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Design of Local Area Network

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EN2150 - Communication Network Engineering

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Contents

1 Introduction

This report presents the design of the backbone network for the University of Moratuwa (UoM) and the internal network of the Department of Electronic and Telecommunication Engineering (ENTC).The backbone network must provide high-speed, reliable, and secure connectivity between multiple buildings, including academic faculties, the library, administrative offices, and the data center (CITeS). Since this infrastructure is expected to last for 20–25 years, careful consideration has been given to cost, scalability, and performance. Both active and passive network components have been selected based on industry best practices and real-world observations of the existing ENTC network.

2 University Backbone network

2.1 Reference Design

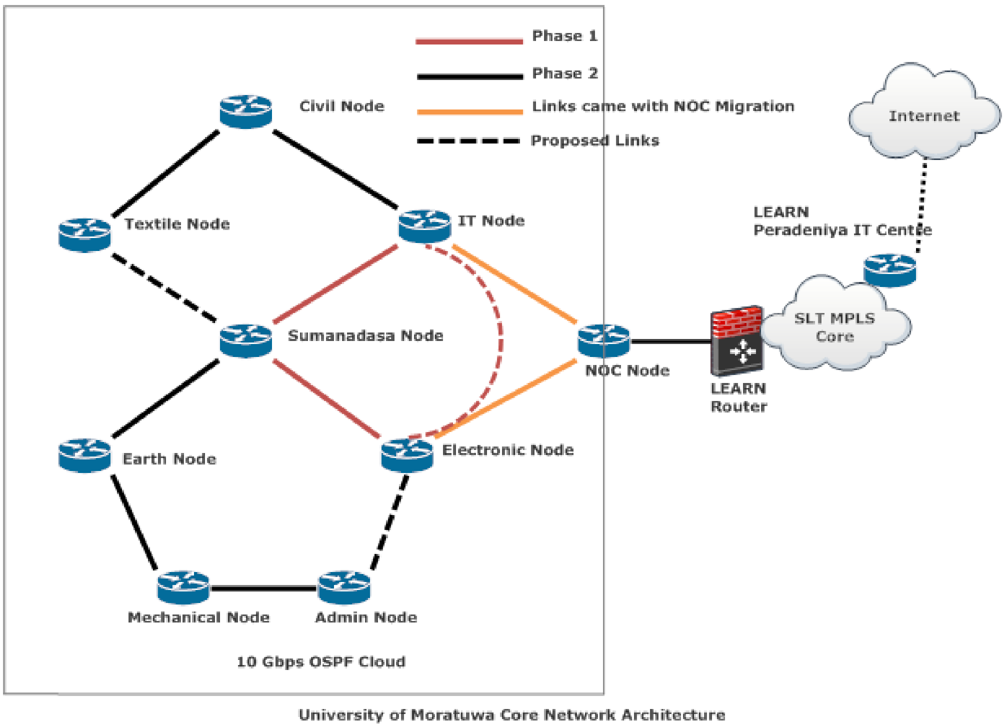


Figure 1: University Backbone Network Described by CITes

University network infrastructure is structured as a ring topology. Nine (9) nodes consist in the overall network Backbone. All the nodes are Layer 3 switches those are running over the OSPF protocol.10Gbps single mode fiber channel travels over the network and 1Gbps multi mode fiber cable connection is used as back up over the network for disaster recoveries.

2.2 Design Progress

2.3 Bandwidth Consideration

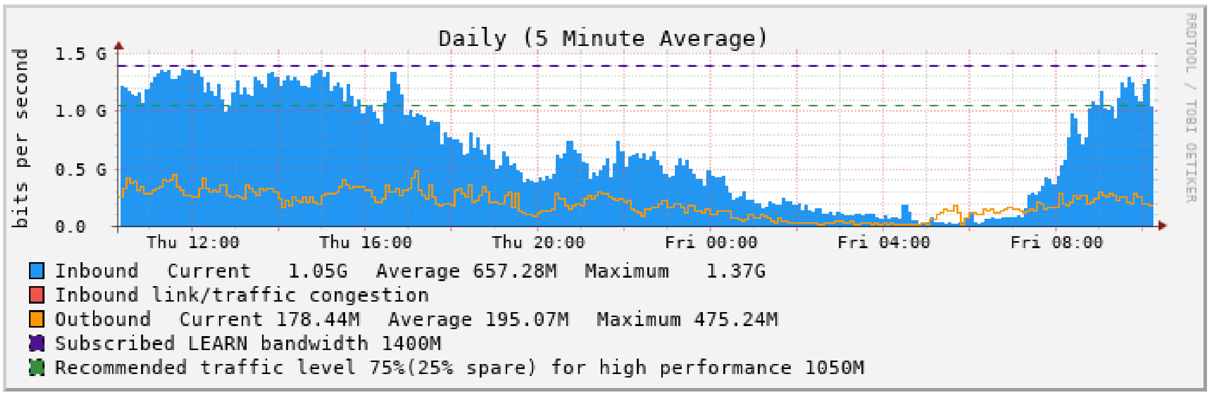


Figure 2: Daily Average of UOM

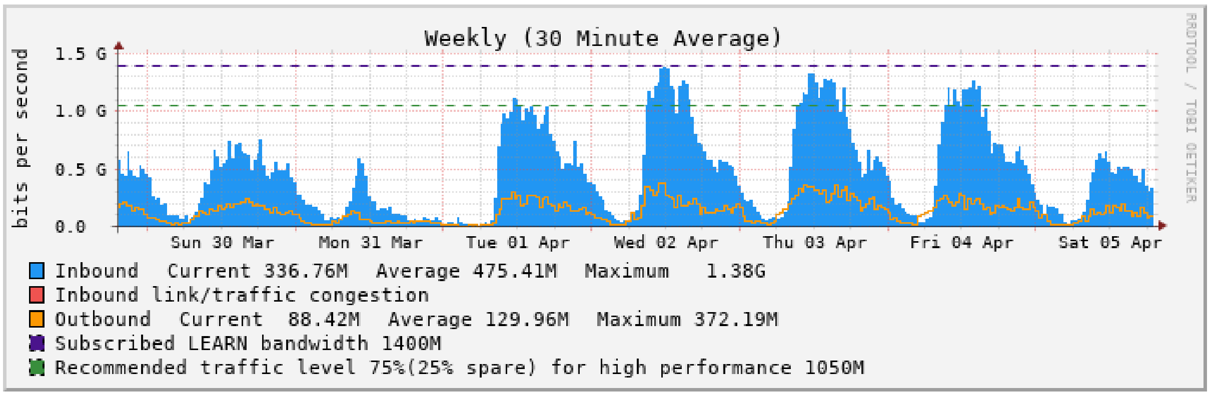


Figure 3: Weekly average of UOM

LEARN has given us a 1.5 Gbps link, but as we can see from the weekly traffic graph, we're hitting that limit pretty frequently. Specially during working days. Peak inbound traffic is going all the way up to 1.38 Gbps, which is basically maxing out the link. That means our network is under a lot of pressure and needs to be capable of handling that much data without any issues.

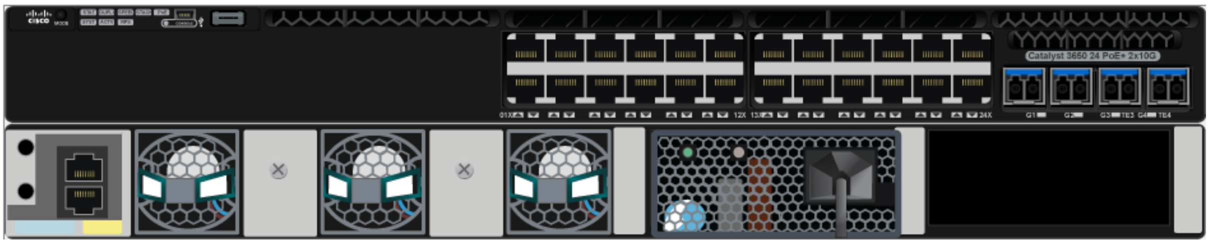
So apart from managing traffic going in and out of the network, we also need to look at what's happening inside the campus. There's a lot of data being shared between departments, labs, and other services. That's where inter-VLAN routing comes in. If we don't handle this internal traffic properly, it can use up the same link and slow things down even more.

2.4 Used Devices & Cables

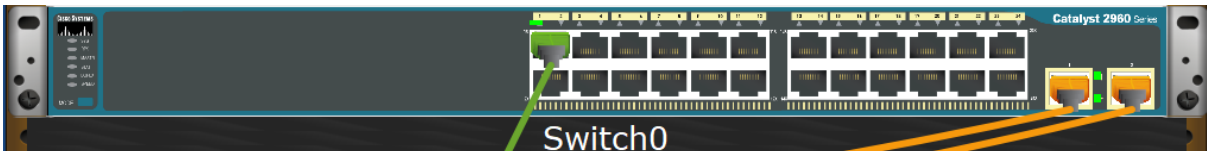
These are the devices we used in the simulation. But since this network is expected to last for 20–25 years, we can't use them in a real setup because Cisco has already ended support for these models.

Also, Cisco Packet Tracer doesn't include newer devices, so we had to use these older ones. Another limitation is that we can't simulate 10G SFP+ connections in Packet Tracer, which are required for high-speed links in a modern campus network.

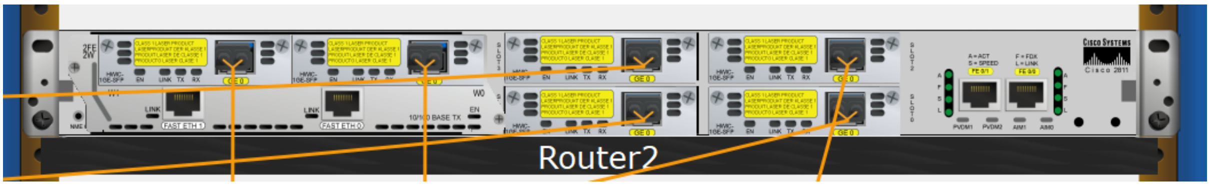
1. **Layer 3 Switches** – Cisco Catalyst 3650 - 24 (2x 10G)



2. **Layer 2 Switches** – Cisco Catalyst 2960 - 24



3. **Routers** – Cisco 2811



4. **Cables** - SMF, MMF, Cat 6/5e/5

3 Routing Protocols and Switching Algorithms

3.1 OSPF Routing Table

The following table summarizes the OSPF routing table obtained from the command `show ip route ospf`. It includes network prefixes, metrics, next-hop addresses, interface details, and other relevant information.

Network	Subnet Mask	Metric	Next Hop	Age	Interface
5.5.5.0	/29	110/2	10.0.1.2	02:00:56	GigabitEth/1/0
6.6.6.0	/29	110/4	10.0.1.2 10.0.2.2	02:00:56 02:00:56	GigabitEth/1/0 GigabitEth/0/0
8.8.8.0	/28	110/2	10.0.1.2	02:00:56	GigabitEth/1/0
9.9.9.0	/28	110/2	10.0.2.2	02:00:56	GigabitEth/0/0
10.0.3.0	/30	110/2	10.0.2.2 10.0.9.1	01:58:06 01:58:06	GigabitEth/0/0 GigabitEth/3/0
10.0.4.0	/30	110/2	10.0.1.2 10.0.9.1	01:58:06 01:58:06	GigabitEth/1/0 GigabitEth/3/0
10.0.5.0	/30	110/2	10.0.1.2 10.0.2.2	02:00:56 02:00:56	GigabitEth/1/0 GigabitEth/0/0
10.10.10.0	/30	110/3	10.0.1.2	02:00:56	GigabitEth/1/0
10.10.20.0	/30	110/2	10.0.1.2	02:00:56	GigabitEth/1/0
10.10.30.0	/30	110/3	10.0.2.2	02:00:56	GigabitEth/0/0
10.10.40.0	/30	110/2	10.0.2.2	02:00:56	GigabitEth/0/0
10.10.50.0	/30	110/3	10.0.2.2	02:00:56	GigabitEth/0/0
10.10.60.0	/30	110/4	10.0.2.2	02:00:56	GigabitEth/0/0
10.10.70.0	/30	110/4	10.0.1.2 10.0.2.2	02:00:56 02:00:56	GigabitEth/1/0 GigabitEth/0/0
10.10.80.0	/30	110/3	10.0.2.2	02:00:56	GigabitEth/0/0
10.10.90.0	/30	110/4	10.0.1.2 10.0.2.2	00:00:01 00:00:01	GigabitEth/1/0 GigabitEth/0/0
10.10.100.0	/30	110/4	10.0.1.2	00:00:01	GigabitEth/1/0
10.10.110.0	/30	110/4	10.0.1.2 10.0.2.2	02:00:56 02:00:56	GigabitEth/1/0 GigabitEth/0/0
10.10.120.0	/30	110/4	10.0.1.2	02:00:56	GigabitEth/1/0
10.10.130.0	/30	110/3	10.0.1.2	02:00:56	GigabitEth/1/0
10.10.140.0	/30	110/3	10.0.1.2	00:00:01	GigabitEth/1/0
10.10.160.0	/30	110/4	10.0.2.2	02:00:56	GigabitEth/0/0
192.10.0.0	/21	110/3	10.0.1.2	02:00:56	GigabitEth/1/0
192.20.0.0	/21	110/5	10.0.1.2 10.0.2.2	02:00:56 02:00:56	GigabitEth/1/0 GigabitEth/0/0
192.30.0.0	/21	110/4	10.0.1.2	00:00:01	GigabitEth/1/0
192.40.0.0	/21	110/4	10.0.2.2	02:00:56	GigabitEth/0/0
192.50.0.0	/21	110/5	10.0.1.2 10.0.2.2	02:00:56 02:00:56	GigabitEth/1/0 GigabitEth/0/0
192.60.0.0	/21	110/4	10.0.2.2	02:00:56	GigabitEth/0/0
192.70.0.0	/21	110/3	10.0.2.2	02:00:56	GigabitEth/0/0
192.120.0.0	/21	110/4	10.0.1.2	02:00:56	GigabitEth/1/0
192.130.0.0	/21	110/4	10.0.1.2 10.0.2.2	02:00:56 02:00:56	GigabitEth/1/0 GigabitEth/0/0
192.140.0.0	/21	110/4	10.0.1.2 10.0.2.2	02:00:56 02:00:56	GigabitEth/1/0 GigabitEth/0/0
192.200.1.0	/21	110/2	10.0.1.2	00:45:28	GigabitEth/1/0

3.2 HSRP

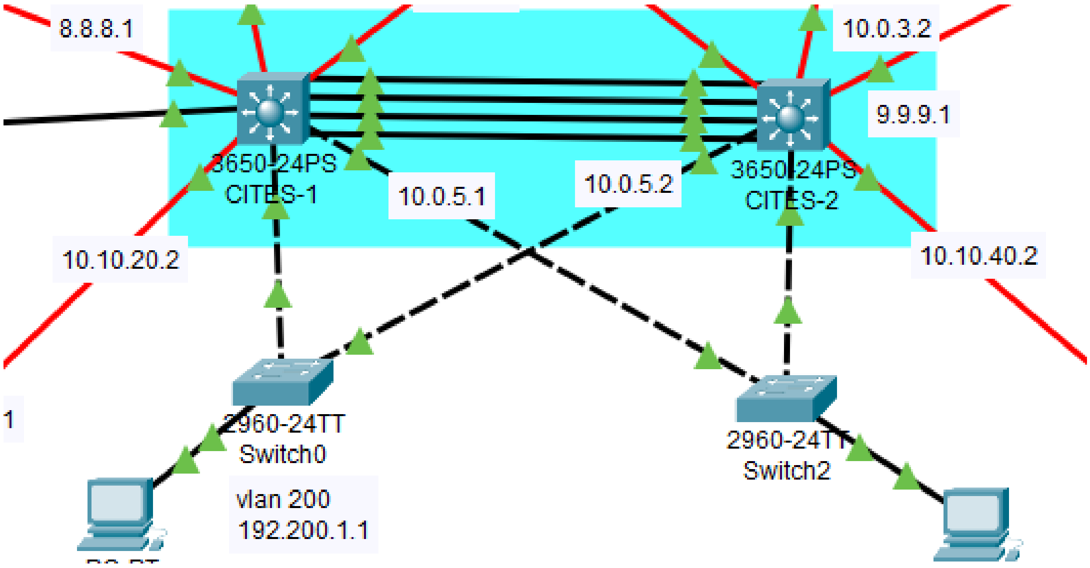


Figure 4: HSRP

```
Switch# show standby
Vlan200 - Group 2 (version 2)
  State is Active
    6 state changes, last state change 01:09:37
  Virtual IP address is 192.200.1.1
  Active virtual MAC address is 0000.0C9F.F002
    Local virtual MAC address is 0000.0C9F.F002 (v2 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 0.964 secs
  Preemption enabled
  Active router is local
  Standby router is 192.200.1.3
  Priority 150 (configured 150)
  Group name is hsrp-Vl2-2 (default)
Switch# show standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State    Active          Standby         Virtual IP
Vl200       2    150 P Active   local           192.200.1.3     192.200.1.1
```

Listing 1: Active Router HSRP Status

```
Switch# show standby
Vlan200 - Group 2 (version 2)
  State is Standby
    9 state changes, last state change 01:11:50
  Virtual IP address is 192.200.1.1
  Active virtual MAC address is 0000.0C9F.F002
    Local virtual MAC address is 0000.0C9F.F002 (v2 default)
  Hello time 3 sec, hold time 10 sec
    Next hello sent in 0.733 secs
  Preemption disabled
  Active router is 192.200.1.2
  Standby router is local
  Priority 100 (default 100)
  Group name is hsrp-Vl2-2 (default)
Switch# show standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State    Active          Standby         Virtual IP
Vl200       2    100   Standby  192.200.1.2     local           192.200.1.1
```

Listing 2: Standby Router HSRP Status

4 Server

4.1 DHCP, DNS

DNS, IPv4 DHCP service is enabled in a dedicated Server. Below table shows the DHCP Pools and details.

Pool Name	D. Gateway	DNS Server	Start IP	Subnet Mask	User	WLC
VLAN200	192.200.1.1	8.8.8.8	192.200.1.5	255.255.255.0	251	5.5.5.2
VLAN140	192.140.1.1	8.8.8.8	192.140.1.5	255.255.248.0	1787	5.5.5.2
VLAN130	192.130.1.1	8.8.8.8	192.130.1.5	255.255.248.0	1787	5.5.5.2
VLAN120	192.120.1.1	8.8.8.8	192.120.1.5	255.255.248.0	1787	5.5.5.2
VLAN110	192.110.1.1	8.8.8.8	192.110.1.5	255.255.248.0	1787	5.5.5.2
VLAN100	192.100.1.1	8.8.8.8	192.100.1.5	255.255.248.0	1787	5.5.5.2
VLAN90	192.90.1.1	8.8.8.8	192.90.1.5	255.255.248.0	1787	5.5.5.2
VLAN80	192.80.1.1	8.8.8.8	192.80.1.5	255.255.248.0	1787	5.5.5.2
VLAN70	192.70.1.1	8.8.8.8	192.70.1.5	255.255.248.0	1787	5.5.5.2
VLAN60	192.60.1.1	8.8.8.8	192.60.1.5	255.255.248.0	1787	5.5.5.2
VLAN50	192.50.1.1	8.8.8.8	192.50.1.5	255.255.248.0	1787	5.5.5.2
VLAN40	192.40.1.1	8.8.8.8	192.40.1.5	255.255.248.0	1787	5.5.5.2
VLAN30	192.30.1.1	8.8.8.8	192.30.1.5	255.255.248.0	1787	5.5.5.2
VLAN20	192.20.1.1	8.8.8.8	192.20.1.5	255.255.248.0	1787	5.5.5.2
VLAN10	192.10.1.1	8.8.8.8	192.10.1.5	255.255.248.0	1787	5.5.5.2

Table 1: DHCP Pool Configuration

4.2 FTP

FTP service is also enabled at a different server.

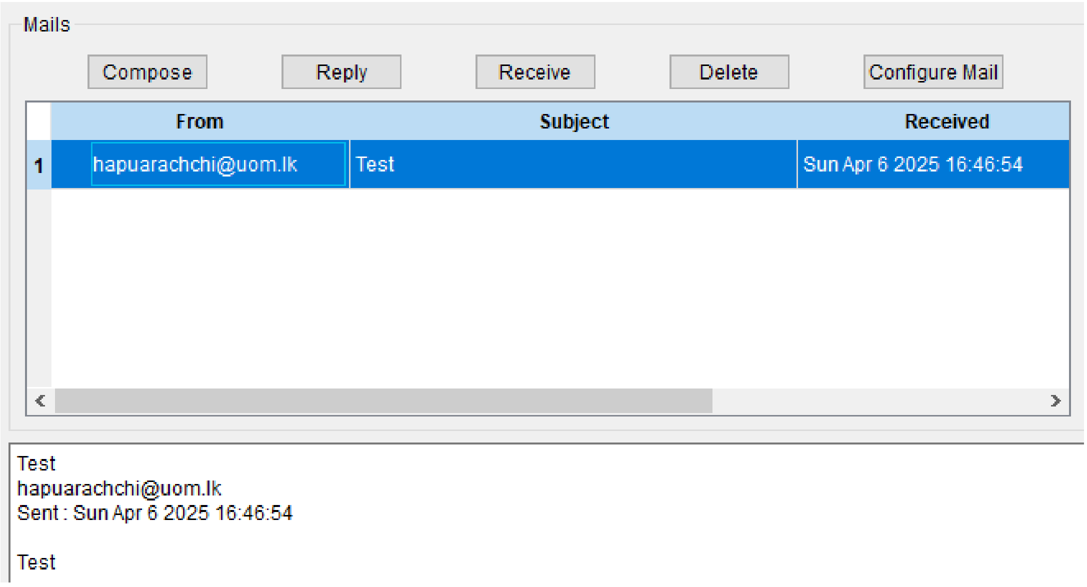
```
C:\>ftp files.mrt.ac.lk
Trying to connect...files.mrt.ac.lk
Connected to files.mrt.ac.lk
220- Welcome to PT Ftp server
Username:cisco
331- Username ok, need password
Password:
230- Logged in
(passive mode On)
ftp>dir

Listing /ftp directory from files.mrt.ac.lk:
0   : asa842-k8.bin                                 5571584
1   : asa923-k8.bin                                 30468096
2   : c1841-advipservicesk9-mz.124-15.T1.bin        33591768
3   : c1841-ipbase-mz.123-14.T7.bin                 13832032
4   : c1841-ipbasek9-mz.124-12.bin                  16599160
```

4.3 RADIUS Authentication

RADIUS authentication is enabled and Access Points are controlled with a Cisco WLC. Management is VLAN 99

4.4 Email



Email Service is also activated in both Main server and CSE server.

5 Final Design

Item	Count	Model/Description	Unit Price	Total Price
Layer 3 Switches	11	Cisco Catalyst 3650 Series	$3,200.00	$35,200.00
Layer 2 Switches	31	Cisco Catalyst 2960-24TT	$1,000.00	$31,000.00
Cisco WLC	1	Cisco 2504 Wireless Controller	$425.00	$425.00
2811 Routers	2	CISCO2811-DC (L2801)	$1,314.00	$2,628.00
4331 Routers	2	Cisco ISR4331/K9 (ADAM)	$850.00	$1,700.00
Servers	3	Enterprise Servers	$3,850.00	$11,550.00
1000BASE-T SFP	45	GLC-T	$72.00	$3,240.00
1000BASE-SX SFP	22	GLC-SX-MMD	$99.00	$2,178.00
1000BASE-LX/LH SFP	24	GLC-LH-SMD	$235.00	$5,640.00
10GBASE-SR SFP+	8	SFP-10G-SR	$152.00	$1,216.00
10GBASE-T SFP+	4	SFP-10G-T	$220.00	$880.00
HWIC-1GE-SFP	2	For 2811 Routers	$1,200.00	$2,400.00
Fiber Cables	24	Fiber Optic Cables (Green lines)	$50.00	$1,200.00
Copper Straight Cables	45	Cat6/Cat6a Cables (Black lines)	$20.00	$900.00
Crossover Cables	22	Cat6 Crossover Cables (Red lines)	$15.00	$330.00
			Total Hardware Cost:	**$82,503.00**
			Total SFP Modules Cost:	**$15,554.00**
			Total Connection Media Cost:	**$2,430.00**
			Grand Total:	**$100,487.00**

Table 2: Updated Network Equipment Bill of Materials (BOM) - These prices are not accurate because these devices are old an they are in the end of support by the CISCO..

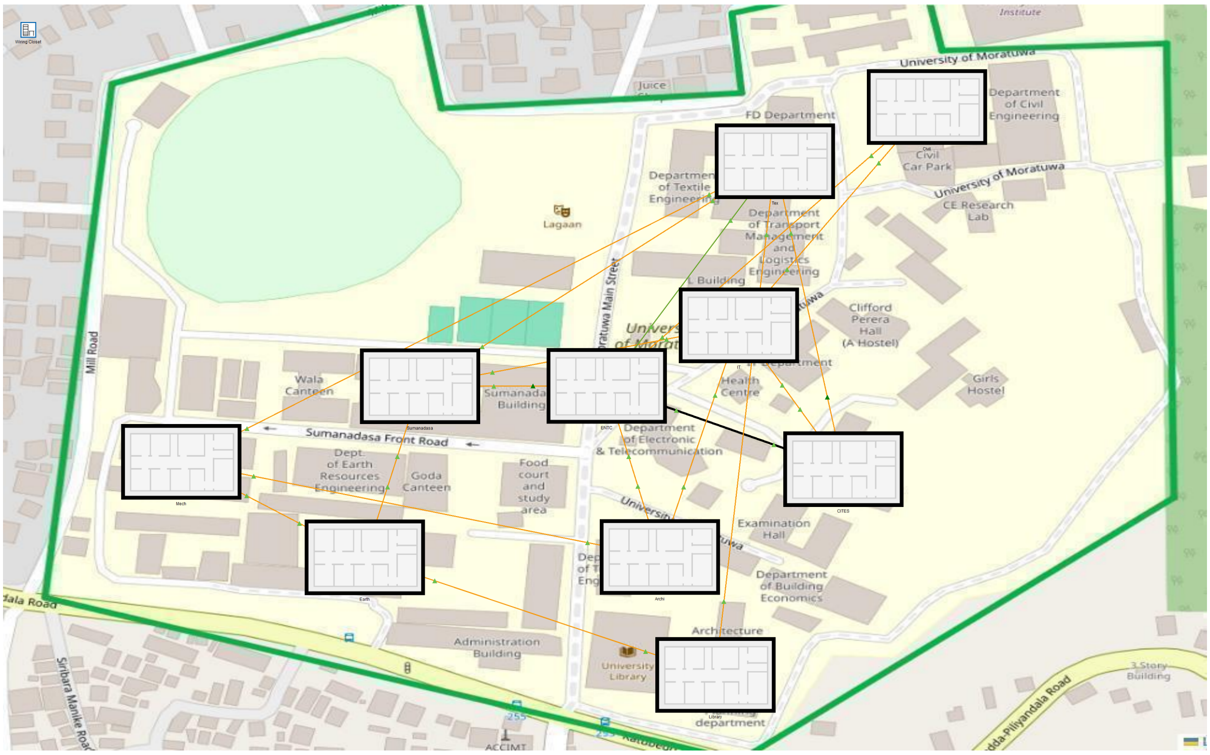


Figure 5: Physical Arrangement of the Network

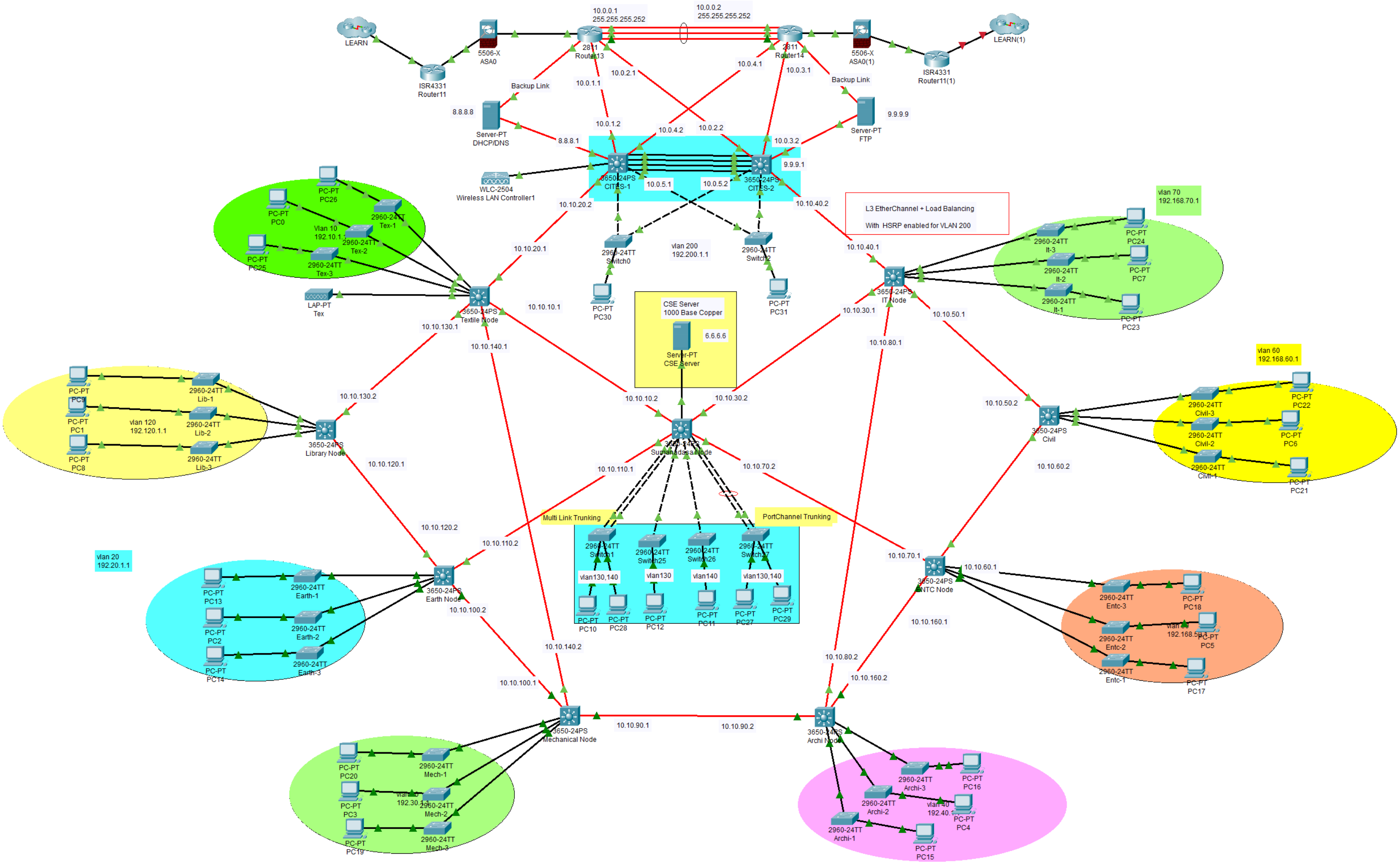


Figure 6: Logical Arrangement of the Network

6 ENTC Network Design

6.1 Objective

The goal of the second part of this assignment is to design a secure, scalable, cost-effective and future-proof backbone network for the Department of Electronic and Telecommunication Engineering building at the University of Moratuwa. The network will serve as a fast and reliable network for Department Laboratories and Common workplaces, as well as security equipment such as network CCTV cameras and RFID-based door locks.

6.2 Reference Design

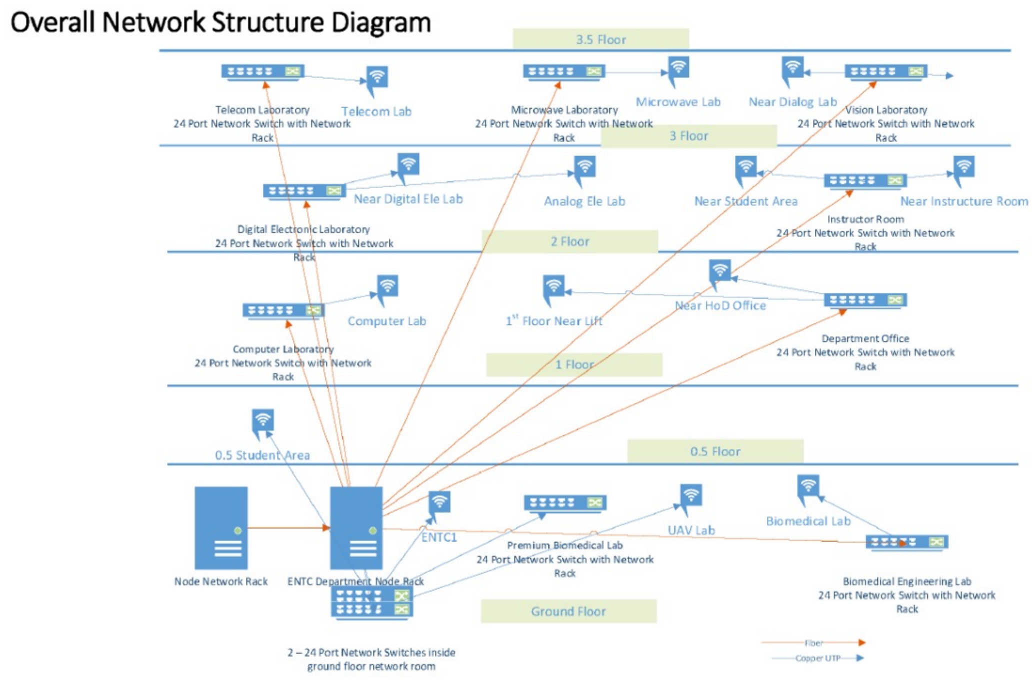


Figure 7: Reference Design - ENTC Building

6.3 Design Approach and Justification

6.3.1 Topology

The ENTC network is built on a **hierarchical star topology**. This topology places a central core switch in the middle of the network, and it is the heart of the network. This layer 3 central core switch is connected to the University Backbone network. All access layer 2 switches are connected directly to it via one gig Ethernet cables. It is ideal for our department.

- It simplifies fault isolation
  - If an access switch fails, only its segment is affected
- It ensures centralised management and routing
- It is modular and scalable and allows future expansion without re-designing the entire network

6.3.2 Used Components

Below devices are used in the simulation. But we cannot use these devices in the real setup because Cisco has already ended support for these devices. Also, Cisco Packet Tracer does nott include newer devices, so we had to use these older ones. So, I want to link the layer 2 and layer 3 switches using fiber cables. I can't find a layer 3 switch which supports for it

1. Layer 3 Switch (Core Switch) - Ciscco 3650-24

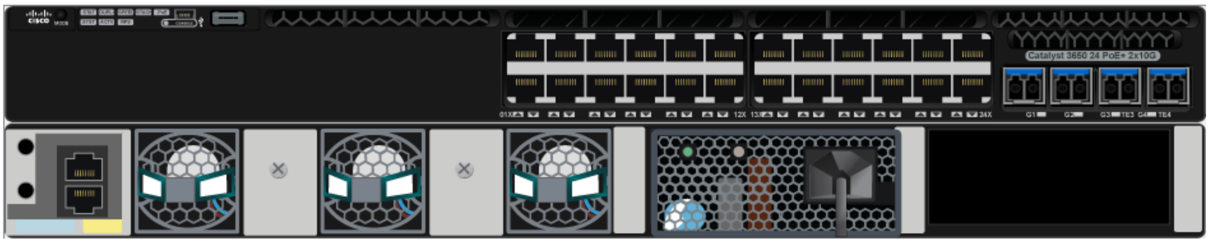


Figure 8: Enter Caption

   I have used Cisco 3650 -24 as the layer 3 switch in the network and it serves as the central device in the network, responsible for both layer 2 and layer 3 functionalities. It handles inter-VLAN routing, DHCP service providing and acts as the gateway for all VLANs via SVIs .

2. Layer 2 Switch – Cisco 2960

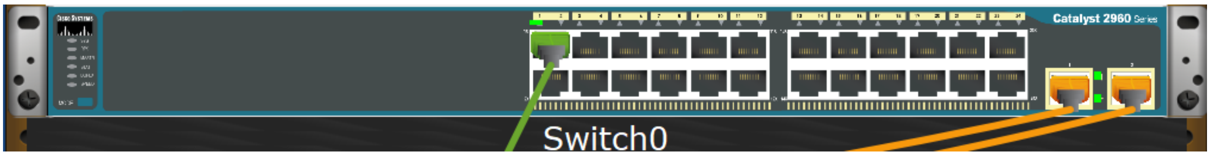


Figure 9: Enter Caption

   These switches are deployed on each floor to aggregate connections from end devices such as PCs, access points and other security devices like IP cameras and RFID Door Locks. Each layer 2 switch is linked to a Cisco 3650 layers 3 switch

3. Access Point

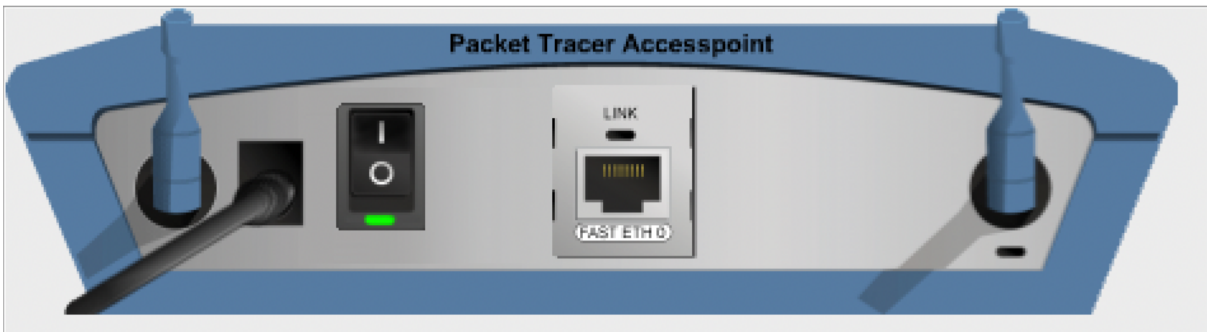


Figure 10: Enter Caption

   Access Points provide wireless coverage across the building, enabling mobility and connectivity for laptops and smart devices. These APs connect to access switches and operate on a dedicated VLAN. DHCP for wireless clients is handled by the core switch

6.4 Ip addressing, Routing and Vlans

- DHCP/ DNS DNS, IPV4 DHCP Service is enabled in a dedicated Server

Table 3: DHCP Pool Configuration

Pool Name	Default Gateway	DNS Server	Start IP	Subnet Mask	Users
Vlan10	10.10.10.1	8.8.8.8	10.10.10.2	255.255.255.0	251
Vlan20	10.10.20.1	8.8.8.8	10.10.20.2	255.255.255.0	251
Vlan30	10.10.30.1	8.8.8.8	10.10.30.2	255.255.255.0	251
Vlan40	10.10.40.1	8.8.8.8	10.10.40.2	255.255.255.0	251
Vlan45	10.10.45.1	8.8.8.8	10.10.45.2	255.255.255.0	251
Vlan50	10.10.50.1	8.8.8.8	10.10.50.2	255.255.255.0	251
Vlan55	10.10.55.1	8.8.8.8	10.10.55.2	255.255.255.0	251
Vlan60	10.10.60.1	8.8.8.8	10.10.60.2	255.255.255.0	251
Vlan65	10.10.65.1	8.8.8.8	10.10.65.2	255.255.255.0	251
Vlan70	10.10.70.1	8.8.8.8	10.10.70.2	255.255.255.0	251
Vlan75	10.10.75.1	8.8.8.8	10.10.75.2	255.255.255.0	251
Vlan80	10.10.80.1	8.8.8.8	10.10.80.2	255.255.255.0	251
Vlan85	10.10.85.1	8.8.8.8	10.10.85.2	255.255.255.0	251
Vlan90	10.10.90.1	8.8.8.8	10.10.90.2	255.255.255.0	251
Vlan95	10.10.95.1	8.8.8.8	10.10.95.2	255.255.255.0	251
Vlan100	10.10.100.1	8.8.8.8	10.10.100.2	255.255.255.0	251
Vlan105	10.10.105.1	8.8.8.8	10.10.105.2	255.255.255.0	251

Each VLAN is assigned its own subnet and gateway IP, with dynamic IP addresses managed through DHCP pools on the 3650 switch, Security-sensitive VLANs such as those used for CCTV and Door locks may utilize static IPs for stability and control

- VLAN Database

  All VLANs are created on the 3650 switch with Layer 3 routing enabled using the ip routing command. Each VLAN has a dedicated SVI with an IP address to act as the default gateway.

Table 4: VLAN Configuration

VLAN ID	VLAN Name	Subnet	Default Gateway	Purpose	DHCP
10	vlan10	10.10.10.0/24	10.10.10.1	Genaral User Devices	enabled
20	vlan20	10.10.20.0/24	10.10.20.1	Genaral User Devices	enabled
30	vlan30	10.10.30.0/24	10.10.30.1	Genaral User Devices	enabled
40	vlan40	10.10.40.0/24	10.10.40.1	Genaral User Devices	enabled
45	vlan45	10.10.45.0/24	10.10.45.1	Genaral User Devices	enabled
50	vlan50	10.10.50.0/24	10.10.50.1	Genaral User Devices	enabled
55	vlan55	10.10.55.0/24	10.10.55.1	Genaral User Devices	enabled
60	vlan60	10.10.60.0/24	10.10.60.1	Genaral User Devices	enabled
65	vlan65	10.10.65.0/24	10.10.65.1	Genaral User Devices	enabled
70	vlan70	10.10.70.0/24	10.10.70.1	Genaral User Devices	enabled
75	vlan75	10.10.75.0/24	10.10.75.1	Genaral User Devices	enabled
80	vlan80	10.10.80.0/24	10.10.80.1	Genaral User Devices	enabled
85	vlan85	10.10.85.0/24	10.10.85.1	Genaral User Devices	enabled
90	vlan90	10.10.90.0/24	10.10.90.1	Genaral User Devices	enabled
95	vlan95	10.10.95.0/24	10.10.95.1	Genaral User Devices	enabled
100	vlan100	10.10.100.0/24	10.10.100.1	Genaral User Devices	enabled
105	vlan105	10.10.105.0/24	10.10.105.1	Genaral User Devices	enabled
110	vlan110	10.10.110.0/24	10.10.110.1	Genaral User Devices	enabled
115	vlan115	10.10.115.0/24	10.10.115.1	Genaral User Devices	enabled
120	vlan120	10.10.120.0/24	10.10.120.1	Genaral User Devices	enabled
125	vlan125	10.10.125.0/24	10.10.125.1	Genaral User Devices	enabled
130	vlan130	10.10.130.0/24	10.10.130.1	Genaral User Devices	enabled
135	vlan135	10.10.135.0/24	10.10.135.1	Genaral User Devices	enabled
200	DoorLocks	10.10.200.0/24	10.10.200.1	RFID Door Locks	Static
220	Camera	10.10.220.0/24	10.10.220.1	Camera	Static

6.5 Simulation Results

- DHCP for each VLAN successfully.
- Devices received correct IPs and gateways
- Inter-VLAN routing functional
- Ping tests between VLANs successful
- Wireless devices accessed the internet via APs.

6.6 Bill of Materials

Device	Cost (LKR)	Quantity	Total (USD)
2960-24TT	1500	11	16500
3650-24	5000	1	500
Access Point	20	17	340
		Total Cost	**21840**

Table 5: Active Device Cost Summary

6.7 Final Design

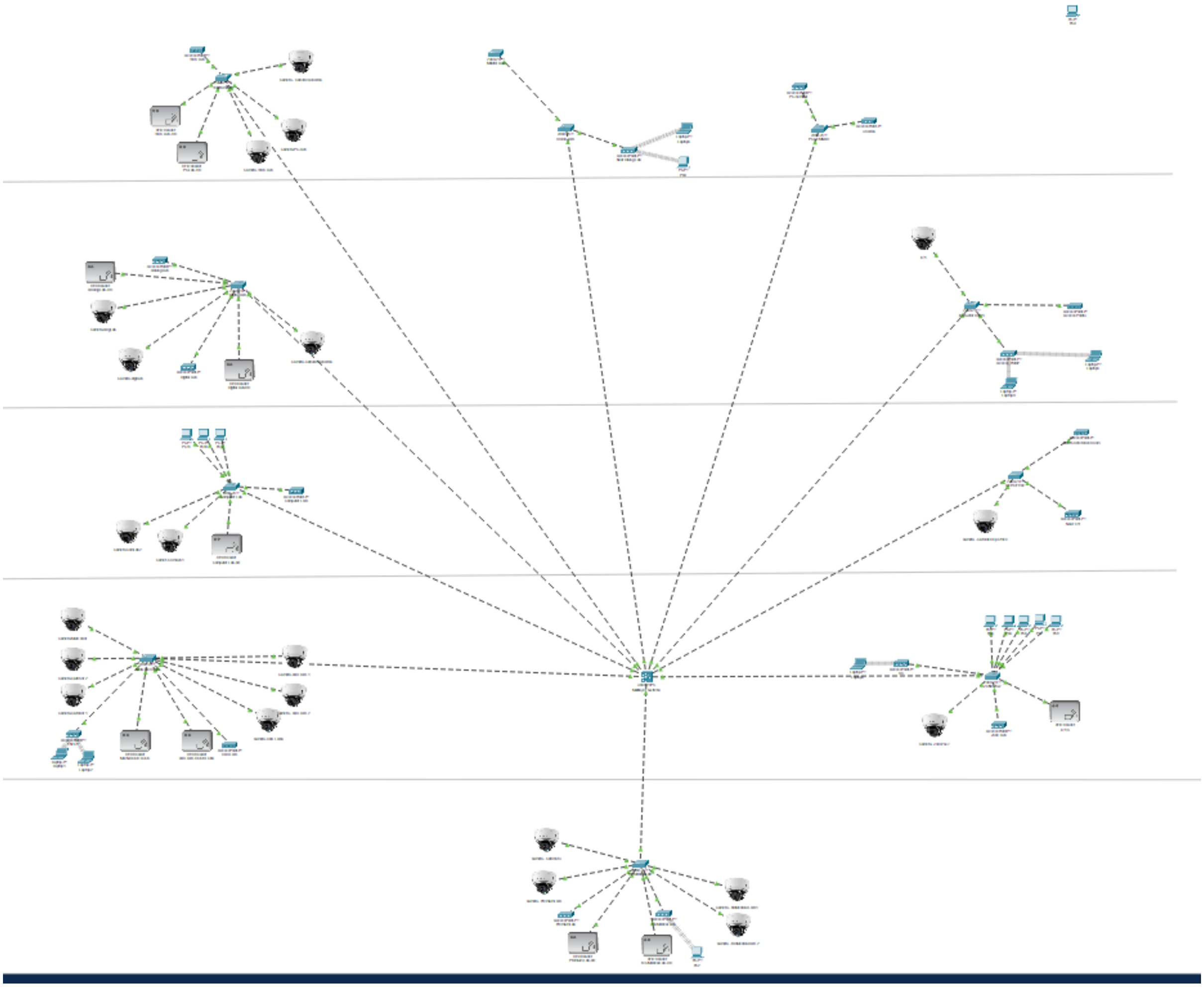


Figure 11: ENTC Network

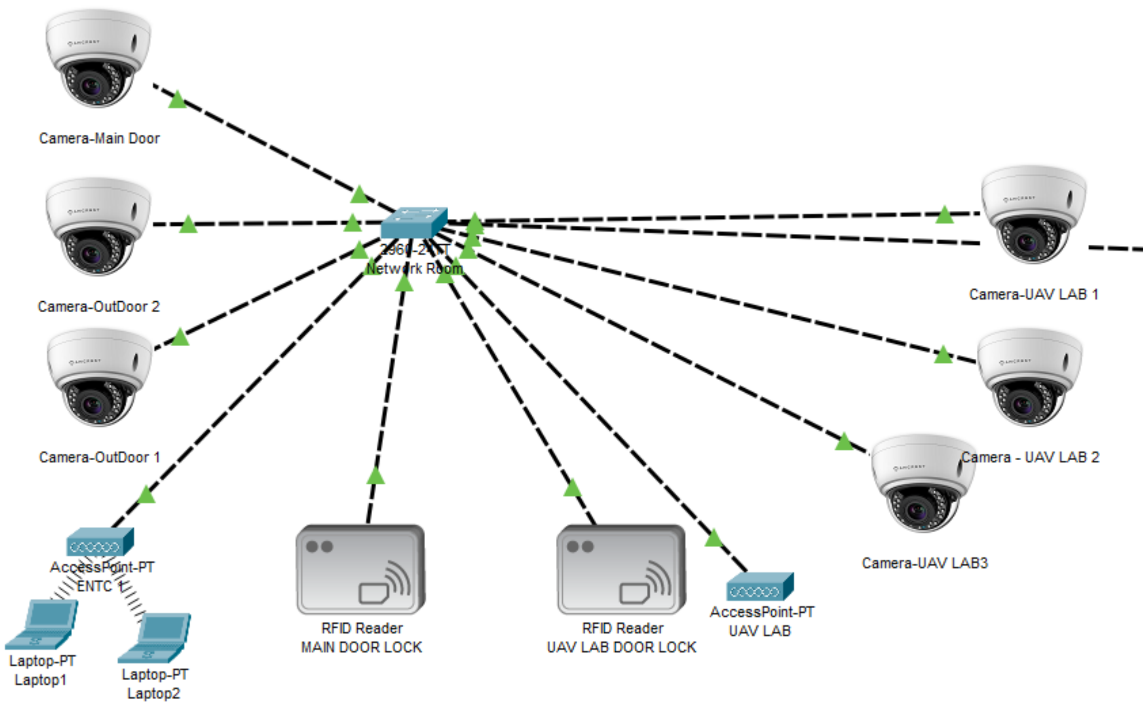


Figure 12: Layer 2 switch star topology