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Network Revolution in the IT Industry: Transforming Connectivity and Innovation

Pradip Suresh Patole
Blackbox Network Services, USA

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:

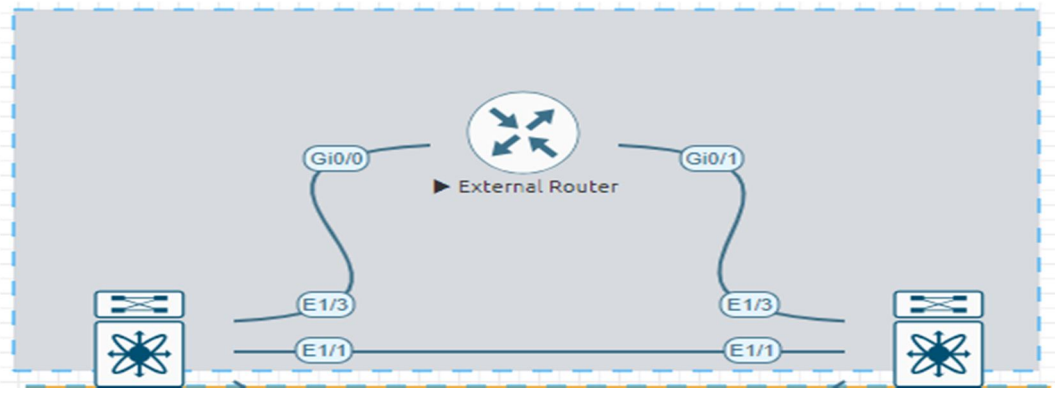
- Hello Time**: Interval between BPDU transmissions (default: 2 seconds).**
- Forward Delay**: Time spent in the listening and learning states (default: 15 seconds each).**
- Max Age: Time before considering a BPDU invalid (default: 20 seconds).

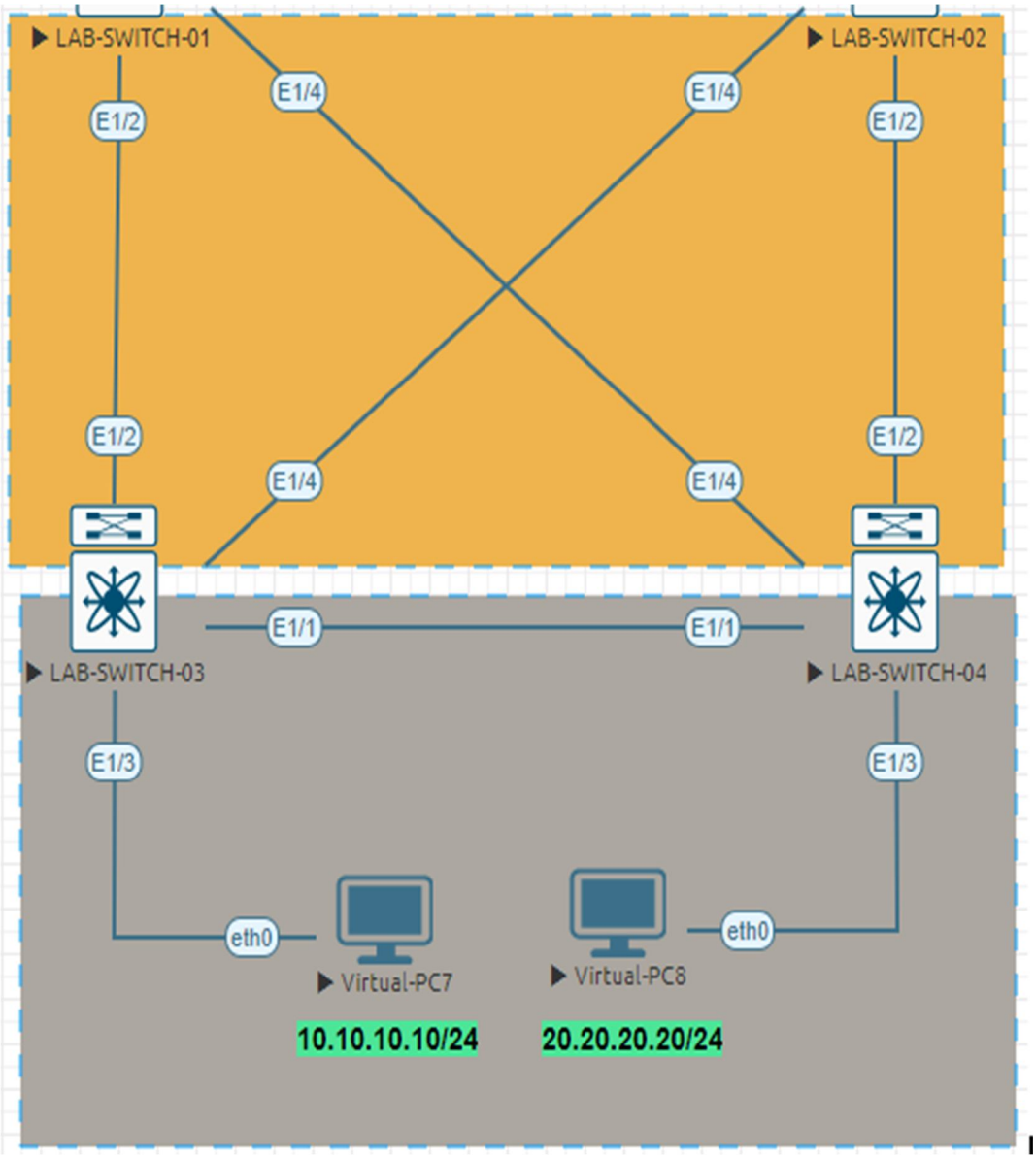
5) Redundant Path Management: Blocks redundant paths and only activates them when the primary path fails.

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.

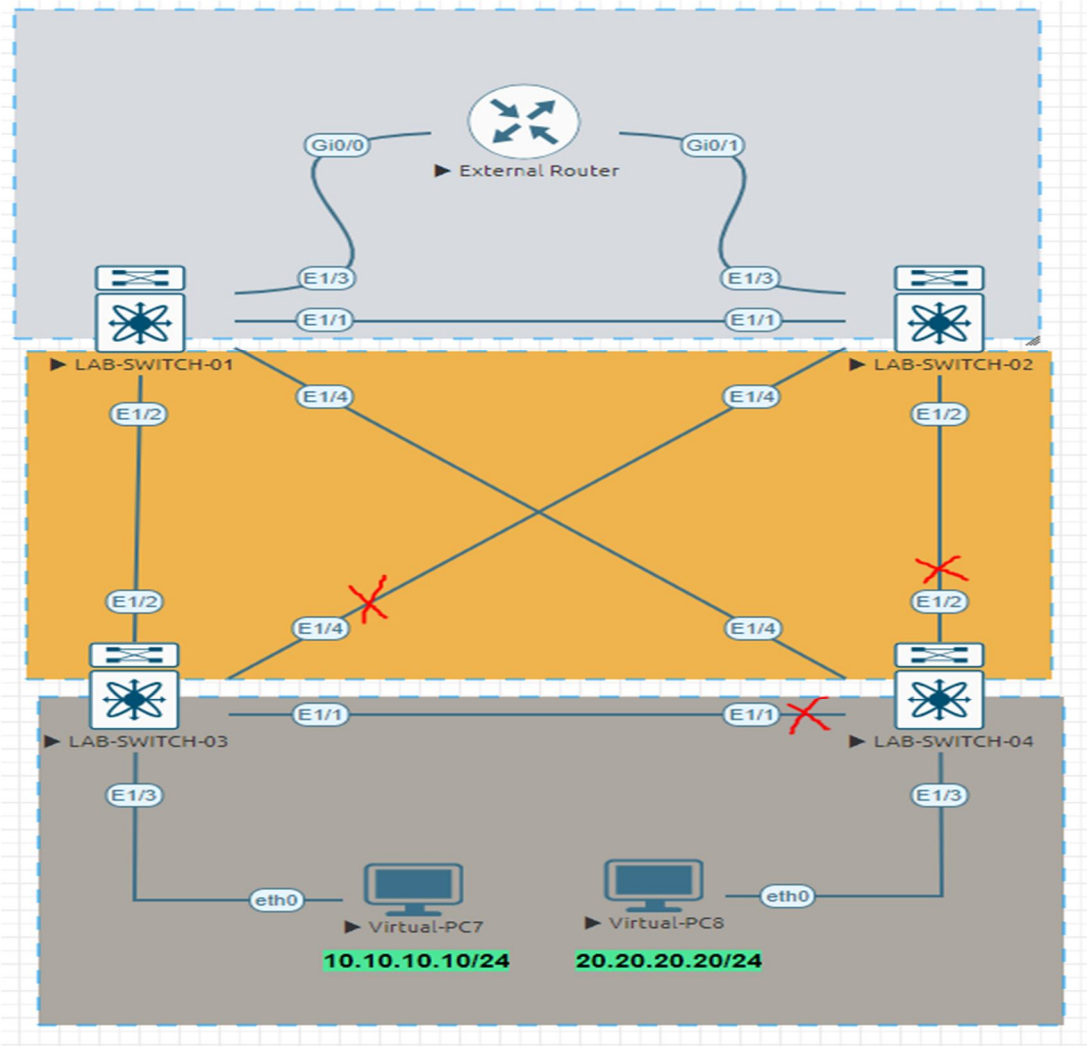
LAB-SWITCH-01 – Root Bridge for Vlan 10, 20

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

                                        Root  Hello Max Fwd
Vlan                Root ID             Cost  Time  Age 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

                                        Root  Hello Max Fwd
Vlan                Root ID             Cost  Time  Age 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

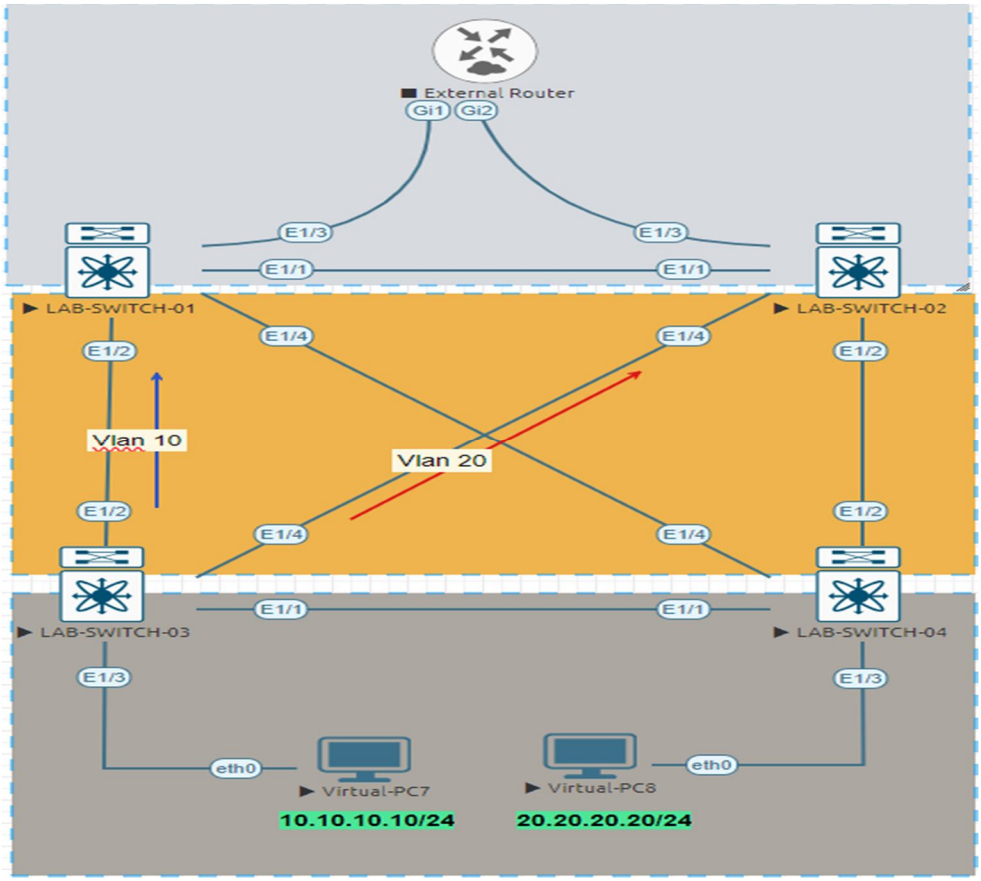
3) Increased HSRP priority for VLAN 20 on the secondary switch to ensure smooth traffic flow at both Layer 2 and Layer 3.

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
```

Base Topology : Traffic Flow per Vlan



LAB-SWITCH-01: Spanning-Tree Status

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

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
Eth1/4           Desg FWD 4         128.4    P2p


VLAN0020
  Spanning tree enabled protocol rstp
  Root ID     Priority    4116
              Address     5002.0000.1b08
              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     5001.0000.1b08
              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

LAB-SWITCH-01#
```

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      1    100    Standby  10.10.10.1       local            10.10.10.3
     (conf)
  Vlan20      2    120  P Active   local            20.20.20.1       20.20.20.3
     (conf)
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-       Type     Protocol   Member Ports
      Channel
--------------------------------------------------------------------------------
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-       Type     Protocol   Member Ports
      Channel
--------------------------------------------------------------------------------
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.

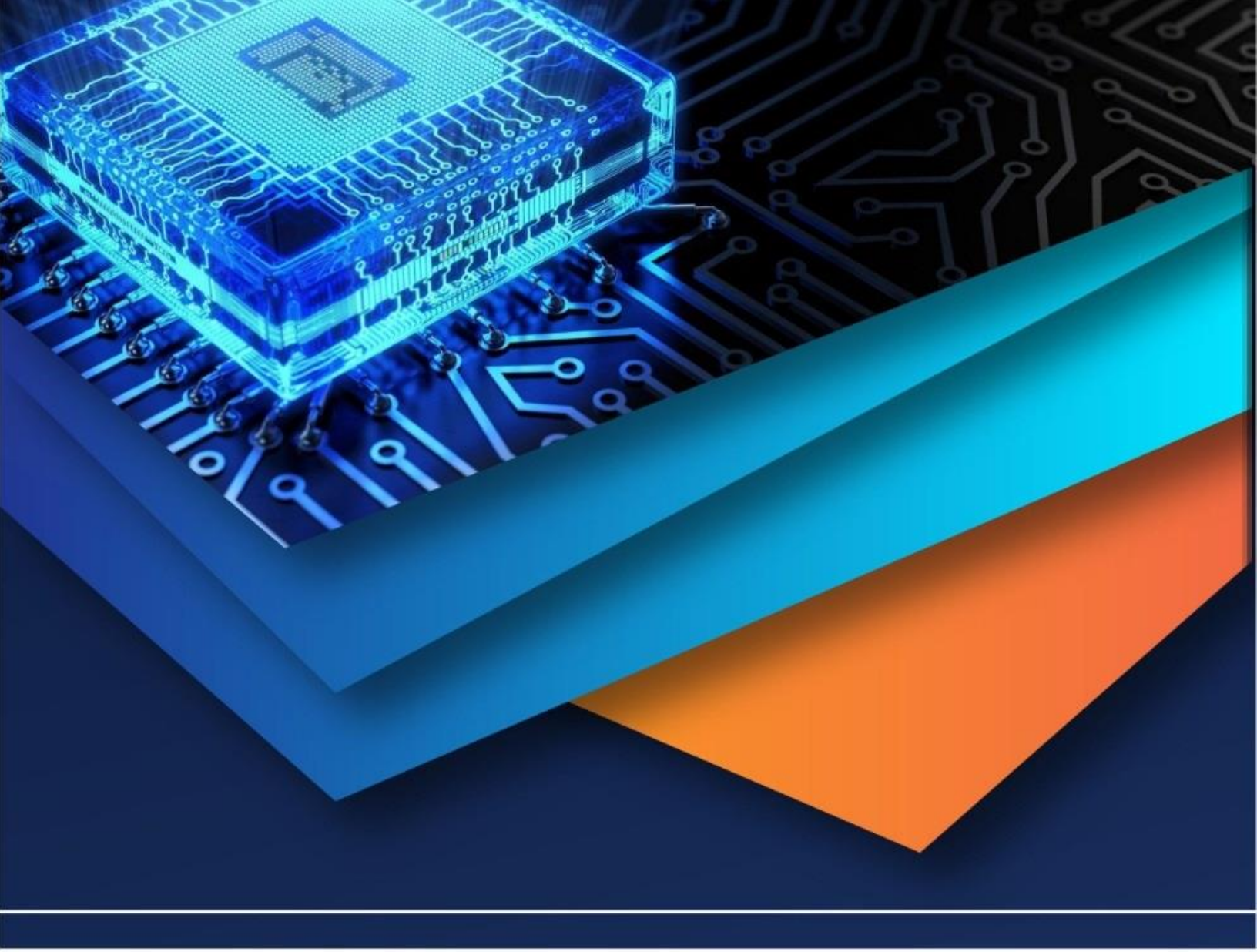
```
LAB-SWITCH-03# sh spanning-tree vlan 10,20 brief

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

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

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