

Introduction:

Communication is of an importance when it comes to our present-day needs. It bonds us all together and keeps our day-to-day operations running smoothly. The foundation of good communication is information. In today's age, computer networking has become a critical means of information interchange between people. A computer network is an interconnection between computers. We may also say that a computer network is a group of computers connected in such a way that one computer can interact with another computer.

With this being said, our group, "Team Frontrow", have come up with a way to create a network between different countries that would showcase how these networks can and would communicate or interact with each other easily.

Objectives:

The aim of this project is to create a network for the XYZ company between four countries; Philippines, Denmark, Las Vegas, and United Arab Emirates and also to allocate a reserved network for America and Africa.

Each of the countries will have its own network design and each of the sites will be compromised with a department and server. Then each department will have its own number of users, the included users for the departments will be based on the following table:

Philippines - PH	Users - 140	Requirements
Accounting	40	SMTP - Primary DHCP DNS Web Server Access Point for Wireless Users
HR	15	
Travel & Expense	30	
Project Management	10	
Service Desk	45	

Denmark - DK	Users - 580	Requirements
Accounting	20	DHCP DNS Web Server Access Point for Wireless Users
Project Management	15	
Maintenance Team	100	
Engineering	250	
Sales and Marketing	175	
Info Sec	20	

Las Vegas - LV	Users - 460	Requirements
HR	20	SMTP - Secondary DHCP DNS Web Server
Project Management	20	
Engineering	200	
Sales and Marketing	220	

United Arab Emirates - UAE	Users - 550	Requirements
Maintenance Team	100	DHCP DNS
Engineering	450	

		Web Server
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Project Scope and Delimitation

The scope of the project will cover the requirements that are given by the company. The countries included in the network are already established sites, with also the required reserve network that is prepared for two countries.

The project scope is only limited to all the requirements needed to implement. Provided the network range of 192.168.0.0/16 for user VLAN and 172.17.0.0/24 for server VLAN. The project was able to comply to all configurations and protocols needed by the XYZ company. The only delimitation of the networking project is the application of access-list. The Frontrow team was able to implement access-list but does not work properly for its purpose.

Network Planning & Design

This project's plan is to have two routers for each country/site and by having each of the departments an own switch that is connected in the said routers. Cisco's three-layer model (Core, Distribution, and Access) is the basis for the design with each layer defined and clearly presented. The network design also applied redundancy.

There are 4 countries connected to each other, with department and servers with their corresponding VLAN.

VLAN	Department
VLAN 10	Service
VLAN 20	Accounting
VLAN 30	Travel & Expense
VLAN 40	HR
VLAN 50	Project Management
VLAN 60	Engineering
VLAN 70	Maintenance
VLAN 80	Sales & Marketing
VLAN 90	InfoSec Team
VLAN 100	Server

Table 1. VLAN Configuration

Design Description

The project used Cisco three-layer model. Core layer includes two routers for each country, Distribution layer includes switches where each department and servers are connected, and Access layer includes PCs of the end users.

The topology used is Partial Mesh Topology, wherein some nodes are organized in a full-mesh scheme, but others are connected to only one or two in the network. The partial mesh is more practical as compared to the full mesh. In a partially connected mesh, all the nodes aren't necessary to be connected with one another during a network. Peripheral networks are connected using partial mesh and work with a full-mesh backbone in tandem.

Figure 1. Philippines Design

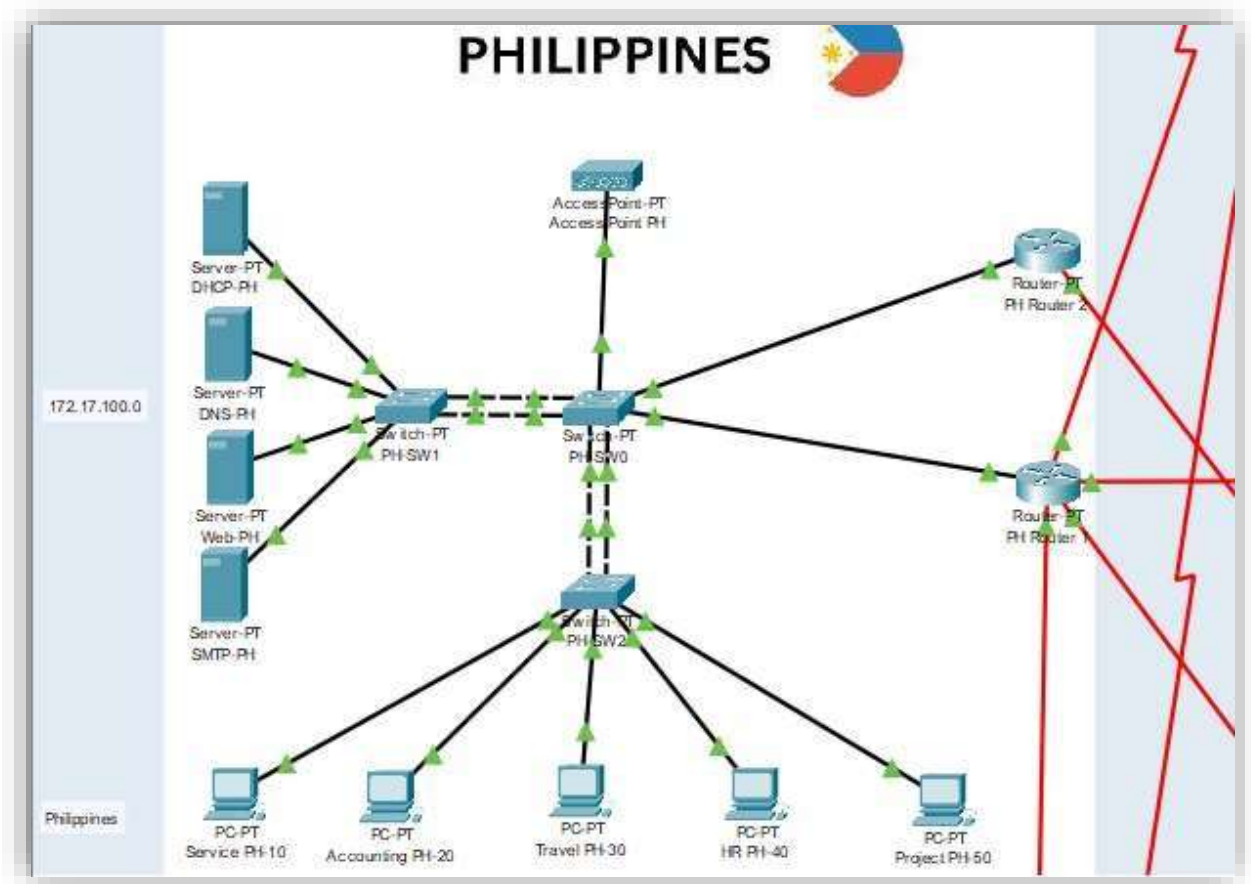


Figure 2. Denmark Design

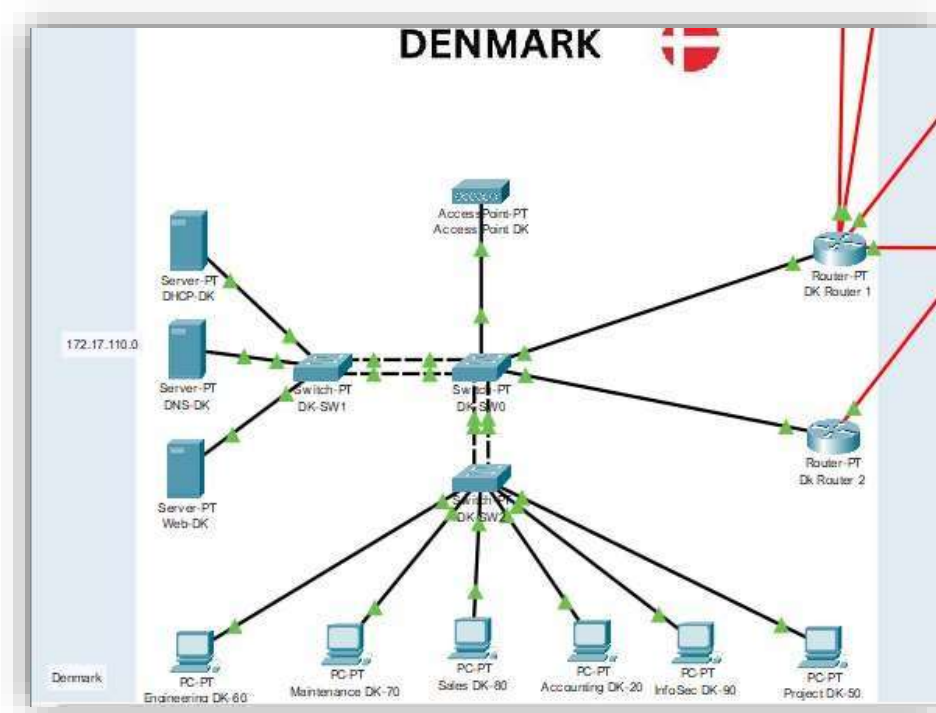


Figure 3. Las Vegas Design

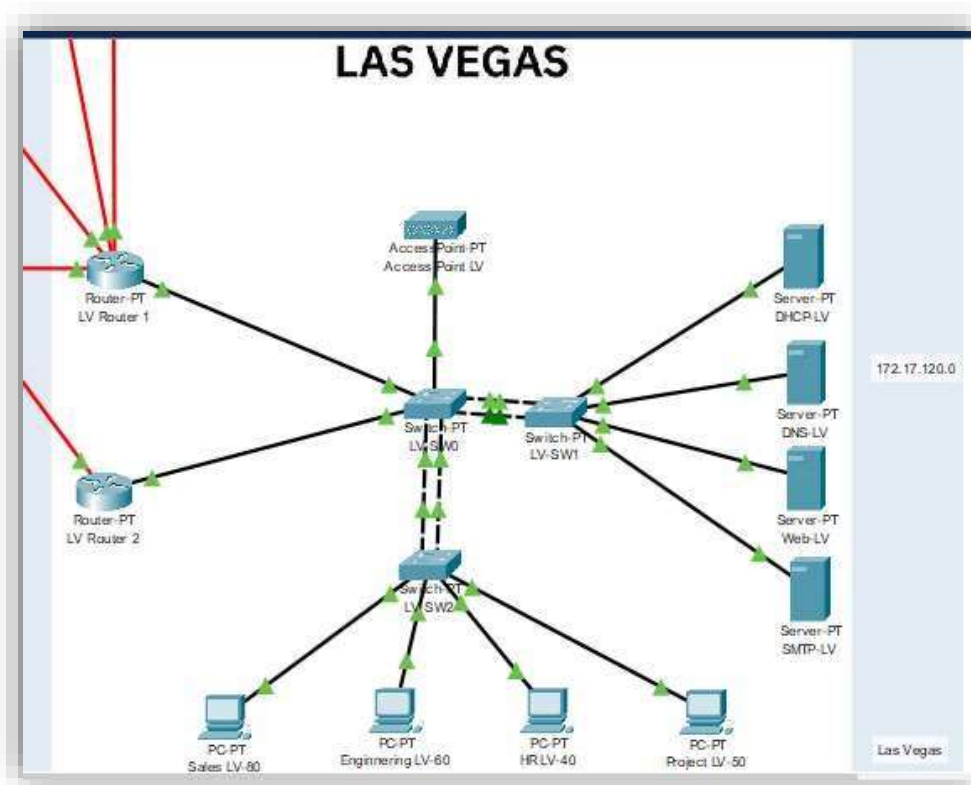


Figure 4. UAE Design

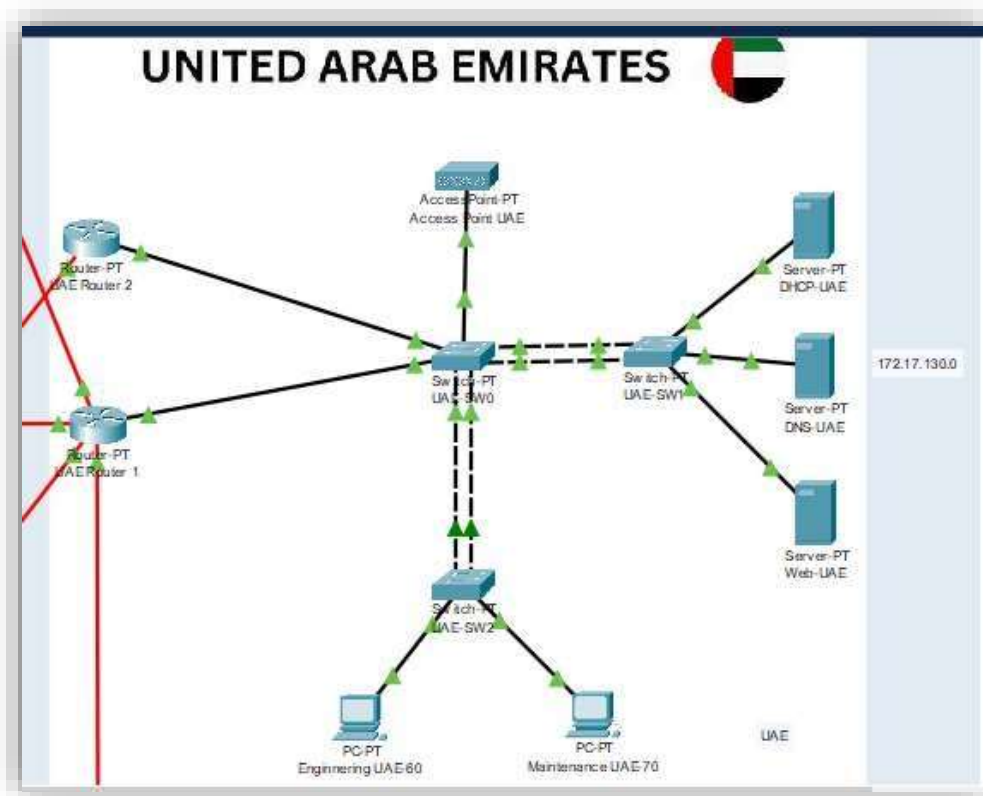
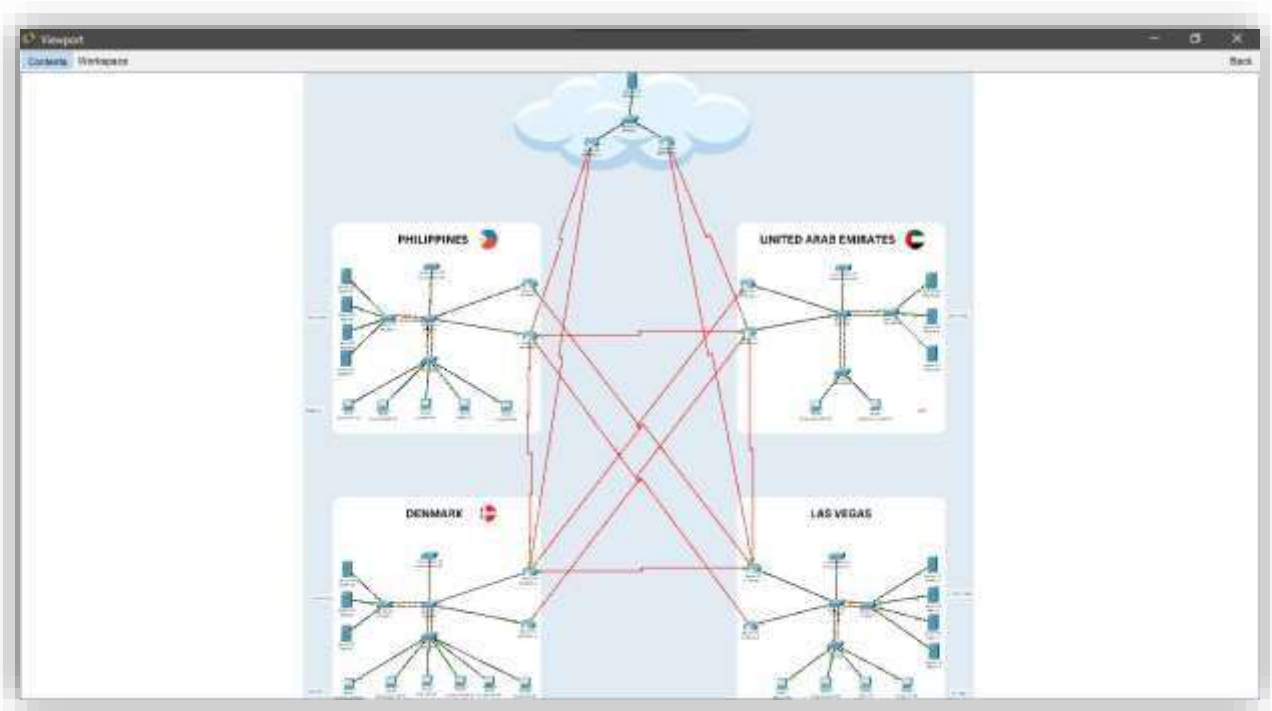


Figure 5. Overall Network Design



Design Traffic flow and techniques

Subnetting of IP Addresses

The team Frontrow used VLSM subnetting to provide IP address for different devices and department. The group was able to successfully assign IP addresses based on the requirements needed by the XYZ company.

VLAN	hosts	Subnet Mask	Octet	Increment	Network Address	Subnet Mask	1st Usable IP address	Last Usable IP address	Broadcast Address
EngineeringDK-60	250	/24	5	1	192.168.1.0	/24	192.168.1.1	192.168.1.254	192.168.1.255
SalesDK-80	175	/24	3	1	192.168.2.0	/24	192.168.2.1	192.168.2.254	192.168.2.255
MaintenanceDK-70	300	/25	4	128	192.168.3.0	/25	192.168.3.1	192.168.3.127	192.168.3.127
AccountingDK-20	20	/27	4	32	192.168.3.128	/27	192.168.3.129	192.168.3.158	192.168.3.159
InfoSecDK-90	20	/27	4	32	192.168.3.160	/27	192.168.3.161	192.168.3.190	192.168.3.191
ProjectDK-50	15	/27	4	32	192.168.3.192	/27	192.168.3.193	192.168.3.222	192.168.3.223

Figure 6. Denmark IP Addresses Plan

Figure 6 shows the IP address plan for Country Denmark using VLSM technique. For full documentation of the team's IP Address Plan, please refer to the excel file named "Frontrow Group 7 IP - VLSM Subnetting"

- **VLAN - Virtual Local Area Network.**
A custom network which is created from one or more local area networks, or the departments VLAN that is the requirement of the project. It enables a group of devices available in multiple networks to be combined into one logical network, such as the engineering department are virtually combined into VLAN 60 in the project.
- **INTER-VLAN TRUNKING**
Inter-VLAN routing can be defined to forward traffic between different VLAN by implementing a router in the network. The switches forward the traffic to the router server and devices using inter-VLAN trunking base on the scope of the project.
- **HSRP – Hot Standby Router Protocol**
Is a CISCO proprietary protocol, which provides redundancy for a local subnet. In HSRP, two or more routers gives an illusion of a virtual router. HSRP allows you to configure two or more routers as standby routers and only a single router as an active router at a time. The priority flow of traffic in the project is the Router 1 of the country which is the main router. And the router 2 serve as the standby router.
- **STP - Spanning Tree Protocol**
Is a Layer 2 network protocol used to prevent looping within a network topology. STP was created to avoid the problems that arise when computers exchange data on a local area network (LAN) that contains redundant paths. The STP make sure that the flow of traffic on the switches in the project is exchanging data properly
- **OSPF - The Open Shortest Path First protocol**
Is a type of IP Routing protocols, used to distribute IP routing information throughout a single Autonomous System (AS) in an IP network. The OSPF protocol is a link-state routing protocol, which means that the routers exchange topology information with the shortest path neighbour. The project was able to implement OSPF to all routers

including the standby routers, because all the network devices can ping to other network.

- **NAT - Network Address Translation**
Is a method designed to conserve IP addresses in a private network, by using a unique IP address to represent the whole private network to access internet services for the network model. In the project the flow of traffic from the Router to ISP router is secured by the NAT protocol.
- **ACCESS LIST - An access control list (ACL)**
Is a list of rules that specifies which users or systems are granted or denied access to a particular object or system resource. The project plan to deny UAE to access the ISP router
- **DHCP SERVER**
A DHCP Server is a network server that automatically provides and assigns IP addresses, default gateways and other network parameters to client devices. It relies on the standard protocol known as Dynamic Host Configuration Protocol or DHCP to respond to broadcast queries by clients. The DHCP server is in the VLAN 100, DHCP server reach all the devices through the switches with inter-VLAN trunking technique.
- **DNS SERVER**
The Domain Name System is a server that is specifically used for matching website hostnames (like example.com) to their corresponding Internet Protocol or IP addresses. The Team Frontrow sets up a server for the DNS server. The traffic flows from the switches through inter-VLAN trunking in the switches that makes the devices access a server using its Domain Name.
- **WEB SERVER**
The main job of a web server is to display website content through storing, processing, and delivering webpages to users. The web server in the project is in VLAN 100 and deliver traffic to devices using inter-VLAN trunking.
- **ISP NETWORK**
An Internet service provider network is an organization that provides services for accessing, using, or participating on the Internet.
- **SMTP SERVER – Simple Mail Transfer Protocol**
The client who wants to send the mail opens a TCP connection to the SMTP server and then sends the mail across the connection.
- **WIRELESS ACCESS POINT**
A wireless access point (wireless AP) is a network device that transmits and receives data over a wireless local area network (WLAN). The project was able to add a wireless point that is connected to a switch with the implementation of inter-VLAN trunking technique for the traffic flow throughout the network.

Implementation:

VLAN

- The department and server must have its respective VLANs
- All the VLAN was configured inside the switches in the network, and configured it using inter-VLAN trunking
- Encapsulation technique was used to assign IP address to the VLAN port of the router.
- Refer to Table 1 of the documentation page 4 to see all the full list of the VLANs.

SERVER

- The design of the servers is solely connected to one VLAN which has a value id of 100. The network consists of DHCP, SMTP, DNS, WEB server.
- DHCP server gives IP address to all department device inside a country.
 - The configuration of DHCP Server was set up in the DHCP services. The team assign IP address in each VLAN in the network, all IP range was based on the VLSM subnetting of the project. Please refer to the excel file named "Frontrow Group 7 IP - VLSM Subnetting" file for the complete list.
 - When accessing the DHCP server to a web browser on a device, use [www.dhcp-*<name-of-the-country>.com*](http://www.dhcp-<i><name-of-the-country>.com</i>) or check the list of domain names on the DNS server. The HTTP page of the DHCP server show 'Welcome to DHCP -*<country name>* Everyone!, if done correctly'.
- SMTP server allows departments to send email in a local network.
 - The team set up SMTP server in the SMTP services mail.
 - The teams were able to assign domain name that was use for user email address, and add devices name and password to each department on the network
- DNS server was set-up in the DNS services.
 - The team set-up domain names to DHCP Server and the Web server, so it is no longer needed to type IP address when accessing those said server in the web browser of a device.
- Web server allows devices to access the web by typing its Domain name in the browser. Please refer to the DNS server services to know all the added domain names
 - The Web Server HTTP page of the Web server show 'Welcome to *<country name>* Everyone! if done correctly'

STP

Spanning-tree Protocol prevents looping within a local network topology with redundant link.

- All the switches' links are applied with the STP. Base the YouTube video the team watched about STP; it is better to apply "BPDU GUARD to the redundant links the team created.
- The mode used in the STP is PVST or Per VLAN Spanning tree, with port fast technique and BPDU GUARD.

Note: The YouTube video that stated above is in the reference section. Disclaimer: Most of the configurations and protocol techniques applied to the project was based on the YouTube links in the reference section of the paper.

OSPF

The project design implements Open Shortest path First to the main and backup or standby router in the network project. This allows devices to find the best optimal path to pass through a network.

- The team included all the serial interface network IP address and all the VLANs network in the main and standby router for every country in the implementation of OSPF.

HSRP

The Hot Standby Router Protocol is a protocol that allows for standby routers to be configured while having a single active router at a time. The HSRP or Hot standby router protocol was used to apply availability on the routers in each country. This will help the network to be available on other network in case a main router is down.

- The team assigned the main router with the priority value of 150, and value 120 for standby router.
- All the routers in the Project Network are in pre-empt mode that allows router to take over when one router in the network is down.

NAT

Network Address Translation allows to map the IP address to another through changing the IP header.

- In the project the main router of every area has NAT protocol implemented. This allows a secure exchanging of traffic when a device or router in a network tries to connect to the ISP network.

ISP

Internet provider to a network. All the main routers in the project are directly connected to ISP using serial port with a NAT protocol and IP routing.

- The routers used in the ISP network also applied with HSRP protocol for availability purposes.
 - The Main Router 1 configured with the priority value of 150 and 120 for ISP Standby Router 2.

REFERENCES

- 📌 OSPF
[VLAN & OSPF - YouTube](#)
- 📌 Encapsulation: connect VLANs to router + Trunking
[Inter VLAN Configuration plus IP- Helper Address - YouTube](#)
- 📌 Server-side Configuration
[How to Setup DHCP Reply on Cisco Switch - YouTube](#)
[Configuration DHCP SERVER and DNS SERVER Assign to VLAN - YouTube](#)
- 📌 STP <https://www.youtube.com/watch?v=9R5vJt8zs90&t=740s>
- 📌 HSRP
<https://www.youtube.com/watch?v=gxsMuHXCOgg&t=761s>
- 📌 SMTP <https://www.youtube.com/watch?v=D0N1EMQe9SA>
- 📌 NAT
<https://www.youtube.com/watch?v=SJ9uXKk59GA&t=423s>