Building Cisco Multilayer Switched Networks (BCMSN)

Advanced
Spanning-Tree Protocol (STP)

http://www.INE.com

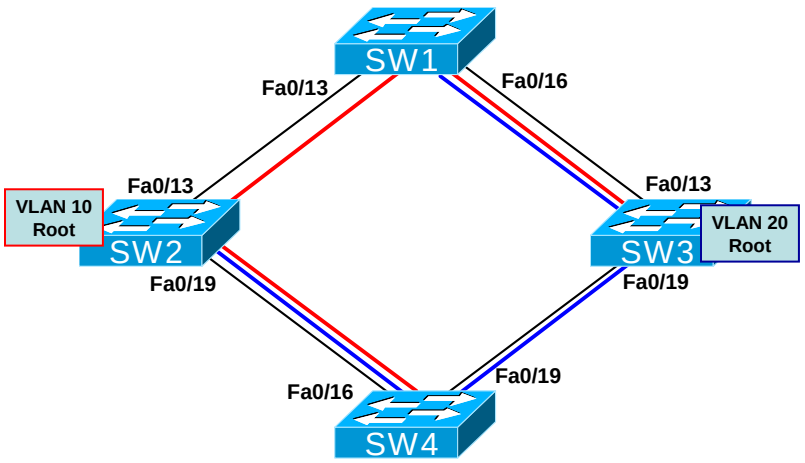
Cisco STP Enhancements

- Common Spanning-Tree (CST)
  - Originally defined in 802.1D
  - One STP instance for all VLANs
    - Does not allow complex layer 2 traffic engineering
- Per-VLAN Spanning-Tree (PVST)
  - Cisco proprietary extensions
  - One STP instance per VLAN
    - Layer 2 traffic engineering per VLAN
  - New features to reduce convergence time
    - PortFast, UplinkFast, etc.
  - PVST+ interoperates with CST
    - Complex tunneling outside our scope
    - See INE Blog's PVST+ Explained for details

PVST/PVST+ Path Selection

- One Root Bridge election per VLAN
  - Bridge priority per VLAN configurable as **`spanning-tree vlan [vlan] [priority|root]`**
- Separate Root Port & Designated Port elections per VLAN
  - Port cost per VLAN configurable as interface **`spanning-tree vlan [vlan] cost [cost]`**
  - Port priority per VLAN configurable as interface **`spanning-tree vlan [vlan] priority [priority]`**

Per-VLAN Path Selection Example



Per-VLAN Path Selection Configuration

```
SW2#
spanning-tree vlan 10 priority 16384
!
interface FastEthernet0/19
 spanning-tree vlan 20 cost 5

SW3#
spanning-tree vlan 20 priority 16384
!
interface FastEthernet0/13
 spanning-tree vlan 10 cost 5
```


Per-VLAN Path Selection Verification

```
SW2#show spanning-tree vlan 10

VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    16394
             Address     0019.aa7e.ea00
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    16394  (priority 16384 sys-id-ext 10)
             Address     0019.aa7e.ea00
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 15

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/13           Desg FWD 19        128.15   P2p
Fa0/19           Desg FWD 19        128.21   P2p

SW3#show spanning-tree vlan 10

VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    16394
             Address     0019.aa7e.ea00
             Cost        24
             Port        13 (FastEthernet0/13)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext 10)
             Address     000a.f4f3.e780
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 15

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/13           Root FWD 5         128.13   P2p
Fa0/19           Altn BLK 19        128.19   P2p
```


Per-VLAN Path Selection Verification (cont.)

```
SW2#show spanning-tree vlan 20

VLAN0020
  Spanning tree enabled protocol ieee
  Root ID    Priority    16404
             Address     000a.f4f3.e780
             Cost        24
             Port        21 (FastEthernet0/19)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32788  (priority 32768 sys-id-ext 20)
             Address     0019.aa7e.ea00
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 15

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/13           Altn BLK 19        128.15   P2p
Fa0/19           Root FWD 5         128.21   P2p

SW3#show spanning-tree vlan 20

VLAN0020
  Spanning tree enabled protocol ieee
  Root ID    Priority    16404
             Address     000a.f4f3.e780
             This bridge is the root
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    16404  (priority 16384 sys-id-ext 20)
             Address     000a.f4f3.e780
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 15

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/13           Desg FWD 19        128.13   P2p
Fa0/19           Desg FWD 19        128.19   P2p
```


Cisco's 802.1D Convergence Enhancements

- PortFast
  - End hosts need not be subject to Forwarding Delay
- UplinkFast
  - Direct Root Port failure should reconverge immediately if Alternate Port available
- BackboneFast
  - Indirect failures should start recalculating immediately

RSTP

- Rapid Spanning-Tree Protocol
- New standard per IEEE 802.1w
- Faster convergence than Cisco's 802.1D enhancements
- Simplifies port states and uses handshaking proposal/agreement process for rapid convergence

RSTP Port States

- 802.1D uses…
  - Disabled
  - Blocking
  - Listening
  - Learning
  - Forwarding
- 802.1w simplifies this to…
  - Discarding
    - Dropping frames
  - Learning
    - Dropping frames but building the CAM
  - Forwarding
    - Normal forwarding

RSTP Port Roles

- New port roles allow for faster convergence than 802.1D
- Root Port & Designated Port
  - Same as before
- Alternate Port
  - Alternate but less desirable path to the root
  - Allows the equivalent of UplinkFast
  - Operates in discarding state
- Backup Port
  - Backup *Designated Port*
  - Could be Alternate if both Root and Designated ports go down
  - Operates in discarding state

RSTP Edge Ports

- Equivalent of PVST+ PortFast enabled ports
  - Immediately transitions to forwarding
  - Still requires **`spanning-tree portfast`** command for backwards compatibility
- Maintains edge status as long as no BPDUs are received
  - If BPDU received, remove edge status and generate TCN

RSTP Link Types

- Non-edge ports fall into two types
- Point-to-point
  - Full-Duplex ports
- Shared
  - Half-Duplex ports
- *Only point-to-point Designated Ports use proposal process for rapid convergence*

RSTP Proposal Process

- Root Bridge sends proposal out Designated Ports
- If downstream switch agrees that Root Bridge has superior BPDU…
  - All other non-edge ports blocked
  - Agreement sent to back out port proposal received on
  - Port immediately transitioned to Root Port
- Proposal continues downstream
- Proposal & agreement process typically happens sub-second
- If no response to proposal received, revert to Listening & Learning
  - Backwards compatibility with 802.1D

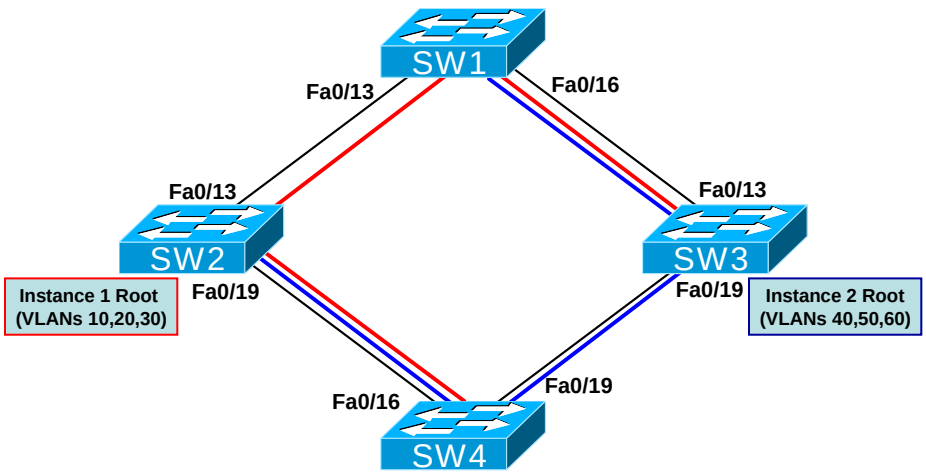
RSTP Reconvergence

- In 802.1D, BPDUs are only generated by Root Bridge
  - All other bridges forward them on
- In RSTP, each bridge generates BPDU every hello interval
  - 2 seconds by default
- If 3 hellos are missed from a neighbor, reconvergence begins
  - 6 seconds vs. 20 seconds MaxAge

Multiple Spanning-Tree Protocol

- IEEE (802.1s) response to PVST/PVST+
- Supports multiple user-defined instances of spanning-tree
- Not as resource intensive as PVST/PVST+
- Automatically runs RSTP

MST & RSTP Example



MST Configuration

```
SW1#
spanning-tree mst configuration
 name MST_REGION1
 revision 1
 instance 1 vlan 10, 20, 30
 instance 2 vlan 40, 50, 60
!
spanning-tree mode mst

SW2#
spanning-tree mst configuration
 name MST_REGION1
 revision 1
 instance 1 vlan 10, 20, 30
 instance 2 vlan 40, 50, 60
!
spanning-tree mode mst
spanning-tree mst 1 priority 4096
!
interface FastEthernet0/19
 spanning-tree mst 2 cost 50000
```

```
SW3#
spanning-tree mst configuration
 name MST_REGION1
 revision 1
 instance 1 vlan 10, 20, 30
 instance 2 vlan 40, 50, 60
!
spanning-tree mode mst
spanning-tree mst 2 priority 4096
!
interface FastEthernet0/13
 spanning-tree mst 1 cost 50000

SW4#
spanning-tree mst configuration
 name MST_REGION1
 revision 1
 instance 1 vlan 10, 20, 30
 instance 2 vlan 40, 50, 60
!
spanning-tree mode mst
```

MST Verification

```
SW2#show spanning-tree mst 1

##### MST1    vlans mapped:   10,20,30
Bridge        address 0019.aa7e.ea00  priority      4097  (4096 sysid 1)
Root          this switch for MST1

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/13           Desg FWD 200000    128.15   P2p
Fa0/19           Desg FWD 200000    128.21   P2p

SW3#show spanning-tree mst 1

##### MST1    vlans mapped:   10,20,30
Bridge        address 000a.f4f3.e780  priority      32769 (32768 sysid 1)
Root          address 0019.aa7e.ea00  priority      4097  (4096 sysid 1)
              port    Fa0/13          cost          250000    rem hops 18

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/13           Root FWD 50000     128.13   P2p
Fa0/19           Altn BLK 200000    128.19   P2p
```


MST Verification (cont.)

```
SW2#show spanning-tree mst 2

##### MST2    vlans mapped:   40,50,60
Bridge        address 0019.aa7e.ea00  priority      32770 (32768 sysid 2)
Root          address 000a.f4f3.e780  priority      4098  (4096 sysid 2)
              port    Fa0/19          cost          250000    rem hops 18

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/13           Altn BLK 200000    128.15   P2p
Fa0/19           Root FWD 50000     128.21   P2p

SW3#show spanning-tree mst 2

##### MST2    vlans mapped:   40,50,60
Bridge        address 000a.f4f3.e780  priority      4098  (4096 sysid 2)
Root          this switch for MST2

Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/13           Desg FWD 200000    128.13   P2p
Fa0/19           Desg FWD 200000    128.19   P2p
```


Rapid PVST+

- Same as PVST+, but uses RSTP enhancements for rapid convergence
- Configured as **`spanning-tree mode rapid-pvst`**

Other STP Features

- BPDU Filter
  - Interface level
    - Filter BPDUs inbound/outbound
  - Global
    - If BPDU is received revert out of portfast state
- BPDU Guard
  - If BPDU is received shut port down
- Root Guard
  - If superior BPDU is received shut port down
- Loop Guard & UDLD
  - Prevent unidirectional links

Advanced STP Q&A