Computer Communication Network- CT-376
Complex Computing Problem

Hospital Network Infrastructure for an Academic Medical Centre

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REPORT

Instructor: Sir Abdul Karim Kazi

Team Members:

1. Muhammad Owais Amin - CT-21046 (**Team Lead**)
2. Syed Azfar Ali - CT-21039
3. Muhammad Zulfiqar Ali - CT-21023

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Introduction

In the modern healthcare landscape, an efficient and reliable network infrastructure is indispensable. It enables seamless collaboration among healthcare professionals, facilitating quick access to vital patient records, medical imaging, and diagnostic information critical for timely decision-making and enhancing patient outcomes.

However, the absence of a reliable network or the presence of network issues can severely disrupt hospital operations and compromise patient care. Delays in accessing patient records during emergencies or failures in medical device communication due to network instability can lead to treatment delays, staff miscommunication, and potential risks to patient safety.

Purpose of the Project

The primary objective of this project is to design a network topology that effectively addresses these challenges. By implementing a structured and modular network design, the project aims to enhance network reliability, ease of troubleshooting, and scalability within the hospital environment. This optimised topology will not only mitigate existing networking issues but also provide a foundation for future technological advancements and expansions.

Proposed Solution

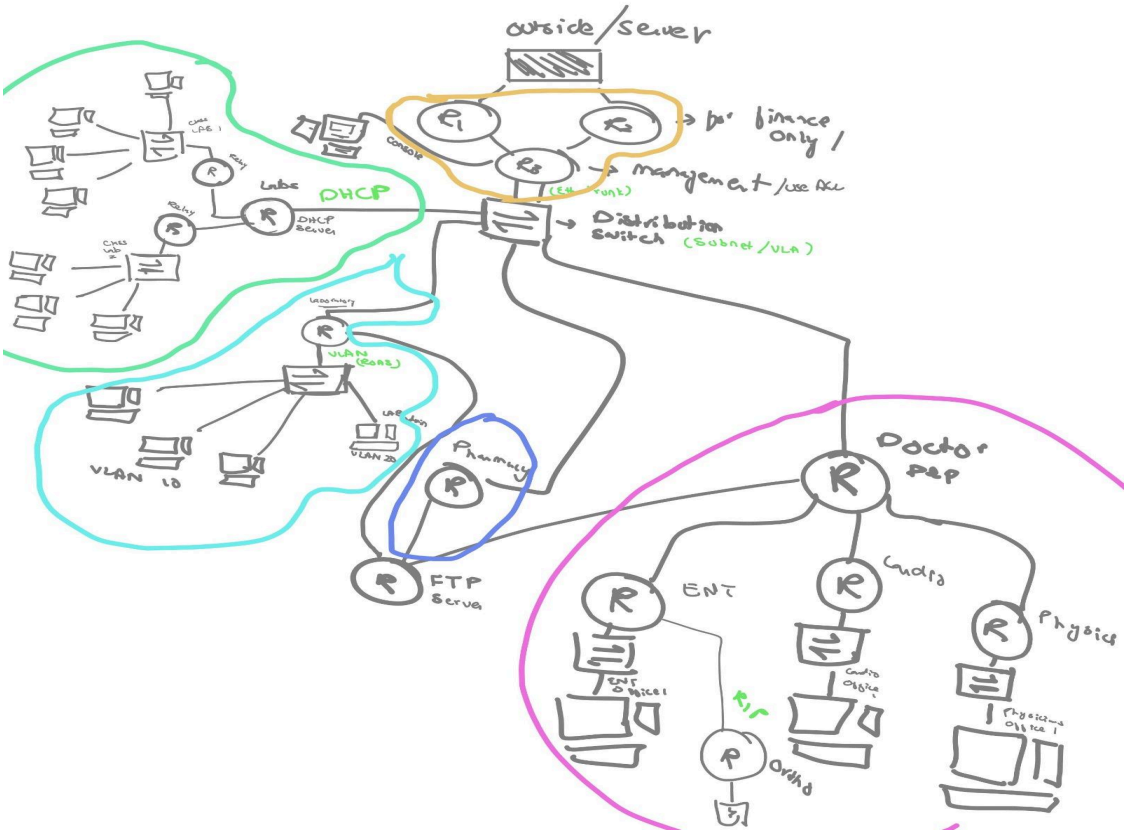
The proposed topology presents a draft countering the same problem criteria. With the help of the following concepts, we were able to depict a sample layout for a **Hospital Network Infrastructure for an Academic Medical Centre.**
The concepts Implemented are as follows:

- **IP Subnetting** - for efficient IP address management and network segmentation between the departments and their respective subdivisions.
- **Telnet** - for remote management and configuration of network devices within the hospital network.
- **Access Control List (ACL)** - to control traffic flow and enhance network security by permitting or denying packets based on specified criteria.
- **Link Aggregation Control Protocol (LACP) based Eth-trunk** - for better fault tolerance and increased bandwidth to handle high network traffic situations.
- **Static Routes** - to establish pre-defined routes for data packets ensuring efficient and reliable communication between distant networks.
- **Routing Information Protocol (RIP)** - for automated and dynamic routing of data packets.
- **Spanning Tree Protocol (STP) Convergence** - to prevent network loops and ensure a loop-free topology by dynamically adjusting the network paths.
- **Router On A Stick (VLANS)** - to enable inter-VLAN communication.
- **Dynamic Host Configuration Protocol (DHCP)** - to automatically assign IP addresses and other parameters from a given pool.
- **File Transfer Protocol (FTP)** - to facilitate the secure and efficient transfer of files, including patient records, test results, and other critical documents, between various departments within the hospital network.

Topology Overview

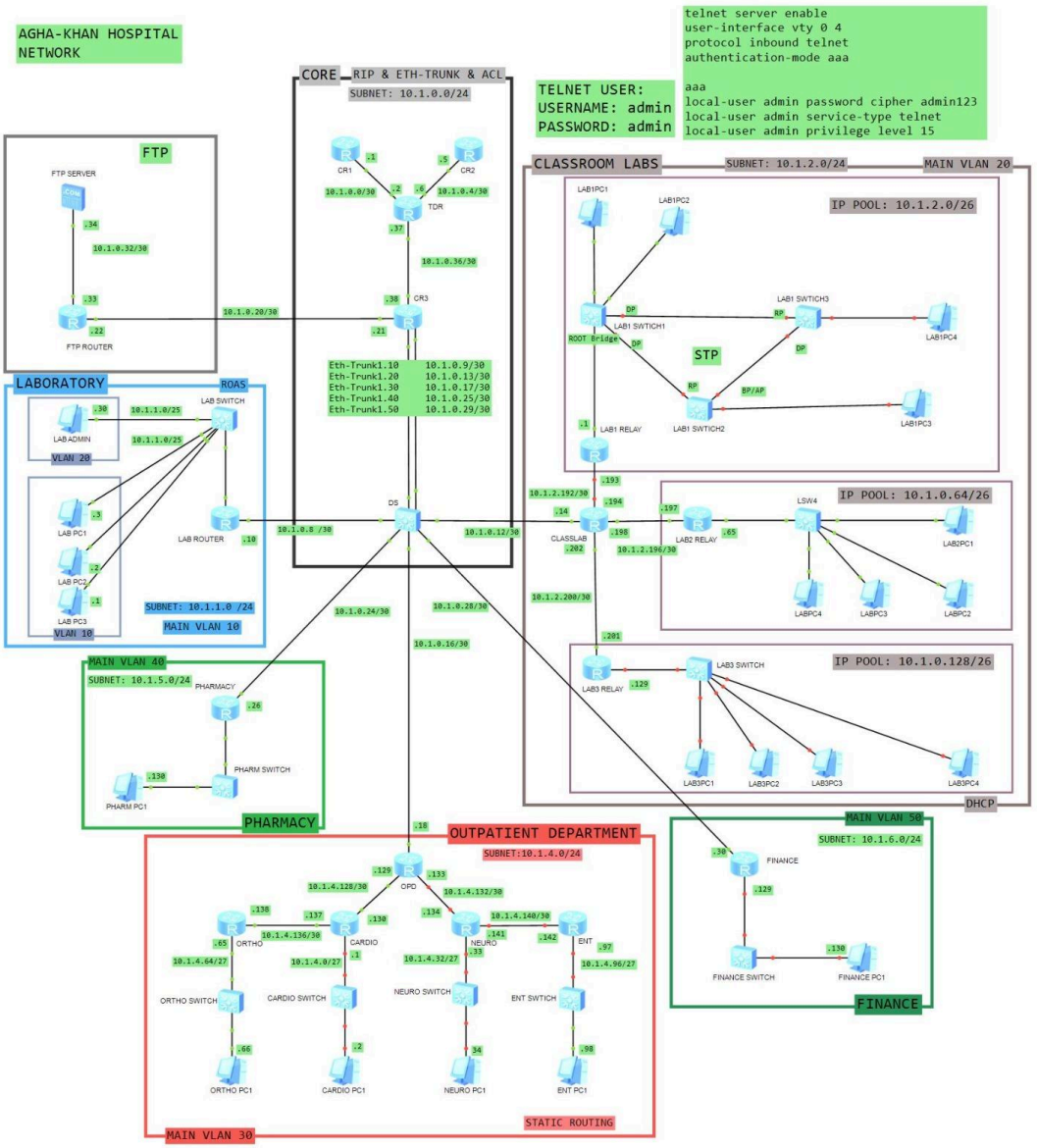
Initial Draft:

Below is the preliminary design of the network infrastructure we implemented, which served as a foundation and reference for a clearer understanding.



Moving forward, the design will undergo further refinement based on feedback and operational requirements. Future enhancements may include additional redundancy measures, advanced monitoring tools, and integration of emerging technologies to support evolving healthcare needs.

Below is the final laid-out topology implemented stated along with the address:
Network Address: 10.1.0.0
Subnet Mask: /21 or **255.255.248.0**



The network infrastructure consists of three main routers:

1. **CR1 - Core Router 1:** Manages non-financial requests for external network traffic.
2. **CR2 - Core Router 2:** Handles financial data packets destined for external network communications.
3. **CR3 - Core Router 3:** Manages internal network traffic. CR3 is equipped with two interfaces configured in an eth-trunk using **Link Aggregation Control Protocol (LACP)**. This setup enhances bandwidth capacity, ensuring efficient handling of high traffic volumes and providing fault tolerance in case of interface failure or disruption.
   Given the critical role of CR3 in the network, this configuration optimises network performance and reliability.

TDR - Traffic Director Router:

This router routes the incoming traffic to either CR1 or CR2 based on the nature of the data packets, directing non-financial requests to CR1 and financial requests to CR2.

The network infrastructure also includes a main switch, **Distribution Switch (DS)**, which connects all internal departments to the **CR3** router. The departments have been segmented using IP subnetting and **VLANs**, with connections established through the **router-on-a-stick (ROAS)** method.

This setup includes VLANs for various departments:

- 10 - Laboratory,
- 20 - College Labs,
- 30 - OPD,
- 40 - Pharmacy, and
- 50 - Finance,

The VLAN InterVLAN configuration, utilising CR3's Eth-trunk for inter-VLAN routing, enhances network security and management by segregating departmental traffic and optimising bandwidth usage through efficient VLAN segmentation.

RIP & STATIC ROUTING are used to establish communication among every router and device.

All Core Routers and FTP Server follow the subnet 10.1.0.0 / 24.

Core Routers

CR1

```
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher 9TI~Q`l.)BbL^B&WSBiQ{yT#
 local-user admin privilege level 3
```

```
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.0.1 255.255.255.252
#
interface GigabitEthernet0/0/1
#
interface GigabitEthernet0/0/2
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.0.2
ip route-static 10.1.4.32 255.255.255.224 10.1.0.2
```

```
ip route-static 10.1.4.64 255.255.255.224 10.1.0.2
ip route-static 10.1.4.96 255.255.255.224 10.1.0.2
ip route-static 10.1.4.136 255.255.255.252 10.1.0.2
ip route-static 10.1.4.140 255.255.255.252 10.1.0.2
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
Return
```

CR 2

```
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher >:{/T'yS94@X,k6.E\Z,+yS#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
```

```
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
#
interface GigabitEthernet0/0/1
 ip address 10.1.0.5 255.255.255.252
#
interface GigabitEthernet0/0/2
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.0.6
ip route-static 10.1.4.32 255.255.255.224 10.1.0.6
ip route-static 10.1.4.64 255.255.255.224 10.1.0.6
ip route-static 10.1.4.96 255.255.255.224 10.1.0.6
ip route-static 10.1.4.136 255.255.255.252 10.1.0.6
ip route-static 10.1.4.140 255.255.255.252 10.1.0.6
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
return
```

CR 3

```
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
```

```
 domain default
 domain default_admin
 local-user admin password cipher l"<Z"L^T@,bL^B&WSBiQGy~#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Eth-Trunk1
 mode lacp-static
#
interface Eth-Trunk1.1
#
interface Eth-Trunk1.10
 dot1q termination vid 10
 ip address 10.1.0.9 255.255.255.252
 arp broadcast enable
#
interface Eth-Trunk1.20
 dot1q termination vid 20
 ip address 10.1.0.13 255.255.255.252
 arp broadcast enable
#
interface Eth-Trunk1.30
 dot1q termination vid 30
 ip address 10.1.0.17 255.255.255.252
 arp broadcast enable
#
interface Eth-Trunk1.40
 dot1q termination vid 40
 ip address 10.1.0.25 255.255.255.252
 arp broadcast enable
#
interface Eth-Trunk1.50
 dot1q termination vid 50
 ip address 10.1.0.29 255.255.255.252
 arp broadcast enable
#
interface Ethernet0/0/0
```

```
 ip address 10.1.0.21 255.255.255.252
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.0.38 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.0.6 255.255.255.252
#
interface GigabitEthernet0/0/2
 eth-trunk 1
#
interface GigabitEthernet0/0/3
 eth-trunk 1
#
wlan
#
interface NULL0
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.0.18
ip route-static 10.1.4.32 255.255.255.224 10.1.0.18
ip route-static 10.1.4.64 255.255.255.224 10.1.0.18
ip route-static 10.1.4.96 255.255.255.224 10.1.0.18
```

```
ip route-static 10.1.4.136 255.255.255.252 10.1.0.18
ip route-static 10.1.4.140 255.255.255.252 10.1.0.18
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
return
```

TDR

```
[V200R003C00]
#
 snmp-agent local-engineid 800007DB03000000000000
 snmp-agent
#
 clock timezone China-Standard-Time minus 08:00:00
#
portal local-server load flash:/portalpage.zip
#
 drop illegal-mac alarm
#
 wlan ac-global carrier id other ac id 0
#
 set cpu-usage threshold 80 restore 75
#
acl number 3000
 rule 5 deny icmp source 10.1.0.28 0.0.0.3 destination 10.1.0.0 0.0.0.3
 rule 10 deny tcp source 10.1.0.28 0.0.0.3 destination 10.1.0.0 0.0.0.3
 rule 15 deny icmp source 10.1.6.0 0.0.0.255 destination 10.1.0.0 0.0.0.3
 rule 20 deny tcp source 10.1.6.0 0.0.0.255 destination 10.1.0.0 0.0.0.3
 rule 25 permit icmp source 10.1.0.28 0.0.0.3 destination 10.1.0.4 0.0.0.3
 rule 26 permit tcp source 10.1.0.28 0.0.0.3 destination 10.1.0.4 0.0.0.3
 rule 30 permit icmp source 10.1.6.0 0.0.0.255 destination 10.1.0.4 0.0.0.3
 rule 31 permit tcp source 10.1.6.0 0.0.0.255 destination 10.1.0.4 0.0.0.3
 rule 35 deny icmp destination 10.1.0.4 0.0.0.3
 rule 36 deny tcp destination 10.1.0.4 0.0.0.3
#
```

```
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher %$%$N{Fx6rVS]KU'F`3U%q!LrT|C%$%$
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 15
#
interface GigabitEthernet0/0/0
 ip address 10.1.0.2 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.0.6 255.255.255.252
#
interface GigabitEthernet0/0/2
 ip address 10.1.0.37 255.255.255.252
 traffic-filter inbound acl 3000
#
interface NULL0
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.0.38
ip route-static 10.1.4.32 255.255.255.224 10.1.0.38
ip route-static 10.1.4.64 255.255.255.224 10.1.0.38
ip route-static 10.1.4.96 255.255.255.224 10.1.0.38
ip route-static 10.1.4.136 255.255.255.252 10.1.0.38
ip route-static 10.1.4.140 255.255.255.252 10.1.0.38
#
user-interface con 0
 authentication-mode password
user-interface vty 0 4
 authentication-mode aaa
```

```
user-interface vty 16 20
#
wlan ac
#
```

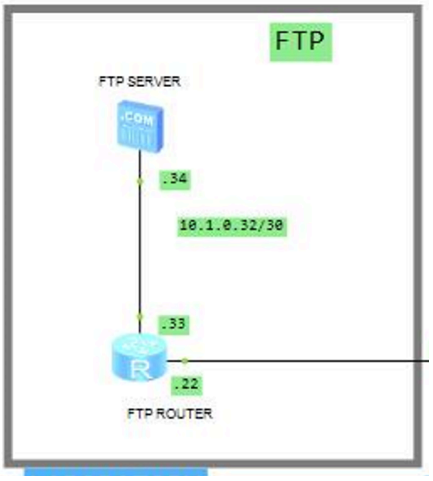
Distribution Switch (DS)

```
vlan batch 10 20 30 40 50
#
cluster enable
ntdp enable
ndp enable
#
drop illegal-mac alarm
#
diffserv domain default
#
drop-profile default
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password simple admin
 local-user admin service-type http
#
interface Vlanif1
#
interface MEth0/0/1
#
interface Eth-Trunk1
 port link-type trunk
 port trunk allow-pass vlan 10 20 30 40 50
 mode lacp-static
#
interface GigabitEthernet0/0/1
 port link-type access
```

```
 port default vlan 10
#
interface GigabitEthernet0/0/2
 eth-trunk 1
#
interface GigabitEthernet0/0/3
 eth-trunk 1
#
interface GigabitEthernet0/0/4
 port link-type access
 port default vlan 20
#
interface GigabitEthernet0/0/5
 port link-type access
 port default vlan 30
#
interface GigabitEthernet0/0/6
 port link-type access
 port default vlan 40
#
interface GigabitEthernet0/0/7
 port link-type access
 port default vlan 50
#
interface GigabitEthernet0/0/8
#
interface GigabitEthernet0/0/9
#
interface GigabitEthernet0/0/10
#
interface GigabitEthernet0/0/11
#
interface GigabitEthernet0/0/12
#
interface GigabitEthernet0/0/13
#
interface GigabitEthernet0/0/14
#
interface GigabitEthernet0/0/15
#
```

```
interface GigabitEthernet0/0/16
#
interface GigabitEthernet0/0/17
#
interface GigabitEthernet0/0/18
#
interface GigabitEthernet0/0/19
#
interface GigabitEthernet0/0/20
#
interface GigabitEthernet0/0/21
#
interface GigabitEthernet0/0/22
#
interface GigabitEthernet0/0/23
#
interface GigabitEthernet0/0/24
#
interface NULL0
#
user-interface con 0
user-interface vty 0 4
#
return
```

FTP Server



Subnet: 10.1.0.32 /24
Concept(s) Implemented: File Transfer Protocol

Reasoning:

An FTP server has been implemented to facilitate the secure and efficient transfer and retrieval of documents and patient reports between various departments. This setup supports multiple use cases:

- Patient Records Access in OPD: When a patient visits the Outpatient Department (OPD), their details are recorded, and doctors in specialised sub-departments (e.g., Orthopedics) can retrieve past reports or test results stored on the FTP server. This ensures that doctors have access to comprehensive patient histories, enabling informed medical decisions.
- Laboratory Test Results: The Laboratory department can generate test results and store them on the FTP server. These results can then be accessed by other departments as needed, ensuring that critical diagnostic information is readily available for patient care.
- Prescription Management in Pharmacy: After a patient consults a doctor in the OPD (e.g., Cardiology), the doctor can prescribe medications and update the patient's records on the FTP server. Subsequently, the Pharmacy department can access these records to dispense the prescribed medications accurately, streamlining the medication fulfilment process.
- Enhanced Security and Data Integrity: The FTP server is configured with robust security measures to ensure that data is transferred and accessed securely between departments. This includes secure login credentials, encrypted data transfer protocols, and access control mechanisms to protect patient information and maintain data integrity.

Configuration:

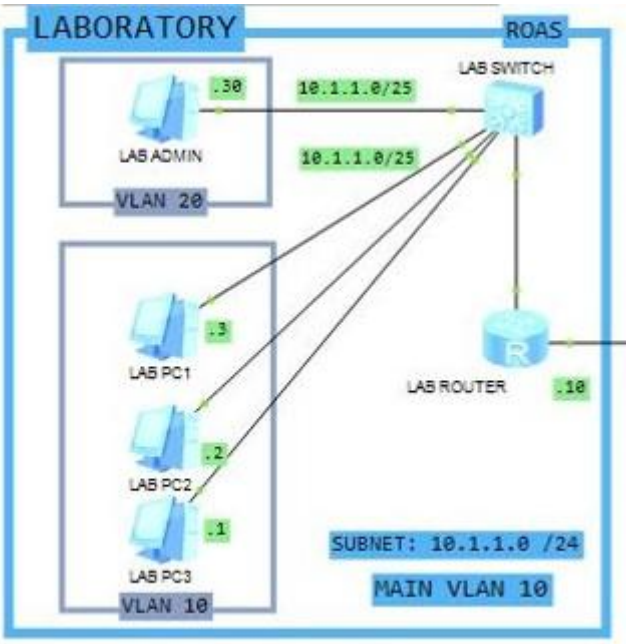
FTP Router:

```
acl number 3000
 rule 5 deny tcp source 10.1.0.28 0.0.0.3 destination 10.1.0.34 0 destination-po
rt range ftp-data ftp
 rule 10 deny tcp source 10.1.0.8 0.0.0.3 destination 10.1.0.34 0 destination-po
rt range ftp-data ftp
 rule 15 deny tcp source 10.1.0.12 0.0.0.3 destination 10.1.0.34 0 destination-p
ort range ftp-data ftp
```

```
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher %$%$J}\yEs#Up7p*<IY0|8f(rTcC%$%$
 local-user admin privilege level 3
 local-user admin service-type telnet
#
interface GigabitEthernet0/0/0
 ip address 10.1.0.22 255.255.255.252
 traffic-filter inbound acl 3000
#
interface GigabitEthernet0/0/1
 ip address 10.1.0.33 255.255.255.252
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.0.21
ip route-static 10.1.4.32 255.255.255.224 10.1.0.21
ip route-static 10.1.4.64 255.255.255.224 10.1.0.21
ip route-static 10.1.4.96 255.255.255.224 10.1.0.21
ip route-static 10.1.4.136 255.255.255.252 10.1.0.21
ip route-static 10.1.4.140 255.255.255.252 10.1.0.21
#
user-interface con 0
 authentication-mode password
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
```

Sub-Topology Overview

1. Laboratory



VLAN: 10
Subnet: 10.1.1.0 /24
Concept(s) Implemented: Virtual LANs (VLANs) & Router On A Stick (ROAS)

Reasoning:
The subnet for the laboratory is structured to efficiently manage all testing activities and related issues. It is divided into two VLANs:

- VLAN for Testing Hosts: This VLAN is dedicated to the hosts that perform the laboratory tests.
- VLAN for Administrative Management: This VLAN is allocated for administrative functions, allowing staff to manage the workflow. Administrative personnel can efficiently direct patients to the appropriate hosts for their tests and manage availability, ensuring that patients are guided to the correct resources without unnecessary delays.

The implementation of VLANs and ROAS enhances network security and performance by segregating different types of traffic, ensuring that sensitive testing data is protected and administrative functions are carried out efficiently.

This setup also allows for easier network management and troubleshooting, improving the overall operational efficiency of the laboratory.

Configuration:

Lab Switch:

```
vlan batch 10 20
#
interface GigabitEthernet0/0/1
 port link-type access
 port default vlan 10
#
interface GigabitEthernet0/0/2
 port link-type access
 port default vlan 10
#
interface GigabitEthernet0/0/3
 port link-type access
 port default vlan 10
#
interface GigabitEthernet0/0/4
 port link-type access
 port default vlan 20
#
interface GigabitEthernet0/0/5
 port link-type trunk
```

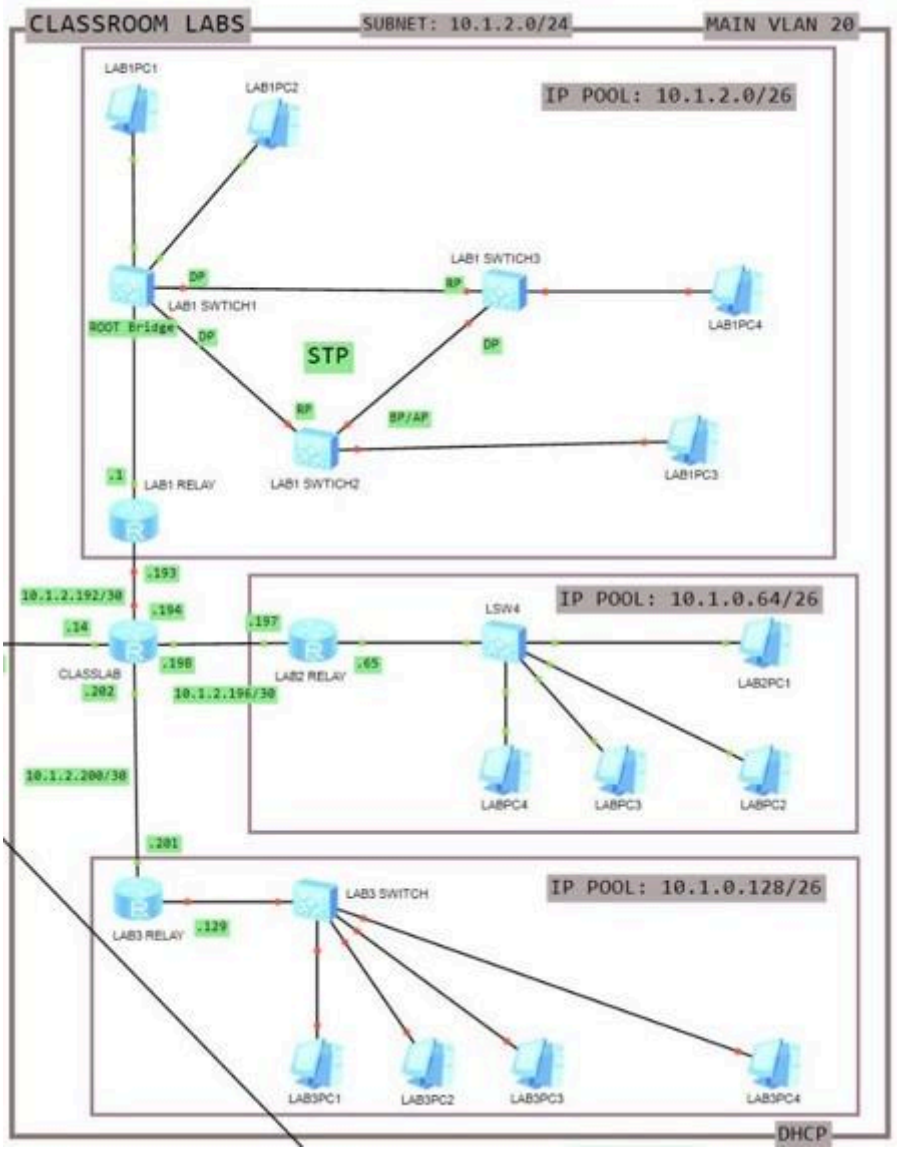
```
 port trunk allow-pass vlan 10 20
```

Lab Router:

```
interface GigabitEthernet0/0/0.10
 dot1q termination vid 10
 ip address 10.1.1.100 255.255.255.128
 arp broadcast enable
#
interface GigabitEthernet0/0/0.20
 dot1q termination vid 20
 ip address 10.1.1.133 255.255.255.128
 arp broadcast enable
#
interface GigabitEthernet0/0/1
 ip address 10.1.0.10 255.255.255.252
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.0.9
ip route-static 10.1.4.32 255.255.255.224 10.1.0.9
ip route-static 10.1.4.64 255.255.255.224 10.1.0.9
ip route-static 10.1.4.96 255.255.255.224 10.1.0.9
```

```
ip route-static 10.1.4.136 255.255.255.252 10.1.0.9
ip route-static 10.1.4.140 255.255.255.252 10.1.0.9
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
```

2. College Labs



VLAN: 20
Subnet: 10.1.2.0 /23
Concept(s) Implemented: Dynamic Host Configuration Protocol & Spanning Tree Protocol (STP)

Reasoning:

- Dynamic Host Configuration Protocol (DHCP): We have implemented a DHCP server to automatically assign IP addresses to the hosts. This approach is necessary due to the impracticality of manually assigning static IPs to a large number of hosts. DHCP streamlines the process, ensuring that each device receives a unique IP address without manual

intervention, thus reducing administrative overhead and configuration errors.

- Spanning Tree Protocol (STP): The network setup includes three relays, each with its own router and switch. To illustrate the functionality and importance of STP, the first relay uses three switches in a looped configuration. STP is automatically configured to detect and eliminate network loops, thereby maintaining a loop-free and efficient sub-topology. This setup demonstrates how STP prevents broadcast storms and ensures continuous network availability by dynamically adjusting to changes in the network topology.

By implementing DHCP and STP, we enhance the network's scalability, efficiency, and resilience. The automated IP assignment through DHCP ensures smooth and error-free network operations, while STP safeguards the network against potential loop-induced issues, thereby optimising the performance and reliability of the College Labs' network infrastructure.

STP Calculation:

The STP Calculation is as follows:

LAB 1 Switch 1 is the root bridge and all its ports GE 0/0/1 and GE 0/0/3 are Designated ports.

In LAB 2 Switch 2 GE0/0/1 is the Root port GE 0/0/4 is the Block port.

In LAB 3 Switch 3 GE 0/0/1 is the Root Port and GE 0/0/2 is the Designated port.

Configuration:

ClassLab:

```
dhcp enable
#
ip pool lab-1
 gateway-list 10.1.2.1
 network 10.1.2.0 mask 255.255.255.192
 dns-list 8.8.8.8
#
ip pool lab-2
 gateway-list 10.1.2.65
 network 10.1.2.64 mask 255.255.255.192
```

```
 dns-list 8.8.8.8
#
ip pool lab-3
 gateway-list 10.1.2.129
 network 10.1.2.128 mask 255.255.255.192
 dns-list 8.8.8.8
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher >E7NKDQ-[-3@9_G-B0Y2&zN#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.0.14 255.255.255.252
#
interface GigabitEthernet0/0/1
```

```
 ip address 10.1.2.198 255.255.255.252
 dhcp select global
#
interface GigabitEthernet0/0/2
 ip address 10.1.2.202 255.255.255.252
 dhcp select global
#
interface GigabitEthernet0/0/3
 ip address 10.1.2.194 255.255.255.252
 dhcp select global
#
wlan
#
interface NULL0
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.0.13
ip route-static 10.1.4.32 255.255.255.224 10.1.0.13
ip route-static 10.1.4.64 255.255.255.224 10.1.0.13
ip route-static 10.1.4.96 255.255.255.224 10.1.0.13
ip route-static 10.1.4.136 255.255.255.252 10.1.0.13
ip route-static 10.1.4.140 255.255.255.252 10.1.0.13
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
return
```

Lab Relay 1:

```
dhcp enable
#
aaa
 authentication-scheme default
```

```
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher >E7NKDQ-[-+/Y@:Y>Lw(fzc#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
interface GigabitEthernet0/0/0
 ip address 10.1.2.193 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.2.1 255.255.255.192
 dhcp select relay
 dhcp relay server-ip 10.1.2.194
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.2.194
ip route-static 10.1.4.32 255.255.255.224 10.1.2.194
ip route-static 10.1.4.64 255.255.255.224 10.1.2.194
ip route-static 10.1.4.96 255.255.255.224 10.1.2.194
ip route-static 10.1.4.136 255.255.255.252 10.1.2.194
ip route-static 10.1.4.140 255.255.255.252 10.1.2.194
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
```

Lab Relay 2:

```
dhcp enable
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
```

```
 domain default
 domain default_admin
 local-user admin password cipher `\^VHF3i&%]@l3D+mKgUHz@#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.2.197 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.2.65 255.255.255.192
 dhcp select relay
 dhcp relay server-ip 10.1.2.198
#
interface GigabitEthernet0/0/2
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
```

```
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 0.0.0.0 0.0.0.0 10.1.2.198
ip route-static 10.1.4.0 255.255.255.224 10.1.2.198
ip route-static 10.1.4.32 255.255.255.224 10.1.2.198
ip route-static 10.1.4.64 255.255.255.224 10.1.2.198
ip route-static 10.1.4.96 255.255.255.224 10.1.2.198
ip route-static 10.1.4.136 255.255.255.252 10.1.2.198
ip route-static 10.1.4.140 255.255.255.252 10.1.2.198
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
return
```

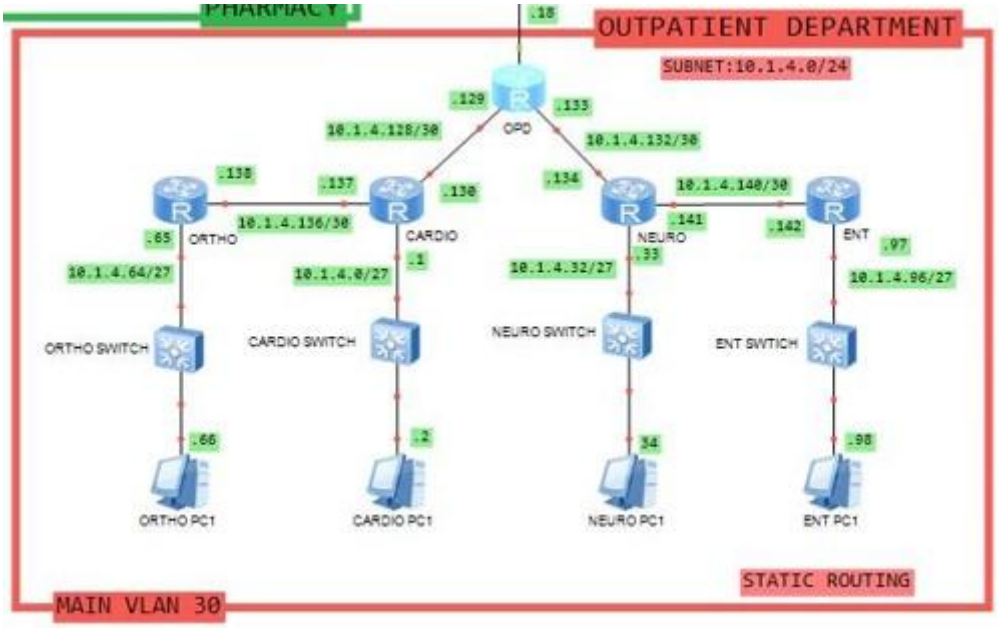
Lab Relay 3:

```
dhcp enable
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher mN-T6j#WvV=H)H2[EInB#zO#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
```

```
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.2.201 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.2.129 255.255.255.192
 dhcp select relay
 dhcp relay server-ip 10.1.2.202
#
interface GigabitEthernet0/0/2
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 0.0.0.0 0.0.0.0 10.1.2.202
ip route-static 10.1.4.0 255.255.255.224 10.1.2.202
ip route-static 10.1.4.32 255.255.255.224 10.1.2.202
ip route-static 10.1.4.64 255.255.255.224 10.1.2.202
ip route-static 10.1.4.136 255.255.255.252 10.1.2.202
ip route-static 10.1.4.140 255.255.255.252 10.1.2.202
#
user-interface con 0
```

```
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
return
```

3. Outpatient Department (OPD)



VLAN: 30
Subnet: 10.1.4.0 /24
Concept(s) Implemented: Static routes

Reasoning:
To integrate the Orthopaedic (Ortho) and Ear, Nose, and Throat (ENT) departments, which were added later and are located relatively far from the central network but close to the Cardio and Neuro departments, we implemented static routes. This approach was chosen to ensure efficient and reliable routing of data packets between these departments and the main network. By using static routes, we could manually specify the paths for data traffic, optimising network performance and ensuring direct communication lines between the Cardio and Ortho departments, as well as the Neuro and ENT departments. This method allows for precise control over routing paths, minimising latency and enhancing the overall network efficiency for the Outpatient Department (OPD).

Configuration:

OPD Main Router:

```
#
sysname OPD
#
undo nap slave enable
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher 1B%*%0r@BC@X,k6.E\Z,Y;;#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.4.129 255.255.255.252
#
interface GigabitEthernet0/0/1
```

```
 ip address 10.1.4.133 255.255.255.252
#
interface GigabitEthernet0/0/2
 ip address 10.1.0.18 255.255.255.252
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.4.130
ip route-static 10.1.4.32 255.255.255.224 10.1.4.134
ip route-static 10.1.4.64 255.255.255.224 10.1.4.130
ip route-static 10.1.4.96 255.255.255.224 10.1.4.134
ip route-static 10.1.4.136 255.255.255.252 10.1.4.130
ip route-static 10.1.4.140 255.255.255.252 10.1.4.134
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
```

Cardio:

```
#
sysname Cardio
#
undo nap slave enable
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
```

```
 local-user admin password cipher ~A~wX{Z9fFani^>"qh^;+;=#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
wlan
#
ip route-static 10.1.0.0 255.255.255.0 10.1.4.129
ip route-static 10.1.0.4 255.255.255.252 10.1.4.129
ip route-static 10.1.0.8 255.255.255.252 10.1.4.129
ip route-static 10.1.0.12 255.255.255.252 10.1.4.129
ip route-static 10.1.0.16 255.255.255.252 10.1.4.129
ip route-static 10.1.0.20 255.255.255.252 10.1.4.129
ip route-static 10.1.0.24 255.255.255.252 10.1.4.129
ip route-static 10.1.0.28 255.255.255.252 10.1.4.129
ip route-static 10.1.1.0 255.255.255.0 10.1.4.129
ip route-static 10.1.2.0 255.255.255.0 10.1.4.129
ip route-static 10.1.2.192 255.255.255.252 10.1.4.129
ip route-static 10.1.4.32 255.255.255.224 10.1.4.129
ip route-static 10.1.4.64 255.255.255.224 10.1.4.138
ip route-static 10.1.4.96 255.255.255.224 10.1.4.129
ip route-static 10.1.4.132 255.255.255.252 10.1.4.129
ip route-static 10.1.4.140 255.255.255.252 10.1.4.129
ip route-static 10.1.5.0 255.255.255.0 10.1.4.129
ip route-static 10.1.6.0 255.255.255.0 10.1.4.129
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
```

Ortho:

```
sysname Ortho
#
undo nap slave enable
#
aaa
 authentication-scheme default
```

```
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher c>Q{<UEr:U3@9_G-B0Y2>zE#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.4.138 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.4.65 255.255.255.224
#
interface GigabitEthernet0/0/2
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
```

```
#
ip route-static 10.1.0.0 255.255.255.0 10.1.4.137
ip route-static 10.1.1.0 255.255.255.0 10.1.4.137
ip route-static 10.1.2.0 255.255.255.0 10.1.4.137
ip route-static 10.1.4.0 255.255.255.224 10.1.4.137
ip route-static 10.1.4.32 255.255.255.224 10.1.4.137
ip route-static 10.1.4.96 255.255.255.224 10.1.4.137
ip route-static 10.1.4.128 255.255.255.252 10.1.4.137
ip route-static 10.1.4.132 255.255.255.252 10.1.4.137
ip route-static 10.1.4.140 255.255.255.252 10.1.4.137
ip route-static 10.1.5.0 255.255.255.0 10.1.4.137
ip route-static 10.1.6.0 255.255.255.0 10.1.4.137
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
return
```

Neuro:

```
#
sysname Neuro
#
undo nap slave enable
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher ;j.vTe-U0H3@9_G-B0Y2U;E#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
```

```
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.4.141 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.4.134 255.255.255.252
#
interface GigabitEthernet0/0/2
 ip address 10.1.4.33 255.255.255.224
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
#
ip route-static 10.1.0.0 255.255.255.0 10.1.4.133
ip route-static 10.1.1.0 255.255.255.0 10.1.4.133
ip route-static 10.1.2.0 255.255.255.0 10.1.4.133
ip route-static 10.1.4.0 255.255.255.224 10.1.4.133
ip route-static 10.1.4.64 255.255.255.224 10.1.4.133
ip route-static 10.1.4.96 255.255.255.224 10.1.4.142
ip route-static 10.1.4.128 255.255.255.252 10.1.4.133
ip route-static 10.1.4.136 255.255.255.252 10.1.4.133
ip route-static 10.1.5.0 255.255.255.0 10.1.4.133
ip route-static 10.1.6.0 255.255.255.0 10.1.4.133
```

```
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
```

ENT:

```
sysname ENT
#
undo nap slave enable
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher l"<Z"L^T@,ZypQCee$t3>yJ#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
```

```
#
interface GigabitEthernet0/0/0
 ip address 10.1.4.142 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.4.97 255.255.255.224
#
interface GigabitEthernet0/0/2
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
#
ip route-static 10.1.0.0 255.255.255.0 10.1.4.141
ip route-static 10.1.1.0 255.255.255.0 10.1.4.141
ip route-static 10.1.2.0 255.255.255.0 10.1.4.141
ip route-static 10.1.4.0 255.255.255.224 10.1.4.141
ip route-static 10.1.4.32 255.255.255.224 10.1.4.141
ip route-static 10.1.4.64 255.255.255.224 10.1.4.141
ip route-static 10.1.4.128 255.255.255.252 10.1.4.141
ip route-static 10.1.4.132 255.255.255.252 10.1.4.141
ip route-static 10.1.4.136 255.255.255.252 10.1.4.141
ip route-static 10.1.4.140 255.255.255.252 10.1.0.2
ip route-static 10.1.5.0 255.255.255.0 10.1.4.141
ip route-static 10.1.6.0 255.255.255.0 10.1.4.141
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
return
```

4. Pharmacy

VLAN: 40
Subnet: 10.1.5.0 /24

The Pharmacy department has been designed to communicate with the FTP server to access relevant documents or reports of patients. This setup allows the pharmacy staff to retrieve patient prescriptions and medication records efficiently.

- **FTP Integration:** The pharmacy network is configured to connect with the FTP server, enabling secure and efficient access to patient documents and reports.
- **Enhanced Access Control:** By directly integrating with the FTP server, we ensure that only authorized pharmacy personnel can access sensitive medical data, maintaining strict access controls.

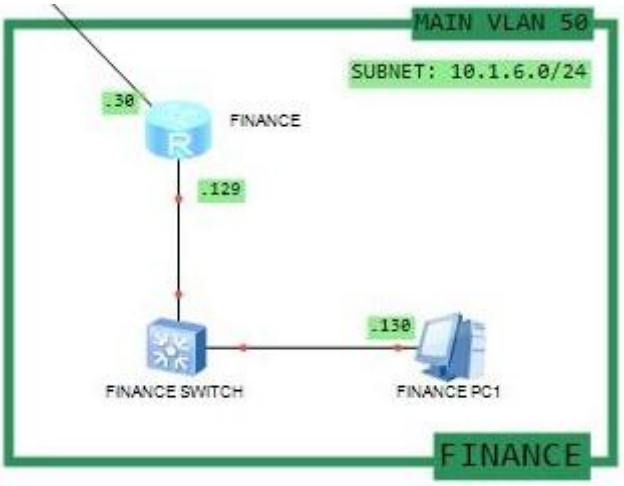
Configuration:
Pharm Router

```
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password cipher &o9(2PRPv4939O4.`(ZG3zC#
 local-user admin privilege level 3
 local-user admin service-type telnet
#
firewall zone Local
 priority 16
```

```
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.0.26 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.5.129 255.255.255.0
#
interface GigabitEthernet0/0/2
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
#
rip 1
 version 2
 network 10.0.0.0
#
ip route-static 10.1.4.0 255.255.255.224 10.1.0.25
ip route-static 10.1.4.32 255.255.255.224 10.1.0.25
ip route-static 10.1.4.64 255.255.255.224 10.1.0.25
ip route-static 10.1.4.96 255.255.255.252 10.1.0.25
ip route-static 10.1.4.136 255.255.255.252 10.1.0.25
```

```
ip route-static 10.1.4.140 255.255.255.252 10.1.0.25
#
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
return
```

5. Finance



VLAN: 50
Subnet: 10.1.6.0 /24

The Finance department is designed to handle critical financial requests and transactions, and it communicates directly with the financial router (CR2) that manages outer network requests.

- **Direct Communication with CR2:** The finance network is set up to interact with the CR2 router, ensuring that financial data can be securely transmitted to and from the outer network.
- **Enhanced Security:** The direct connection to CR2 helps to segregate financial data, ensuring that sensitive information is accessible only to authorized personnel.
- **Optimized Network Management:** This configuration allows for efficient handling of financial transactions, ensuring that the Finance department has the necessary network resources for optimal performance.

Configuration:

Finance Router:

```
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
```

```
 local-user admin password cipher A0=AAb(`sFjKUGU-KkpB/z/#
 local-user admin service-type http
#
firewall zone Local
 priority 16
#
interface Ethernet0/0/0
#
interface Ethernet0/0/1
#
interface Serial0/0/0
 link-protocol ppp
#
interface Serial0/0/1
 link-protocol ppp
#
interface Serial0/0/2
 link-protocol ppp
#
interface Serial0/0/3
 link-protocol ppp
#
interface GigabitEthernet0/0/0
 ip address 10.1.0.30 255.255.255.252
#
interface GigabitEthernet0/0/1
 ip address 10.1.6.129 255.255.255.0
#
interface GigabitEthernet0/0/2
#
interface GigabitEthernet0/0/3
#
wlan
#
interface NULL0
#
rip 1
 version 2
 network 10.0.0.0
#
```

```
ip route-static 10.1.4.0 255.255.255.224 10.1.0.29
ip route-static 10.1.4.32 255.255.255.224 10.1.0.29
ip route-static 10.1.4.64 255.255.255.224 10.1.0.29
ip route-static 10.1.4.96 255.255.255.224 10.1.0.29
ip route-static 10.1.4.136 255.255.255.252 10.1.0.29
ip route-static 10.1.4.140 255.255.255.252 10.1.0.29
#
user-interface con 0
user-interface vty 0 4
user-interface vty 16 20
#
Return
```

Conclusion

The network infrastructure designed for our major academic medical center addresses the critical needs for security, scalability, and reliability. By implementing a comprehensive set of network configurations and technologies, we have created a robust and efficient network capable of supporting the hospital's operational demands and future growth.

Key Implementations and Their Benefits:

1. **IP Subnetting & VLANs**: These techniques were employed to enhance network organization and security. By segmenting the network into smaller, manageable subnets and VLANs, we have isolated sensitive data and optimized network performance across departments, such as Laboratory, College Labs, and Outpatient Department (OPD).
2. **Router On A Stick (ROAS)**: Implemented on CR3 and the Distribution Switch, ROAS enables inter-VLAN communication, ensuring that different departments can interact seamlessly while maintaining network security and efficiency.
3. **Dynamic Host Configuration Protocol (DHCP)**: Used in College Labs, DHCP facilitates automatic IP address assignment, making network management more efficient and reducing the risk of IP conflicts.
4. **Spanning Tree Protocol (STP)**: Implemented to prevent network loops and ensure a loop-free topology, STP enhances the reliability of the network, particularly in scenarios with multiple switches.

5. **Static Routes**: Used in the Outpatient Department (OPD) to ensure reliable and efficient communication between distant networks, particularly for newly introduced departments like Ortho and ENT.
6. **Access Control List (ACL)**: Deployed to control traffic flow and enhance security by permitting or denying packets based on specified criteria, ensuring that only authorized devices can access sensitive data.
7. **Link Aggregation Control Protocol (LACP) based Eth-trunk**: Used on CR3, this configuration provides better fault tolerance and increased bandwidth, handling high network traffic situations efficiently.
8. **Telnet**: For remote management and configuration of network devices, ensuring that administrators can manage the network efficiently from any location.
9. **File Transfer Protocol (FTP)**: Integrated with the Pharmacy department for secure and efficient transfer of patient documents and reports, enhancing operational efficiency and patient care.
10. **Finance Department Configuration**: Designed to handle financial transactions and requests securely, with direct communication to CR2 for managing outer network requests, ensuring robust security and optimal performance for financial operations.

Overall Network Architecture: The core of our network infrastructure is built around three main routers (CR1, CR2, CR3) and a Distribution Switch that connects all internal departments. By leveraging advanced network technologies and best practices, we have created a scalable, secure, and highly available network capable of supporting the hospital's diverse needs.

Future-Proofing: This network design not only addresses current challenges but also provides a scalable foundation for future expansions and technological advancements. As the hospital continues to grow and evolve, the network infrastructure can be easily adapted to meet new requirements and support additional services and departments.

In conclusion, our network infrastructure is a testament to thoughtful planning and implementation of cutting-edge networking technologies. It ensures that the hospital can deliver exceptional patient care and academic excellence while maintaining the highest standards of security and reliability.