

Deploying basic STP

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

本实验面向对生成树知之甚少或希望对关键的生成树概念有重新认识的受众。

在本研讨会结束时，您将能够实施并了解启用生成树协议(STP)的基本配置。

本实验的主要目标是部署具有冗余链路的基本局域网拓扑，配置并启用生成树，并观察正常情况下的STP状态和行为。

为了加深理解，引入了生成树根网桥root bridge、根端口root port、指定网桥designated bridge和指定端口designated port、路径开销path cost和STP计时器timer等关键STP概念。

本实验重点介绍STP协议，该协议利用默认区域0(region 0)的MSTP来简化配置。MSTP向后兼容STP(基于消除局域网中数据链路层环路的IEEE 802.1d标准)，并支持本实验中使用的配置文件。

狭义上，STP指的是IEEE 802.1d STP。广义上，STP指的是IEEE 802.1d STP以及从该协议派生的各种增强型生成树协议，例如RPVST+和MSTP。

STP的基本概念适用于所有生成树协议，正是这些基本概念是本实验的重点。

Lab Overview

在发生故障时，局域网通常有冗余链路作为备份，但环路是一个非常严重的问题。运行STP的设备通过彼此交换信息来检测网络中的环路。它们通过选择性地阻塞某些端口来消除环路，从而将环路结构修剪成无环路的树结构。这避免了在环状网络中可能发生的数据包扩散和无限循环。

在本实验中，将在所有交换机上启用区域0(默认区域)的MSTP以参与生成树。

- A root bridge will be identified 确定根网桥
- Bridge priorities will be changed 更改网桥优先级
- Port costs will be changed 更改端口开销

BPDUs

STP使用网桥协议数据单元(BPDU)(也称为配置消息)作为其协议数据包。启用STP的网络设备交换BPDU以建立生成树。STP使用以下类型的BPDU（两种消息类型）：

- Configuration BPDUs: Used by the network devices to calculate a spanning tree and maintain the spanning tree topology. 配置BPDU:由网络设备用来计算和维护生成树拓扑
- Topology change notification (TCN) BPDUs: Use to notify network devices of network topology changes.

TCN BPDU，传达网络拓扑变更

Root Bridge

树状网络(tree network)必须有根网桥。整个网络只包含一个根桥，网络中的所有其他网桥都称为叶节点（leaf nodes）。根桥不是永久性的，会随着网络拓扑的变化而变化。

BID (bridgeID) 最小为根桥

在网络初始化时，每台交换机设备都会生成并定期发送配置BPDU，并将其自身作为根桥。网络收敛(network convergence)后，只有根桥生成并定期发送配置BPDU。其他设备仅转发BPDU。

Root Port

在非根网桥上，到达根网桥的开销最低的端口是根端口。

根端口与根网桥通信。每个非根网桥只有一个根端口。根网桥没有根端口。

Designated port

指定端口不是根端口，但允许转发流量。根据网段两端的端口开销为每个网段选择指定端口，并由STP用于计算返回根网桥的总成本。如果交换机链路(网段)的一端是指定端口，则另一端是根端口或被阻止的端口。根桥上的所有端口都被分配为指定端口。

Alternate port

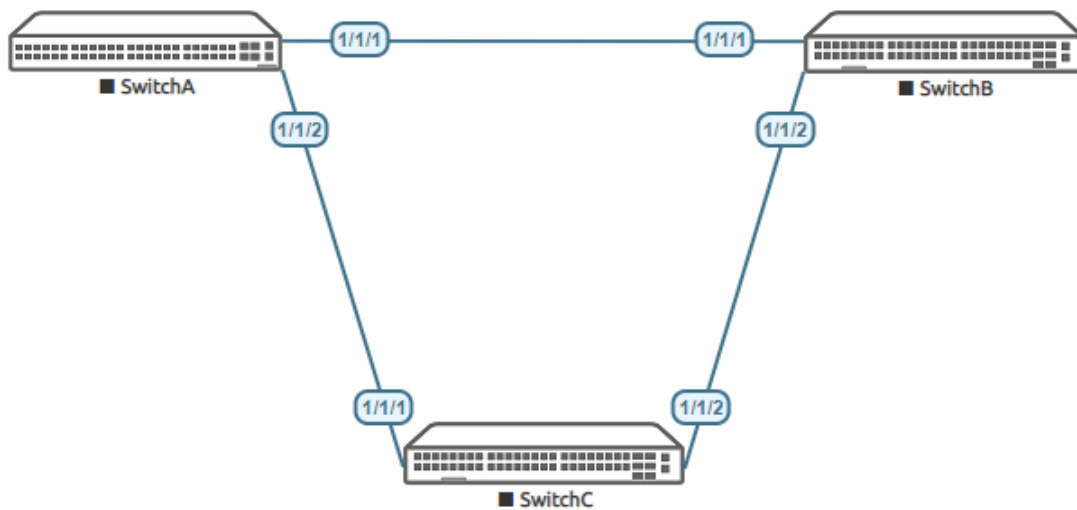
替换端口与生成树(802.1D)的阻塞状态有关。被阻止的端口既不是根端口，也不是指定端口。

Path cost

路径开销是STP中用于链路选择的参考值。STP计算路径开销以选择首选链路，并阻塞冗余链路将网络修剪成无环树。

Lab Network Layout

Basic Spanning Tree



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

参与生成树的每台交换机都有网桥优先级。具有最低网桥优先级的交换机将成为“根”网桥。默认网桥优先级为32768，本例中的所有交换机的默认网桥优先级均为32768。

- 如果每个生成树交换机‘网桥’具有相同的网桥优先级，则打破平局是网桥MAC地址。
- 如果所有交换机具有相同的生成树网桥优先级，则具有最低网桥MAC地址的交换机将成为根桥。

在本例中，显示了交换机A、B和交换机C的输出。所有交换机都具有相同的网桥优先级，但交换机B的网桥MAC地址较低，因此成为根网桥。

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

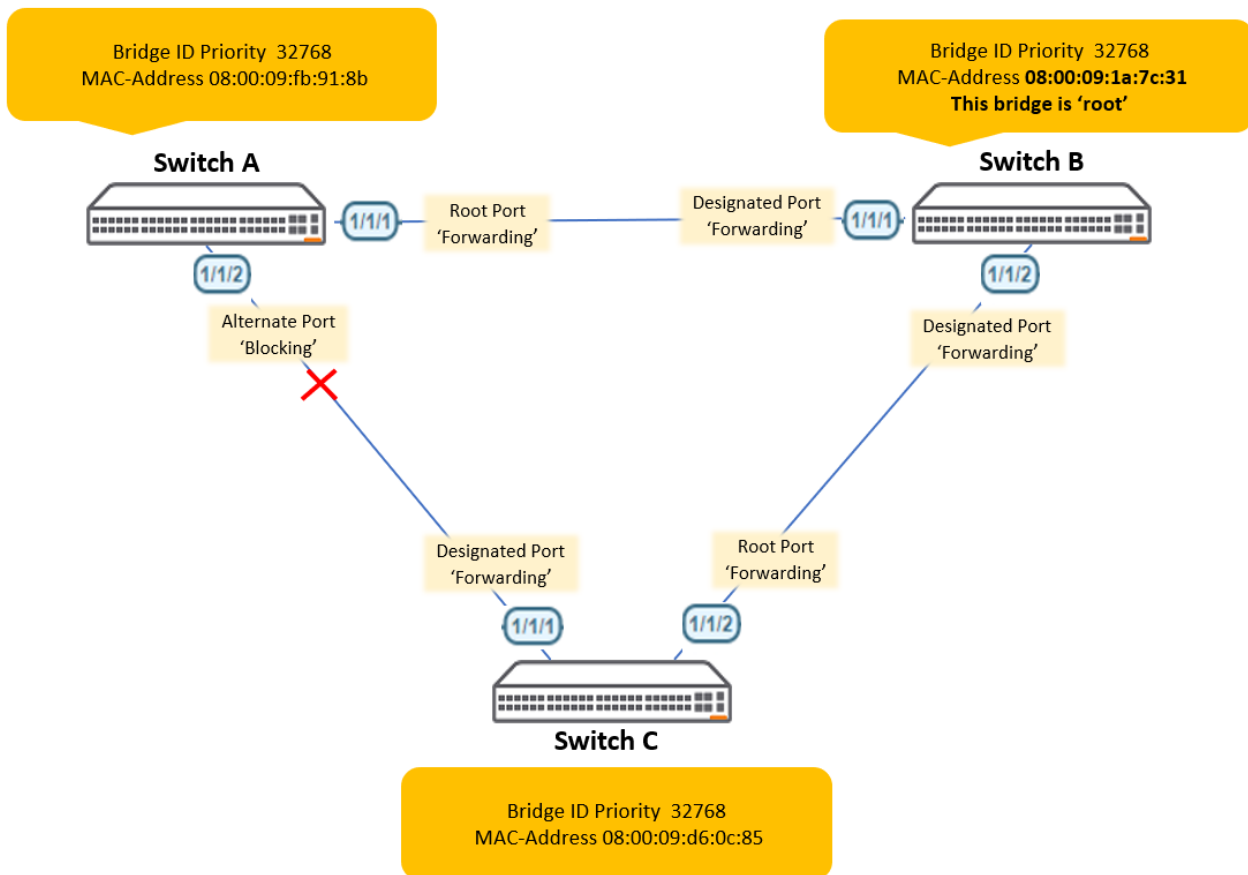
Port	Role	State	Cost	Priority	Type	BPDU-Tx	BPDU-Rx	TCN-Tx	TCN-Rx
1/1/1	Designated	Forwarding	20000	128	P2P	983	4	4	3
1/1/2	Root	Forwarding	20000	128	P2P Bound	23	962	2	2

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.

本例中的生成树拓扑如下例所示(其他实验中的确切端口转发状态可能与本例有所不同):



- STP根网桥的所有STP端口都将处于“指定转发”角色。
- 参与STP的其他交换机(非根网桥)将有一个端口被指定为“根端口转发”。这是到达根网桥的开销最低的端口，也是根端口
- 非根网桥上的其他端口将处于非根端口的指定端口转发角色，但允许转发通信量，或者处于备用端口“阻止”状态，以防止桥接“环路”。

END OF TASK2

Task 3 – Changing Bridge priorities

在交换机A上，通过更改“网桥优先级”来更改生成优先级，使交换机A成为“根”桥。如果您的环境下由于具有最低的MAC地址，交换机A可能已经是根桥，可尝试修改其他交换机优先级。

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

```
Enter
SwitchA# sh spanning-tree
```

根网桥优先级将更改为4096，交换机A将成为‘根’网桥，接口1/1/1和1/1/2都将扮演‘指定转发’的角色。

CX-OS优先级的范围为0-15。每个数字的值都是‘4096’。默认网桥优先级id 32768，等于值8，(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

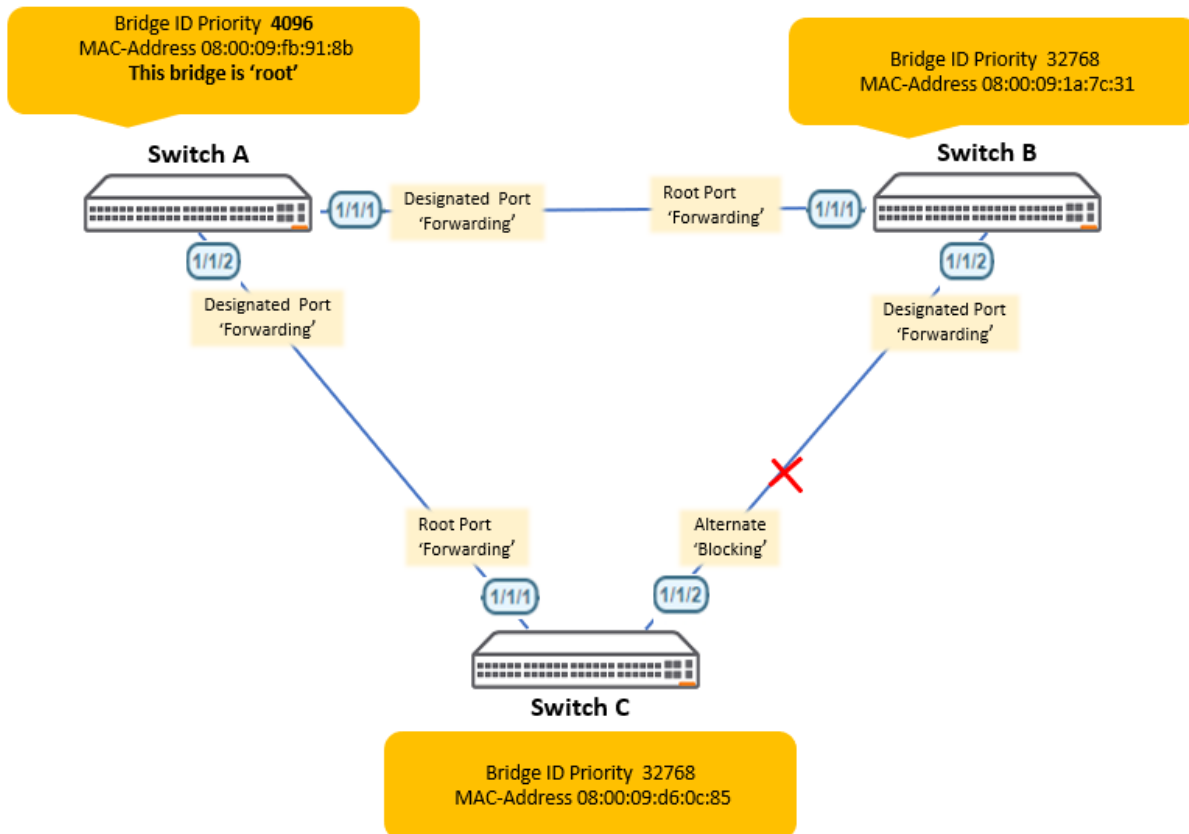
MAC-Address: 08:00:09:1a:7c:31

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

可能存在这样的情况，其中转发根端口可能不是转发数据的最优接口，而备用阻塞或指定转发端口可能是交换机上最优的STP根转发端口。可以在每个接口上更改端口成本，这会改变转发/阻塞STP角色。

- 在交换机C上，将'根'端口转发接口开销从默认开销20000(10Gbps)更改为2000000(10 Mbps)。这是位于直接连接到根桥的接口上。(接口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.

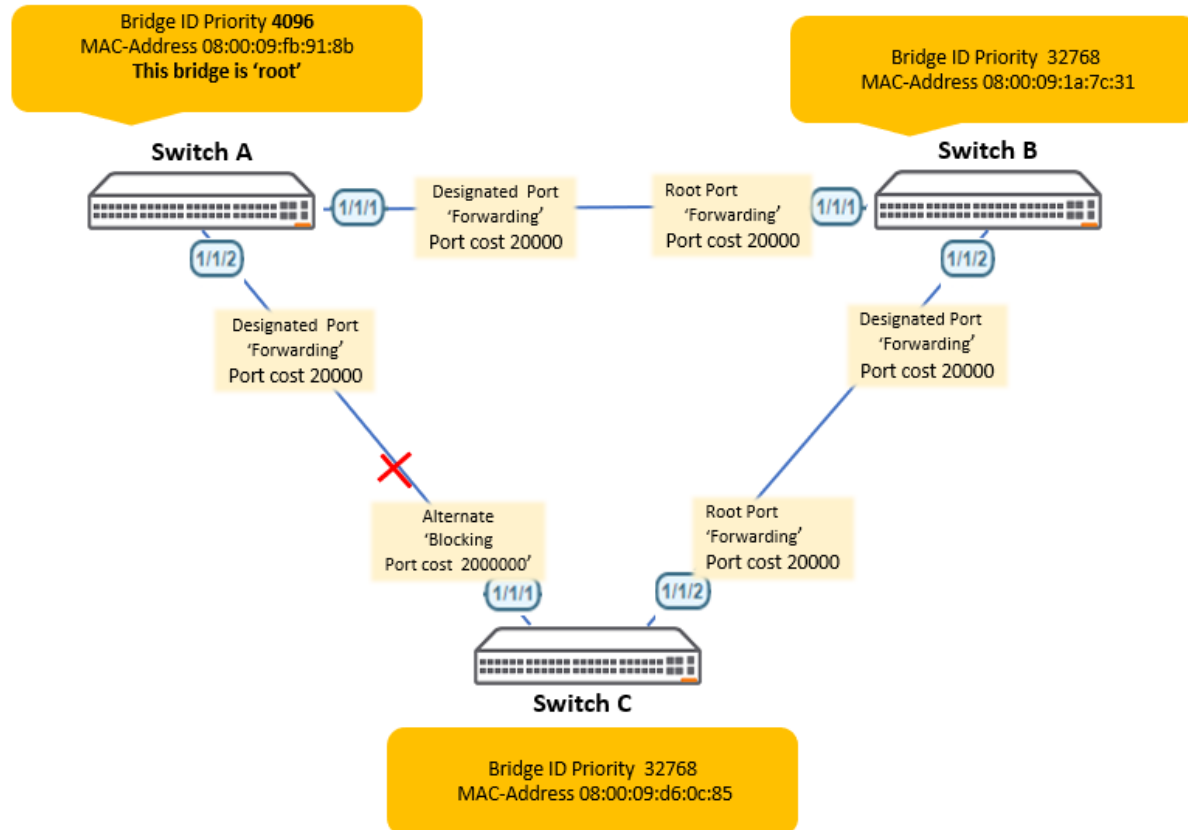
默认情况下，端口开销由端口的运行速度定义，并与端口关联的带宽直接相关。到根桥的累积开销最低的端口将成为“根”转发端口。如果未配置端口开销，则开销由接口链路速度和到达根网桥的跳数决定。

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