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Network Revolution in the IT Industry: Transforming Connectivity and Innovation

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I. SPANNING TREE PROTOCOL (STP) OVERVIEW

Spanning Tree Protocol (STP) is a Layer 2 protocol essential in Ethernet networks to prevent network loops. Redundant paths in a network can cause:

- 1) Broadcast storms: Excessive traffic that floods the network.
- 2) Multiple frame copies: Duplication of frames, creating confusion.
- 3) MAC table instability: Incorrect MAC address mapping due to looped traffic.

STP ensures there is always a single active path between devices in a network by blocking redundant paths until needed.

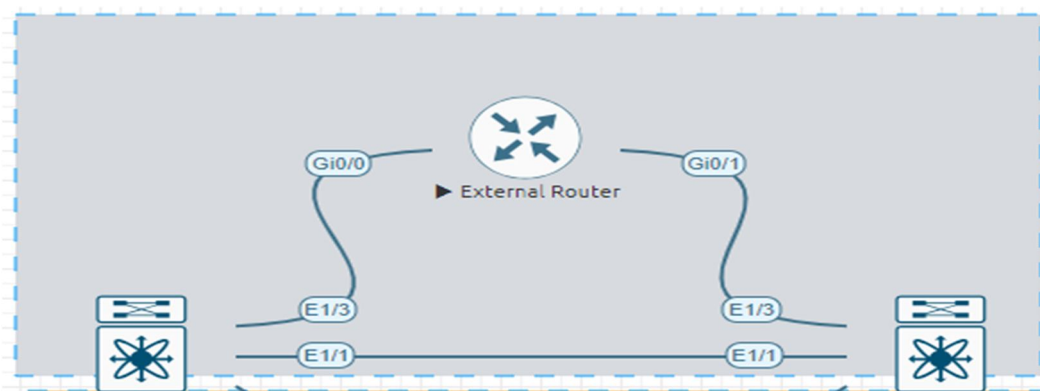
II. KEY FEATURES OF TRADITIONAL STP

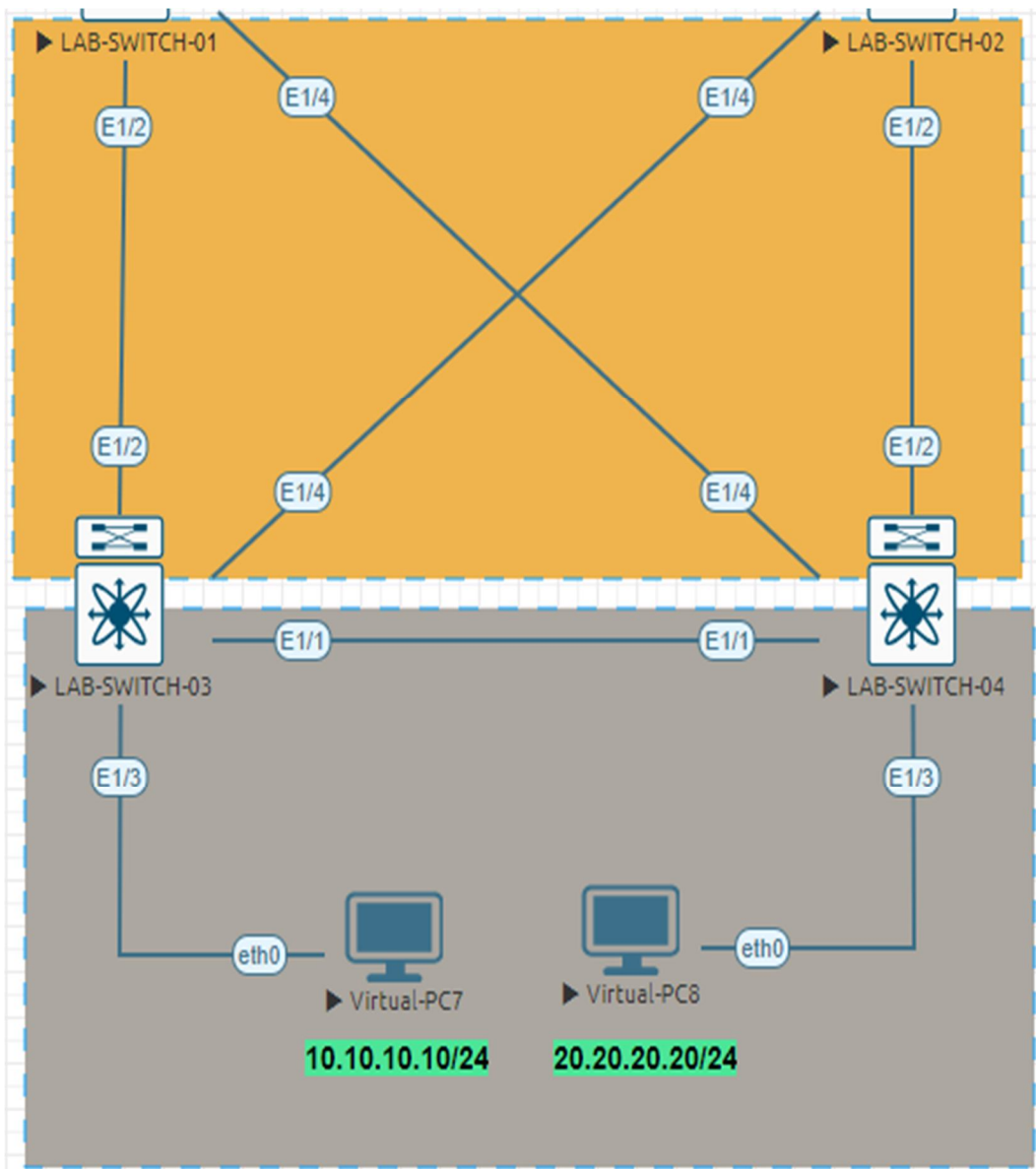
- 1) IEEE Standard: Defined by the IEEE 802.1D specification.
- 2) Root Bridge Election: Utilizes Bridge Protocol Data Units (BPDUs) to elect a Root Bridge, which acts as the central reference point in the network topology.
- 3) Port States:
 - Blocking: Prevents loops by not forwarding frames.
 - Listening: Monitors BPDUs but doesn't forward traffic.
 - Learning: Builds MAC address tables without forwarding frames.
 - Forwarding: Operates normally by forwarding frames.
 - Disabled: No activity on the port.
- 4) Timers:
 - Hello Time: **Interval between BPDU transmissions (default: 2 seconds).**
 - Forward Delay: **Time spent in the listening and learning states (default: 15 seconds each).**
 - Max Age: Time before considering a BPDU invalid (default: 20 seconds).
- 5) Redundant Path Management: Blocks redundant paths and only activates them when the primary path fails.

III. LIMITATIONS OF TRADITIONAL STP

- 1) Convergence Time: Takes 30-50 seconds to stabilize the network after a topology change.
- 2) Inefficiency: Redundant links remain blocked, resulting in underutilized bandwidth.

A. Base Topology





B. Configuration Details

- Created two Layer 3 VLANs (VLAN 10 and VLAN 20) on LAB-SWITCH-01, making it the Root Bridge for these VLANs.
- Configured LAB-SWITCH-02 as the Backup Root Bridge for both VLANs.
- Assigned Higher HSRP Priority to LAB-SWITCH-01, ensuring it is the active switch for both VLANs.

Switch Roles:

- LAB-SWITCH-01: Root Bridge for VLANs 10 and 20.
- LAB-SWITCH-02: Backup Root Bridge for VLANs 10 and 20.

C. Traffic Flow (Layer 2 STP)

Due to STP:

- Looped interfaces or redundant links are blocked to prevent Layer 2 loops.
- Traffic for VLANs 10 and 20 flows through a single active link, while the second link operates in a standby state.

LAB-SWITCH-01 – Root Bridge for Vlan 10, 20

```
LAB-SWITCH-01# sh spanning-tree root
```

| Vlan | Root ID | Root Cost | Hello Time | Max Age | Fwd Dly | Root Port |
|----------|----------------------|-----------|------------|---------|---------|---------------------|
| VLAN0001 | 32769 5001.0000.1b08 | 0 | 2 | 20 | 15 | This bridge is root |
| VLAN0010 | 32778 5001.0000.1b08 | 0 | 2 | 20 | 15 | This bridge is root |
| VLAN0020 | 32788 5001.0000.1b08 | 0 | 2 | 20 | 15 | This bridge is root |

```
LAB-SWITCH-01#
```

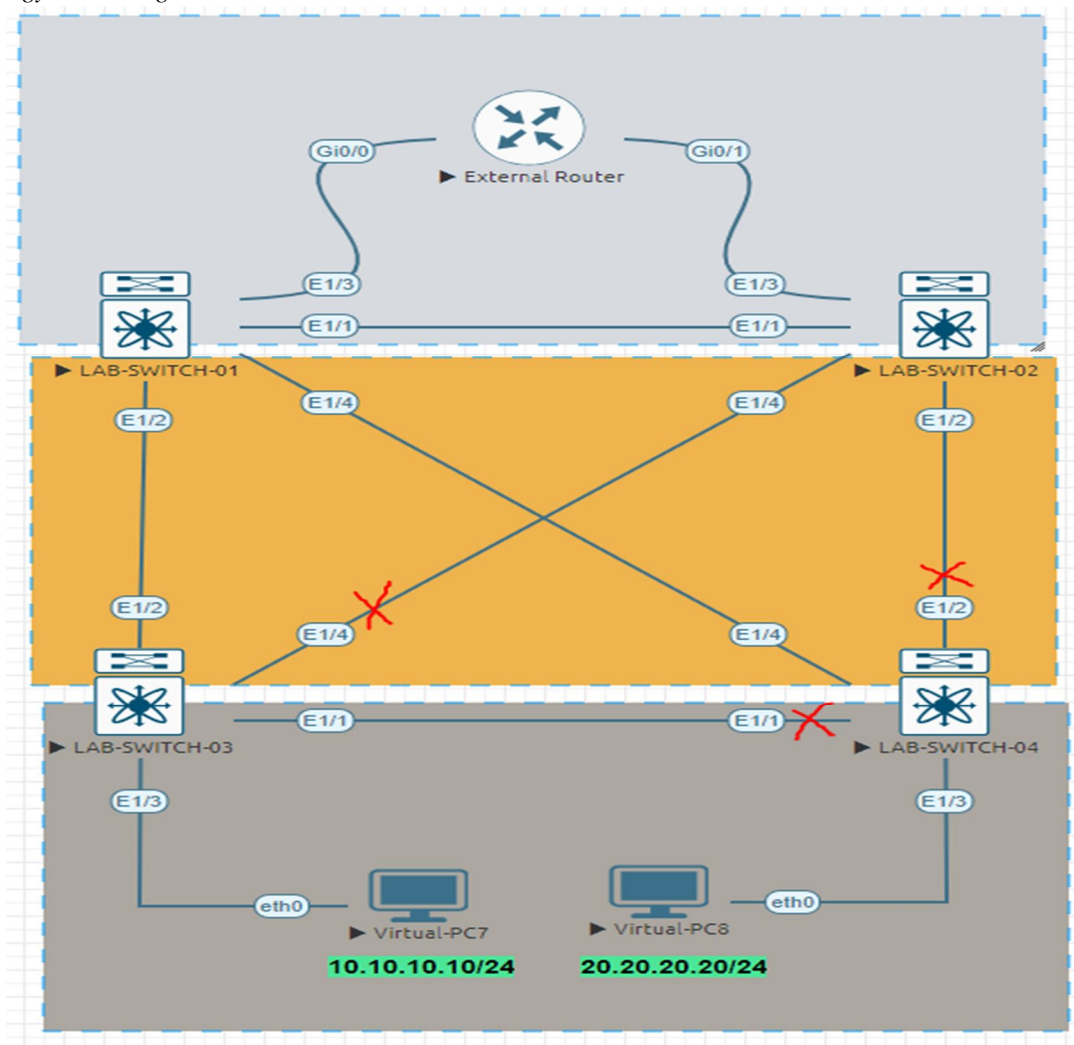
LAB-SWITCH-02 – Backup Root Bridge for Vlan 10, 20

```
LAB-SWITCH-02# sho spanning-tree root
```

| Vlan | Root ID | Root Cost | Hello Time | Max Age | Fwd Dly | Root Port |
|----------|----------------------|-----------|------------|---------|---------|-------------|
| VLAN0001 | 32769 5001.0000.1b08 | 4 | 2 | 20 | 15 | Ethernet1/1 |
| VLAN0010 | 32778 5001.0000.1b08 | 8 | 2 | 20 | 15 | Ethernet1/4 |
| VLAN0020 | 32788 5001.0000.1b08 | 8 | 2 | 20 | 15 | Ethernet1/4 |

```
LAB-SWITCH-02#
```

D. Base Topology – Blocking links



LAB-SWITCH-01: Spanning-Tree status

```
LAB-SWITCH-01# sh spanning-tree vlan 10,20 brief

VLAN0010
  Spanning tree enabled protocol rstp
  Root ID      Priority      32778
                Address      5001.0000.1b08
                This bridge is the root
                Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec

  Bridge ID     Priority      32778 (priority 32768 sys-id-ext 10)
                Address      5001.0000.1b08
                Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Eth1/1         Desg FWD 4        128.1    P2p
Eth1/2         Desg FWD 4        128.2    P2p
Eth1/3         Desg FWD 4        128.3    P2p
Eth1/4         Desg FWD 4        128.4    P2p

VLAN0020
  Spanning tree enabled protocol rstp
  Root ID      Priority      32788
                Address      5001.0000.1b08
                This bridge is the root
                Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec

  Bridge ID     Priority      32788 (priority 32768 sys-id-ext 20)
                Address      5001.0000.1b08
                Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Eth1/1         Desg FWD 4        128.1    P2p
Eth1/2         Desg FWD 4        128.2    P2p
Eth1/3         Desg FWD 4        128.3    P2p
Eth1/4         Desg FWD 4        128.4    P2p

LAB-SWITCH-01#
```

LAB-SWITCH-02 : Spanning-Tree status

```
LAB-SWITCH-02# sh spanning-tree vlan 10,20 brief

VLAN0010
  Spanning tree enabled protocol rstp
  Root ID      Priority      32778
                Address      5001.0000.1b08
                Cost          4
                Port          1 (Ethernet1/1)
                Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec

  Bridge ID     Priority      32778 (priority 32768 sys-id-ext 10)
                Address      5002.0000.1b08
                Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Eth1/1         Root FWD 4        128.1    P2p
Eth1/2         Desg FWD 4        128.2    P2p
Eth1/3         Desg FWD 4        128.3    P2p
Eth1/4         Desg FWD 4        128.4    P2p

VLAN0020
  Spanning tree enabled protocol rstp
  Root ID      Priority      32788
                Address      5001.0000.1b08
                Cost          4
                Port          1 (Ethernet1/1)
                Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec

  Bridge ID     Priority      32788 (priority 32768 sys-id-ext 20)
                Address      5002.0000.1b08
                Hello Time    2 sec   Max Age 20 sec   Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Eth1/1         Root FWD 4        128.1    P2p
Eth1/2         Desg FWD 4        128.2    P2p
Eth1/3         Desg FWD 4        128.3    P2p
Eth1/4         Desg FWD 4        128.4    P2p

LAB-SWITCH-02#
```

LAB-SWITCH-03 : Spanning-Tree status

```
LAB-SWITCH-03# sh spanning-tree vlan 10,20 brief

VLAN0010
  Spanning tree enabled protocol rstp
  Root ID      Priority      32778
                Address      5001.0000.1b08
                Cost          4
                Port          2 (Ethernet1/2)
                Hello Time    2 sec Max Age 20 sec Forward Delay 15 sec

  Bridge ID    Priority      32778 (priority 32768 sys-id-ext 10)
                Address      5003.0000.1b08
                Hello Time    2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost          Prio.Nbr Type
-----
Eth1/1         Desg FWD 4             128.1    P2p
Eth1/2         Root FWD 4             128.2    P2p
Eth1/3         Desg FWD 4             128.3    P2p
Eth1/4         Altn BLK 4             128.4    P2p

VLAN0020
  Spanning tree enabled protocol rstp
  Root ID      Priority      32788
                Address      5001.0000.1b08
                Cost          4
                Port          2 (Ethernet1/2)
                Hello Time    2 sec Max Age 20 sec Forward Delay 15 sec

  Bridge ID    Priority      32788 (priority 32768 sys-id-ext 20)
                Address      5003.0000.1b08
                Hello Time    2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost          Prio.Nbr Type
-----
Eth1/1         Desg FWD 4             128.1    P2p
Eth1/2         Root FWD 4             128.2    P2p
Eth1/4         Altn BLK 4             128.4    P2p

LAB-SWITCH-03#
```

LAB-SWITCH-04 : Spanning-Tree status

```
LAB-SWITCH-04# sh spanning-tree vlan 10,20 brief

VLAN0010
  Spanning tree enabled protocol rstp
  Root ID      Priority      32778
                Address      5001.0000.1b08
                Cost          4
                Port          4 (Ethernet1/4)
                Hello Time    2 sec Max Age 20 sec Forward Delay 15 sec

  Bridge ID    Priority      32778 (priority 32768 sys-id-ext 10)
                Address      5004.0000.1b08
                Hello Time    2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost          Prio.Nbr Type
-----
Eth1/1         Altn BLK 4             128.1    P2p
Eth1/2         Altn BLK 4             128.2    P2p
Eth1/4         Root FWD 4             128.4    P2p

VLAN0020
  Spanning tree enabled protocol rstp
  Root ID      Priority      32788
                Address      5001.0000.1b08
                Cost          4
                Port          4 (Ethernet1/4)
                Hello Time    2 sec Max Age 20 sec Forward Delay 15 sec

  Bridge ID    Priority      32788 (priority 32768 sys-id-ext 20)
                Address      5004.0000.1b08
                Hello Time    2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost          Prio.Nbr Type
-----
Eth1/1         Altn BLK 4             128.1    P2p
Eth1/2         Altn BLK 4             128.2    P2p
Eth1/3         Desg FWD 4             128.3    P2p
Eth1/4         Root FWD 4             128.4    P2p

LAB-SWITCH-04#
```


LAB-SWITCH-01: HSRP Status

```
LAB-SWITCH-01# sh hsrp brief
*:IPv6 group  #:group belongs to a bundle
                P indicates configured to preempt.
                |
Interface      Grp  Prio P State   Active addr   Standby addr   Group addr
Vlan10         1    110 P Active   local         10.10.10.2     10.10.10.3
(conf)
Vlan20         2    110 P Active   local         20.20.20.2     20.20.20.3
(conf)
LAB-SWITCH-01#
```

LAB-SWITCH-02 : HSRP Status

```
LAB-SWITCH-02# sh hsrp brief
*:IPv6 group  #:group belongs to a bundle
                P indicates configured to preempt.
                |
Interface      Grp  Prio P State   Active addr   Standby addr   Group addr
Vlan10         1    100 Standby 10.10.10.1    local         10.10.10.3
(conf)
Vlan20         2    100 Standby 20.20.20.1    local         20.20.20.3
(conf)
LAB-SWITCH-02#
```

IV. BUSINESS CHALLENGE

From a business perspective:

- 1) Blocking expensive fiber links leads to resource underutilization.
- 2) All VLAN traffic passing through a single link increases operational costs and reduces network efficiency.

V. IMPLEMENTED SOLUTION

To optimize resource utilization and enhance network performance, the following solutions were implemented:

Per-VLAN Spanning Tree (PVST)

- 1) Configured separate primary and secondary paths for each VLAN to distribute traffic efficiently:
 - VLAN 10: Uses Link A as its primary path.
 - VLAN 20: Uses Link B as its primary path.
- 2) HSRP Configuration
- 3) Increased HSRP priority for VLAN 20 on the secondary switch to ensure smooth traffic flow at both Layer 2 and Layer 3.
- 4) To address this issue, we have implemented the following solutions to optimize resource utilization and enhance network performance:
- 5) For example, VLAN 10 uses Link A as its primary path, while VLAN 20 uses Link B.

```
LAB-SWITCH-02(config)# spanning-tree vlan 20 priority 4096
```


LAB-SWITCH-02: Spanning-Tree Status

```
LAB-SWITCH-02# sh spanning-tree vlan 10, 20 brie

VLAN0010
Spanning tree enabled protocol rstp
Root ID      Priority      32778
              Address      5001.0000.1b08
              Cost         4
              Port         1 (Ethernet1/1)
              Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID    Priority      32778 (priority 32768 sys-id-ext 10)
              Address      5002.0000.1b08
              Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Eth1/1         Root FWD 4         128.1    P2p
Eth1/2         Desg FWD 4         128.2    P2p
Eth1/4         Desg FWD 4         128.4    P2p

VLAN0020
Spanning tree enabled protocol rstp
Root ID      Priority      4116
              Address      5002.0000.1b08
              This bridge is the root
              Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID    Priority      4116 (priority 4096 sys-id-ext 20)
              Address      5002.0000.1b08
              Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Eth1/1         Desg FWD 4         128.1    P2p
Eth1/2         Desg FWD 4         128.2    P2p
Eth1/4         Desg FWD 4         128.4    P2p

LAB-SWITCH-02#
```

LAB-SWITCH-03: Spanning-Tree Status

```
LAB-SWITCH-03# sh spanning-tree vlan 10, 20 brie

VLAN0010
Spanning tree enabled protocol rstp
Root ID      Priority      32778
              Address      5001.0000.1b08
              Cost         4
              Port         2 (Ethernet1/2)
              Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID    Priority      32778 (priority 32768 sys-id-ext 10)
              Address      5003.0000.1b08
              Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Eth1/1         Desg FWD 4         128.1    P2p
Eth1/2         Root FWD 4         128.2    P2p
Eth1/3         Desg FWD 4         128.3    P2p
Eth1/4         Altn BLK 4         128.4    P2p

VLAN0020
Spanning tree enabled protocol rstp
Root ID      Priority      4116
              Address      5002.0000.1b08
              Cost         4
              Port         4 (Ethernet1/4)
              Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID    Priority      32788 (priority 32768 sys-id-ext 20)
              Address      5003.0000.1b08
              Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Type
-----
Eth1/1         Desg FWD 4         128.1    P2p
Eth1/2         Altn BLK 4         128.2    P2p
Eth1/4         Root FWD 4         128.4    P2p

LAB-SWITCH-03#
```

LAB-SWITCH-04: Spanning-Tree Status

```
LAB-SWITCH-04# sh spanning-tree vlan 10, 20 brie
```

VLAN0010

Spanning tree **enabled** protocol **rstp**

Root ID Priority 32778
Address 5001.0000.1b08
Cost 4
Port 4 (**Ethernet1/4**)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32778 (priority 32768 sys-id-ext 10)
Address 5004.0000.1b08
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

| Interface | Role | Sts | Cost | Prio.Nbr | Type |
|-----------|-------------|------------|------|----------|------|
| Eth1/1 | Altn | BLK | 4 | 128.1 | P2p |
| Eth1/2 | Altn | BLK | 4 | 128.2 | P2p |
| Eth1/4 | Root | FWD | 4 | 128.4 | P2p |

VLAN0020

Spanning tree **enabled** protocol **rstp**

Root ID Priority 4116
Address 5002.0000.1b08
Cost 4
Port 2 (**Ethernet1/2**)
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 32788 (priority 32768 sys-id-ext 20)
Address 5004.0000.1b08
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

| Interface | Role | Sts | Cost | Prio.Nbr | Type |
|-----------|-------------|------------|------|----------|------|
| Eth1/1 | Altn | BLK | 4 | 128.1 | P2p |
| Eth1/2 | Root | FWD | 4 | 128.2 | P2p |
| Eth1/3 | Desg | FWD | 4 | 128.3 | P2p |
| Eth1/4 | Altn | BLK | 4 | 128.4 | P2p |

```
LAB-SWITCH-04#
```

We need to increase the HSRP priority for VLAN 20 on the secondary switch to ensure smooth traffic flow not only at Layer 2 but also at Layer 3

LAB-SWITCH-02: HSRP Status

```
LAB-SWITCH-02# show hsrp brief
```

*:IPv6 group #:group belongs to a bundle
P indicates configured to preempt.

| Interface | Grp | Prio | P State | Active addr | Standby addr | Group addr |
|-------------------------|-----|------|----------------|-------------------|---------------------|-------------------|
| Vlan10 (conf) | 1 | 100 | Standby | 10.10.10.1 | local | 10.10.10.3 |
| Vlan20 (conf) | 2 | 120 | P Active | local | 20.20.20.1 | 20.20.20.3 |

```
LAB-SWITCH-02#
```

LAB-SWITCH-01: HSRP Status

```
LAB-SWITCH-01# sh hsrp brief
*:IPv6 group  #:group belongs to a bundle
                P indicates configured to preempt.
                |
Interface      Grp   Prio P State      Active addr      Standby addr      Group addr
Vlan10         1     110 P Active      local             10.10.10.2         10.10.10.3
(conf)
Vlan20         2     110 P Standby     20.20.20.2        local              20.20.20.3
(conf)
LAB-SWITCH-01#
```

VI. CISCO VIRTUAL PORT-CHANNEL (vPC)

Cisco's Virtual Port-Channel (vPC) is a groundbreaking feature available on Nexus switches. It enables two switches to function as a single logical switch to downstream devices, ensuring high availability, redundancy, and loop-free topologies.

A. Why vPC is Needed?

Traditional Layer 2/Layer 3 designs heavily relied on STP, which has limitations:

- Redundant Path Blocking: STP blocks redundant links, wasting valuable bandwidth.
- Convergence Delays: Topology changes can cause high delays, impacting performance.

B. vPC Advantages

- Enables active-active forwarding on multiple links.
- Eliminates STP blocking on redundant paths.
- Provides faster convergence, ensuring high availability.

C. Key Benefits of vPC

- 1) Reduces STP Dependency: Minimizes reliance on STP for loop prevention.
- 2) Maximizes Link Utilization: Supports active-active forwarding, using all available links.
- 3) Simplifies Network Architecture: Makes dual-homed device configurations straightforward.
- 4) Improves Reliability and Performance: Enhances network uptime and efficiency.

D. Base vPC Configuration

1) vPC Peer-Link

A dedicated port-channel between two Nexus switches for synchronization.

2) Downstream Devices

Devices connected to both switches via active-active links, leveraging vPC for optimal bandwidth and redundancy.

LAB-SWITCH-01: vPC status

```
LAB-SWITCH-01# sh run | sec vpc
feature vpc
vpc domain 1
  role priority 100
  peer-keepalive destination 1.1.1.2 source 1.1.1.1 vrf default
  vpc peer-link
  vpc 51
  vpc 52
LAB-SWITCH-01#
```




LAB-SWITCH-02: vPC status

```
LAB-SWITCH-02# sh run | sec vpc
feature vpc
vpc domain 1
  role priority 200
  peer-keepalive destination 1.1.1.1 source 1.1.1.2 vrf default
vpc peer-link
vpc 51
vpc 52
LAB-SWITCH-02#
```

Configuration for the downstream interface connected to the downstream switches

LAB-SWITCH-01

```
interface port-channel1
  switchport mode trunk
  spanning-tree port type network
  vpc peer-link

interface port-channel51
  switchport mode trunk
  vpc 51

interface port-channel52
  switchport mode trunk
  vpc 52

LAB-SWITCH-01#
```

LAB-SWITCH-02

```
interface port-channel1
  switchport mode trunk
  spanning-tree port type network
  vpc peer-link

interface port-channel51
  switchport mode trunk
  vpc 51

interface port-channel52
  switchport mode trunk
  vpc 52

LAB-SWITCH-02#
```

LAB-SWITCH-03 : Active interfaces connected to northbound devices

| Group | Port-Channel | Type | Protocol | Member Ports |
|----------------|--------------|------|----------|-----------------------|
| 10 | Po10 (SU) | Eth | LACP | Eth1/2 (P) Eth1/4 (P) |
| LAB-SWITCH-03# | | | | |

LAB-SWITCH-04 : Active interfaces connected to northbound devices

| Group | Port-Channel | Type | Protocol | Member Ports |
|----------------|--------------|------|----------|-----------------------|
| 10 | Po10 (SU) | Eth | LACP | Eth1/2 (P) Eth1/4 (P) |
| LAB-SWITCH-04# | | | | |

LAB-SWITCH-03 : Traffic is passing through both links without any blockage.

```
LAB-SWITCH-03# sh spanning-tree vlan 10,20 brief
```

| | | | | | | |
|---------------------------------------------------|-------------|-----------------------|-----------------|-----------------|---------------|--------|
| VLAN0010 | | | | | | |
| Spanning tree enabled protocol rstp | | | | | | |
| Root ID | Priority | 32778 | | | | |
| | Address | 5001.0000.1b08 | | | | |
| | Cost | 3 | | | | |
| | Port | 4105 (port-channel10) | | | | |
| | Hello Time | 2 sec | Max Age | 20 sec | Forward Delay | 15 sec |
| Bridge ID | Priority | 32778 | (priority 32768 | sys-id-ext 10) | | |
| | Address | 5003.0000.1b08 | | | | |
| | Hello Time | 2 sec | Max Age | 20 sec | Forward Delay | 15 sec |
| Interface | Role | Sts | Cost | Prio.Nbr | Type | |
| Po10 | Root | FWD | 3 | 128.4105 | P2p | |
| Eth1/3 | Desg | FWD | 4 | 128.3 | P2p | |
| VLAN0020 | | | | | | |
| Spanning tree enabled protocol rstp | | | | | | |
| Root ID | Priority | 32788 | | | | |
| | Address | 5001.0000.1b08 | | | | |
| | Cost | 3 | | | | |
| | Port | 4105 (port-channel10) | | | | |
| | Hello Time | 2 sec | Max Age | 20 sec | Forward Delay | 15 sec |
| Bridge ID | Priority | 32788 | (priority 32768 | sys-id-ext 20) | | |
| | Address | 5003.0000.1b08 | | | | |
| | Hello Time | 2 sec | Max Age | 20 sec | Forward Delay | 15 sec |
| Interface | Role | Sts | Cost | Prio.Nbr | Type | |
| Po10 | Root | FWD | 3 | 128.4105 | P2p | |

LAB-SWITCH-03#

LAB-SWITCH-04 : Traffic is passing through both links without any blockage.

```
LAB-SWITCH-04# sh spanning-tree vlan 10,20 brief

VLAN0010
  Spanning tree enabled protocol rstp
  Root ID    Priority      32778
             Address      5001.0000.1b08
             Cost         3
             Port         4105 (port-channel10)
             Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

  Bridge ID  Priority      32778 (priority 32768 sys-id-ext 10)
             Address      5004.0000.1b08
             Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Interface    Role Sts Cost      Prio.Nbr Type
-----
Po10         Root FWD 3         128.4105 P2p

VLAN0020
  Spanning tree enabled protocol rstp
  Root ID    Priority      32788
             Address      5001.0000.1b08
             Cost         3
             Port         4105 (port-channel10)
             Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

  Bridge ID  Priority      32788 (priority 32768 sys-id-ext 20)
             Address      5004.0000.1b08
             Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

Interface    Role Sts Cost      Prio.Nbr Type
-----
Po10         Root FWD 3         128.4105 P2p
Eth1/3       Desg FWD 4         128.3     P2p

LAB-SWITCH-04#
```

VII. CONCLUSION

With the implementation of PVST and vPC, we addressed inefficiencies in traditional STP by enabling better resource utilization and ensuring a robust, scalable, and high-performing network. By increasing HSRP priority for VLAN 20 on the secondary switch, traffic flow has been optimized at both Layer 2 and Layer 3, enhancing overall network stability and business operations.



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45.98



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