LAB GUIDE

Deploying basic STP

a Hewlett Packard Enterprise company

IMPORTANT! THIS GUIDE ASSUMES THAT THE AOS-CX OVA HAS BEEN INSTALLED AND WORKS IN GNS3 OR EVE-NG. PLEASE REFER TO GNS3/EVE-NG INITIAL SETUP LABS IF REQUIRED.

WRITE MEM SAVED CONFIGS DON'T IMPORT CORRECTLY, READER SHOULD COPY/PASTE LAB CONFIGS FROM APPENDIX INTO LAB IF REQUIRED.

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Lab Objective

This lab is aimed at audiences who have little knowledge of spanning-tree or wish to have a 'refresh' on the key spanning tree concepts.

At the end of this workshop, you will be able to implement and understand the basic configuration to enable the Spanning Tree Protocol (STP).

The main goal of this lab is to deploy a basic LAN Topology with redundant links, configure and enable spanning -tree and observe the STP status and behavior under normal conditions.

The key STP concepts of spanning tree root bridge, root port, designated bridge and designated port, path cost and STP timers are introduced to consolidate understanding.

This lab concentrates on the STP protocol leveraging MSTP with a default region 0 to simplify configuration. MSTP is backwardly compatible with STP (based on the IEEE 802.1d standard of to eliminate loops at the data link layer in a LAN) and it this configuration profile which is used in the lab.

In a narrow sense, STP refers to IEEE 802.1d STP. In a broad sense, STP refers to the IEEE 802.1d STP and various enhanced spanning tree protocols derived from that protocol, such as RPVST+ and MSTP.

The underlying concepts of STP apply to all Spanning tree protocols and it is these fundamental concepts that are the focus of this lab.

Lab Overview

LANs often have redundant links as backups in case of failures, but loops are a very serious problem. Devices running STP detect loops in the network by exchanging information with one another. They eliminate loops by selectively blocking certain ports to prune the loop structure into a loop-free tree structure. This avoids proliferation and infinite cycling of packets that would occur in a loop network.

In the lab, MSTP with region 0 , the default region, will be enabled on all switches to participate in the spanning-tree.

- A root bridge will be identified
- Bridge priorities will be changed
- Port costs will be changed

BPDUs

STP uses bridge protocol data units (BPDUs), also known as configuration messages, as its protocol packets. STP-enabled network devices exchange BPDUs to establish a spanning tree. STP uses the following types of BPDUs:

- Configuration BPDUs: Used by the network devices to calculate a spanning tree and maintain the spanning tree topology.

- Topology change notification (TCN) BPDUs: Use to notify network devices of network topology changes.

Root Bridge

A tree network must have a root bridge. The entire network contains only one root bridge, and all the other bridges in the network are called leaf nodes. The root bridge is not permanent, but can change with changes of the network topology.

Upon initialization of a network, each switch device generates and periodically sends configuration BPDUs, with itself as the root bridge. After network convergence, only the root bridge generates and periodically sends configuration BPDUs. The other devices only forward the BPDUs.

Root Port

On a non-root bridge, the port which has the least cost to reach the root bridge is the root port.

The root port communicates with the root bridge. Each non-root bridge has only one root port. The root bridge has no root port.

Designated port

A designated port is a not a root port but is it permitted to forward traffic . Designated ports are selected per segment based on the ‘port’ cost on either side of the segment and used by STP for the total cost calculation back to the root bridge. If one end of a switch link (segment) is a designated port then the other end is a root port or a ‘blocked’ port. All ports on the root bridge are assigned as designated ports.

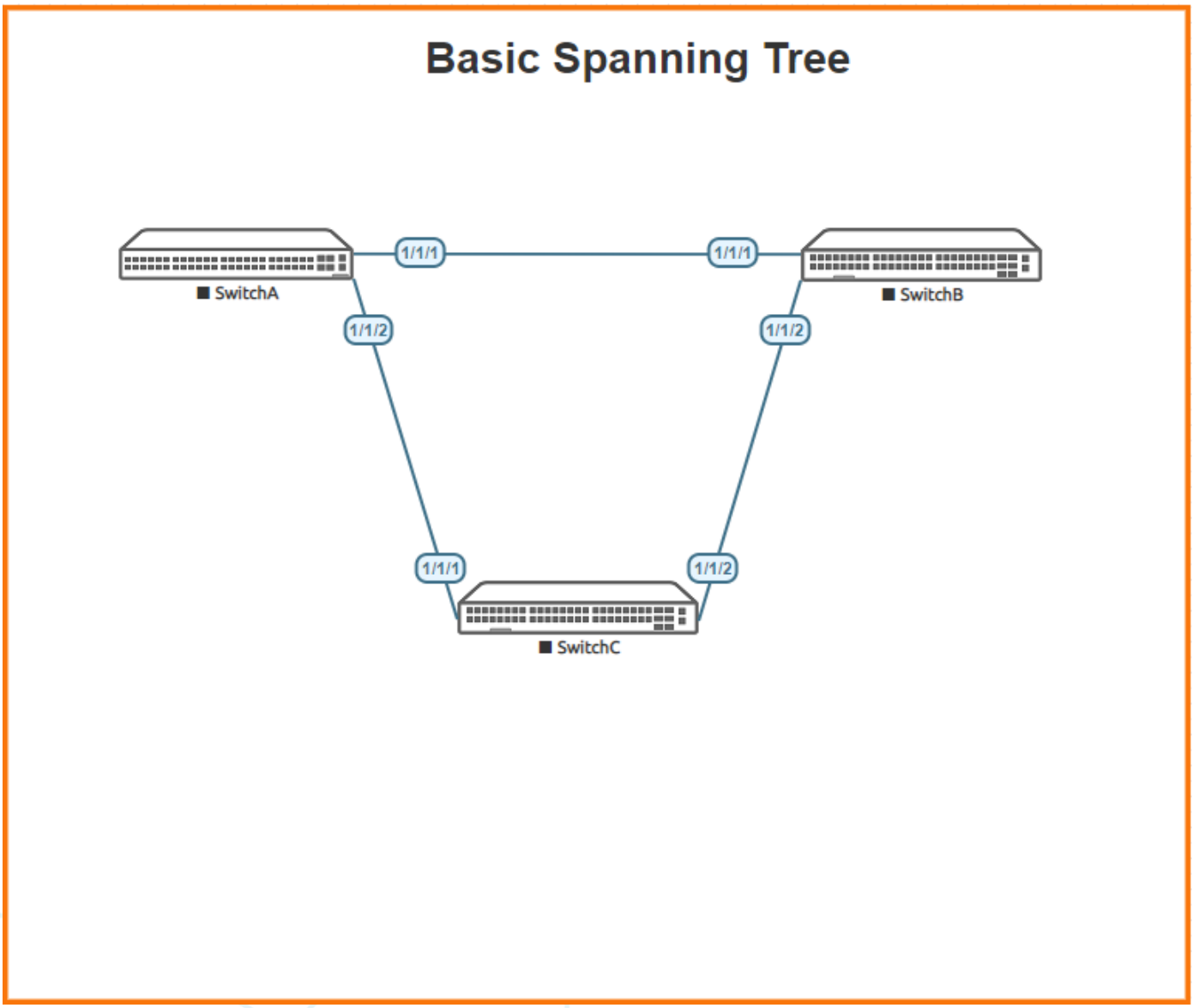
Alternate port

An alternate port relates to the blocking state of spanning tree (802.1D) . A blocked port is neither the root port or the designated port.

Path cost

Path cost is a reference value used fo link selection in STP. STP calculates the path costs to select the preferred links and blocks redundant links to prune the network into a loop free tree.

Lab Network Layout



Lab Tasks

Task 1 - Lab setup

MAC addressing and forwarding states will vary between labs and are presented as examples for illustration along with the interface forwarding states..

For this lab refer to Figure 1 for topology.

- Start all the devices
- Open each switch console and log in with user “admin” and no password
- Change all hostnames as shown in the topology:

```
hostname …
```

- On all devices, bring up required ports and remove routing:

```
int 1/1/1-1/1/2
  no shutdown
no routing
```

- Validate LLDP neighbors appear as expected

```
show lldp neighbor
```

SwitchA

```
SwitchA# sh lldp neighbor-info

LLDP Neighbor Information
=========================

Total Neighbor Entries          : 2
Total Neighbor Entries Deleted  : 0
Total Neighbor Entries Dropped  : 0
Total Neighbor Entries Aged-Out : 0

LOCAL-PORT  CHASSIS-ID         PORT-ID          PORT-DESC               TTL      SYS-NAME
-------------------------------------------------------------------------------------------
1/1/1       08:00:09:1a:7c:31  1/1/1            1/1/1                   120      SwitchB

1/1/2       08:00:09:d6:0c:85  1/1/1            1/1/1                   120      SwitchC

SwitchA#
```

END OF TASK1

Task 2 – Enable Spanning Tree on Switch A, B & C and review output

- On all switches, enable spanning tree and set the spanning tree mode to MSTP
- Identify the current root bridge within the topology using the 'sh spanning-tree' command

Configure spanning tree on all switches.

```
SwitchA(config)# spanning-tree mode mstp
```

Enable spanning-tree

```
SwitchA(config)# spanning-tree
```

Identify the current root bridge

On all switches

```
sh spanning-tree
```

Example output –

SwitchA

```
SwitchA# sh spanning-tree
Spanning tree status      : Enabled Protocol: MSTP
MST0
  Root ID    Priority    : 32768
             MAC-Address: 08:00:09:1a:7c:31
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15
  Bridge ID  Priority  : 32768
             MAC-Address: 08:00:09:fb:91:8b
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15
Port         Role          State      Cost          Priority   Type             BPDU-Tx    BPDU-Rx  TCN-Tx  TCN-Rx
------------ ------------- ---------- ------------- ---------- ---------------- ---------- ---------- ---------- -
1/1/1        Root          Forwarding 20000         128        P2P  Bound       39         104        2          2
1/1/2        Alternate     Blocking   20000         128        P2P  Bound       21         125        3          4
```

SwitchB

```
SwitchB# sh spanning-tree
Spanning tree status      : Enabled Protocol: MSTP
```

```
MST0
  Root ID    Priority    : 32768
             MAC-Address: 08:00:09:1a:7c:31
             This bridge is the root
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15
  Bridge ID  Priority    : 32768
             MAC-Address: 08:00:09:1a:7c:31
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15
Port         Role           State      Cost           Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx TCN-Rx
------------ -------------- ---------- -------------- ---------- --------------- ---------- ---------- ---------- -
1/1/1        Designated     Forwarding 20000          128        P2P             359          2          2        2
1/1/2        Designated     Forwarding 20000          128        P2P             359          3          2        2
```

SwitchC

```
SwitchC# sh spanning-tree
Spanning tree status      : Enabled Protocol: MSTP
MST0
  Root ID    Priority    : 32768
             MAC-Address: 08:00:09:1a:7c:31
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15
  Bridge ID  Priority  : 32768
             MAC-Address: 08:00:09:d6:0c:85
             Hello time(in seconds):2  Max Age(in seconds):20
             Forward Delay(in seconds):15
Port         Role           State      Cost           Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx    TCN-Rx
------------ -------------- ---------- -------------- ---------- --------------- ---------- ---------- ---------- -
1/1/1        Designated     Forwarding 20000          128        P2P               586        4          4          3
1/1/2        Root           Forwarding 20000          128        P2P  Bound        23         564        2          2
```

Bridge Priorities

Every switch participating spanning tree has a bridge priority. The switch with the lowest bridge priority becomes the ‘root’ bridge. The default bridge priority is 37268 and all switches in this example have the default bridge priority of 32768.

- The tie break if each spanning tree switch ‘bridge’ has the same bridge priority is the bridge mac address.
- If all switches have the same spanning tree bridge priority the switch with the lowest bridge mac address becomes the root bridge.

In the example, Switch A,B & Switch C output is shown. All switches have the same bridge priority, but Switch B has a lower bridge mac address and becomes the root bridge.

Switch A STP interface port status

Port	Role	State	Cost	Priority	Type		BPDU-Tx	BPDU-Rx	TCN-Tx	TCN-Rx
1/1/1	Root	Forwarding	20000	128	P2P	Bound	39	806	2	2
1/1/2	Alternate	Blocking	20000	128	P2P	Bound	21	827	3	4

Port 1/1/1 is in the ‘root ‘ port role and is in the forwarding state to the root bridge – to Switch B

Port 1/1/2 is in the ‘Alternate’ role and is in the ‘blocking’ state – to Switch C

Switch B STP interface port status

Port	Role	State	Cost	Priority	Type	BPDU-Tx	BPDU-Rx	TCN-Tx	TCN-Rx
1/1/1	Designated	Forwarding	20000	128	P2P	889	2	2	2
1/1/2	Designated	Forwarding	20000	128	P2P	889	3	2	2

Ports 1/1/1 & 1/1/2 are both in the ‘Designated’ port role and are forwarding to Switch A and Switch C respectively

Switch C STP interface port status

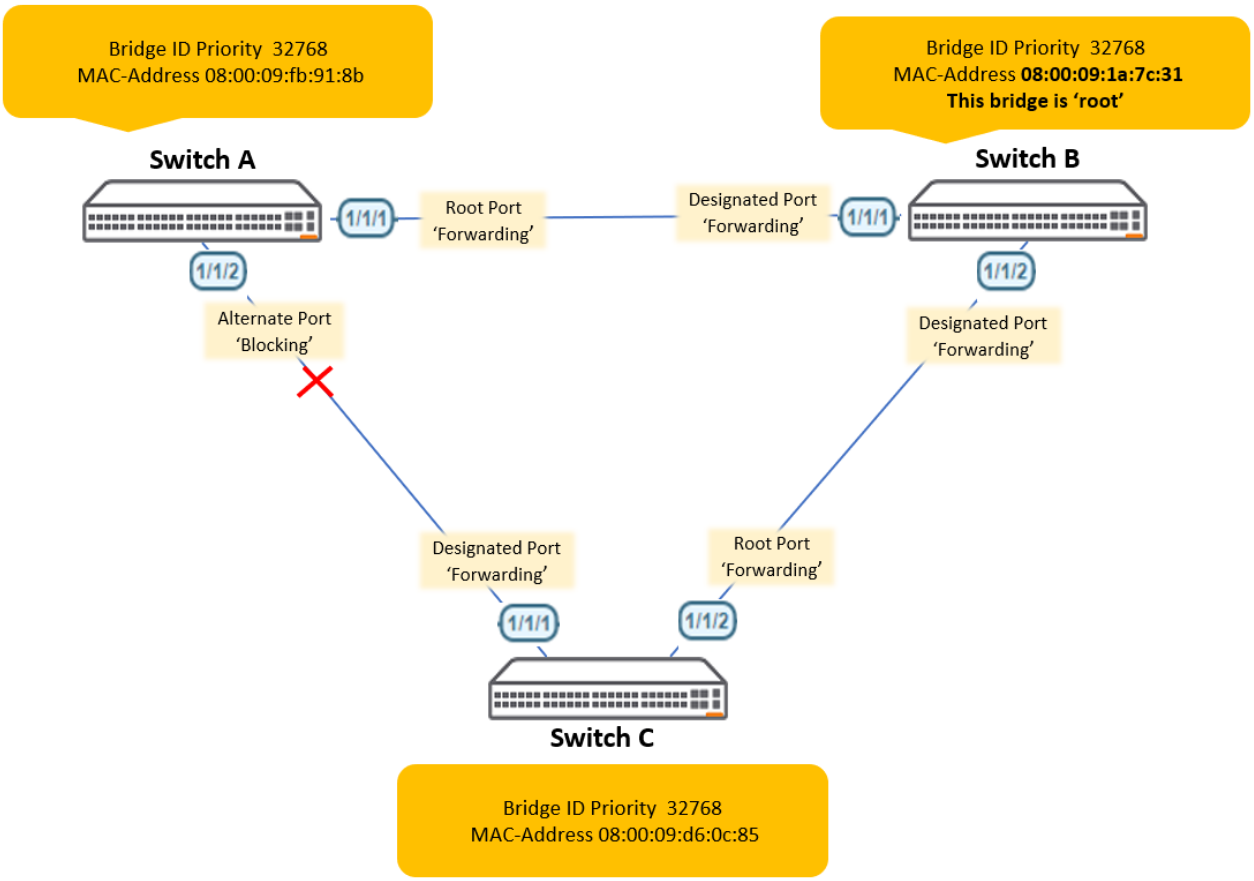
Port	Role	State	Cost	Priority	Type		BPDU-Tx	BPDU-Rx	TCN-Tx	TCN-Rx
1/1/1	Designated	Forwarding	20000	128	P2P		983	4	4	3
1/1/2	Root	Forwarding	20000	128	P2P	Bound	23	962	2	2

Port 1/1/2 is the root forwarding port. The port with the least cost to the root bridge.

Port 1/1/1 is in the designated forwarding state.

Switch A port 1/1/2 is in the alternate blocking state to provide a loop free network.

The spanning tree topology in this example will look like the example below(exact port forwarding states in other labs may vary from this example):-



- The STP root bridge will have all STP ports in the 'designated forwarding' Role.

- Other switches, non-root bridges, participating in STP will have 1 port designated as the 'Root Port Forwarding'. This is the port which has the least cost to reach the root bridge and is the root port

- Other ports on non-root bridges will either be in the 'Designated Port Forwarding ' role which is a non-root port but permitted to forward traffic or in the alternate port 'blocking' state to prevent a bridging 'loop'.

END OF TASK2

Task 3 – Changing Bridge priorities

On Switch A change the spanning priority to make Switch A the ‘root’ bridge by changing the ‘bridge priority’. Switch A may already be the root bridge by having the lowest mac address.

```
SwitchA(config)# spanning-tree priority 1
```

Enter
`SwitchA# sh spanning-tree`

The root bridge priority will change to 4096 and Switch A will become the ‘root’ bridge and interfaces 1/1/1 and 1/1/2 will both be in the ‘designated forwarding’ role.

The CX-OS spanning priorities range from 0-15. Each number has a value of ‘4096’ . The default bridge priority id 32768 , equaling the value 8, as the default spanning priority (8*4096=32768)

Switch A

```
SwitchA# sh spanning-tree

Spanning tree status      : Enabled Protocol: MSTP

MST0

  Root ID    Priority    : 4096

             MAC-Address: 08:00:09:fb:91:8b

             This bridge is the root

             Hello time(in seconds):2  Max Age(in seconds):20

             Forward Delay(in seconds):15

  Bridge ID  Priority  : 4096

             MAC-Address: 08:00:09:fb:91:8b

             Hello time(in seconds):2  Max Age(in seconds):20

             Forward Delay(in seconds):15

Port         Role           State      Cost           Priority   Type             BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx

------------ -------------- ---------- -------------- ---------- ---------------- ---------- ---------- ---------- ----------

1/1/1        Designated     Forwarding 20000          128        P2P              138        1990       4          2

1/1/2        Designated     Forwarding 20000          128        P2P              120        2011       5          4
```

Enter the `‘sh spanning-tree’` command on switch B & C and identify which port is in the ‘alternate port blocking’ state

Each switch bridge should recognize a change in the STP root bridge priority, a change in the root bridge mac address and the STP port role state will change on each switch for each port participating in STP.

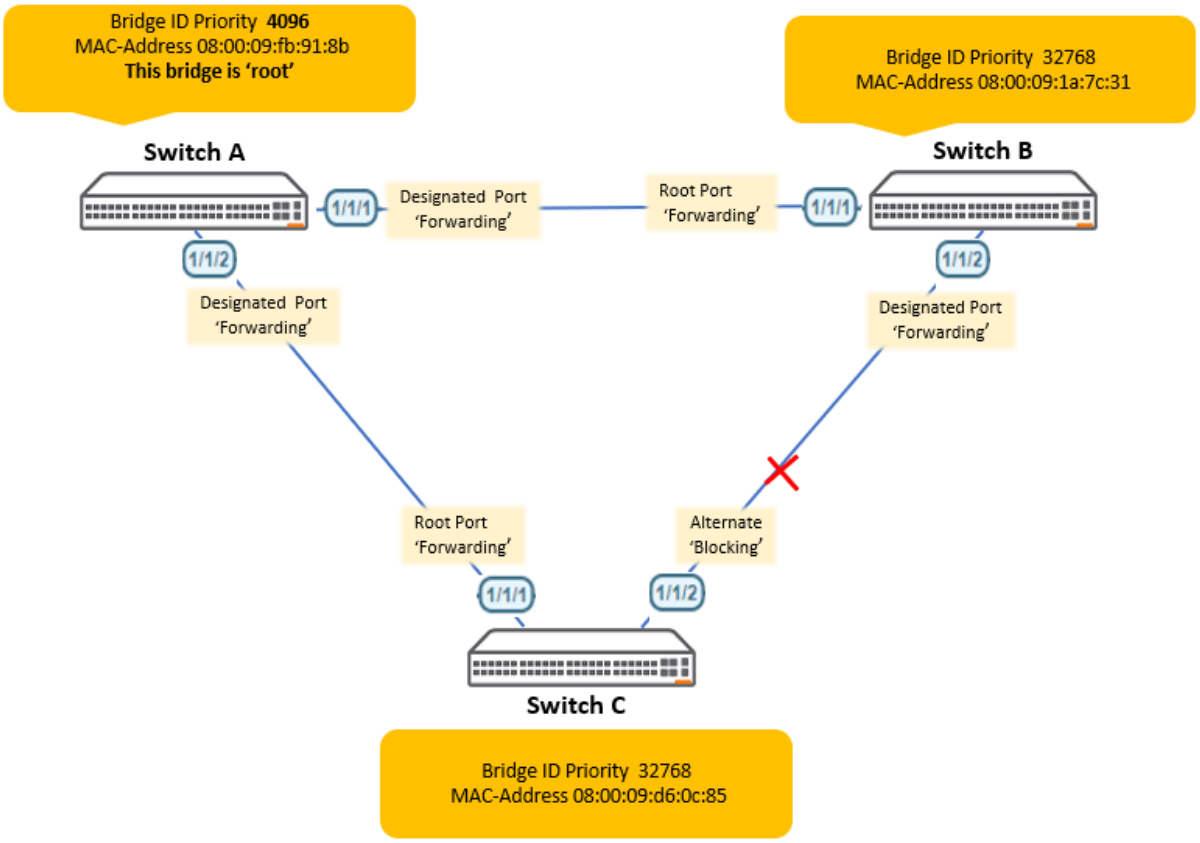
Switch B

```
SwitchB# sh spanning-tree

Spanning tree status      : Enabled Protocol: MSTP

MST0

  Root ID    Priority   : 4096

             MAC-Address: 08:00:09:fb:91:8b

             Hello time(in seconds):2  Max Age(in seconds):20

             Forward Delay(in seconds):15

  Bridge ID  Priority  : 32768

             MAC-Address: 08:00:09:1a:7c:31

             Hello time(in seconds):2  Max Age(in seconds):20

             Forward Delay(in seconds):15

Port         Role           State      Cost           Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx

------------ -------------- ---------- -------------- ---------- --------------- ---------- ---------- ---------- ----------

1/1/1        Root           Forwarding 20000          128        P2P  Bound      1990       913        2          4

1/1/2        Designated     Forwarding 20000          128        P2P             2900       5          4          2
```

Switch C

```
SwitchB# sh spanning-tree

Spanning tree status      : Enabled Protocol: MSTP

MST0

  Root ID    Priority   : 4096

             MAC-Address: 08:00:09:fb:91:8b

             Hello time(in seconds):2  Max Age(in seconds):20

             Forward Delay(in seconds):15

  Bridge ID  Priority  : 32768

             MAC-Address: 08:00:09:1a:7c:31

             Hello time(in seconds):2  Max Age(in seconds):20

             Forward Delay(in seconds):15

Port         Role           State      Cost           Priority   Type            BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx

------------ -------------- ---------- -------------- ---------- --------------- ---------- ---------- ---------- ----------

1/1/1        Root           Forwarding 20000          128        P2P  Bound      2021       2860       10         11
1/1/2        Alternate      Blocking   20000          128        P2P  Bound      57         4818       3          12
```

The spanning tree topology in this example will now look like the example below(exact port forwarding states in other labs may vary from this example):-



END OF TASK3

Task 4 – Changing port costs

There may be situations where the forwarding root port may not be the preferred interface to forward data and the alternate blocking or designated forwarding ports maybe the preferable STP 'root' forwarding port on a switch. Port costs can be changed on each interface which can alter the forwarding/blocking STP roles.

- On Switch C, change the 'root' port forwarding interface cost from the default cost of 20000 (10Gbps) to 2000000 (10mbps). This will be on the interface directly connect to the root bridge.(interface 1/1/1)

An example below on Switch C with Switch A as root using the default port costs:-:

```
Port          Role           State      Cost           Priority   Type             BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx

------------ -------------- ---------- -------------- ---------- ---------------- ---------- ---------- ---------- ----------

1/1/1         Root           Forwarding 20000          128        P2P  Bound       2021       2860       10         11
1/1/2         Alternate      Blocking   20000          128        P2P  Bound       57         4818       3          12
```

On Switch C

Change interface 1/1/1 to reflect a port cost of 2000000 (to reflect a low speed 10mbps link)

```
SwitchC(config)# interface 1/1/1
SwitchC(config-if)# spanning-tree cost 2000000
```

Review the changed port cost with the '`sh spanning-tree`' command

```
Port          Role           State      Cost           Priority   Type             BPDU-Tx    BPDU-Rx    TCN-Tx     TCN-Rx

------------ -------------- ---------- -------------- ---------- ---------------- ---------- ---------- ---------- ----------

1/1/1         Alternate      Blocking   2000000        128        P2P  Bound       2029       3798       12         17
1/1/2         Root           Forwarding 20000          128        P2P  Bound       179        5640       8          16
```

The STP port roles are now reversed as interface 1/1/1 is now perceived to be further away from the root bridge with a higher path cost back to the root even though it is directly connected to the root bridge.

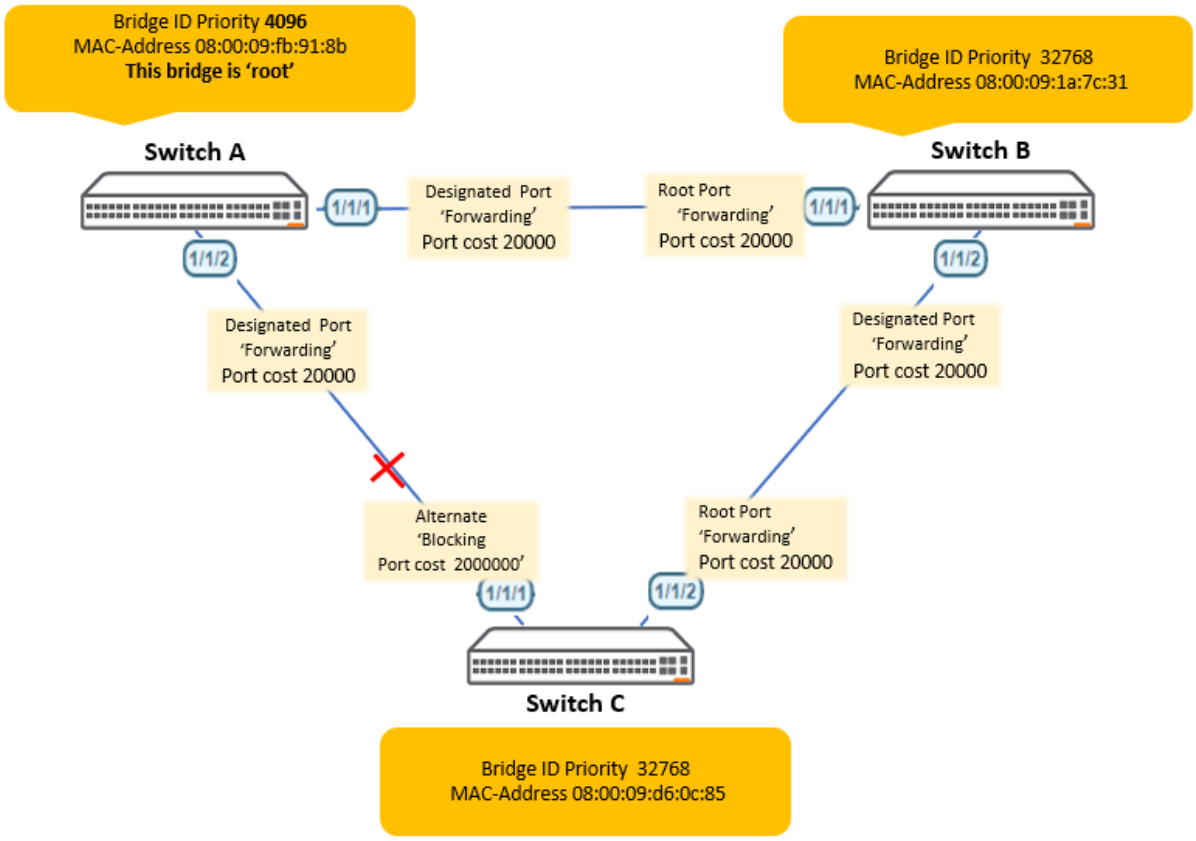
By default, a port cost is defined by the speed at which the port operates and is directly related to the ports associated bandwidth. A port with the lowest accumulated cost to the root bridge will become the 'root ' forwarding port. If an interface cost is not configured, the cost is determined by the interface link speed and the number of 'hops' to the root bridge.

The default interface port costs are:-

- 10 Mbps link speed equals a path cost of 2,000,000.
- 100 Mbps link speed equals a path cost of 200,000.
- 1 Gbps link speed equals a path cost of 20,000.
- 2 Gbps link speed equals a path cost of 10,000.
- 10 Gbps link speed equals a path cost of 2,000.
- 100 Gbps link speed equals a path cost of 200.

- 1 Tbps link speed equals a path cost of 20.

The final STP topology in the lab will look like :-



END OF LAB TASKS

Appendix – Complete Configurations

SwitchA

```
Current configuration:
!
!Version ArubaOS-CX Virtual.10.06.0001
!export-password: default
hostname SwitchA
led locator on
!
!
!
!
ssh server vrf mgmt
vlan 1
spanning-tree
spanning-tree priority 1
interface mgmt
    no shutdown
    ip dhcp
interface 1/1/1
    no shutdown
    no routing
    vlan access 1
interface 1/1/2
    no shutdown
    no routing
    vlan access 1
!
!
!
!
!
https-server vrf mgmt
```

SwitchB

```
Current configuration:
!
!Version ArubaOS-CX Virtual.10.06.0001
!export-password: default
hostname SwitchB
!
!
!
!
ssh server vrf mgmt
vlan 1
spanning-tree
interface mgmt
    no shutdown
    ip dhcp
interface 1/1/1
    no shutdown
    no routing
    vlan access 1
interface 1/1/2
    no shutdown
    no routing
    vlan access 1
!
!
!
!
!
https-server vrf mgmt
```

SwitchC

```
SwitchC# sh runn
Current configuration:
!
```

```
!Version ArubaOS-CX Virtual.10.06.0001
!export-password: default
hostname SwitchC
led locator on
!
!
!
!
ssh server vrf mgmt
vlan 1
spanning-tree
interface mgmt
    no shutdown
    ip dhcp
interface 1/1/1
    no shutdown
    no routing
    vlan access 1
    spanning-tree cost 2000000
interface 1/1/2
    no shutdown
    no routing
    vlan access 1
!
!
!
!
!
https-server vrf mgmt
```

END OF DOCUMENT

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