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**MSc Information Technology**

**COMP11107 - Business Data Communication & Networks**

**Coursework Report**

**Modern Network for Two New University Buildings**

**by**

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# Introduction

TODO1. Proposed Solution Addressing User Needs

## 1.1 Discussion

This section outlines a modern, scalable network design for the two new buildings (Building 1 and Building 2) at the University of the West of Scotland (UWS). The system aims to provide seamless connectivity for administrative staff, academics, and students while balancing their requirements for performance, security, and future growth.

**Networking Floors within Each Building**

Every building has three floors. Each floor has different facilities and is used by different groups of people. To make sure everyone in the building stays connected without issues, we suggest using both wired (like Ethernet cables) and Wi-Fi networks together.

* **Ground Floor:** For administrative staff working on the ground floor, we will provide secure wired internet connections in their offices. Since they handle important university data, their network will be kept separate from others to prevent unauthorized access. We will also install backup power systems to make sure their work is never interrupted.
* **First and Second Floor:** These floors are mainly used for academic activities, including lecture halls, tutorial rooms, and computer labs. Each floor will use managed switches to provide wired connections for devices like desktops and lab equipment. Wi-Fi 6 access points (APs) will offer fast wireless connectivity for laptops, tablets, and smartphones used by students and staff. The network will support digital learning tools, online resources, and collaboration platforms for multiple users at the same time.

**Connecting the Two Buildings**

To enable effective collaboration and resource sharing between both buildings, a high-performance inter-building network link is crucial. Our solution utilizes fibre optic cabling to interconnect the facilities. This technology provides distinct benefits such as exceptional bandwidth capacity, minimal latency, and long-term scalability.

* **Fibre Optic Backbone:** A dedicated single-mode fibre link will connect both buildings, supporting >10Gbps data transfer, video conferencing, and real-time collaboration. The enterprise-grade infrastructure delivers low-latency performance for all academic/administrative needs. The scalable design accommodates future bandwidth upgrades while maintaining compatibility with existing systems.
* **Redundancy:** Dual fibre paths with automatic failover ensures uninterrupted connectivity. This fault-tolerant design eliminates single points of failure for critical operations.

**Integrating Building with Network**

The new buildings need to connect smoothly to the university’s existing network. This will let users access shared resources, administrative systems, and the internet. The connection will use both hardware (like routers) and software (like network management systems) to work properly.

* **Switches & Routers:** Routers direct traffic between networks and buildings, while switches connect all devices within each building. Together they enable seamless communication across the entire campus network.
* **VPNs:** VPNs create secure encrypted tunnels for all data moving between buildings, protecting sensitive information from external threats.
* **Network Segmentation:** VLANs separate network traffic by user groups and purposes, improving security and performance across different departments.

**Future Proofing the Network**

To ensure long-term usability, the network will be designed to adapt to growing demands and emerging technologies.

* **Scalable Infrastructure:** The architecture supports easy upgrades, allowing bandwidth and capacity to expand as needed without major redesigns.
* **New Technology Advancements:** The system will accommodate innovations like IoT, AI tools, and higher-speed standards (e.g., Wi-Fi 7, 100Gbps fibre) through modular hardware and flexible configurations.

## 1.2 Justification

This network solution delivers fast, secure connectivity for all users while supporting future growth. It balances performance and security with scalable infrastructure. The design meets current needs and adapts to emerging technologies.

* **Administrative Staff Offices:** The dedicated wired connections and isolated VLAN ensure secure, uninterrupted access to sensitive systems like student records and financial data. Redundant power and network paths prevent disruptions to critical operations. Strict access controls protect confidential information while maintaining high-speed performance.
* **Academics Offices**: High bandwidth wired/Wi-Fi 6E connectivity supports research data transfers and hybrid teaching tools. Quality of Service prioritizes video calls and cloud collaboration platforms. Future-ready multi-gigabit ports accommodate evolving academic workloads.
* **Social/Common Room:** Bandwidth-throttled Wi-Fi 6E allows 50+ concurrent users for casual browsing without impacting critical networks. Separate guest VLAN protects core systems while enabling device flexibility.
* **Tutorial Classrooms:** Reliable Wi-Fi 6 handles small-group collaboration with low-latency screen sharing. Wired ports for tutors enable stable connections to presentation systems. Device isolation prevents cross-interference during simultaneous logins.
* **Computer Labs:** The wired network in computer labs ensures fast and stable connections for resource-intensive tasks like programming and simulations. Each workstation gets dedicated bandwidth to prevent slowdowns during class activities. The system supports quick software deployments and secure logins for students and instructors.
* **Future Needs:** The proposed network is designed to scale effortlessly as user demands grow, with modular infrastructure that adapts to emerging technologies.

This network solution gives each user group exactly what they need - fast internet for teachers, secure connections for office staff, and strong Wi-Fi for students. It keeps everything safe and running smoothly while making it easy to upgrade later. The system works perfectly today but is also ready for future improvements.

# 2. Proposed Hardware

## 2.1 Discussion

Choosing the right hardware is very important to make sure the network works well in the new Buildings 1 and 2 at UWS. This section talks about the main hardware devices we will use and why we selected them. The network will follow the standard 3-layer design (core, distribution, and access) for better performance.

**Core Switches**

To manage the university's high-volume data traffic with minimal delay, we require powerful core switches capable of handling heavy workloads. The Cisco Catalyst 9500 Series is ideal for this role, offering superior routing functions, exceptional data transfer speeds, and compatibility with multiple network standards.

* **Cisco Catalyst C9500-48Y4C** is a high-performance core switch designed for enterprise networks, featuring 48x 25G/10G ports and 4x 100G uplinks for ultra-fast data transfer.



Fig 2.1

**Distribution Switches**

The distribution layer utilizes high-performance switches like the Cisco Catalyst 9300 Series to consolidate traffic from access switches and link to the core. These switches enable fast uplink speeds, QoS prioritization for critical applications, and VLAN-based network segmentation. Their scalable design ensures efficient traffic flow between layers while supporting advanced campus-wide features.

* **Cisco Catalyst C9300-48UXM** offers 48 multi-gigabit ports (up to 10G) with PoE++ support and 100G uplinks, ideal for bandwidth-heavy areas like lecture halls and labs. Its StackWise-480 technology provides seamless scalability for growing networks.

A white device with many ports

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Fig 2.2

**Access Switches**

For connecting computers, phones, and Wi-Fi access points, we use Cisco Catalyst 9200 switches. These switches provide Power over Ethernet (PoE) to run devices like wireless access points and IP phones without extra power cables. They are simple to manage and work well for classrooms, labs, and offices.

* **Cisco Catalyst C9200L-48P-4X-A** has 48 PoE ports to support devices like Wi-Fi 6 access points and IP phones, plus 4 high-speed uplinks for fast data transfer. It’s perfect for areas needing both power and strong network performance.

A close-up of a device

AI-generated content may be incorrect.

Fig 2.3

**Firewalls**

To protect the entire network, we use advanced firewalls like Cisco Firepower at the core layer. These firewalls block cyber threats, prevent attacks, and inspect all data traffic for safety. They keep the network secure while maintaining fast performance for all users.

* **Cisco FPR2130-ASA-K9 Firepower** is a powerful firewall that protects large networks like universities from cyber threats. It combines Cisco ASA security with Firepower threat detection to block attacks in real-time while supporting fast VPN access. Ideal for 1000+ users, it integrates smoothly with the existing Cisco switches and future upgrades.

A close up of a device

AI-generated content may be incorrect.

Fig 2.4

**Wireless Access Points (WAP)**

We'll use Cisco Catalyst 9136 wireless devices to give strong internet all over the buildings. These support the latest Wi-Fi 6 technology, which means faster speeds for everyone. They work well in crowded areas like classrooms where many students connect at once.

* **Cisco Catalyst 9136I** is a top-tier Wi-Fi 6E access point that delivers blazing speeds up to 3.5Gbps using the 6GHz band. It effortlessly handles 150+ concurrent devices in high-density areas like lecture halls, while its smart antenna design ensures full coverage. Perfect for future-proofing the campus network.

A white electronic device with a black handle

AI-generated content may be incorrect.

Fig 2.5

**Cabling Infrastructure**

We’ll use Cat6a cables for wired connections in offices and classrooms, supporting 10Gbps speeds and PoE++ for devices like Wi-Fi access points. Fiber optic cables (OS2) will link buildings and server rooms for high-speed, long-distance connections. This hybrid approach balances cost, performance, and future needs.

* **Cat6a Ethernet Bulk Cable Shielded** is high-quality 23AWG solid copper cable supports 10Gbps speeds up to 100m and 750MHz bandwidth, ideal for reliable wired networks. Its shielded design reduces interference, perfect for offices and classrooms with PoE devices like Wi-Fi APs.

A cable and a box

AI-generated content may be incorrect.

Fig 2.6

* **Single Mode (OS2) 2.0mm, Tight Buffered** is a long-distance fiber optic cable supports 10Gbps to 100Gbps speeds over 10km+, ideal for connecting buildings. The tight-buffered design makes it durable and easy to install in tight spaces.

A close up of a cable

AI-generated content may be incorrect.

Fig 2.7

**Rack-Mounted Servers**

We'll deploy rack-mounted Dell PowerEdge servers with high-performance processors and SSD storage to handle academic databases, virtual labs, and shared resources. These servers will ensure 24/7 uptime with redundant power and cooling for critical university operations.

* **Dell PowerEdge R740 512GB 2 Xeon Gold** is high-performance server delivers extreme processing power for virtualization, databases, and campus-wide applications. With 512GB RAM and dual Xeon Gold CPUs, it handles heavy workloads while ensuring reliability for 24/7 university operations.

A silver computer device with a white background

AI-generated content may be incorrect.

Fig 2.8

**UPS (Uninterruptible Power Supply)**

We’ll deploy UPS systems to protect servers, switches, and critical hardware from power outages, ensuring 24/7 uptime and safe shutdowns during failures.

**Eaton 9PX 2000VA 1800W 120V Online** is high-efficiency online UPS delivers 1800W/2000VA pure sine wave power, ensuring zero downtime for critical lab equipment and servers. With double-conversion technology, it protects against surges, outages, and voltage fluctuations.

A black electronic device with a blue screen

AI-generated content may be incorrect.

Fig 2.9

**Additional Hardware**

* **Printers:** High-volume enterprise printers will be installed in admin offices and labs for staff/student use, supporting secure, networked printing with user authentication to reduce waste.
* **IP Phones:** Cisco IP phones (PoE-powered) will provide crystal-clear voice calls across campus, integrated with your network for seamless internal communication.

## 2.2 Justification

**Core Switches**

Core switches are the backbone of the network, connecting all buildings and handling heavy data traffic. We chose high-performance switches like the Cisco Catalyst 9500 because they support fast speeds (up to 100Gbps) and ensure smooth communication across campus. Their advanced features, like redundancy and scalability, prevent downtime and allow future upgrades. This keeps the network reliable for students, teachers, and staff, even during peak usage. Investing in strong core switches now saves costs later by avoiding frequent replacements.

**Distribution Switches**

These switches connect all floors and buildings while handling heavy traffic. The C9300-48UXM model offers 48 multi-gigabit ports and 100G uplinks, ensuring fast data flow between rooms and labs. It supports VLANs to separate staff/student traffic securely. Its stackable design allows easy expansion as the university grows.

**Access Switches**

Used in classrooms and offices, the C9200L-48P-4X-A provides Power over Ethernet (PoE++) to run Wi-Fi 6 access points and IP phones without extra wiring. Its 48 ports support high-speed connections for PCs and printers, while 10G uplinks prevent bottlenecks. Easy to manage and scalable for future needs.

**Firewall**

This firewall blocks hackers and malware, keeping student/staff data safe. It combines Cisco ASA security with Firepower threat detection for real-time protection. Supports VPNs for remote access and works smoothly with your switches. Ideal for a campus with 1000+ users.

**Wireless Access Points (WAP)**

The 9136I Wi-Fi 6 access points deliver fast, reliable internet in crowded lecture halls and labs. Handles 100+ devices at once with speeds up to 1.7Gbps. Easy to set up and manage through Cisco’s cloud tools.

**Cables**

* **Cat6a Shielded:** Supports 10Gbps speeds and PoE++ for devices like APs and phones. Reduces interference in busy areas.
* **OS2 Single-Mode Fiber:** Connects buildings with 10Gbps+ speeds over long distances. Future-proof for upgrades.

**Servers**

The R740 server (with 512GB RAM and dual Xeon Gold CPUs) runs databases, virtual labs, and campus apps without slowing down. 24/7 reliability with redundant power and storage.

**UPS**

Protects servers and switches from power cuts, ensuring no data loss. Provides clean power for 30+ minutes during outages. Easy to monitor via LCD.

**Additional Hardware**

* Printers: Networked printers with secure login for staff/students, reducing waste.
* IP Phones: Cisco PoE phones for clear calls across campus, powered by switches.

This network setup gives every user—students, teachers, and staff—the speed, security, and reliability they need. From high-speed Wi-Fi in classrooms to secure data storage in servers, each part is chosen to work smoothly together. The system is easy to upgrade as the university grows, saving time and money later. With backup power and strong security, the network will run safely for years.

# 2. Proposed Software

## 2.1 Discussion

Picking the right software is key to making the network run smoothly, stay secure, and be easy to manage. In this section, we'll explain the software we plan to use for the switches, Wi-Fi, firewalls, VPN, Antivirus and servers - all chosen to work perfectly with our Cisco hardware. We'll focus on solutions that are powerful yet simple to use, keeping costs reasonable for the university's needs.

**Network OS (Cisco IOS-XE)**

Cisco IOS-XE is the operating system for Cisco's modern switches and routers. It is used across core, distribution, and access layers to manage connectivity, security, and traffic flow. Key features include automation tools (SD-Access), real-time monitoring, and advanced security like MACsec encryption. Its modular design allows updates without downtime, making it ideal for high-availability networks like universities. IOS-XE simplifies management while ensuring reliability for 24/7 operations.

**Firewall (Cisco Firepower Threat Defence)**

Cisco Firepower Threat Defence (FTD) is the security software for your Cisco FPR2130 firewall, combining firewall protection with advanced threat detection. It monitors all network traffic in real-time to block viruses, hackers, and intrusions using features like IPS (Intrusion Prevention System), malware scanning, and VPN support. Easy to manage through a central dashboard, it enforces security policies for staff/student devices while allowing secure remote access. Ideal for campuses, it balances strong protection with simple controls.

**Server OS (Windows 2022)**

Windows Server 2022 is the recommended operating system for your Dell PowerEdge R740 servers. It provides a stable and secure platform for running university applications, databases, and virtual labs. Key features include Active Directory for user management, Hyper-V for virtualization, and built-in security tools to protect sensitive data.

**Monitoring & Backup (Cisco DNA Center)**

Cisco DNA Center is the centralized management platform for your university's Cisco network hardware (switches, routers, wireless). It simplifies configuration, monitoring, and troubleshooting through an intuitive dashboard, while automating tasks like software updates and policy enforcement.

**Antivirus (McAfee)**

This software protects all university devices (PCs, servers) from viruses, ransomware, and spyware. It runs quietly in the background with real-time scanning, automatic updates, and web protection to block dangerous sites. Easy to manage centrally for all campus computers.

**Virtual Private Network (Cisco AnyConnect VPN)**

Cisco AnyConnect VPN is the ideal choice for your university as it integrates perfectly with your existing Cisco firewall and switches. It offers secure remote access with military-grade encryption, ensuring staff and students can safely connect from anywhere. The simple one-click login and centralized management save IT time while keeping threats out.

**Access Management (Cisco Identity Services Engine)**

Cisco Identity Services Engine securely manages Wi-Fi access by requiring login via a portal before granting internet. It works with your Cisco network to enforce policies (like blocking guests) and track connected devices. Keeps campus Wi-Fi safe and controlled.

## 2.2 Justification

**Network OS (Cisco IOS-XE)**

We chose Cisco IOS-XE because it’s designed specifically for Cisco switches and routers, ensuring perfect compatibility and smooth performance. It simplifies management with both web and command-line interfaces, while automatic updates keep security tight against new threats. This OS is trusted by universities globally for building stable, scalable networks that grow with student needs.

**Firewall (Cisco Firepower Threat Defence)**

Cisco Firepower is ideal for blocking viruses, hackers, and intrusions in real-time, keeping campus data safe. It integrates seamlessly with your existing switches and VPN, creating a unified security system. As the industry’s top enterprise firewall, it’s proven to handle high-traffic networks like universities without slowing down.

**Server OS (Windows 2022)**

Windows Server 2022 runs smoothly on your Dell PowerEdge servers, supporting academic apps and databases with ease. Its familiar interface reduces training time for IT staff, while built-in tools like Active Directory and Hyper-V simplify user and resource management. Regular updates from Microsoft ensure long-term reliability.

**Monitoring & Backup (Cisco DNA Center)**

Cisco DNA Center provides a single dashboard to monitor and manage all network devices, from switches to Wi-Fi. It automates backups, preventing costly downtime from configuration errors, and includes tools for troubleshooting. This centralized control saves IT teams hours of manual work while keeping the network secure.

**Virtual Private Network (Cisco AnyConnect VPN)**

AnyConnect VPN provides secure remote access for staff and students, encrypting data even on public Wi-Fi. It comes included with the Cisco firewall license, so there’s no extra cost, and it offers one-click login for ease of use. It also has military-grade encryption and malware blocking for added security.

The VPN is also used to connect other university buildings through a secure WAN, which is more cost-effective than setting up a dedicated WAN line. This setup keeps the network safe, reliable, and budget-friendly.

**Access Management (Cisco Identity Services Engine)**

Cisco ISE ensures only authorized users access campus Wi-Fi by requiring login credentials via a captive portal. It tracks connected devices to prevent abuse and enforces policies like bandwidth limits for guests. Tight integration with Cisco APs and switches makes it a no-brainer for your secure network.

Every software chosen is Cisco-branded because it guarantees compatibility, reduces complexity, and leverages industry-trusted security. This all-Cisco ecosystem is cost-effective, easy to maintain, and scales effortlessly as your university grows. From firewall protection to Wi-Fi logins, this setup delivers reliability, safety, and simplicity.

# 4. Proposed Network Circuits

## 4.1 Discussion

To ensure a reliable and scalable network for the university, we propose a three-tier architecture comprising core, distribution, and access layers. This design efficiently manages traffic flow, enhances performance, and simplifies troubleshooting across Buildings 1 and 2. The core layer handles high-speed data transfer between buildings, the distribution layer routes traffic between floors, and the access layer connects end-user devices. Fiber optic cables link the core and distribution layers for speed, while shielded Cat6a cables serve access-layer devices. This structured approach ensures seamless connectivity, security, and future scalability for the entire campus network.

**Three-Tier Network Architecture**

The 3-tier network design splits the system into three layers: the core (connects buildings), distribution (routes traffic between floors), and access (links devices like PCs and phones). This keeps the network fast, organized, and easy to manage.

1. **Core Layer:** The backbone of the network, connecting buildings with high-speed fiber for maximum data flow.
2. **Distribution Layer:** Routes traffic between floors and enforces security policies across the campus.
3. **Access Layer:** Connects end-user devices (PCs, phones, Wi-Fi) with Cat6a cables for reliable daily use.

A group of blue cubes with white circles and arrows

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Fig 4.1

**Network Configuration by Floor**

This section details the wired/wireless setup, VLANs, and cabling for each floor—ground (admin), first (classrooms), and second (labs)—ensuring optimal performance and security.

**Ground Floor**

This floor handles administrative offices (Finance, HR, Admissions) with dedicated VLANs for secure, high-speed wired connections to protect sensitive data with VLAN 10, 20 and 30. The social/common room uses VLAN 40 for student Wi-Fi, with bandwidth throttling to prevent network slowdowns. Cat6a cables connect all devices, while PoE switches power IP phones and Wi-Fi 6 access points.

1. **Finance Computers:** The finance team uses 10 computers, 1 network printer, and 10 IP phones, all connected via Cat6a cables to a Cisco Catalyst C9200L switch. These devices are isolated in VLAN 10 (Finance) with the subnet 192.168.10.0/24 for secure traffic management. VPN access is enabled for remote work on financial systems, with strict port security (MAC filtering) to prevent unauthorized connections.
2. **HR Computers:** The HR team uses 5 computers, 1 network printer, and 5 IP phones, all connected via Cat6a cables to the same Cisco Catalyst C9200L switch (shared with Finance). These devices are assigned to VLAN 20 (HR) with the subnet 192.168.20.0/24 to isolate sensitive employee data. VPN access is enabled for HR managers, and port security (sticky MAC) restricts unauthorized device connections.
3. **Admission Department Computers:** The admissions team uses 5 computers, 1 network printer, and 5 IP phones, connected via Cat6a cables to the Cisco Catalyst 9200 switch. These devices are assigned to VLAN 30 (Admissions) with the subnet 192.168.30.0/24, keeping student application data secure. Limited VPN access is granted only to senior staff.
4. **Common Rooms for Students:** This shared common space supports 50+ users with 2 Wi-Fi 6 access points (Cisco Catalyst 9136I) for seamless connectivity. Devices connect to VLAN 40 (Common) with subnet 192.168.40.0/24, offering open but throttled Wi-Fi for students/staff. No VPN or port security is applied, as it’s a public zone with limited bandwidth.

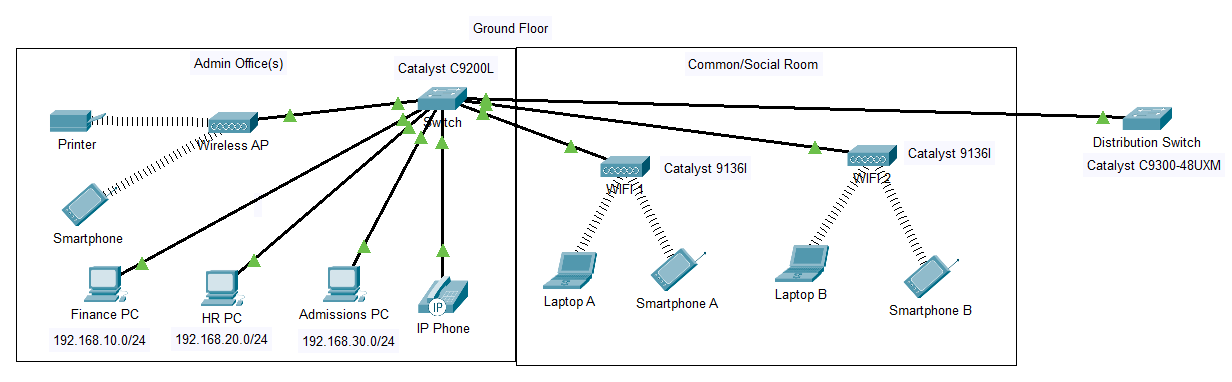


Fig 4.2 Image of Ground Floor in Packet Tracer

**First Floor**

The first floor supports academic offices, lecture halls, tutorial rooms, and computer labs, each with unique connectivity needs. High-speed wired and wireless networks ensure seamless teaching and research, with VLAN segmentation to separate traffic (e.g., faculty, students, lab devices). Cisco Catalyst switches manage connections, while Wi-Fi 6 access points handle dense classroom demands. Structured cabling (Cat6a/fiber) future-proofs the infrastructure.

1. **Academics Offices:**

The first floor accommodates 10 academic offices, each provisioned with two dedicated Ethernet ports to support laptops, desktops, and research devices. These ports are linked with Cat6a shielded cabling and connected to a Cisco Catalyst C9200L-48P-4X-A 48-port PoE+ switch, ensuring reliable 1Gbps+ wired connectivity for resource-intensive tasks like data analysis and video conferencing. All academic devices are segmented into VLAN 50 (subnet: 192.168.50.0/24) to isolate research traffic and prioritize bandwidth. VPN access is enabled for secure remote collaboration, with port security. The switch’s 28 reserved ports future-proof the setup for Wi-Fi 6 AP expansions or additional workstations. This design balances performance, security, and scalability for faculty needs.

A diagram of a computer network

AI-generated content may be incorrect.

Fig 4.3 Image of First floor Academics in Packet Tracer

1. **Lecture and Tutorial Rooms:**

The first floor includes 6 lecture rooms and 6 tutorial rooms, each connected to 2 Ethernet ports to support teaching devices like laptops and presentation systems. These ports connect via Cat6a cables to a Cisco Catalyst C9200L-48P-4X-A 48-port PoE+ switch, with VLAN 60 (192.168.60.0/24) for lectures and VLAN 70 (192.168.70.0/24) for tutorials to separate traffic. Every room has a dedicated Wi-Fi 6 access point and networked projectors, powered by the switch’s PoE+ ports.

A diagram of a computer network

AI-generated content may be incorrect.

Fig 4.4 Image of First Floor Lecture & Tutorial Rooms in Packet Tracer

1. **Computer Labs:**

The first floor includes 4 computer labs, each with 20 PCs and 1 networked printer. Every lab uses a dedicated Cisco Catalyst C9200L-48P-4X-A switch to connect all devices via Cat6a Ethernet cables, ensuring fast and stable wired connections. Wi-Fi 6 access points are installed for wireless devices, while VLAN 80 (192.168.80.0/24) isolates lab traffic for security and performance.

A diagram of a computer network

AI-generated content may be incorrect.

Fig 4.5 Image of First Floor Computer Labs in Packet Tracer

**Second Floor**

Since the second floor has identical usage requirements as the first floor (academic offices, classrooms, and labs), we'll implement the same network design. This ensures consistency in performance, security, and management across both floors while simplifying maintenance.

**Second Building**

Building 2 will use the exact same network architecture as Building 1—matching switches, VLANs, cabling, and security policies—since both buildings serve identical academic and administrative functions. This standardized design ensures consistent performance, easier maintenance, and seamless connectivity across the entire campus.

**Connectivity Between Buildings**

The distribution layer switches (Catalyst C9300-48UXM) in each building aggregate traffic and connect to the core layer via 10G fibre uplinks. At the core, Catalyst C9500-48Y4C switches route data between buildings, while the Cisco Firepower firewall inspects and secures all traffic. The core also links to university servers and the ISP router for internet access. Buildings are interconnected with OS2 single-mode fibre cables, ensuring high-speed, low-latency communication. This design guarantees secure, reliable connectivity across campus while maintaining scalability for future needs.

**Fibre Optic Cables Deployment**

The connectivity between buildings relies on a robust star topology, where each building's network infrastructure connects back to centralized Cisco Catalyst 9500 core switches through OS2 single-mode fibre optic cables. These fibre cables act as the network's backbone, capable of transmitting data at 10Gbps+ speeds over long distances with minimal signal loss, making them ideal for campus-wide links.

At the core layer, the Catalyst 9500 switches serve as the central hub, equipped with high-density 10/25/40/100Gbps ports to handle heavy traffic between buildings. Each floor's Cisco Catalyst 9300 distribution switches aggregate data from access-layer devices (computers, phones, Wi-Fi) and uplink to the core via fibre, ensuring seamless communication.

The star topology ensures reliability—if one link fails, the rest of the network stays operational. Advanced features like QoS (Quality of Service) prioritize critical traffic (e.g., video lectures), while VLAN segmentation keeps departments (admin, faculty, students) securely separated.

The proposed three-tier network design (core-distribution-access) with fibre backbone (OS2) and Cat6a cabling provides a reliable, high-performance infrastructure for the university. By using standardized VLANs, PoE switches, and centralized management, the design ensures security, scalability, and seamless connectivity across all floors and buildings. This future-proof approach minimizes downtime, simplifies troubleshooting, and supports growing tech needs for the next 10+ years.

## 4.2 Justification

Our network design combines a fibre backbone, VLAN segmentation, and star topology to deliver speed, security, and scalability. The fibre ensures fast connectivity, VLANs separate traffic for security, and the star topology simplifies management. Each component was chosen for performance, cost-efficiency, and future readiness, ensuring reliability and easy maintenance while maximizing ROI.

**Choice of Fiber Optic Cables**

We selected OS2 single-mode fibre for its ability to support 10Gbps+ speeds over long distances (up to 10km) with minimal signal loss. Its immunity to electromagnetic interference ensures reliable performance, even in high-traffic campus environments. The tight-buffered design simplifies installation, while LC connectors provide low-loss connections. This future-proof solution accommodates upgrades to 40G/100G+ speeds as needs grow.

**Core Switches (Cisco Catalyst C9500-48Y4C)**

These high-performance switches form the backbone of the network, offering 48x 25G/10G ports and 4x 100G uplinks for ultra-fast data transfer between buildings. Their modular design supports future upgrades, while Software Defined-Access compatibility enables seamless automation. With redundant power and cooling, they ensure 24/7 reliability for critical university operations.

**Distribution Switches (Cisco Catalyst C9300-48UXM)**

These switches act as the middle layer, connecting all the access switches to the main core switches. They offer flexible ports that support everything from basic 1Gbps connections up to 10Gbps for high-demand areas, with powerful 40G/100G uplinks to handle heavy traffic between floors. Features like easy stacking (up to 8 switches) and smart traffic prioritization (QoS) make them perfect for a busy campus, while keeping different groups (students, staff) securely separated with VLANs.

**Star Topology**

We chose a star topology because all distribution switches connect directly to the central core switches (Catalyst 9500), creating a simple and reliable hub-and-spoke design. This setup ensures that if one link fails (e.g., a fibre cut to Building 1), other connections remain unaffected—critical for minimizing downtime in a busy university.

**Why Not Other Topologies?**

* **Ring Topology:** Data must travel through multiple switches, causing delays.
* **Mesh Topology:** Expensive and complex to wire.

The star design strikes the perfect balance between cost, simplicity, and fault tolerance.

**Integrated Campus Network Architecture**

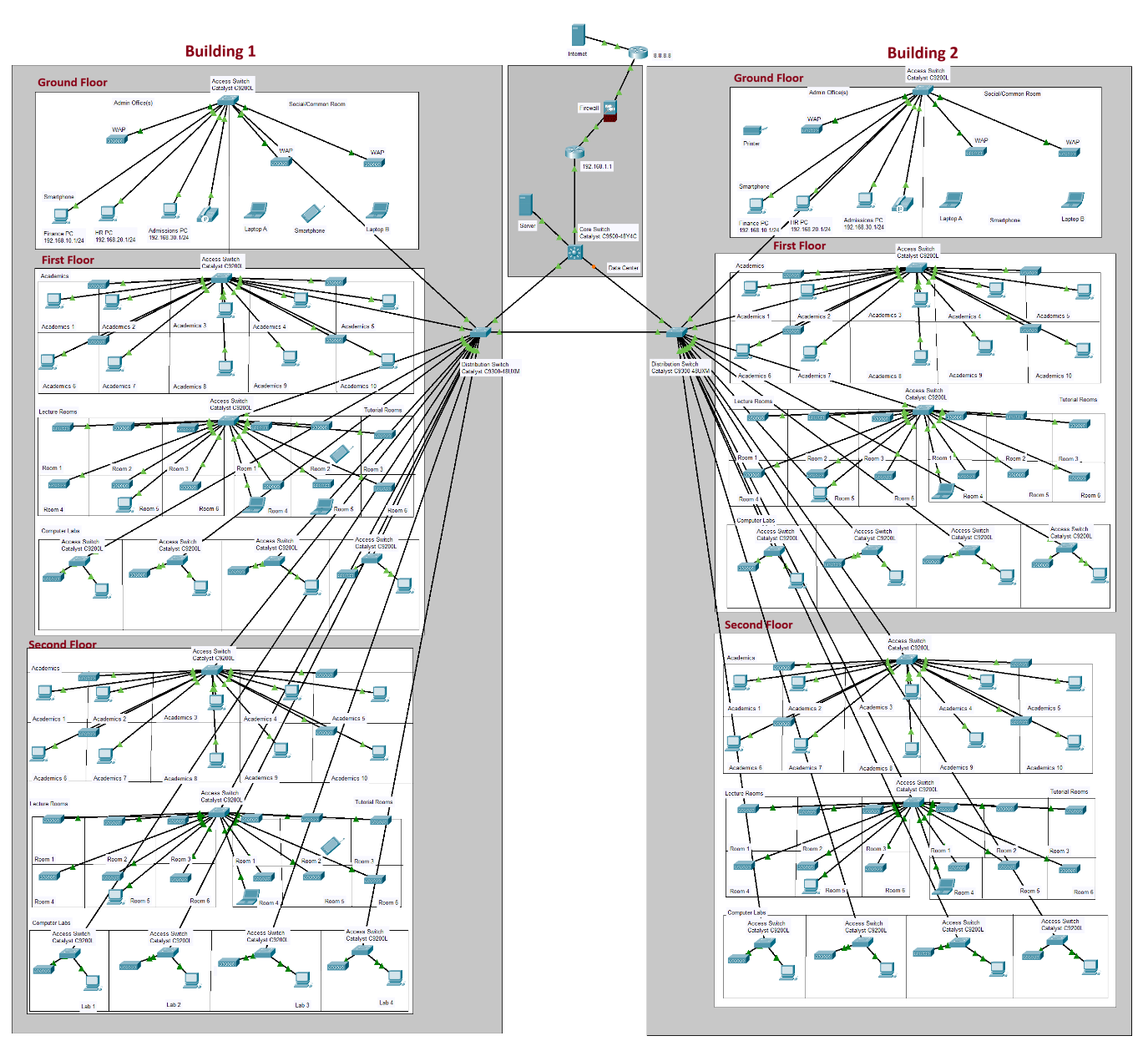


Fig 4.6

# 5 Proposed Cloud-Based Services

## 5.1 Discussion

As the University of the West of Scotland modernizes its two new buildings, integrating cloud-based services is essential to deliver scalable, resilient, and cost-efficient solutions. These services will address current academic and administrative needs while ensuring long-term adaptability for emerging technologies. Below are the proposed cloud solutions tailored for the campus:

* Microsoft 365 Education:
* Aula Learning Management System
* Microsoft Azure Blob Storage (Backups)
* Datadog Monitoring
* Okta SSO/Identity Management

**Microsoft 365 Education**

This comprehensive cloud platform provides essential productivity tools including Outlook for email, Teams for virtual classrooms/collaboration, and OneDrive for secure file storage. Its education-specific licensing offers cost-effective access to premium features while maintaining compliance with academic data regulations. Tight integration with other university systems enables seamless workflows for staff and students. The platform scales effortlessly to accommodate growing user numbers across both new buildings.

**Aula Learning Management System**

Aula's modern LMS delivers an engaging digital learning environment through intuitive course organization and interactive tools. It supports multimedia content, real-time feedback, and student discussion forums while integrating with existing university authentication systems. The mobile-friendly interface ensures accessibility across devices, crucial for today's hybrid learning needs. Its analytics dashboard helps instructors track student progress and engagement effectively.

**Microsoft Azure Blob Storage (Backups)**

Azure's enterprise-grade storage solution provides reliable, secure backup for critical university data including research files, administrative records, and system configurations. With geo-redundant storage options, it ensures business continuity even during local infrastructure failures. The pay-as-you-go model eliminates upfront hardware costs while offering virtually unlimited scalability. Advanced encryption and access controls meet strict data protection requirements.

**Datadog Network Monitoring**

This cloud-native monitoring platform delivers full visibility into network performance, application health, and security threats across the university's hybrid infrastructure. Custom dashboards provide real-time insights on Wi-Fi performance, server uptime, and bandwidth utilization. Automated alerts enable proactive issue resolution before users are impacted. The solution scales with the university's growing technology footprint while maintaining simple centralized management.

**Okta Identity Management**

Okta's SSO (Single Sign-On) and MFA (Multi-Factor Authentication) solutions secure access to all university cloud applications and services. It simplifies login processes for users while enforcing robust security policies across devices and locations. The platform seamlessly connects Aula, Microsoft 365, and other systems through standardized protocols.

## 5.2 Justification

We chose these cloud tools because they grow with your needs (no expensive upgrades), keep data safe (with encryption and secure logins), and save money (pay only for what you use). They work smoothly with your current systems while making collaboration easier for staff and students—whether they're on campus or learning remotely.

* **Scalability:** The cloud services use elastic computing resources that automatically expand as demand grows - more students, courses, or data won't require hardware upgrades. Microsoft 365 licenses scale instantly, while Azure storage allocates additional capacity through software controls.
* **Cost Efficiency:** Cloud services operate on operational expenditure models with education discounts avoiding capital costs for physical servers while benefiting from Microsoft's academic pricing tiers and Azure's pay-per-use storage billing.
* **Collaboration Tools:** The integrated platform combines Teams for real-time communication with Aula's LMS features, creating a unified collaboration environment with single sign-on (SSO) through Okta.
* **Data Security:** The cloud keeps university data safe with strong protections. Okta verifies every login, while Microsoft encrypts all files and emails. Automatic security rules block leaks of sensitive info like grades or research. These measures meet strict education privacy laws.
* **Backups & Recovery:** All data is automatically saved in multiple locations. If files get deleted or servers fail, the system can quickly restore from backups. Azure guarantees 99.9% uptime, so systems stay available during emergencies.
* **Learning Management:** Aula provides all-in-one teaching tools including Hosts course materials and assignments, Hosts course materials and assignments, Hosts course materials and assignments and Hosts course materials and assignments.

In Conclusion, by integrating these cloud services, the University of The West of Scotland gains a scalable, secure, and cost-effective digital foundation. The solutions enhance collaboration, safeguard data, and ensure reliable performance across both new buildings.

# 6. Proposed Detail Costings

## 6.1 Discussion

The price breakdown for the UWS’s new buildings covers hardware, software, cloud services and installation & labour fees. It contains switches, firewalls, Access Points, fibre optic cables and others. It also includes licensing fees for network management, software and cloud services.

## 6.2 Justification

The cost includes discounts, warranties and technical support from vendors. Major vendors like Cisco, Microsoft offer educational discounts and warranties which can be extended to universities which helps us to reduce costs. They provide better technical support and training for IT employees to manage and maintain the network. By gaining these offers, the university is able to receive cost-effective network which meets both current and future needs.

**6.3 Costing Breakdown**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Description** | **Quantity** | **Per Unit Cost** | **Total** |
| Cisco Catalyst C9500-48Y4C | Core Switch | 1 | £14,000 | £14,000 |
| Cisco Catalyst C9300-48UXM | Distribution Switch | 2 | £7,500 | £15,000 |
| Cisco Catalyst C9200L-48P-4X-A | Access Switch | 26 | £2,000 | £52,000 |
| Cisco FPR2130-ASA-K9 Firepower | Firewall | 1 | £10,000 | £10,000 |
| Cisco Catalyst 9136I | Access Points | 86 | £1,000 | £86,000 |
| Cat6a Cable | Copper Cable | 1 | £1,000 | £1,000 |
| OS2 Cable | Fibre Optic cable | 1 | £200 | £200 |
| Dell PowerEdge R740 512GB 2 Xeon Gold 14 CPU 1TB SSD 64TB HDD | High Performance Server | 2 | £3,000 | £6,000 |
| Eaton 9PX 2000VA 1800W 120V Online | UPS | 1 | £1,800 | £1,800 |
| Cisco Firepower Threat Defence | Software Firewall | - | £2,500 | £2,500 |
| McAfee Antivirus | Antivirus | - | £1,500 | £1,500 |
| Cisco AnyConnect | VPN | - | £200 | £200 |
| Cloud Services | MS 365, Azure Storage, Datadog Monitoring, Aula, Okta Identity | - | £10,000 | £10,000 |
| Installation | Labour Charge | - | £15,000 | £15,000 |
| **Total** |  |  |  | £212,000 |

# 7. Conclusion & Future Recommendations

## 7.1 Conclusion

The proposed network solution for the University of the West of Scotland’s new Buildings 1 and 2 is designed to be strong, scalable, and secure, meeting the needs of staff and students now and in the future. The three-tier network structure ensures high performance, easy management, and backup options in case of failures.

High-quality hardware like Cisco Catalyst switches and firewalls ensures strong security and stable connections. Software tools such as Cisco DNA Center for network management and backup, along with McAfee for antivirus, help keep the network efficient and safe. Cloud services like Azure Blob Storage, OneDrive, and Aula LMS offer flexible and scalable options for storage, learning, and security. A VPN is also included to connect other university buildings through a secure WAN. Costs have been planned well, using vendor discounts, extended warranties, and support options to keep it affordable. The detailed costing makes the plan clear and shows it is financially practical.

## 7.2 Future Recommendations

To make sure the network infrastructure remains future-proof and continues to meet the growing requirements of the university, some recommendations are proposed.

1. **Regular Check-ups & Updates:** Doing regular network checks and identification of weak areas and bottlenecks. Upgrading software/hardware when needed to handle growing demands.
2. **Scalable Cloud Services:** Using more cloud services for storage, teamwork, and online learning tools such as Aula.
3. **Training & Development:** Providing training to IT staff to make sure they are professional in managing and maintaining network.
4. **Advanced Security Measures:** Monitoring network continuously and improving the security of the systems from potential threats. Using AI solutions to find the patterns of risks and issues which may arise.

By taking these steps, the university can ensure a reliable, modern network that supports learning, research while providing secure, efficient network infrastructure for all the users.

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