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School of Electronics Engineering (SENSE)

PROJECT BASED LEARNING (CAMP) - REPORT

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TEAM MEMBERS DETAILS	REGISTER NO.	NAME	
	22BLC1076	N Shrinidhi	
	22BLC1350	Thurlapati Sai Sree Praneetha	
	22BLC1381	Sahnaaz Mariam	
J TITLE	Enterprise Management System Hospital Management Network Design and Implementation using Cisco Packet Tracer Technologies Implemented: Hierarchical Network Design, ISPs, VLANs, Inter VLAN Routing (SVI), DHCP Server, Port-security, SSH, NAT Overload (PAT), ACL, VPN, WLAN, Static IPv4 Addressing, Host configurations		
COURSE HANDLER'S NAME	Dr. T. Jayavignesh	REMARKS	
COURSE HANDLER'S SIGN			

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ABSTRACT:

This project showcases the design and implementation of a Hospital Management Network using Cisco Packet Tracer, focusing on creating a secure and efficient Enterprise Management System for healthcare environments. This network adopts a Hierarchical Network Design and thus ensures scalability, modularity, and streamlined traffic management, providing the operational needs of a hospital. The design employs Virtual Local Area Networks (VLANs) to isolate and manage traffic between departments, complemented by Inter-VLAN Routing (SVI) to facilitate seamless communication across the network.

The implementation integrates a Dynamic Host Configuration Protocol (DHCP) Server for automated IP address assignment, reducing manual errors and improving operational efficiency. Port Security and Access Control Lists (ACLs) are configured to safeguard the network from unauthorized access, while Secure Shell (SSH) enables encrypted remote management. Network Address Translation (NAT) Overload (PAT) ensures efficient use of public IP addresses, and Virtual Private Networks (VPNs) provide secure remote connectivity for healthcare professionals and administrators. Additionally, a Wireless Local Area Network (WLAN) extends mobility for staff and devices, ensuring continuous service delivery.

The project incorporates static IPv4 addressing for critical devices to ensure reliability and easy troubleshooting. Detailed host configurations and device setups reflect the real-world requirements of hospital operations. By combining advanced networking features with a practical approach, this project highlights how modern technologies can address the challenges of connectivity, security, and management in healthcare. The outcome is a scalable, secure, and efficient network model that supports uninterrupted operations, data integrity, and secure communication, serving as a benchmark for future healthcare networks.

INTRODUCTION:

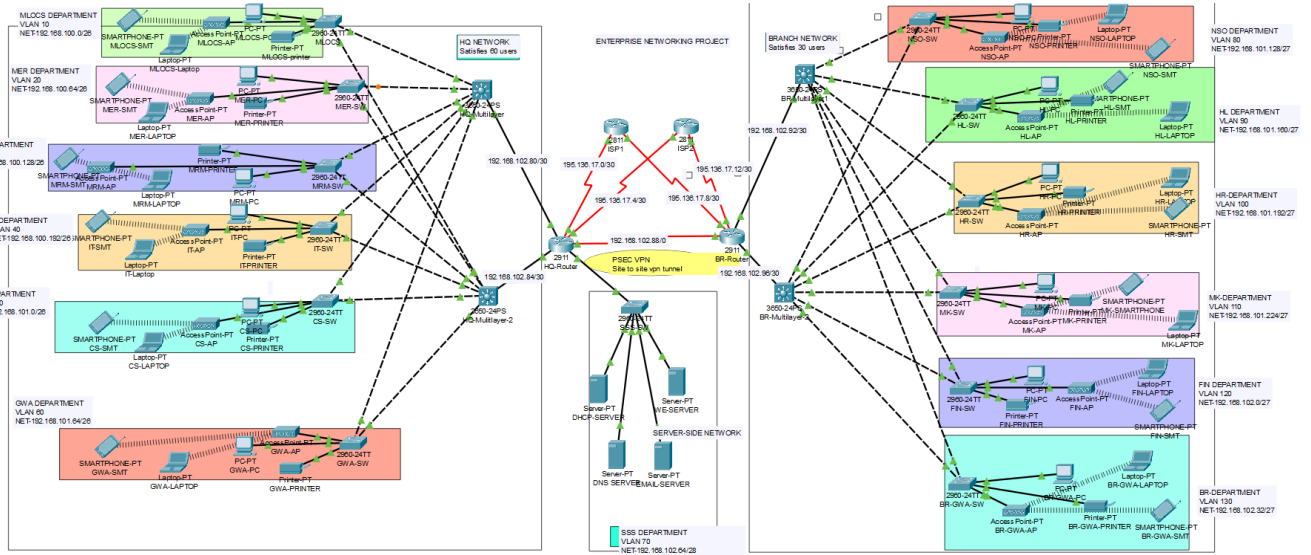
In today's fast-paced digital era, networking plays a pivotal role in enabling seamless communication and management within organizations. The healthcare industry, in particular, requires robust, secure, and scalable network infrastructures to handle sensitive data and ensure uninterrupted operations. This project delves into the theoretical and practical aspects of designing a Hospital Management Network, emphasizing the implementation of modern networking principles and technologies using Cisco Packet Tracer.

At the heart of the project lies the Hierarchical Network Design Model, a widely adopted framework in network architecture. This model divides the network into three logical layers: Core, Distribution, and Access, ensuring modularity, scalability, and fault isolation. The use of VLANs provides traffic segregation for different hospital departments, enhancing security and performance, while Inter-VLAN Routing (SVI) ensures efficient inter-department communication.

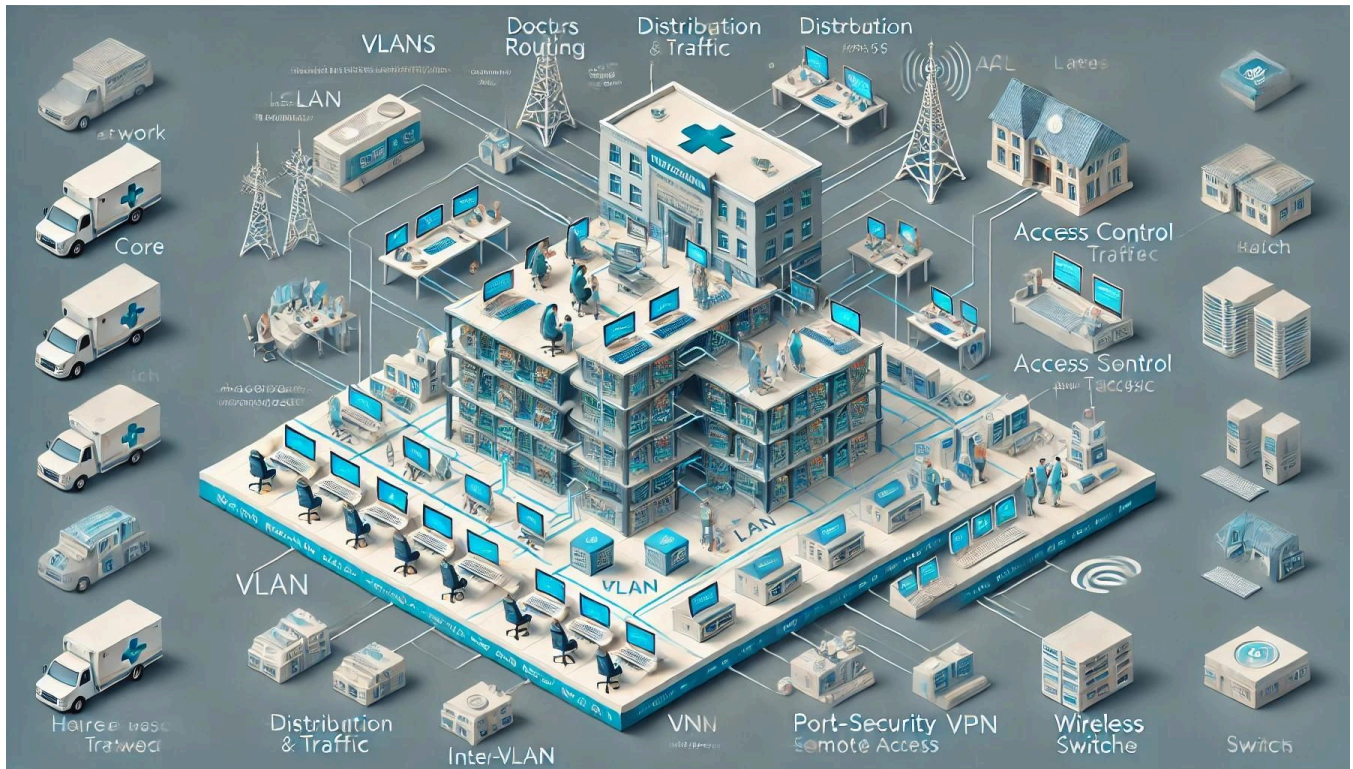
Advanced security mechanisms such as Port Security, Access Control Lists (ACLs), and Secure Shell (SSH) are incorporated to protect the network from unauthorized access and cyber threats. Additionally, the project leverages NAT Overload (PAT) for optimal utilization of public IP addresses and VPNs to provide secure remote access, a crucial requirement in modern healthcare. Wireless Local Area Networks (WLANs) add mobility, enabling staff to access resources on the go.

This project also highlights the theoretical foundation of addressing schemes, including static IPv4 addressing, which is crucial for critical devices requiring constant IPs. The practical implementation reflects real-world scenarios where healthcare facilities depend on efficient, reliable, and secure networks to ensure quality service delivery. Overall, the project combines theoretical knowledge and practical skills to address the challenges of modern healthcare network management.

ALGORITHM: THE CIRCUIT



NETWORK SCHEMATIC



FLOWCHARTS AND TECHNICAL EXPLANATION OF CODES

Basic settings to all devices along with SSH on the routers and multilayer switches:

```
Start
|
Set Hostname (MLOCS-SW)
|
Set Enable Password (cisco)
|
Disable Domain Lookup (no ip domain lookup)
|
Set MOTD Banner ("No Unauthorized Access!!!")
|
Configure Console Line Access (login)
|
Encrypt Passwords (service password-encryption)
|
End
```

This configuration sets the switch's hostname to "MLOCS-SW" and applies basic security measures like setting an enable password (cisco) and encrypting passwords. It also disables DNS lookup to prevent delays from invalid commands and sets a message of the day (MOTD) banner for users. The console login is enabled, and the *service password-encryption* command ensures that passwords are stored in an encrypted format in the configuration.

```
Start
|
Set Enable Password (cisco)
|
Set MOTD Banner ("No Unauthorized Access!!!")
|
Disable Domain Lookup (no ip domain lookup)
|
Configure Console Line Password (cisco)
|
Enable Console Login (login)
|
Enable Password Encryption (service password-encryption)
|
```

```
Set Domain Name (cisco.net)
|
Create User Account (username admin password cisco)
|
Generate RSA Keys (1024 bits)
|
Configure VTY Lines for SSH (login local, transport input ssh)
|
Save Configuration (do wr)
|
End
```

This configuration sets up security and management for a Cisco switch. It sets the enable password to "cisco", configures a MOTD banner, and disables IP domain lookup to prevent unnecessary delays. Console login is secured with the password "cisco", and the *service password-encryption* command encrypts passwords. The domain name "cisco.net" is set, and an RSA key pair is generated for SSH. Access to the VTY lines is restricted to local login and SSH. Finally, the configuration is saved with *do wr*.

VLANs assignment along with all access and trunk ports on all switches

```
Start
|
Create VLAN 130 (name BR-GWA)
|
Configure Trunk Ports (fa0/1-2)
|
Configure Access Ports (fa0/3-24)
|
Assign Access Ports to VLAN 130
|
End
```

This configuration creates VLAN 130 with the name "BR-GWA" and assigns it to specific switch ports. The *int range fa0/1-2* command configures ports Fa0/1 and Fa0/2 to operate in trunk mode, allowing multiple VLAN traffic. The *int range fa0/3-24* command sets ports Fa0/3 to Fa0/24 to access mode and assigns them to VLAN 130 using *switchport access vlan 130*. This setup is typical for segmenting

network traffic and ensuring that devices connected to specific ports belong to the correct VLAN.

Start

|
Create VLANs 10, 20, 30, 40, 50, 60

|
Select Ports (gig1/0/2-7)

|
Configure Trunk Mode on Ports (gig1/0/2-7)

|
End

This configuration creates VLANs 10, 20, 30, 40, 50, and 60 on the switch. The *int range gig1/0/2-7* command selects the range of Gigabit Ethernet ports 2 to 7. The *switchport mode trunk* command configures these ports to trunk mode, allowing them to carry traffic for multiple VLANs. This setup is used to enable communication between VLANs across different switches, as trunk ports can transmit traffic for multiple VLANs simultaneously.

Switchport security to server-side site department

Start

|
Select Ports (fa0/3-24)

|
Set Port Security Maximum 1 MAC Address

|
Enable Sticky MAC Address Learning

|
Set Violation Action to Shutdown

|
Save Configuration (do wr)

|
End

This configuration enables port security on ports Fa0/3 to Fa0/24. It sets the maximum number of allowed MAC addresses to 1 per port, ensures that the switch dynamically learns and assigns MAC addresses using the *sticky* option,

and configures the switch to shut down the port if a violation occurs (such as more than one MAC address being detected).

Subnetting and IP addressing

HQ Hospital

Department	Network Address	Subnet Mask	Host Address Range	Broadcast Address
MLOCS	192.168.100.0	255.255.255.192/26	192.168.100.1 to 192.168.100.62	192.168.100.63
MER	192.168.100.64	255.255.255.192/26	192.168.100.64 to 192.168.100.126	192.168.100.127
MRM	192.168.100.128	255.255.255.192/26	192.168.100.129 to 192.168.100.190	192.168.100.191
IT	192.168.100.192	255.255.255.192/26	192.168.100.193 to 192.168.100.254	192.168.100.255
CS	192.168.101.0	255.255.255.192/26	192.168.101.1 to 192.168.101.62	192.168.101.63
GWA	192.168.101.64	255.255.255.192/26	192.168.101.64 to 192.168.101.126	192.168.101.127

Branch Hospital

Department	Network Address	Subnet Mask	Host Address Range	Broadcast Address
NSO	192.168.101.128	255.255.255.224/27	192.168.101.129 to 192.168.101.158	192.168.101.159
HL	192.168.101.160	255.255.255.224/27	192.168.101.161 to 192.168.101.190	192.168.101.191
HR	192.168.101.192	255.255.255.224/27	192.168.101.193 to 192.168.101.222	192.168.101.223
MK	192.168.101.224	255.255.255.224/27	192.168.101.225 to 192.168.101.254	192.168.101.255
FIN	192.168.102.0	255.255.255.224/27	192.168.102.1 to 192.168.102.30	192.168.102.31
GWA	192.168.102.32	255.255.255.224/27	192.168.102.33 to 192.168.102.62	192.168.102.63

Server-side Site

Department	Network Address	Subnet Mask	Host Address Range	Broadcast Address
SSS	192.168.102.64	255.255.255.240/28	192.168.102.65 to 192.168.102.78	192.168.102.79

Between the Routers and Layer-3 Switches

No.	Network Address
HQR1- HQMLSW1	192.168.102.80/30
HQR1- HQMLSW2	192.168.102.84/30
BRR1- BRMLSW1	192.168.102.88/30
BRR1- BRMLSW1	192.168.102.92/30
HQR1- BRR1	192.168.102.96/30

Between the Routers and ISPs

Public IP addresses 195.136.17.0/30, 195.136.17.4/30, 195.136.17.8/30 and 195.136.17.12/30

Start

```
|  
Select Interface (GigabitEthernet1/0/1)  
|  
Disable Switchport (no switchport)  
|  
Assign IP Address (192.168.102.97/255.255.255.252)  
|  
Exit Interface Configuration  
|  
Save Configuration (do wr)  
|  
End
```

This configuration creates a routed port on *GigabitEthernet1/0/1* by disabling the switchport with the *no switchport* command. It then assigns an IP address (192.168.102.97) and a subnet mask (255.255.255.252) to the interface. Finally, the configuration is saved using *do wr* to write the changes to the device.

OSPF on the routers and switches along with default static route

Start

```
|  
Enable IP Routing (ip routing)  
|  
Enable OSPF Routing Protocol (router ospf 10)  
|
```

Define OSPF Networks (network 192.168.100.0 0.0.0.63 area 0)

|

Define Additional OSPF Networks (network 192.168.100.64 0.0.0.63 area 0, etc.)

|

Exit Router OSPF Configuration (ex)

|

Set Default Route (ip route 0.0.0.0 0.0.0.0 192.168.102.04)

|

Save Configuration (do wr)

|

End

This configuration enables IP routing on the *HQ-MultilayerSW2* switch and sets up OSPF (Open Shortest Path First) routing protocol with process ID 10. The *network* commands associate specific IP address ranges (192.168.100.0, 192.168.100.64, 192.168.100.128, etc.) with OSPF area 0, enabling OSPF to advertise these networks. The *ip route 0.0.0.0 0.0.0.0 192.168.102.04* command sets a default route to the specified gateway IP. Finally, the configuration is saved using *do wr*.

Static IP address to server room devices - DHCP, DNS, Email, and Web servers

The screenshot shows a window titled "DHCP-SERVER" with tabs for Physical, Config, Services, Desktop, Programming, and Attributes. The "Config" tab is active, and the "IP Configuration" sub-tab is selected. The "IP Configuration" section has two radio buttons: "DHCP" (unselected) and "Static" (selected). Below these are fields for "IPv4 Address" (192.168.102.67), "Subnet Mask" (255.255.255.240), "Default Gateway" (192.168.102.65), and "DNS Server" (192.168.102.68). The "IPv6 Configuration" section has two radio buttons: "Automatic" (unselected) and "Static" (selected). Below these are fields for "IPv6 Address" (empty), "Link Local Address" (FE80::201:C9FF:FE94:809A), "Default Gateway" (empty), and "DNS Server" (empty). The "802.1X" section has a checkbox for "Use 802.1X Security" (unchecked), a dropdown for "Authentication" (MD5), and fields for "Username" and "Password" (both empty). A "Top" button is at the bottom left.

DNS SERVER

Physical Config Services Desktop Programming Attributes

IP Configuration X

IP Configuration

☐ DHCP ☒ Static

IPv4 Address 192.168.102.68

Subnet Mask 255.255.255.240

Default Gateway 192.168.102.65

DNS Server 0.0.0.0

IPv6 Configuration

☐ Automatic ☒ Static

IPv6 Address /

Link Local Address FE80::260:2FFF:FEB3:1ACB

Default Gateway

DNS Server

802.1X

☐ Use 802.1X Security

Authentication MD5

Username

Password

☐ Top

EMAIL-SERVER

Physical Config Services Desktop Programming Attributes

IP Configuration X

IP Configuration

☐ DHCP ☒ Static

IPv4 Address 192.168.102.69

Subnet Mask 255.255.255.240

Default Gateway 192.168.102.65

DNS Server 192.168.102.68

IPv6 Configuration

☐ Automatic ☒ Static

IPv6 Address /

Link Local Address FE80::202:16FF:FE1C:B83D

Default Gateway

DNS Server

802.1X

☐ Use 802.1X Security

Authentication MD5

Username

Password

☐ Top

WE-SERVER

Physical Config Services **Desktop** Programming Attributes

IP Configuration

IP Configuration

☐ DHCP ☒ Static

IPv4 Address: 192.168.102.70

Subnet Mask: 255.255.255.240

Default Gateway: 192.168.102.65

DNS Server: 192.168.102.68

IPv6 Configuration

☐ Automatic ☒ Static

IPv6 Address: /

Link Local Address: FE80::2E0:B0FF:FE3A:C58D

Default Gateway:

DNS Server:

802.1X

☐ Use 802.1X Security

Authentication: MD5

Username:

Password:

☐ Top

DHCP server device configurations

DHCP-SERVER

Physical Config **Services** Desktop Programming Attributes

SERVICES

- HTTP
- DHCP**
- DHCPv6
- TFTP
- DNS
- SYSLOG
- AAA
- NTP
- EMAIL
- FTP
- IoT
- VM Management
- Radius EAP

DHCP

Interface: FastEthernet0 Service: ☒ On ☐ Off

Pool Name: serverPool

Default Gateway: 0.0.0.0

DNS Server: 0.0.0.0

Start IP Address: 192.168.102.168

Subnet Mask: 255.255.255.240

Maximum Number of Users: 512

TFTP Server: 0.0.0.0

WLC Address: 0.0.0.0

Pool Name	Default Gateway	DNS Server	Start IP Address	Subnet Mask	Max User	TFTP Server	WLC Address
BRAGWAPool	192.168.102.33	192.168.102.68	192.168.102.37	255.255.255.224	25	0.0.0.0	0.0.0.0
FINPool	192.168.102.1	192.168.102.68	192.168.102.6	255.255.255.224	25	0.0.0.0	0.0.0.0
MkPool	192.168.101.225	192.168.102.68	192.168.101.230	255.255.255.224	25	0.0.0.0	0.0.0.0
HRPool	192.168.101.193	192.168.102.68	192.168.101.196	255.255.255.224	25	0.0.0.0	0.0.0.0
NSOPool	192.168.101.129	192.168.102.68	192.168.101.135	255.255.255.224	25	0.0.0.0	0.0.0.0
HLPool	192.168.101.161	192.168.102.68	192.168.101.166	255.255.255.224	26	0.0.0.0	0.0.0.0
GWAPool	192.168.101.65	192.168.102.68	192.168.101.70	255.255.255.192	57	0.0.0.0	0.0.0.0
CSPool	192.168.101.1	192.168.102.68	192.168.101.6	255.255.255.192	57	0.0.0.0	0.0.0.0
ITPool	192.168.100.193	192.168.102.68	192.168.100.197	255.255.255.192	57	0.0.0.0	0.0.0.0
MRMPool	192.168.100.129	192.168.102.68	192.168.100.135	255.255.255.192	57	0.0.0.0	0.0.0.0
MERPool	192.168.100.65	192.168.102.68	192.168.100.70	255.255.255.192	58	0.0.0.0	0.0.0.0
MLLOCSPool	192.168.100.1	192.168.102.68	192.168.100.6	255.255.255.192	58	0.0.0.0	0.0.0.0
serverPool	0.0.0.0	0.0.0.0	192.168.102.64	255.255.255.240	512	0.0.0.0	0.0.0.0

☐ Top

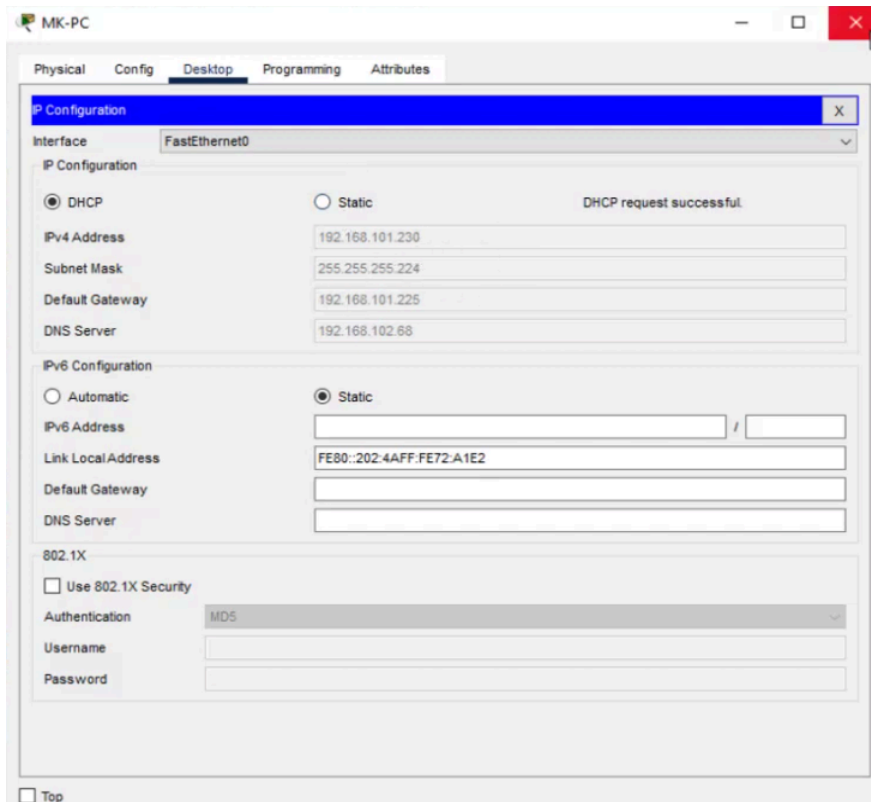
Inter-VLAN routing on the switches along with IP DHCP helper addresses

Start

```
|  
Configure GigabitEthernet0/2 (no ip address)  
|  
Exit GigabitEthernet0/2 Configuration (exit)  
|  
Configure Subinterface GigabitEthernet0/2.70  
|  
Set Encapsulation (encapsulation dot10 70)  
|  
Assign IP Address (ip address 192.168.102.65 255.255.255.240)  
|  
Exit Subinterface Configuration (ex)  
|  
Save Configuration (do wr)  
|  
Configure VLAN 10 (ip address 192.168.100.1 255.255.255.192)  
|  
Set Helper Address for VLAN 10 (ip helper-address 192.168.102.67)  
|  
Configure VLAN 20 (ip address 192.168.100.65 255.255.255.192)  
|  
Set Helper Address for VLAN 20 (ip helper-address 192.168.102.67)  
|  
Configure VLAN 30 (ip address 192.168.100.129 255.255.255.192)  
|  
Set Helper Address for VLAN 30 (ip helper-address 192.168.102.67)  
|  
Configure VLAN 40 (ip address 192.168.100.193 255.255.255.192)  
|  
Set Helper Address for VLAN 40 (ip helper-address 192.168.102.67)  
|  
Configure VLAN 50 (ip address 192.168.101.1 255.255.255.192)  
|  
Set Helper Address for VLAN 50 (ip helper-address 192.168.102.67)  
|  
Configure VLAN 60 (ip address 192.168.101.65 255.255.255.192)  
|  
Set Helper Address for VLAN 60 (ip helper-address 192.168.102.67)
```

|
End

This configuration removes the IP address from *GigabitEthernet0/2*, then sets up a subinterface *GigabitEthernet0/2.70* with encapsulation *dot10 70* and assigns the IP address *192.168.102.65* with a subnet mask of *255.255.255.240*. The router also configures several VLAN interfaces (*vlan 10*, *vlan 20*, *vlan 30*, *vlan 40*, *vlan 50*, *vlan 60*) with corresponding IP addresses and subnet masks, while setting a *helper-address* for DHCP forwarding.



Wireless network configurations

Start

|
Connect all the devices to wireless access point

|
Configure the router using CLI

|
Configure DHCP to assign IP addresses to devices

|

Configure the SSID (Network Name) under the Wireless Settings

|

Set WPA2-PSK security and assign a passphrase

|

Connect all the Wireless End Devices to Access point using the SSID and password

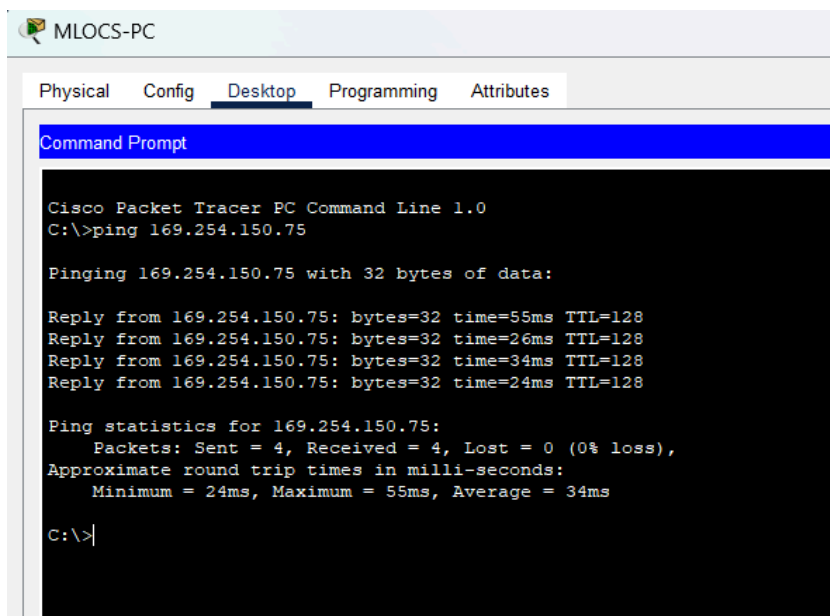
|

Save Configuration (do wr)

|

End

Wireless configuration in Cisco Packet Tracer is an Access Point (WAP) that enables devices to connect to the network via Wi-Fi. It supports dynamic IP assignment through DHCP, secure protocols such as WPA2-PSK, allows for wireless access to the internet or other network resources, and also supports mobility within the wireless range.



```
MLOCS-PC
Physical  Config  Desktop  Programming  Attributes
Command Prompt
Cisco Packet Tracer PC Command Line 1.0
C:\>ping 169.254.150.75

Pinging 169.254.150.75 with 32 bytes of data:

Reply from 169.254.150.75: bytes=32 time=55ms TTL=128
Reply from 169.254.150.75: bytes=32 time=26ms TTL=128
Reply from 169.254.150.75: bytes=32 time=34ms TTL=128
Reply from 169.254.150.75: bytes=32 time=24ms TTL=128

Ping statistics for 169.254.150.75:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 24ms, Maximum = 55ms, Average = 34ms

C:\>
```

Port Address Translation (PAT) + Access Control Lists (ACLs)

Start

|

Configure NAT Outside Interfaces

| -- Interface Serial 0/1/2: Assign NAT Outside

| -- Interface Serial 0/2/1: Assign NAT Outside

|

Configure NAT Inside Interfaces (Range Gigabit 0/2-3: Assign NAT Inside)


```

|
Save Configuration (do wr)
|
Configure Access List (1)
|-- Permit traffic from 192.168.1.0/24
|-- Permit traffic from 192.168.3.0/24
|-- Permit traffic from 192.168.4.0/24
|-- Permit traffic from 192.168.5.0/24
|-- Permit traffic from 192.168.6.0/24
|-- Permit traffic from 192.168.7.0/24
|
Save Configuration (do wr)
|
End

```

This code configures NAT (Network Address Translation) on the HQ-Router to allow internal devices with private IP addresses to access external networks. It specifies which interfaces are designated for inside (LAN) and outside (WAN) NAT. Access list 1 is used to define which internal networks can be translated. This setup is critical for routing private IP traffic to the internet while maintaining security and connectivity.

```

Start
|
Configure NAT Overload (ip nat inside source list 1 interface se0/2/1 overload)
|
Save Configuration (do wr)
|
Configure NAT Outside Interfaces
|-- Interface Serial 0/1/1: Assign NAT Outside
|-- Interface Serial 0/2/0: Assign NAT Outside
|
Configure NAT Inside Interfaces
|-- Range GigabitEthernet 0/0-1: Assign NAT Inside
|
Save Configuration (do wr)
|
Define Access List (1)
|-- Permit traffic from:
   - 192.168.101.120/27

```

- 192.168.101.160/27
- 192.168.101.192/27
- 192.168.101.224/27
- 192.168.102.0/27
- 192.168.102.32/27

```
|
Reapply NAT Overload (ip nat inside source list 1 interface se0/2/0 overload)
|
Save Configuration (do wr)
|
End
```

This code configures NAT on the BR-Router for dynamic overload translation, allowing multiple internal devices to share a single public IP address. The access list identifies the internal networks eligible for NAT. The interfaces are assigned roles as inside (LAN) or outside (WAN) to facilitate NAT operation. This setup ensures efficient address translation for connectivity between internal and external networks.

```
HQ-Router(config)#
HQ-Router(config)#
HQ-Router(config)#do sh ip nat translations
Pro  Inside global      Inside local      Outside local      Outside global
icmp 195.136.17.5:1      192.168.100.77:1  195.136.17.6:1     195.136.17.6:1
icmp 195.136.17.5:2      192.168.100.77:2  195.136.17.6:2     195.136.17.6:2
icmp 195.136.17.5:3      192.168.100.77:3  195.136.17.6:3     195.136.17.6:3
icmp 195.136.17.5:4      192.168.100.77:4  195.136.17.6:4     195.136.17.6:4
```

Site-to-Site VPN

Start

```
|
Configure ISAKMP Policy
|-- Set encryption to AES 256
|-- Set authentication method (pre-share)
|-- Set DH Group to 5
|
```

Exit ISAKMP Configuration

```
|
Configure Pre-Shared Key for Peer (192.168.102.90)
```

```
|
Define IPsec Transform Set (Set encryption (AES) and authentication (SHA-HMAC))
```

```

|
Exit Transform Set Configuration
|
Create Crypto Map (VPN-MAP)
|-- Description: "VPN connection to BR-Router"
|-- Set peer IP (192.168.102.90)
|-- Use transform set (VPN-SET)
|-- Match traffic using access-list 110
|
Exit Crypto Map Configuration
|
Define Access List (110)
|-- Permit traffic from 192.168.1.0/24 to 192.168.2.0/24
|
Apply Crypto Map to Interface (S0/2/0)
|
Enable Security License (securityk9)
|
Save Configuration (do wr)
|
End

```

This configuration establishes an IPsec VPN tunnel between the HQ-Router and the BR-Router. It uses ISAKMP for Phase 1 of the IPsec connection, setting up security policies and pre-shared key authentication. It then creates an IPsec transform set (VPN-SET) to define encryption and authentication methods for Phase 2. The crypto map (VPN-MAP) binds these settings, specifies the peer router, and references an access list to filter traffic eligible for encryption. The crypto map is applied to the router's interface to enable VPN functionality.

```

Start
|
Configure ISAKMP Policy
|-- Set encryption to AES 256
|-- Set authentication method (pre-share)
|-- Set DH Group to 5
|
Exit ISAKMP Configuration
|

```

```

Configure Pre-Shared Key for Peer (192.168.102.89)
|
Define IPsec Transform Set (Set encryption (AES) and authentication (SHA-HMAC))
|
Exit Transform Set Configuration
|
Create Crypto Map (VPN-MAP)
|-- Description: "VPN connection to HQ-Router"
|-- Set peer IP (192.168.102.89)
|-- Use transform set (VPN-SET)
|-- Match traffic using access-list 110
|
Exit Crypto Map Configuration
|
Define Access List (110) (Permit traffic from 192.168.2.0/24 to 192.168.1.0/24)
|
Apply Crypto Map to Interface (S0/2/0)
|
Enable Security License (securityk9)
|
Save Configuration (do wr)
|
End

```

This configuration establishes an IPsec VPN tunnel from BR-Router to HQ-Router, mirroring the setup on HQ-Router. It uses ISAKMP for Phase 1 to set encryption, authentication, and Diffie-Hellman (DH) parameters. The IPsec transform set (VPN-SET) defines encryption and authentication protocols for Phase 2. A crypto map (VPN-MAP) binds these settings, specifies the peer (HQ-Router), and filters eligible traffic using an access list. The VPN map is applied to the interface, and a security license (securityk9) is enabled to support VPN functionality.

```

HQ-Router(config)#do sh crypto ipse sa

interface: Serial0/2/0
  Crypto map tag: VPN-MAP, local addr 192.168.102.89

  protected vrf: (none)
  local ident (addr/mask/prot/port): (192.168.100.0/255.255.255.0/0/0)
  remote ident (addr/mask/prot/port): (192.168.101.0/255.255.255.0/0/0)
  current_peer 192.168.102.90 port 500
    PERMIT, flags={origin_is_acl,}
    #pkts encaps: 0, #pkts encrypt: 0, #pkts digest: 0
    #pkts decaps: 0, #pkts decrypt: 0, #pkts verify: 0
    #pkts compressed: 0, #pkts decompressed: 0
    #pkts not compressed: 0, #pkts compr. failed: 0
    #pkts not decompressed: 0, #pkts decompress failed: 0
    #send errors 0, #recv errors 0

  local crypto endpt.: 192.168.102.89, remote crypto endpt.: 192.168.102.90
  path mtu 1500, ip mtu 1500, ip mtu idb Serial0/2/0
  current outbound spi: 0x0(0)

inbound esp sas:

```

NSO-LAPTOP

Physical Config Desktop Programming Attributes

Command Prompt

```

Cisco Packet Tracer PC Command Line 1.0
C:\>ping 169.254.153.151

Pinging 169.254.153.151 with 32 bytes of data:

Reply from 169.254.153.151: bytes=32 time=39ms TTL=128
Reply from 169.254.153.151: bytes=32 time=8ms TTL=128
Reply from 169.254.153.151: bytes=32 time=22ms TTL=128
Reply from 169.254.153.151: bytes=32 time=16ms TTL=128

Ping statistics for 169.254.153.151:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 8ms, Maximum = 39ms, Average = 21ms

C:\>

```

CS-PC

Physical Config Desktop Programming Attributes

Command Prompt

```

Cisco Packet Tracer PC Command Line 1.0
C:\>ping 169.254.188.201

Pinging 169.254.188.201 with 32 bytes of data:

Reply from 169.254.188.201: bytes=32 time=64ms TTL=128
Reply from 169.254.188.201: bytes=32 time=12ms TTL=128
Reply from 169.254.188.201: bytes=32 time=5ms TTL=128
Reply from 169.254.188.201: bytes=32 time=6ms TTL=128

Ping statistics for 169.254.188.201:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 5ms, Maximum = 64ms, Average = 21ms

C:\>

```

IMPLEMENTATION (REAL TIME):

The Enterprise Network System was carefully designed and implemented using Cisco Packet Tracer to build a network that meets the needs of modern businesses. It includes essential features like VLANs, Inter-VLAN Routing, ACLs, DHCP, DNS, OSPF, and IPsec VPN to ensure secure remote access and smooth internal communication. These features were selected to create a scalable, secure, and efficient network, making it ideal for industries like banking, healthcare, and education, where reliable data handling and secure connectivity are critical. By integrating OSPF, the system ensures dynamic routing, which is useful for especially handling large volumes of traffic in high-demand environments.

Although Cisco Packet Tracer doesn't have a traditional Graphical User Interface (GUI) like other software, it offers a network map that visually represents all connected devices, such as routers, switches, and servers. This map shows real-time updates on device configurations, IP addresses, and connection statuses. It's an intuitive tool that makes it easy to track how different parts of the network work together. Users can monitor traffic flow, troubleshoot issues, and ensure everything is configured correctly. This visual representation adds clarity and helps in managing the system efficiently.

The standards used for the application of the above protocols are:

- IEEE 802.1Q: Used for VLAN tagging and Inter-VLAN Routing, correct.
- RFC 2131: Defines DHCP, so spot on there.
- RFC 1035: Pertains to DNS setup, absolutely right.
- IPsec standards: Used for VPN security and encryption, that's accurate.
- OSPF (Open Shortest Path First): Used for dynamic routing and scalable network design.

The network system underwent rigorous testing in stages to ensure its functionality, reliability, and security. Unit tests validated the proper instantiation of components including routers, switches, VLANs, ACLs, and DHCP servers to confirm that each component functions correctly. Integration testing then ensued, validating seamless VLAN communication, Inter-VLAN Routing, and secure

IPSec VPN communication thereby confirming the proper functionality of all components when interlinked. Performance tests assessed data throughput, latency and routing efficiency under real-world traffic simulations and showed how the network can manage high-traffic conditions without significant delays. Security tests confirmed that ACLs could properly limit unauthorized access, while VPNs could properly protect sensitive info, thanks to encryption. This step-by-step testing approach identified and resolved potential issues, fine-tuning the network to be robust, secure, and ready for real-world enterprise environments.

To ensure the network was free of major issues, we carried out basic testing to check for misconfigurations and performance problems. Simulated traffic was used to identify any potential bottlenecks in the network, allowing us to pinpoint areas where data flow might slow down or get delayed. Manual checks of ACLs, security protocols, and VPN configurations ensured that sensitive data was properly protected, and access was restricted to authorized users only. The network's performance was continuously monitored for any routing issues or disruptions in data flow. When problems were detected, adjustments were made to the configurations, and the tests were repeated to verify the issue was resolved. This iterative process helped fine-tune the network, ensuring that all protocols were functioning correctly and efficiently. By keeping the testing simple but thorough, we ensured that the system met both security and performance standards, making it a reliable and secure network architecture capable of supporting real-world applications.

CODING:

Basic settings to all devices along with SSH on the routers and multilayer switches:

```
Switch(config)#hostname MLOCS-SW
MLOCS-SW(config)#enable password cisco
MLOCS-SW(config)#no ip domain lookup
MLOCS-SW(config) #banner motd #No Unauthorised Access!!!#
HLOCS-SW(config)#line console 0
HLOCS-SW(config-line)#login
MLOCS-SW(config-line)#exit
MLOCS-SW(config)#service password-encryption

HQ-MultilayerSW(config)#enable password cisco
HQ-MultilayerSW(config)#banner motd #No Unauthorised Access!!18
HQ-MultilayerSW(config)#no ip domain lookup
HQ-MultilayerSW(config)#line console 0
HQ-MultilayerSW(config-line)#password cisco
HQ-MultilayerSW(config-line)#login
HQ-MultilayerSW(config-line)#exit
HQ-MultilayerSW(config)#service password-encryption
HQ-MultilayerSW (config)#ip domain name
HQ-MultilayerSW(config)#ip domain name cisco.net
HQ-MultilayerSW(config)#user
HQ-MultilayerSW(config)#username admin password cisco
HQ-MultilayerSW(config)#crypto key generate rsa
How many bits in the modulus (512): 1024
HQ-MultilayerSW(config)#line vty 0 15
HQ-MultilayerSW(config-line)#login local
HQ-MultilayerSW(config-line)#transport input ssh
HQ-MultilayerSW(config-line)#exit
HQ-MultilayerSW(config)#do wr
```

VLANs assignment along with all access and trunk ports on all switches

```
BRA-GWA-SW (config)#vlan 130
```


BRA-GWA-SW(config-vlan)#name BR-GWA
BRA-GWA-SW (config-vlan)#exit
BRA-GMA-SW(config)#int range fa0/1-2
BRA-GWA-SW(config-if-range)#switchport mode trunk
BRA-GMA-SW(config-if-range)#exit
BRA-GMA-SW(config)#int range fa0/3-24
BRA-GMA-SW(config-if-range)#switchport mode access
BRA-GWA-SW(config-if-range)#switchport access vlan 130
BRA-GMA-SW(config-if-range)#exit

HQ-MultilayerSW2(config)#vlan 10
HQ-MultilayerSW2(config-vlan)#vlan 20
HQ-MultilayerSW2(config-vlan)#vlan 30
HQ-MultilayerSW2(config-vlan)#vlan 40
HQ-MultilayerSW2(config-vlan)#vlan 50
HQ-MultilayerSW2(config-vlan)#vlan 60
HQ-MultilayerSW2(config-vlan)#int range gig1/0/2-7
HQ-MultilayerSW2(config-if-range)#switchport mode trunk
HQ-MultilayerSW2 (config-if-range)#exit

Switchport security to server-side site department

SSS-SW(config)#int range fa0/3-24
SSS-SM(config-if-range)#switchport port-security maximum 1
SSS-SW(config-if-range)#switchport port-security mac-address sticky
SSS-SW(config-if-range)#switchport port-security violation shutdown
SSS-SW(config-if-range)#ex
SSS-SW(config)#do wr

Subnetting and IP addressing

BR-MultilayerSW2(config)#interface GigabitEthernet1/0/1
BR-MultilayerSW2(config-if)#no switchport
BR-MultilayerSW2(config-if)#ip add 192.168.102.97 255.255.255.252
BR-MultilayerSM2(config-if)#ex
BR-MultilayerVW2 (config)#do wr

OSPF on the routers and switches along with default static route

```
HQ-MultilayerSW2 (config)#ip routing
HQ-MultilayerSW2 (config)#router ospf 10
HQ-MultilayerSW2 (config-router)#network 192.168.100.0 0.0.0.63 area 0
HQ-MultilayerSW2(config-router)#network 192.168.100.64 0.0.0.63 area 0
HQ-MultilayerSW2(config-router)#network 192.168.100.128 0.0.0.63 area 0
HQ-MultilayerSW2(config-router)#network 192.168.100.192 0.0.0.63 area 0
HQ-MultilayerSW2(config-router)#network 192.168.101.0 0.0.0.63 area 0
HQ-MultilayerSW2(config-router)#network 192.168.101.64 0.0.0.63 area 0
HQ-MultilayerSW2(config-router)#network 192.168.102.84 0.0.0.3 area 0
HQ-MultilayerSW2(config-router)#ex
HQ-Multilayer W2 (config)#ip route 0.0.0.0 0.0.0.0 192.168.102.04
HQ-MultilayerSM2(config)#do wr
```

Inter-VLAN routing on the switches along with IP DHCP helper addresses

```
HQ-Router(config)#interface GigabitEthernet0/2
HQ-Router(config-if)#no ip address
HQ-Router(config-if)#exit
HQ-Router(config)#interface GigabitEthernet0/2
HQ-Router(config-if)#interface GigabitEthernet0/2.70
HQ-Router(config-subif)#encapsulation dot10 70
HQ-Router(config-subif)#ip address 192.168.102.65 255.255.255.240
HQ-Router(config-subif)#ex
HQ-Router(config)#do wr
HQ-Router(config)#int vlan 10
HQ-Router(config-if)#ip address 192.168.100.1 255.255.255.192
HQ-Router(config-if)#ip helper-address 192.168.102.67
HQ-Router(config-if)#int vlan 20
HQ-Router(config-if)#ip address 192.168.100.65 255.255.255.192
HQ-Router(config-if)#ip helper-address 192.168.102.67
HQ-Router(config-if)#int vlan 30
HQ-Router(config-if)#ip address 192.168.100.129 255.255.255.192
HQ-Router(config-if)#ip helper-address 192.168.102.67
HQ-Router(config-if)#int vlan 40
HQ-Router(config-if)#ip address 192.168.100.193 255.255.255.192
```

```
HQ-Router(config-if)#ip helper-address 192.168.102.67
HQ-Router(config-if)#int vlan 50
HQ-Router(config-if)#ip address 192.168.101.1 255.255.255.192
HQ-Router(config-if)#ip helper-address 192.168.102.67
HQ-Router(config-if)#int vlan 60
HQ-Router(config-if)#ip address 192.168.101.65 255.255.255.192
HQ-Router(config-if)#ip helper-address 192.168.102.67
```

Port Address Translations (PAT) and Access Control Lists (ACLs):

```
HQ-Router(config)#int se0/1/2
HQ-Router(config-if)#ip nat outside
HQ-Router(config-if)#int se0/2/1
HQ-Router(config-if)#ip nat outside
HQ-Router(config-if)#ex
HQ-Router(config)#int range gig0/2-3
HQ-Router(config-if-range)#ip nat inside
HQ-Router(config-if-range)#ex
HQ-Router(config)#do wr
HQ-Router(config)#access-list 1 permit 192.168.1.0 0.0.0.255
HQ-Router(config)#access-list 1 permit 192.168.3.0 0.0.0.255
HQ-Router(config)#access-list 1 permit 192.168.4.0 0.0.0.255
HQ-Router(config)#access-list 1 permit 192.168.5.0 0.0.0.255
HQ-Router(config)#access-list 1 permit 192.168.6.0 0.0.0.255
HQ-Router(config)#access-list 1 permit 192.168.7.0 0.0.0.255
HQ-Router(config)#do wr
```

```
BR-Router(config)#ip nat inside source list 1 interface se0/2/1 overload
BR-Router(config)#do wr
BR-Router(config)#int se0/1/1
BR-Router(config-if)#ip nat outside
BR-Router(config-if)#int se0/2/0
BR-Router(config-if)#ip nat outside
BR-Router(config-if)#ex
BR-Router(config)#int range gigo/0-1
BR-Router(config-if-range)#ip nat inside
```

```
BR-Router(config-if-range) #ex
BR-Router(config)#do wr
BR-Router(config)#access-list 1 permit 192.168.101.120 0.0.0.31
BR-Router(config)#access-list 1 permit 192.168.101.160 0.0.0.31
BR-Router(config)#access-list 1 permit 192.168.101.192 0.0.0.31
BR-Router(config)#access-list 1 permit 192.168.101.224 0.0.0.31
BR-Router(config)#access-list 1 permit 192.168.102.0 0.0.0.31
BR-Router(config)#access-list 1 permit 192.168.102.32 0.0.0.31
BR-Router(config)#ip nat inside source list 1 interface se0/2/0 overload
BR-Router(config)#do wr
```

Site-to-Site VPN

```
HQ-Router(config)#crypto isakmp policy 10
HQ-Router(config-isakmp)#encryption aes 256
HQ-Router(config-isakmp)#authentication pre-share
HQ-Router(config-isakmp)#group 5
HQ-Router(config-isakmp)#exit
HQ-Router(config)#crypto isakmp key vpnpa55 address 192.168.102.90
HQ-Router(config)#crypto ipsec transform-set VPN-SET esp-aes esp-sha-hmac
HQ-Router(cfg-crypto-trans)#exit
HQ-Router(config)#crypto map VPN-MAP 10 ipsec-isakmp
HQ-Router(config-crypto-map)#description VPN connection to BR-Router
HQ-Router(config-crypto-map)#set peer 192.168.102.90
HQ-Router(config-crypto-map)#set transform-set VPN-SET
HQ-Router(config-crypto-map)#match address 110
HQ-Router(config-crypto-map)#exit
HQ-Router(config)#access-list 110 permit ip 192.168.1.0 0.0.0.255 192.168.2.0
0.0.0.255
HQ-Router(config)#interface S0/2/0
HQ-Router(config-if)#crypto map VPN-MAP
HQ-Router(config-if)#exit
HQ-Router(config)#license boot module c2900 technology-package securityk9
HQ-Router(config)#do wr
```

```
BR-Router(config)#crypto isakmp policy 10
```

```
BR-Router(config-isakmp)#encryption aes 256
BR-Router(config-isakmp)#authentication pre-share
BR-Router(config-isakmp)#group 5
BR-Router(config-isakmp)#exit
BR-Router(config)#crypto isakmp key vpnpa55 address 192.168.102.89
BR-Router(config)#crypto ipsec transform-set VPN-SET esp-aes esp-sha-hmac
BR-Router(cfg-crypto-trans)#exit
BR-Router(config)#crypto map VPN-MAP 10 ipsec-isakmp
BR-Router(config-crypto-map)#description VPN connection to HQ-Router
BR-Router(config-crypto-map)#set peer 192.168.102.89
BR-Router(config-crypto-map)#set transform-set VPN-SET
BR-Router(config-crypto-map)#match address 110
BR-Router(config-crypto-map)#exit
BR-Router(config)#access-list 110 permit ip 192.168.2.0 0.0.0.255 192.168.1.0 0.0.0.255
BR-Router(config)#interface S0/2/0
BR-Router(config-if)#crypto map VPN-MAP
BR-Router(config-if)#exit
BR-Router(config)#license boot module c2900 technology-package securityk9
BR-Router(config)#do wr
```

RESULTS & INFERENCES:

The Enterprise Network system was evaluated based on four key factors: performance, security, data throughput, scalability, and fault tolerance. When it comes to security, the system used Access Control Lists (ACLs) and IPSec VPN to ensure that only authorized users could access sensitive information and to protect data during remote communications. The ACLs helped restrict access to specific network resources based on user permissions, while the VPN allowed secure connections for users working remotely. No unauthorized access was detected during testing, which indicates that the security measures were effective in protecting the network and its data. This demonstrated that the network's security was strong and reliable, meeting the needs for confidentiality and safe communication.

The system showed good data throughput performance. The OSPF dynamic routing protocol helped reduce delays by quickly finding the best paths for data, ensuring smooth and efficient communication between different departments. This also demonstrates that the system can manage heavy traffic loads while keeping delays to a minimum. To illustrate the network's scalability, VLANs and Inter-VLAN Routing were implemented. This setup allowed for the easy addition of new departments and remote offices without compromising performance.

Compared to static networks, the dynamic features of OSPF and secure VPN connections offer more flexibility, scalability, and security. While static networks require manual updates and fixed routing paths, OSPF automatically adjusts to changes, like adding new departments or remote offices, without needing a reconfiguration. This makes the network more efficient and responsive. Additionally, the IPSec VPN provides a secure way for remote workers to connect, which is essential for businesses with a distributed workforce. These advanced features make this network more adaptable and easier to expand than traditional static systems. In today's fast-moving business world, where security and flexibility are key, this setup is a better fit for modern businesses. It can grow with the company, handle more traffic, and protect sensitive data without the limitations of older, static networks.

APPLICATION ORIENTED LEARNING:

This enterprise network system is designed for organizations that need reliable internal communication and secure external connectivity. It acts as the central communication hub for all LANs, ensuring seamless data flow across the network. The project creates clear divisions between the data allowed for the headquarters and branch network, encompassing 12 departments on both sides.

With the implementation of Access Control Lists (ACLs) and IPSec VPNs, the system secures data transmission while restricting access to confidential information. Future integrations of HTTP and email servers further extend its applicability to support enterprise web hosting and communication systems.

This solution applies to industries such as banking, healthcare, education, IT services, retail, and government, all of which require secure data handling, seamless internal communication, and secure external access. In banking, it ensures secure transactions and access to sensitive financial data across multiple branches and remote locations. In healthcare, it supports the secure transfer of patient information and telemedicine services, complying with stringent data protection regulations like HIPAA. Educational institutions benefit from secure access to resources, enabling communication between campuses, online courses, and remote students while safeguarding student data.

The estimated cost for implementing this enterprise network system ranges from ₹11,00,000 to ₹21,00,000, depending on the scale and complexity. The cost covers networking hardware such as routers, switches, and access points, which are mainly used for the 12 departments for each of the LAN configurations. Servers for DNS, DHCP, HTTP, and email functionalities add to the expenditure, along with software licenses for operating systems, VPNs, and management tools. Additionally, configuration, testing, and ongoing support contribute to the overall cost. The price is influenced by the need for high-quality, reliable components to ensure security, scalability, and efficient performance across multiple departments and remote users.

CONCLUSION:

The enterprise network system, created using Cisco Packet Tracer, incorporated features such as VLANs, Inter-VLAN Routing, ACLs, DHCP, DNS, ISAKMP-based VPN, and OSPF. VLANs enhanced the network segmentation, while ACLs provided traffic control. DHCP automated the distribution of IP addresses, and DNS made hostname resolution easier. OSPF facilitates dynamic and efficient routing, and VPNs ensure secure remote communication. Together, these configurations significantly improved the network's security, reliability, performance, and scalability, meeting the demands of a modern enterprise environment.

Some challenges encountered included ISAKMP issues, like mismatched encryption policies and pre-shared keys. This was addressed by aligning the parameters for Phase 1 and Phase 2.

Future improvements could involve integrating HTTP and email servers to enhance web and communication capabilities within the network. On the server side, adding load balancers and redundant servers could boost reliability. To optimize performance, automation through SDN tools and quality of service (QoS) enhancements could further refine the system. For the improvement of the working of system, we can enhance the performance by using GRE or MPLS VPNs, along with implementing advanced security measures like firewalls and intrusion prevention systems.

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