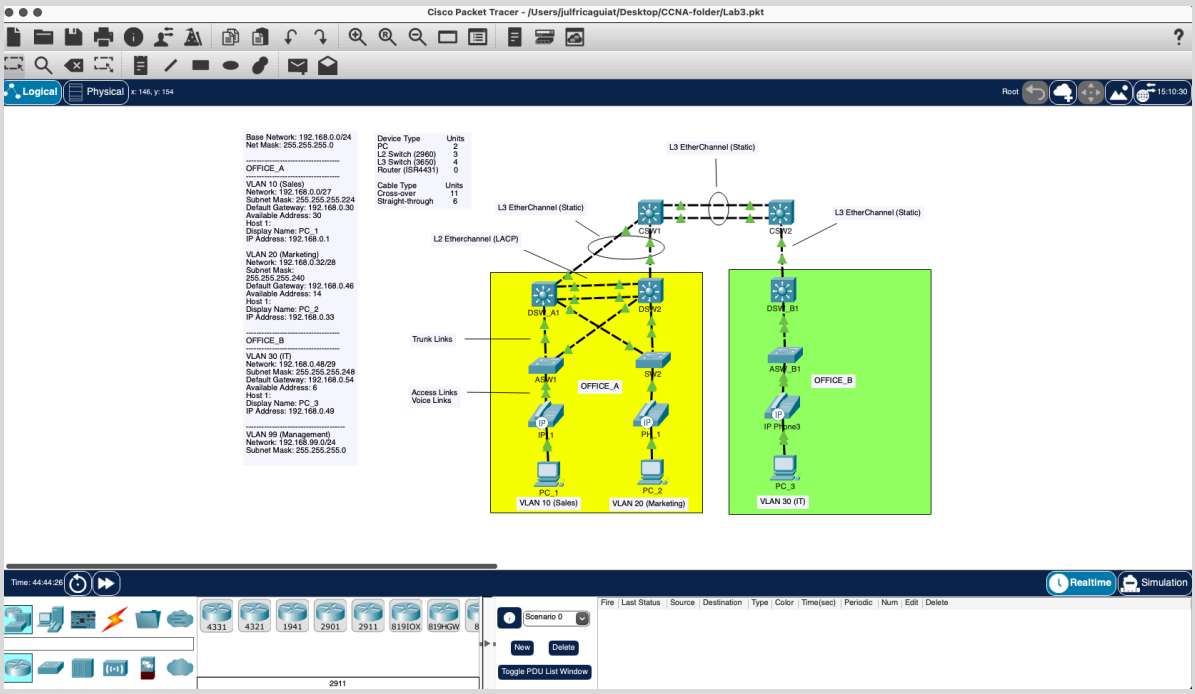
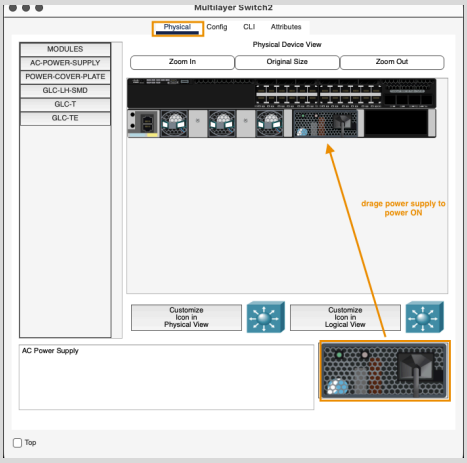
Lab 3: Implementing Enterprise VLANs: VLSM, VTP, Voice VLANs, EtherChannel, and Static IP Routing

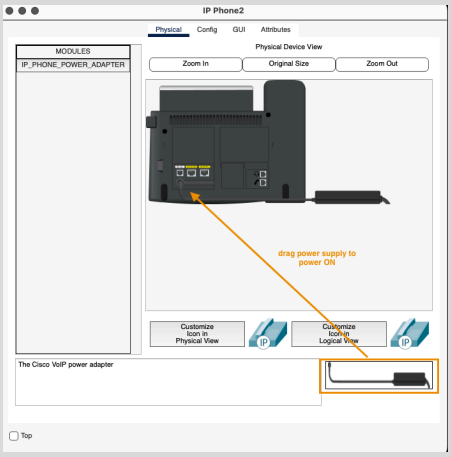
This lab focuses on designing and implementing an enterprise-style campus switching infrastructure using industry best practices. It incorporates **VLSM-based IP addressing**, centralized **VLAN management with VTP**, and multiple EtherChannel implementations, including **Layer 2, Layer 3, and static EtherChannel** configurations to improve redundancy and bandwidth utilization. The lab also integrates **IP phones through voice VLAN** configuration, assigns a **dedicated management VLAN**, and applies **native VLAN reassignment on trunk links** to enhance security and consistency. A **multi-tier core, distribution, and access switching topology** is used to reflect real-world enterprise environments, reinforcing practical skills in Layer 2 design, VLAN segmentation, trunking, redundancy, VoIP integration, and **static IP routing** for predictable inter-VLAN and inter-office connectivity.

Network Topology:



Powering On Devices: Multi-Layer (L3) Switch & IP Phone





Network Addressing Plan (VLSM-Based)

Base Network

- Network: 192.168.0.0/24
- Subnet Mask: 255.255.255.0
- Design: VLSM for offices, management, and core EtherChannel links

VLAN ID	VLAN Name	Purpose	Subnet	Usable Host Range	Default Gateway
10	Sales	User data	192.168.0.0/27	192.168.0.1 – 192.168.0.30	192.168.0.30
20	Marketing	User data	192.168.0.32/28	192.168.0.33 – 192.168.0.46	192.168.0.46
30	IT	User data	192.168.0.48/29	192.168.0.49 – 192.168.0.54	192.168.0.54
99	Management	Switch management / Native VLAN	192.168.99.0/24	192.168.99.1 – 192.168.99.254	192.168.99.254

Layer 3 EtherChannel Addressing

Device	Interface / Port-Channel	IP Address	Subnet	Connected To	Type
CSW1	Po1	192.168.10.0	/30	CSW2 Po1	L3 EtherChannel
DSW_A1	Po10	192.168.10.4	/30	CSW1 Po10	L3 EtherChannel
CSW1	Po10	192.168.10.5	/30	DSW_A1 Po10	L3 EtherChannel
DSW_A2	Po20	192.168.10.8	/30	CSW1 Po20	L3 EtherChannel
CSW1	Po20	192.168.10.9	/30	DSW_A2 Po20	L3 EtherChannel
CSW2	Po10	192.168.10.12	/30	DSW_B1 Po10	L3 EtherChannel
DSW_B1	Po10	192.168.10.13	/30	CSW2 Po10	L3 EtherChannel

Management Infrastructure IP Assignments (VLAN 99)

Device	Interface	IP Address
CSW_A	SVI VLAN 99	192.168.99.11
CSW_B	SVI VLAN 99	192.168.99.12
DSW_A1	SVI VLAN 99	192.168.99.21
DSW_B1	SVI VLAN 99	192.168.99.22
ASW_A1	SVI VLAN 99	192.168.99.31
ASW_B1	SVI VLAN 99	192.168.99.32
ASW_C1	SVI VLAN 99	192.168.99.33

Addressing Logic

- .11–.12 → Core switches
- .21–.22 → Distribution switches
- .31–.33 → Access switches
- .254 → Default gateway for VLAN 99

Host IP Assignment

VLAN 10 – Sales (OFFICE_A):

- Available Host IPs: 30
- Host 1: PC_1
- IP Address: 192.168.0.1
- Subnet Mask: 255.255.255.224 (/27)
- Default Gateway: 192.168.0.30

VLAN 20 – Marketing (OFFICE_A)

- Available Host IPs: 14
- Host 1: PC_2
- IP Address: 192.168.0.33
- Subnet Mask: 255.255.255.240 (/28)
- Default Gateway: 192.168.0.46

VLAN 30 – IT (OFFICE_B)

- Available Host IPs: 6
- Host 1: PC_3
- IP Address: 192.168.0.49
- Subnet Mask: 255.255.255.248 (/29)
- Default Gateway: 192.168.0.54

VTP VLAN Creation

- VTP propagates VLAN configuration across all switches in the same VTP domain.
- Reduces manual VLAN configuration on each switch, simplifying network management.
- Operates only on trunk links, not access ports.

on DSW_A1 (VTP server OFFICE_A)

! Create VLANs on DSW1

```
vlan 10
  name Marketing
vlan 20
  name Sales
vlan 50
  name Phones
vlan 99
  name Management
```

on DSW_A2, ASW_A1, ASW_A2 (VTP Clients OFFICE_A)

! Configure Switch as VTP Clients

```
vtp mode client
```

on DSW_B1 (VTP server OFFICE_B)

! Create VLANs on DSW_B1

```
vlan 30
 name Marketing
vlan 50
  name Phones
vlan 99
  name Management
```

on ASW_A2 (VTP Client OFFICE_B)

! Configure Switch as VTP Client

```
vtp mode client
```

Assign VLANs & Voice VLAN to Access Ports on ASWs

- Separates traffic types: Data (PCs) and voice (IP phones) are placed in different VLANs for security and QoS.
- Ensures proper tagging: Voice VLAN allows IP phones to tag traffic correctly while PCs use the data VLAN.
- Simplifies management: Each access port clearly knows which VLANs it carries, reducing misconfigurations.

on ASW_A1 (OFFICE_A)

! Configure Access Switch

```
int f0/1
  sw access vlan 10
  sw voice vlan 50
```

on ASW_A2 (OFFICE_A)

! Configure Access Switch

```
int f0/1
  sw access vlan 20
  sw voice vlan 50
```

on ASW_B (OFFICE_B)

! Configure Access Switch

```
int f0/1
  sw access vlan 30
  sw voice vlan 50
```

Layer 3 EtherChannel Configuration (Core Switches - CSW1 & CSW2)

- Purpose: Combines two GigabitEthernet links into a single Layer 3 EtherChannel for redundancy and increased bandwidth.
- no switchport converts the Port-Channel to a Layer 3 interface.
- IP address is the first usable address in the /30 subnet.

on CSW1:

! Enable IP routing for Layer 3 interfaces

```
ip routing
```

! Configure physical interfaces as a Layer 3 EtherChannel
```
interface range g1/0/1 - 2
  channel-group 1 mode on
  exit
```

! Configure the Port-Channel interface as routed
```
interface port-channel 1
  no switchport
  ip address 192.168.10.1 255.255.255.252
  exit
```

on CSW2:
! Enable IP routing
```
ip routing
```

! Configure physical interfaces as a Layer 3 EtherChannel
```
interface range g1/0/1 - 2
  channel-group 1 mode on
  exit
```

! Configure the Port-Channel interface as routed
```
interface port-channel 1
  no switchport
  ip address 192.168.10.2 255.255.255.252
  exit
```

Layer 3 EtherChannel Configuration (CSW1 & DSW_A1 / DSW_A2 - OFFICE_A)

Link	Port-Channel	DSW IP	CSW1 IP	Subnet
DSW_A1 → CSW1	Po10	192.168.10.6	192.168.10.5	/30
CSW1 → DSW_A1	Po10	192.168.10.6	192.168.10.5	/30
DSW_A2 → CSW1	Po20	192.168.10.10	192.168.10.9	/30
CSW1 → DSW_A2	Po20	192.168.10.10	192.168.10.9	/30

DSW_A1 Configuration
! Assign interface to Layer-3 EtherChannel
```
interface g1/0/5
 channel-group 10 mode on
 exit
```

! Configure Port-Channel 10 as L3
```
interface port-channel10
 no switchport
 ip address 192.168.1.6 255.255.255.252
 no shutdown
 exit
```

DSW_A2 Configuration

```
interface g1/0/5
 channel-group 20 mode on
 exit

interface port-channel20
 no switchport
 ip address 192.168.1.10 255.255.255.252
 no shutdown
 exit
```

CSW1 Configuration

```
! DSW_A1 uplink
interface g1/0/3
 channel-group 10 mode on
 exit

interface port-channel10
 no switchport
 ip address 192.168.1.5 255.255.255.252
 no shutdown
 exit

! DSW_A2 uplink
interface g1/0/4
 channel-group 20 mode on
 exit

interface port-channel20
 no switchport
 ip address 192.168.1.9 255.255.255.252
 no shutdown
 exit
```

Layer 3 EtherChannel Configuration (CSW2 & DSW_B1 - OFFICE_B)

Link	Port-Channel	DSW IP	CSW2 IP	Subnet
DSW_B1 → CSW2	Po10	192.168.10.14	192.168.10.13	/30
CSW2 → DSW_B1	Po10	192.168.10.14	192.168.10.13	/30

DSW_B1 Configuration

```
! Assign interface to Layer-3 EtherChannel
interface g1/0/3
 channel-group 10 mode on
 exit

! Configure Port-Channel 10 as L3
interface port-channel10
 no switchport
 ip address 192.168.10.14 255.255.255.252
```

```
 no shutdown
 exit
```

DSW_B1 Configuration

! Assign interface to Layer-3 EtherChannel

```
interface g1/0/3
 channel-group 10 mode on
 exit
```

! Configure Port-Channel 10 as L3

```
interface port-channel10
 no switchport
 ip address 192.168.10.14 255.255.255.252
 no shutdown
 exit
```

! Default route to CSW2

```
ip route 0.0.0.0 0.0.0.0 192.168.10.14
```

CSW2 Configuration

! DSW_B1 uplink

```
interface g1/0/3
 channel-group 10 mode on
 exit

interface port-channel10
 no switchport
 ip address 192.168.10.13 255.255.255.252
 no shutdown
 exit
```

FHRP (HSRP Implementation)

- Provides default gateway redundancy for hosts in a VLAN.
- Allows two or more routers/switches to share a single virtual IP address (VIP).
- Ensures high availability: if the active device fails, the standby device automatically takes over.

HSRP Design Rules (OFFICE_A):

- DSW_A1 = Active for VLAN 10 & VLAN 20
- DSW_A2 = Active for VLAN 50 & VLAN 99
- HSRP VIP = last usable IP in each subnet
- IP Routing enabled on both switches

DSW_A1 Configuration (Active for VLANs 10 & 20)

! Enable IP routing

```
ip routing
```

! VLAN 10 – Sales (192.168.0.0/27)

```
interface vlan 10
  ip address 192.168.0.29 255.255.255.224
  standby 10 ip 192.168.0.30
  standby 10 priority 110
  standby 10 preempt
```

```
  no shutdown
  exit

! VLAN 20 – Marketing (192.168.0.32/28)
interface vlan 20
  ip address 192.168.0.45 255.255.255.240
  standby 20 ip 192.168.0.46
  standby 20 priority 110
  standby 20 preempt
  no shutdown
  exit

! VLAN 50 – Phones (192.168.50.0/24)
interface vlan 50
  ip address 192.168.50.253 255.255.255.0
  standby 50 ip 192.168.50.254
  standby 50 priority 100
  standby 50 preempt
  no shutdown
  exit

! VLAN 99 – Management (192.168.99.0/24)
interface vlan 99
  ip address 192.168.99.253 255.255.255.0
  standby 99 ip 192.168.99.254
  standby 99 priority 100
  standby 99 preempt
  no shutdown
  exit
```

DSW_A2 Configuration (Active for VLANs 50 & 99)

```
! Enable IP routing
ip routing

! VLAN 10 – Sales (Standby)
interface vlan 10
  ip address 192.168.0.28 255.255.255.224
  standby 10 ip 192.168.0.30
  standby 10 priority 100
  standby 10 preempt
  no shutdown
  exit

! VLAN 20 – Marketing (Standby)
interface vlan 20
  ip address 192.168.0.44 255.255.255.240
  standby 20 ip 192.168.0.46
  standby 20 priority 100
  standby 20 preempt
  no shutdown
  exit
```

! VLAN 50 – Phones (Active)

```
interface vlan 50
  ip address 192.168.50.254 255.255.255.0
  standby 50 ip 192.168.50.254
  standby 50 priority 110
  standby 50 preempt
  no shutdown
  exit
```

! VLAN 99 – Management (Active)

```
interface vlan 99
  ip address 192.168.99.254 255.255.255.0
  standby 99 ip 192.168.99.254
  standby 99 priority 110
  standby 99 preempt
  no shutdown
  exit
```

Access and Trunk Configuration (OFFICE_B)

- Access ports connect end devices (PCs and IP phones) to the network, assigning data VLAN and voice VLAN.
- Voice VLAN ensures IP phones tag traffic separately, enabling QoS and traffic prioritization.
- Trunk ports connect switches (ASW ↔ DSW ↔ CSW) and carry multiple VLANs over a single link.
- Explicitly defining allowed VLANs on trunks prevents unnecessary VLAN propagation.
- SVIs on distribution switches provide the default gateway for each VLAN, enabling inter-VLAN routing.

ASW_B1 Configuration

! Configure access port for PC and IP phone

```
interface f0/1
  switchport mode access
  switchport access vlan 30       ! Data VLAN
  switchport voice vlan 50        ! Voice VLAN for IP phones
  no shutdown
  exit
```

! Configure uplink to Distribution Switch (trunk)

```
interface g0/1
  switchport mode trunk
  switchport trunk allowed vlan 30,50,99
  no shutdown
  exit
```

DSW_B1 Configuration

! VLAN 30 SVI – Default Gateway for VLAN 30

```
interface vlan 30
  ip address 192.168.0.54 255.255.255.248
  no shutdown
  exit
```

! Trunk uplink to ASW_B1

```
interface g1/0/1
  switchport mode trunk
  switchport trunk allowed vlan 30,50,99
  no shutdown
  exit
```

! Trunk uplink to CSW2 (Core Switch)

```
interface g1/0/3
  switchport mode trunk
  switchport trunk allowed vlan 30,50,99
  no shutdown
  exit
```

Configure VLAN 99 (Management) as the Native VLAN on all trunk ports

- Separates management traffic from user and voice VLANs, improving security and control.
- Ensures trunk negotiation and untagged traffic are handled consistently across switches.
- Simplifies network management, as all switches use the same native VLAN for infrastructure.

ASW1

```
int range g0/1-2
  sw trunk native vlan 99
```

ASW2

```
int range g0/1-2
  sw trunk native vlan 99
```

DSW_A1

```
int po1
  sw trunk native vlan 99
int po10
  sw trunk native vlan 99
int range g1/0/1-2
  sw trunk native vlan 99
```

DSW_A2

```
int po1
  sw trunk native vlan 99
int po10
  sw trunk native vlan 99
int range g1/0/1-2
  sw trunk native vlan 99
```

Complete Lab Trunk Port List

Device	Interface	Connected To	Type	Notes
DSW_A1	G1/0/1	ASW_B1 G1/0/1	Trunk	Allow VLANs 30,50,99, native VLAN 99
DSW_A1	G1/0/2	CSW_A G1/0/1	Trunk	Core switch uplink, allow VLANs 30,50,99, native VLAN 99
DSW_B1	G1/0/1	ASW_B1 G1/0/2	Trunk	Allow VLANs 30,50,99, native VLAN 99
DSW_B1	G1/0/2	CSW_B G1/0/1	Trunk	Core switch uplink, allow VLANs 30,50,99, native VLAN 99

ASW_B1	G1/0/1	DSW_A1 G1/0/1	Trunk	Mirror of DSW_A1 trunk
ASW_B1	G1/0/2	DSW_B1 G1/0/1	Trunk	Mirror of DSW_B1 trunk
CSW_A	G1/0/1	DSW_A1 G1/0/2	Trunk	Core uplink, native VLAN 99
CSW_A	G1/0/2	CSW_B G1/0/2	Trunk	Core-to-core link, native VLAN 99

Static IP Routing

- Directs traffic via a specific next-hop or interface.
- Ensures predictable and deterministic packet forwarding.
- Connects isolated or stub networks without dynamic routing.

OFFICE A — Distribution Layer

DSW_A1 Configuration

```
! Default route to Core (CSW1)
ip route 0.0.0.0 0.0.0.0 192.168.10.5
```

DSW_A2 Configuration

```
! Default route to Core (CSW1)
ip route 0.0.0.0 0.0.0.0 192.168.10.9
```

OFFICE B — Distribution Layer

DSW_B1 Configuration

```
! Default route to Core (CSW2)
ip route 0.0.0.0 0.0.0.0 192.168.10.13
```

CORE — Routing

CSW1 (Core – Office A side)

```
! Office B (IT VLAN 30)
ip route 192.168.0.48 255.255.255.248 192.168.10.2

! Phone VLAN
ip route 192.168.50.0 255.255.255.0 192.168.10.2

! Management VLAN
ip route 192.168.99.0 255.255.255.0 192.168.10.2
```

CSW2 (Core – Office B side)

```
! Sales VLAN 10
ip route 192.168.0.0 255.255.255.224 192.168.10.1

! Marketing VLAN 20
ip route 192.168.0.32 255.255.255.240 192.168.10.1

! Phone VLAN
ip route 192.168.50.0 255.255.255.0 192.168.10.1

! Management VLAN
ip route 192.168.99.0 255.255.255.0 192.168.10.1
```

Verification Commands

Command	What It Shows
show ip int brief	IP addresses, interface status (up/down)
show etherchannel summary	EtherChannel status and port membership
show ip route	Routing table and next hops
show int trunk	Trunk ports, allowed VLANs, native VLAN
ping <IP>	End-to-end connectivity test
tracert <IP>	Path to destination and next-hop check
show vlan brief	VLANs active on the switch

Successful ping from PC_1 : VLAN 10:

`ping 192.168.0.33` (PC_2 : VLAN 20)

`Ping 192.168.0.49` (PC_3 : VLAN 30)