>AC1750 Wireless MU-MIMO Gigabit Ceiling Mount Access Point (EAP245). (n.d.). <i>Omada Networks</i>. Retrieved January 18, 2026, from https://www.omadanetworks.com/my/business-networking/omada-wifi-ceiling-mount/eap245/</p> <p>Tech Specs UniFi UAP-AC-Mesh Wi-Fi 5 Access Point. (n.d.). <i>Ubiquiti</i>. Retrieved January 18, 2026, from https://techspecs.ui.com/unifi/wifi/uap-ac-mesh</p>
6	FIREWALL /ROUTER	<p>Cisco Firepower 1010 NGFW (FPR1010-NGFW-K9) firewall appliance. (n.d.). <i>Router-Switch.com</i>. Retrieved January 18, 2026, from https://www.router-switch.com/fpr1010-ngfw-k9.html</p> <p>Ubiquiti UDM-SE (Dream Machine Special Edition). (n.d.). <i>Ubiquiti Store</i>. Retrieved January 18, 2026, from https://store.ui.com/us/en/products/udm-se</p> <p>FortiGate 80F series firewall. (n.d.). <i>AVFirewalls.com</i>. Retrieved January 18, 2026, from https://www.avfirewalls.com/FortiGate-80F.asp</p>

7	CABLE	<p>RS PRO 100 m Cat6a F/FTP shielded ethernet cable, unterminated (209-7610). (n.d.). <i>RS Online Malaysia</i>. Retrieved January 18, 2026, from https://my.rs-online.com/web/p/ethernet-cable/2097610</p> <p>RS PRO 100 m Cat6 U/UTP unshielded ethernet cable, unterminated (209-7614). (n.d.). <i>RS Online Malaysia</i>. Retrieved January 18, 2026, from https://my.rs-online.com/web/p/ethernet-cable/2097614?gb=a</p> <p>RS PRO 100 m Cat8 S/FTP shielded ethernet cable, unterminated (207-8191). (n.d.). <i>RS Online Malaysia</i>. Retrieved January 18, 2026, from http://my.rs-online.com/web/p/ethernet-cable/2078191</p>
8	CABLE (FIBER)	<p>FOB-MFD-24FM4R-M fiber optic cable, OM4 multimode, 24 fibres, 50 µm/125 µm. (n.d.). <i>element14 Malaysia</i>. Retrieved January 18, 2026, from https://my.element14.com/l-com/fob-mfd-24fm4r-m/fibre-optic-cable-24fibre-om4/dp/4215959</p> <p>OPTI-CORE outside plant armored cable, 250 µm, OM3, 6 fiber. (n.d.). <i>KVC.com.my</i>. Retrieved January 18, 2026, from https://www.kvc.com.my/Products/Cables-and-Wires/Fiber-Optic/Multimode/Fiber-Optic-Cable/OPTI-CORE-OUTSIDE-PLANT-ARMORED-CABLE-250UM-OM3-6-FIBER-zid2594478</p> <p>FS bulk fiber optic cable. (n.d.). <i>FS.com</i>. Retrieved January 18, 2026, from https://www.fs.com/sg/products/39051.html</p>

9	PATCH PANEL	<p>Ubiquiti Networks UniFi Dual-Band Outdoor AC Mesh Access Point UAP-AC-M-US (eBay item 401756101919). (n.d.). <i>eBay</i>. Retrieved January 18, 2026, from https://www.ebay.com/itm/401756101919?chn=ps&mkevt=1&mkcid=28&google_free_listing_action=view_item&</p> <p>Omada TP-Link Gigabit AP Ceiling Mount EAP-245. (n.d.). <i>Rapidsat.com.cy</i>. Retrieved January 18, 2026, from https://rapidsat.com.cy/product/omada-tp-link-gigabit-ap-ceiling-mount-eap-245/</p> <p>Ubiquiti Wi-Fi 6 Access Point (product 56680436/18323385500). (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/product/56680436/18323385500?gads_t_sig=VTJGc2RHVmtYMTlxTFVSVVRrdENkWWp3RFo3Mkw5czd4Z0hzdEF1WVFibWwvWXJUM01tMXpxbWttWlhJa0wyazZvQmYwRktvT01VSkJ0SkV2eWtydHVpaWIBbVhtQzZRUGR2eEk5djMwUUZ6bGpvc3MxQ2psams4Mk1LT3ZuQTFOdzF5aGdTMTQ5U2VPNnBaVzVzczBBPT0</p>
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10	DESKTOP COMPUTER (STD)	<p>Dell OptiPlex 7020 Tower desktop. (n.d.). <i>Dell.com Malaysia</i>. Retrieved January 18, 2026, from https://www.dell.com/en-my/shop/pcs-desktop-computers/optiplex-tower/spd/optiplex-7020t-desktop?msoclkid=1e0d0e6a180661a82e7c1850199160fc</p> <p>HP Pro Tower 400 G9 PCI Desktop PC. (n.d.). <i>HP.com Malaysia</i>. Retrieved January 18, 2026, from https://www.hp.com/my-en/shop/hp-pro-tower-400-g9-pci-desktop-pc-c6qr8at.html?msoclkid=1e0d0e6a180661a82e7c1850199160fc</p> <p>ACER Aspire XC-1785 desktop PC. (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/ACER-ASPIRE-XC-1785-14400W11S-DESKTOP-PC-%28I5-14400-8GDR5-512SSD-WIN11H-OPI%29-i.213243429.4358966411</p>
11	DESKTOP COMPUTER (PRO)	<p>Lenovo ThinkCentre neo 50s Gen 5 (without speakers) desktop. (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/LENOVO-THINKCENTRE-neo-50s-GEN-5-(without-speakers)-i.391926361.44101378603</p> <p>HP Pro Mini 400 G9 desktop PC. (n.d.). <i>HP.com Malaysia</i>. Retrieved January 18, 2026, from https://www.hp.com/my-en/shop/hp-pro-mini-400-g9-desktop-pc-c0br4pt.html?msoclkid=1e0d0e6a180661a82e7c1850199160fc</p> <p>ASUS ROG NUC (2025) mini PC. (n.d.). <i>ASUS ROG</i>. Retrieved January 18, 2026, from https://rog.asus.com/desktops/mini-pc/rog-nuc-2025/</p>

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13	IP WEBCAM	<p>Tenveo UHD 4K AI Auto-Tracking Conference PTZ Camera with 12X Zoom and Wireless Bluetooth Conference Microphone & Speakerphone. (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/Tenveo-UHD-4K-AI-Auto-Tracking-Conference-PTZ-Camera-12X-Zoom-and-Wireless-Bluetooth-Conference-Microphone-Speakerphone-2-Expansion-Mics-i.1041035085.27677154554</p> <p>Portable PTZ Camera with 4K UHD and AI Tracking (AliExpress item 1005004333997439). (n.d.). <i>AliExpress</i>. Retrieved January 18, 2026, from https://www.aliexpress.com/item/1005004333997439.html#nav-specification</p> <p>OBSBOT Tail Air AI Tracking PTZ Camera. (n.d.). <i>OBSBOT.com</i>. Retrieved January 18, 2026, from https://www.obsbot.com/store/products/obsbot-tail-air?product_id=5c3511378fba4</p>

14	IP SPEAKER	<p>Axis C1210-E Network Ceiling Speaker. (n.d.). <i>B&H Photo Video</i>. Retrieved January 18, 2026, from https://www.bhphotovideo.com/c/product/1722808-REG/axis_communications_02324_001_c1210_e_network_ceiling_speaker.html?msockid=1e0d0e6a180661a82e7c1850199160fc</p> <p>IP Speaker Clock (Model 8190). (n.d.). <i>Algo Solutions</i>. Retrieved January 18, 2026, from https://www.algosolutions.com/product/8190-ip-speaker-clock/</p> <p>Grandstream GSC3510 SIP Intercom Speaker. (n.d.). <i>Shopee Indonesia</i>. Retrieved January 18, 2026, from https://shopee.co.id/Grandstream-GSC3510-GSC3510-SIP-Intercom-Speaker-i.21746128.4621777367?is_from_signup=true</p>
15	KEYBOARD & MOUSE	<p>HP 225 Wired Mouse and Keyboard Combo (AX2Y7AA). (n.d.). <i>HP.com Malaysia</i>. Retrieved January 18, 2026, from https://www.hp.com/my-en/shop/hp-225-wired-mouse-and-keyboard-combo-ax2y7aa.html</p> <p>Dell KB216 Multimedia USB Chiclet Keyboard & MS116 USB Optical Mouse Combo. (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/Dell-KB216-Multimedia-USB-Chiclet-Keyboards-MS116-USB-Optical-Mouse-Combo-Black-White-i.157405.2126464016</p> <p>Lenovo Keyboard and Mouse Combo (4X31R64400). (n.d.). <i>Lenovo Malaysia</i>. Retrieved January 18, 2026, from https://www.lenovo.com/my/en/p/accessories-and-software/keyboards-and-mice/keyboard-and-mouse-combos/4x31r64400?msockid=1e0d0e6a180661a82e7c1850199160fc</p>

16	SMART BOARD	<p>SAMSUNG Flip Pro 65" LH65WMB-WBGC 4K Interactive Display. (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/SAMSUNG-Flip-Pro-65-LH65WMB-WBGC-4K-Interactive-Display-Digital-Flipboard-Flipchart-Display-(WM65B)-Business-Education-i.13800378.19327659662</p> <p>VIEWSONIC 65" IFP6533-G VIEWBOARD® 4K Interactive Display Smart Board. (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/VIEWSONIC-65-IFP6533-G-VIEWBOARD%C2%AE-65-4K-INTERACTIVE-DISPLAY-SMART-BOARD-i.252512310.24037709410</p> <p>BenQ Board Pro RP04 Interactive Display (pre-order). (n.d.). <i>Cresdo</i>. Retrieved January 18, 2026, from https://cresdo.com/BenQ-Board-Pro-RP04-Pre-Order-p174396578</p>
17	UPS (Lab)	<p>Prolink 1200VA 720W UPS power backup with AVR (PRO1201SFCU). (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/Prolink-1200VA-720W-UPS-Power-Backup-with-AVR-for-Computer-Modem-Router-Switch-NAS-CCTV-PRO1201SFCU-2-Year-Warranty-i.588884.6332441</p> <p>RIGHT POWER PowerTank F800/F800P (USB) 800VA UPS. (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/RIGHT-POWER-POWERTANK-F800-F800P-(USB)-800VA-UPS-i.618503907.16320871954</p> <p>APC BVX1200LI-MS APC Easy UPS, 1200VA, Tower, 230V, 4 Universal + 1 IEC C13 outlets, AVR. (n.d.). <i>Shopee Malaysia</i>. Retrieved January 18, 2026, from https://shopee.com.my/APC-BVX1200LI-MS-APC-Easy-UPS-1200VA-Tower-230V-4-Universal-1-IEC-C13-outlets-AVR-i.370742898.25478680399</p>

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21	VLSM	<p>GeeksforGeeks. (2025b, December 12). Introduction of Variable Length Subnet Mask (VLSM). GeeksforGeeks. https://www.geeksforgeeks.org/computer-networks/introduction-of-variable-length-subnet-mask-vlsm/</p>
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23	NAT	Cisco Catalyst 8000 Edge Platforms Family Overview. (2025, March 20). [Video]. Cisco. https://www.cisco.com/site/us/en/learn/topics/networking/what-is-network-address-translation-nat.html
24	Cisco stackwise	Molenaar, R., & Molenaar, R. (2025, August 13). Cisco Stackwise. NetworkLessons.com. https://networklessons.com/switching/cisco-stackwise
25	Public & Private IP Address	Marijan, B. (2025, December 18). Public vs. Private IP Address: What's the Difference. Knowledge Base by phoenixNAP. https://phoenixnap.com/kb/public-vs-private-ip-address
26	Backbone Cabling	Van Waes, E. (2026, January 15). What is Backbone Cabling? A Wiring Infrastructure Guide. Signal Solutions. https://www.signalsolutions.com/blog/what-is-backbone-cabling
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28	MDF & IDF	Devasia, A. (2025, November 24). MDF vs IDF: Key Differences Explained. The Network Installers. https://thenetworkinstallers.com/blog/mdf-vs-idf/
29	Subnetting	GeeksforGeeks. (2025c, December 30). Introduction To Subnetting. GeeksforGeeks. https://www.geeksforgeeks.org/computer-networks/introduction-to-subnetting/
30	Fiber optic cable EMI	Yan, J. (2025, December 8). EMI in Communication Networks: Causes, challenges, and why fiber wins. FiberMania Link. https://www.fibermanialink.com/blog/emi-causes-challenges-fiber-role/
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32	Transmission media	GeeksforGeeks. (2026, January 5). Transmission media in computer networks. GeeksforGeeks. https://www.geeksforgeeks.org/computer-networks/types-transmission-media/

Table 7.1: References

APPENDICES

FINANCIAL BUDGET

Purpose	Model Name	Price x Quantity	Total
Router/Firewall	Fortinet FortiGate 80F	4,617.43 x 1	4,617.43
Core Switch	Huawei CloudEngine S6730-H24X6C	12,484.47 x 2	24,968.94
Access Switch (PoE)	Cisco Catalyst 9200L-24P-4X-E	5,234.87 x 2	10,469.74
Access Switch (non-PoE)	Cisco Catalyst 9200L-24T-4X-E	4,059.05 x 8	32,472.40
Wireless Access Point (Student Lounge, Labs)	Ubiquiti UniFi 6 Enterprise	1,131.35 x 6	6,788.10
Wireless Access Point (Hybrid, Smart Classroom)	Huawei AirEngine 6760-X1	2,319.46 x 2	4,638.92
Server	HPE ProLiant ML30 Gen10 Plus Server	8,440 x 1	8,440.00
Desktop (standard)	ACER ASPIRE XC-1785-14400W11S	2,452.20 x 60 (including mouse & keyboard)	147,132
Desktop (Advanced)	Lenovo Legion Tower 5i	5,517.01 x 60	331,020.60
Keyboard & Mouse	Lenovo Essential Wired Combo	88.20 x 60	5,292
Monitor	ThinkVision S22i-30	534 x 120	64,080
IP Webcam	TENVEO VL12U (4K AI PTZ Camera)	2,530.24 x 2	5,060.48
IP Speaker	AXIS C1210-E	2,142.45 x 3	6,427.35
Projector	Epson EB-FH52	4,189 x 4	16,756.00
Smart TV	Samsung 75" Crystal UHD	3,549 x 1	3,549.00

	UE100F		
Smart Board	Samsung Flip Pro 65” (WM65B)	14,999 x 1	14,999.00
UPS	HPE ProLiant ML30 Gen10 Plus	8,440 x 1	8,440.00
Cable (Copper)	CommScope CS30CM Cat6 (100m)	372.00(per 100 meter) x 4	1,488.00
Cable (Fiber)	OM4 Multi-Mode Fiber Optic	133.51(per 1 meter) x 90	12,015.90
Patch Panel	CommScope SL Series 24-Port	300.00 x 2	600.00
Budget Allocated			RM 900,000
Total Spend			RM 709,255.86
Money Left			RM 190,744.14

Table 8.1: Financial Budget

MEETING MINUTES
Minutes Meeting Bil.01

DATE / TIME	10 JANUARY 2026
LOCATION	WA2, KDSE
AGENDA	<ol style="list-style-type: none"> 1. Project Kick-off & Understanding Task 6A Requirements. 2. Task 1: Floor Plan & Layout Analysis. 3. Task 2: Requirement Analysis (User Interviews). 4. Initial Budget Planning.
Meeting MC	ABDURRAFIQ BIN ZAKARIA

ATTENDANCE		
NAME	TIME	REASON FOR ABSENCE
ABDURRAFIQ BIN ZAKARIA	21:00	
AHMAD MUNIF BIN BAHARUM	21:00	
NAJMUDDIN BIN KAMARUDIN	21:00	
DANIEL IMAN HAQIMIE BIN YUSOFF	21:00	

MINUTES			
NO.	ITEM DISCUSSED	IDEAS/SUGGESTIONS AND PERSON GIVING IT	PERSON IN CHARGE
1	Project Kick-off & Role Assignment	<ul style="list-style-type: none"> - Abdurrafik proposed dividing roles to ensure we meet the final report (Task 6A) criteria: Daniel on Physical Design, Munif on Financials/Hardware, Najmuddin on User Requirements, and Abdurrafik on Logical Design. 	All Members

2	Task 1: Floor Plan Layout	<ul style="list-style-type: none"> - Daniel presented the layout drafts. Suggested prioritizing the Student Lounge and General Labs on the Ground Floor for easy access. Munif noted we must include "Additional Spaces" (Toilets/Stairs) to match the building blueprints. 	Daniel
3	Task 2: User Needs Analysis	<ul style="list-style-type: none"> - Najmuddin shared interview findings: The new building needs to support Hybrid Learning and high-density BYOD usage (approx. 4,500 connections). Group agreed to focus on Wi-Fi 6E solutions. 	Najmuddin
4	Financial Constraints	<ul style="list-style-type: none"> - Abdurrafiq highlighted the RM 900,000 budget. The team agreed to aim for ~RM 800k spending to leave a ~RM 100k "Emergency Buffer" as a strong point for the financial reflection in the final report. 	Abdurrafiq
5	Meeting ended	<ul style="list-style-type: none"> - Rafiq ends this meeting with tasbeeh kifarah and surah al-asr. - Next meeting will be held on 12 January 2026 - Meeting ended at 22:30 	-

Minutes Meeting Bil.02

DATE / TIME	12 JANUARY 2026
LOCATION	WA2, KDSE
AGENDA	<ol style="list-style-type: none"> 1. Task 3: Choosing LAN Devices (Switches, Routers, PCs). 2. Comparisons & Justifications (Core vs. Access). 3. Specialized Equipment for Hybrid Classroom. 4. Feasibility Analysis for the Report.
Meeting MC	ABDURRAFIQ BIN ZAKARIA

ATTENDANCE		
NAME	TIME	REASON FOR ABSENCE
ABDURRAFIQ BIN ZAKARIA	21:00	
AHMAD MUNIF BIN BAHARUM	21:00	
NAJMUDDIN BIN KAMARUDIN	21:00	
DANIEL IMAN HAQIMIE BIN YUSOFF	21:00	

MINUTES			
NO.	ITEM DISCUSSED	IDEAS/SUGGESTIONS AND PERSON GIVING IT	PERSON IN CHARGE
1	Core Switch Selection	<ul style="list-style-type: none"> - Munif proposed the Huawei CloudEngine S6730 because its "Native AC" feature eliminates the need for a separate controller. Abdurrafiq noted this "cost-saving feature" should be highlighted in the Report Conclusion as a key strength. 	Munif

2	Workstation Selection	<ul style="list-style-type: none"> - Daniel suggested mixing Acer Aspire (Standard Labs) with Lenovo Legion (Multimedia Labs). Najmuddin agreed, noting that this "tiered hardware" approach demonstrates budget efficiency for the Task 6A reflection. 	Daniel
3	Hybrid Classroom Tech	<ul style="list-style-type: none"> - Najmuddin recommended the Samsung Flip Pro smartboard. Munif added the Tenveo 4K PTZ Camera because its optical zoom is better for whiteboard visibility, crucial for the "Hybrid Learning" requirement. 	Najmuddin
4	Initial Budget Check	<ul style="list-style-type: none"> - Abdurrafiq reviewed the device list. Total estimated spend is roughly RM 798,000. The group approved this list as it fits the "Feasibility Analysis" criteria perfectly. 	All Members
5	Meeting ended	<ul style="list-style-type: none"> - Rafiq ends this meeting with tasbeeh kifarah and surah al-asr. - Next meeting will be held on 16 January 2026 - Meeting ended at 00:30 	-

Minutes Meeting Bil.03

DATE / TIME	16 JANUARY 2026
LOCATION	WA2, KDSE
AGENDA	<ol style="list-style-type: none"> 1. Task 4: Network Topology & Cabling. 2. Task 5: IP Addressing (VLSM Strategy). 3. DHCP Policies & Logical Security. 4. Preparing Data for the Final Report.
Meeting MC	AHMAD MUNIF BIN BAHARUM

ATTENDANCE		
NAME	TIME	REASON FOR ABSENCE
ABDURRAFIQ BIN ZAKARIA	21:00	
AHMAD MUNIF BIN BAHARUM	21:00	
NAJMUDDIN BIN KAMARUDIN	21:00	
DANIEL IMAN HAQIMIE BIN YUSOFF	21:00	

MINUTES			
NO.	ITEM DISCUSSED	IDEAS/SUGGESTIONS AND PERSON GIVING IT	PERSON IN CHARGE
1	Task 4: Cabling Infrastructure	<ul style="list-style-type: none"> - Daniel finalized the topology. He suggested using OM4 Fiber for the backbone to support 10Gbps uplinks and Cat6 Copper for desktops. Munif noted this balances performance and cost effectively. 	Daniel

2	Task 5: IP Addressing (VLSM)	<ul style="list-style-type: none"> - Abdurrafiq presented the VLSM strategy: Splitting the /23 block into Labs (56.x) and Wi-Fi/Admin (57.x). Najmuddin verified that this leaves 62 IPs reserved, which we should list as a "Future Suggestion" for scalability in the report. 	Abdurrafiq
3	DHCP Lease Policy	<ul style="list-style-type: none"> - Munif suggested a 2-hour Lease for Student Wi-Fi to prevent IP exhaustion. Abdurrafiq added that fixed Lab PCs should have a 7-day Lease to reduce traffic. This logic must be detailed in the Task 5 Report section. 	Munif
4	Security Implementation	<ul style="list-style-type: none"> - Group agreed on VLANs (10, 20, 30, 90). Rafiq emphasized that SSH v2 must be enforced for Management (VLAN 90) to meet the security reflection criteria. 	All Members
5	Meeting ended	<ul style="list-style-type: none"> - Munif ends this meeting with tasbeeh kifarah and surah al-asr. - Next meeting will be held on 18 January 2026 - Meeting ended at 01:30 	-

Minutes Meeting Bil.04

DATE / TIME	18 JANUARY 2026
LOCATION	WA2, KDSE
AGENDA	<ol style="list-style-type: none"> 1. Task 6A: Final Report Compilation (Reflection & Suggestions). 2. Final Financial Budget Reconciliation. 3. Review of Team Contributions (% Work Done). 4. Individual Reports & Video Preparation.
Meeting MC	AHMAD MUNIF BIN BAHARUM

ATTENDANCE		
NAME	TIME	REASON FOR ABSENCE
ABDURRAFIQ BIN ZAKARIA	18:00	
AHMAD MUNIF BIN BAHARUM	18:00	
NAJMUDDIN BIN KAMARUDIN	18:00	
DANIEL IMAN HAQIMIE BIN YUSOFF	18:00	

MINUTES			
NO.	ITEM DISCUSSED	IDEAS/SUGGESTIONS AND PERSON GIVING IT	PERSON IN CHARGE
1	Report: Reflection & Suggestions	<ul style="list-style-type: none"> - Najmuddin proposed the "Future Suggestions" should include a centralized Network Management System (NMS) and UPS maintenance. Daniel suggested highlighting the "Scalability" of Wi-Fi 6E as our main design strength. 	Najmuddin

2	Final Financial Budget	<ul style="list-style-type: none"> - Munif presented the final table. Total Spend: RM 798,841.86. Money Left: RM 101,158.14. The group agreed to frame this surplus as "Maintenance Reserves" in the report conclusion. 	Munif
3	Team Contributions	<ul style="list-style-type: none"> - Abdurrafik reviewed the work distribution. The group agreed on an equal 25% contribution for each member, as everyone led specific tasks (Daniel: Physical, Munif: Hardware, Rafiq: Logical, Najmuddin: Analysis). 	Abdurrafik
4	Final Compilation	<ul style="list-style-type: none"> - Abdurrafik will compile the Group Report PDF. All members must submit their Individual Reports. Daniel will upload the final files to e-learning. 	Abdurrafik
5	Meeting ended	<ul style="list-style-type: none"> - Munif ends this meeting with tasbeeh kifarah and surah al-asr. - Meeting ended at 21:00 	-

PICTURES



Figure 3.0 Interview session with Mr Firdaus, Technical staff



Figure 3.1 Interview session with Mr Firdaus, Technical staff



Figure 4.0 Voice recording of interview sessions

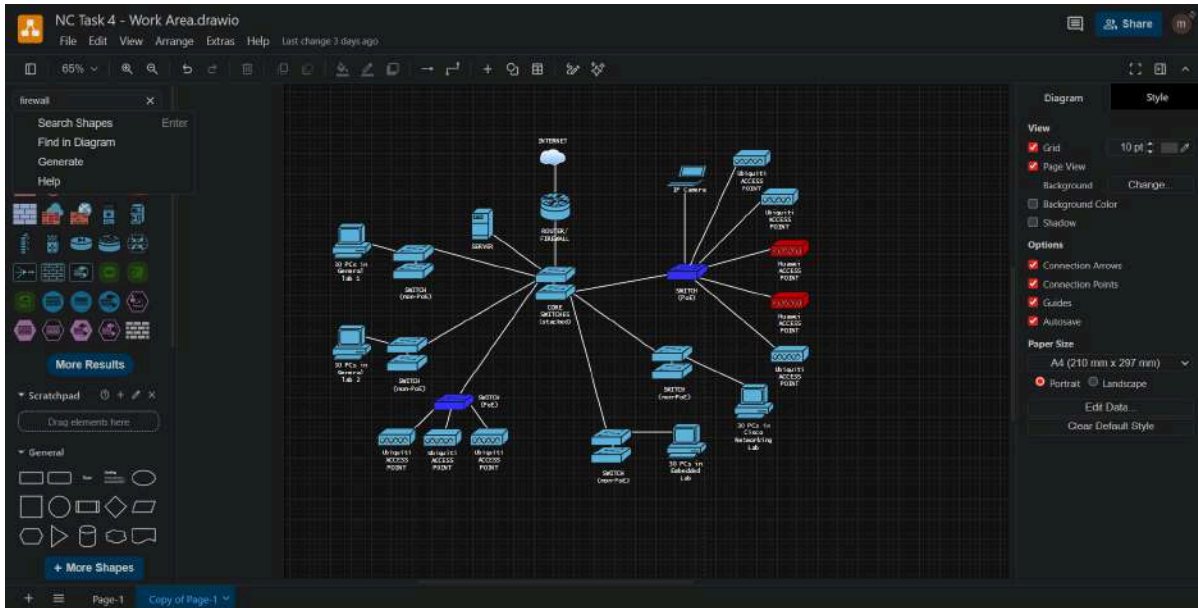


Figure 5.0 Consultation of network topology for Work Area with Dr Zafran



Figure 5.1 Consultation of network topology for Work Area with Dr Zafran