The Goals Of Loop Prevention

What Is A Bridging Loop?

Broadcast

A

1

2   3
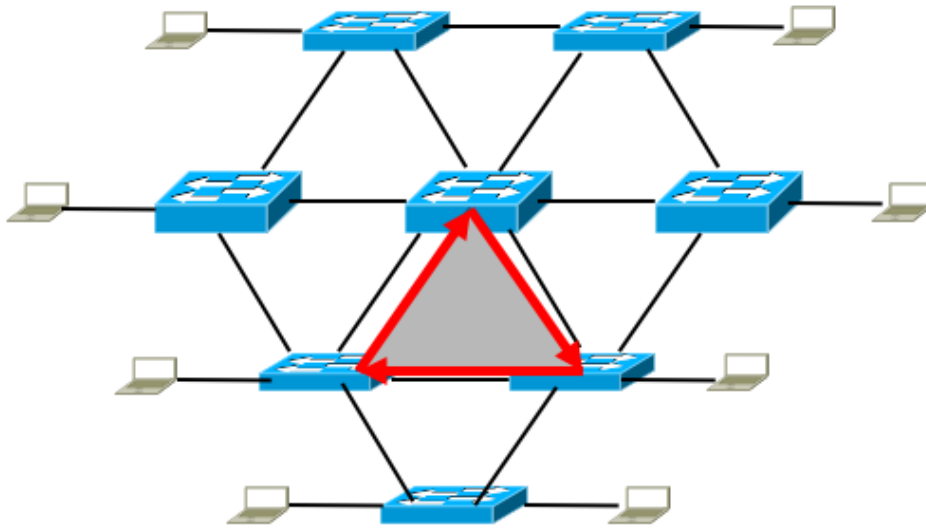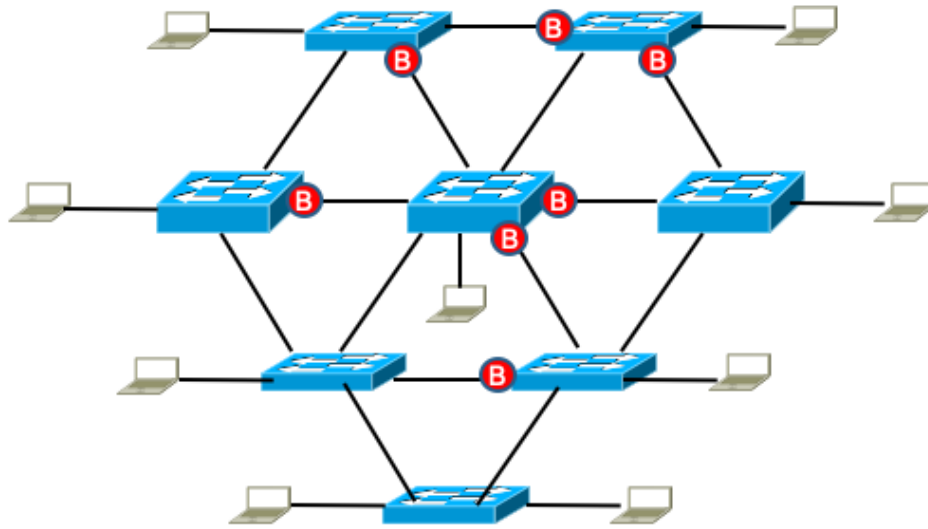
4   5

6

B
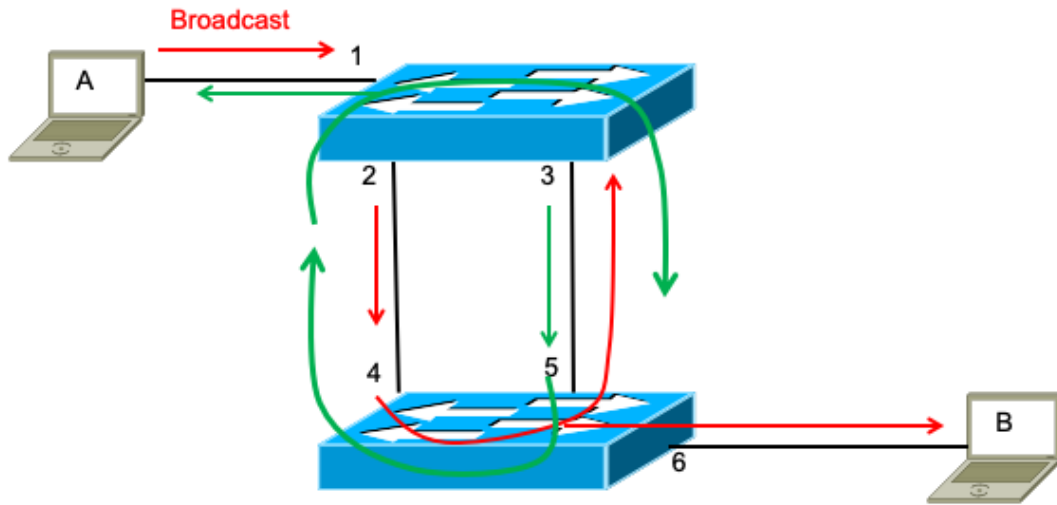
Introduction To Rapid Spanning-Tree

+ Originally introduced in 2001 as IEEE 802.1w standard
+ Incorporated into the IEEE 802.1d standard in 2004
+ Usually called CST (Common Spanning Tree)
+ No redundancy in traffic paths for frames

The Concept Of A Tree

The Concept Of A Tree

Reviewing RSTP Functionality

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How RSTP Works

+ Elect one Root Bridge
+ Elect one Root Port per bridge
+ Elect Designated Ports
+ Block Non-Designated Ports

Root Bridge Election

+ Switch with lowest Bridge ID in the network becomes Root Bridge
+ Bridge ID contains...
    + Bridge Priority
        + 0 - 61440 in increments of 4096
    + System ID Extension
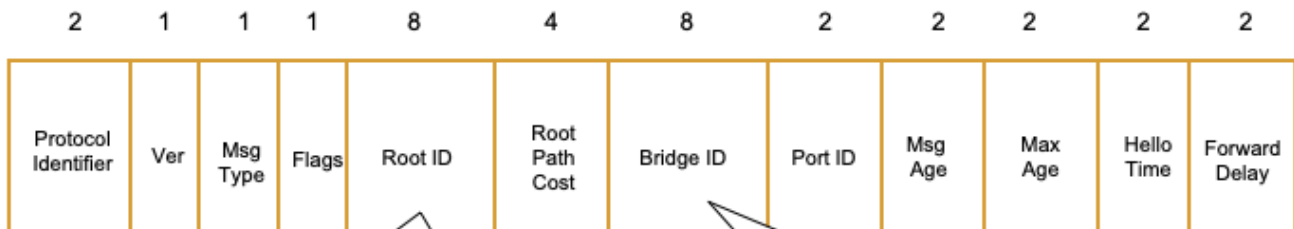   + 0 - 4095
    + MAC Address

You cannot configure a Bridge-Priority unless it is an increment of 4096.
--
Root Bridge also in charge of dictating STP timers to be used within Broadcast Domain. We'll talk more about these timers in a moment.

The Bridge Protocol Data Unit

+ BPDU = Bridge Protocol Data Unit
+ Required to determine, and maintain, STP topology

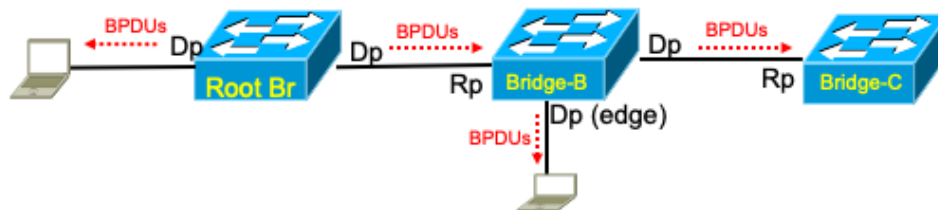| 2	1	1	1	8	4	8	2	2	2	2	2
Protocol Identifier	Ver	Msg Type	Flags	Root ID	Root Path Cost	Bridge ID	Port ID	Msg Age	Max Age	Hello Time	Forward Delay

2 byte priority
6 byte ID (MAC address)

2 byte priority
6 byte ID (MAC address)

RSTP Port Roles & States

RSTP Port Role	RSTP Port State

We're concentrating right now on Designated and Root Ports. We'll talk about Alternate and Backup ports later on.
-
Main takeaways here:
---Designated Ports "deliver"
---Root Ports "receive"

Essential RSTP Cisco IOS Commands

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RSTP Essential Commands

+ Enable RSTP
    + (config)#spanning-tree mode rapid-pvst
    + Automatically backwards compatible with legacy STP
+ Enable PortFast for RSTP Edge Port recognition
    + (config-if)#spanning-tree portfast [trunk]
    + ...or...
    + (config)#spanning-tree portfast default
+ Deterministically set RSTP Root Bridge per VLAN
    + (config)#spanning-tree vlan <vlan-id> root primary
    + ...or...
    + (config)#spanning-tree vlan <vlan-id> priority <value>

If performing VLAN Trunking to something like a server or router-on-a-stick, you would want that trunk link to be recognized by RSTP as an Edge Port.

Spanning-tree vlan x root primary
--If bridge is already STP Root…lowers priority to 24576
--If current Root is already 24576, this command:
-----Lowers current priority to 24576 if this bridge has lower MAC than existing Root Br.
-----Selects next-lowest priority in increment of 4096 if this bridge has higher MAC than existing Root Br.
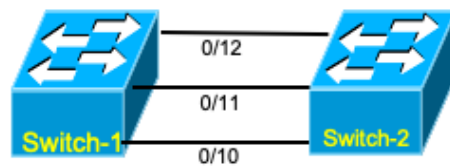--If current Root is already 4096, this command fails with error message.
--
Spanning-tree vlan x root secondary
--Lowers priority to 28672
--Assumption is that NO other switches within broadcast domain are lower than this other than Root Bridge.

Verifying The RSTP Root Bridge

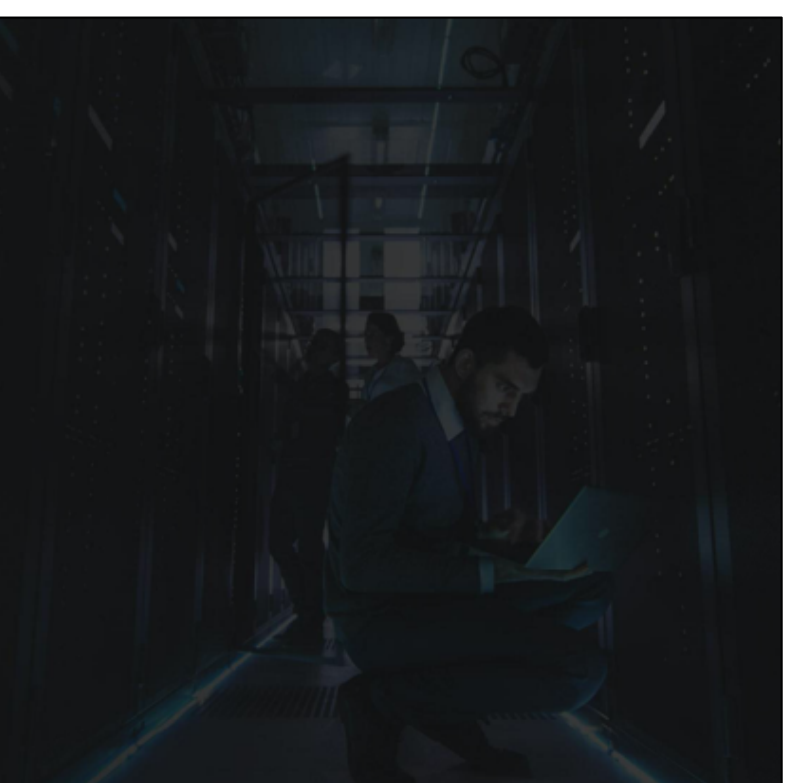+ Switch#show spanning-tree root
+ Switch#show spanning-tree vlan <vlan-id>

Let's do a quick demonstration to view the output of these commands.

Root Port Election

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Root Port Election

+ RP is upstream facing towards Root Bridge
+ Elected based on lowest Root Path Cost
    + Cumulative cost of all links to get to the root
+ Cost based on inverse bandwidth
    + i.e. higher bandwidth, lower cost
    + Not linear
+ If tie in cost...
    + Choose lowest upstream BID
    + Choose lowest upstream Port ID

RSTP Cost Values

+ Every switch that transmits/forwards a BPDU includes its own, local cost to reach STP Root
+ 802.1d specified some default port costs but does NOT specify any formula for ports outside of these values

Table 8-5—Path Cost Parameter Values

Parameter	Link Speed	Recommended value	Recommended range	Range
Path Cost	4 Mb/s	250	100–1000	1–65 535
Path Cost	10 Mb/s	100	50–600	1–65 535
Path Cost	16 Mb/s	62	40–400	1–65 535
Path Cost	100 Mb/s	19	10–60	1–65 535
Path Cost	1 Gb/s	4	3–10	1–65 535
Path Cost	10 Gb/s	2	1–5	1–65 535

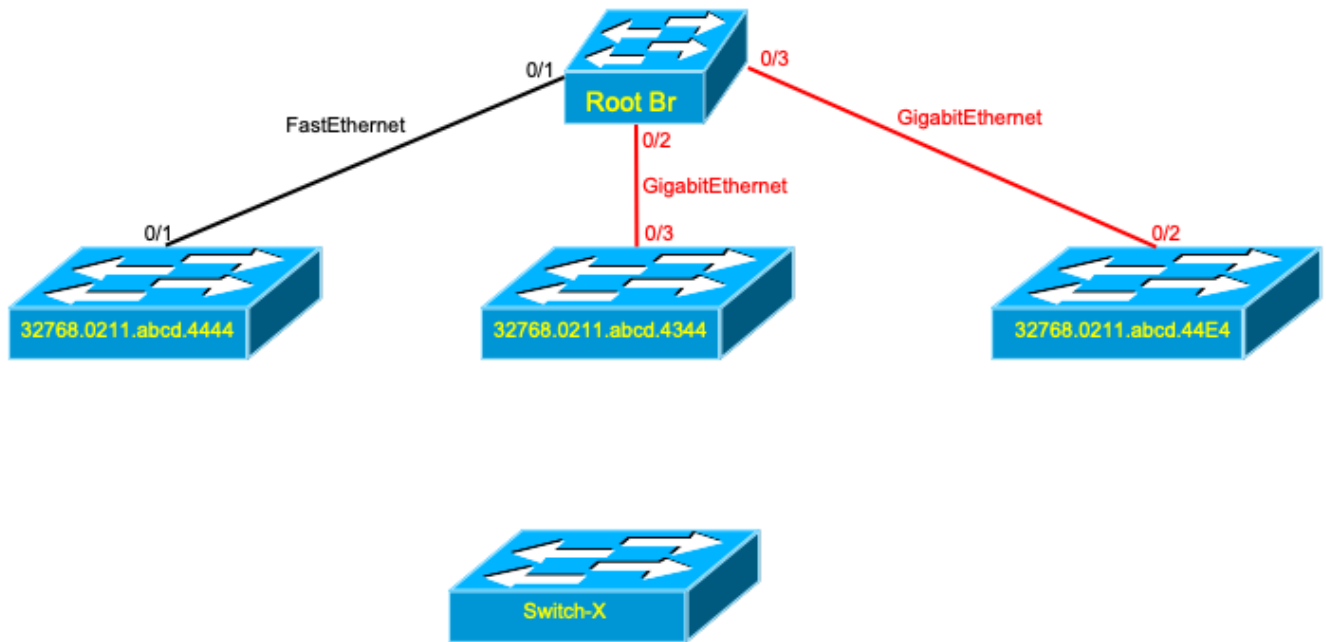Image taken from page-109 of IEEE 802.1d (1998) specification.
-
Interesting gotcha: On page 154 of the latest IEEE 802.1d revision (2004) the costs were upgraded to totally different values than what is shown here, however Cisco switches to this day (15-years later) are still using the costs shown in the graphic above.
-
On ports that are Blocking, you can see what value your upstream neighbor advertised in their BPDU by viewing the output of the "show spanning-tree detail" command.

Root Port Election

0/1   Root Br   0/3

FastEthernet

GigabitEthernet

0/2

GigabitEthernet

0/1   0/3   0/2

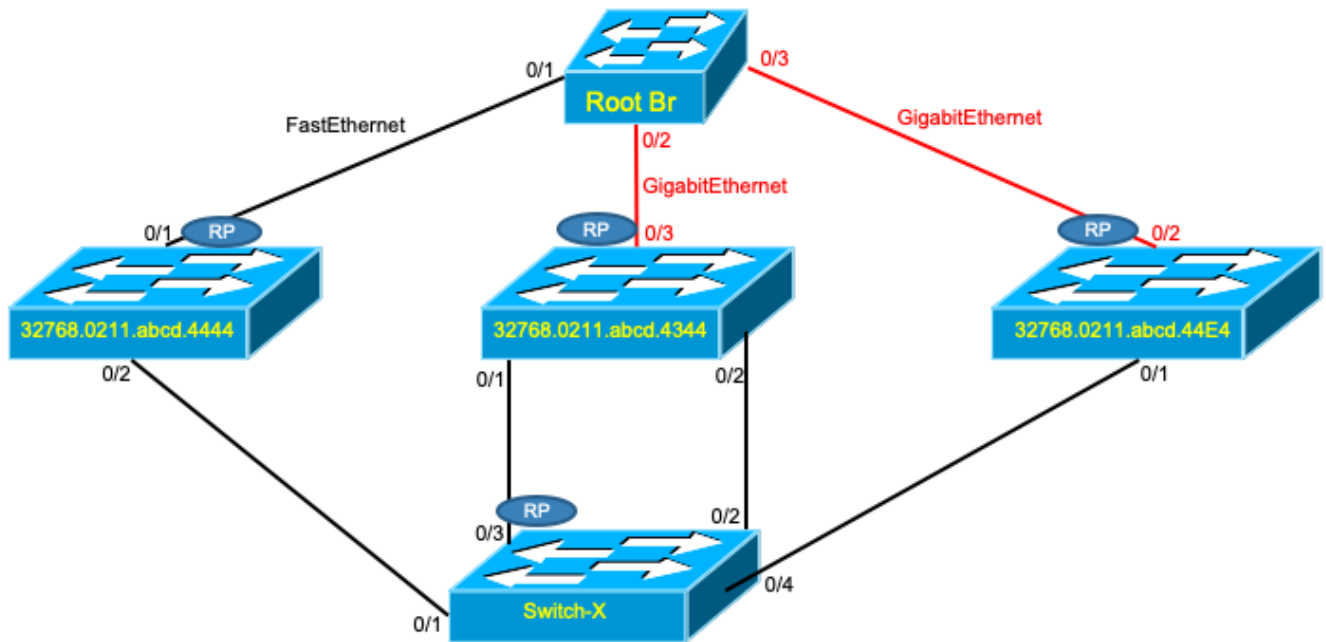32768.0211.abcd.4444   32768.0211.abcd.4344   32768.0211.abcd.44E4

Switch-X

Designated & Non-Designated Port Election

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Designated Port Election

+ DPs are downstream facing away from Root Bridge
+ Like Root Port, elected based on...
    + Lowest Root Path Cost
    + Lowest BID
    + Lowest Port ID
+ All other ports in the same collision domain go into either Root or Non-Designated (blocking) roles

# Designated Port Election

Root Br — 0/1, 0/2, 0/3

FastEthernet

GigabitEthernet

GigabitEthernet

RP — 0/1
32768.0211.abcd.4444 — 0/2

RP — 0/3
32768.0211.abcd.4344 — 0/1, 0/2

RP — 0/2
32768.0211.abcd.44E4 — 0/1

RP — 0/3
Switch-X — 0/1, 0/2, 0/4

BPDUs As Keepalives

+ In classic (pre-2004) 802.1d, BPDUs:
    + Were only generated by the Root Bridge
    + Were forwarded by non-Root bridges
    + If a non-Root bridge were to stop receiving BPDUs it could NOT answer the question...
        + Did the Root Bridge fail?
        + Did the upstream (non-Root) neighbor fail?
+ In RSTP:
    + BPDUs are used as keepalives
    + Designated Ports on non-Root bridges must always transmit BPDUs
    + Loss of 3-BPDUs triggers action on a downstream switch

BPDUs As Keepalives
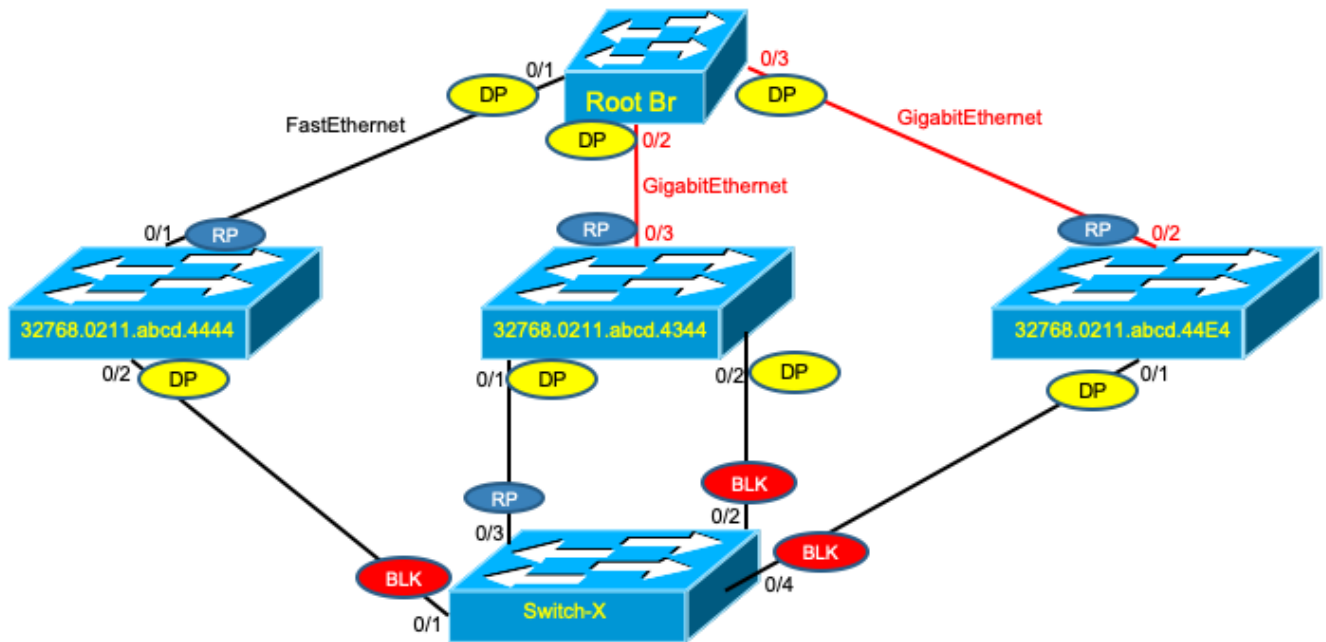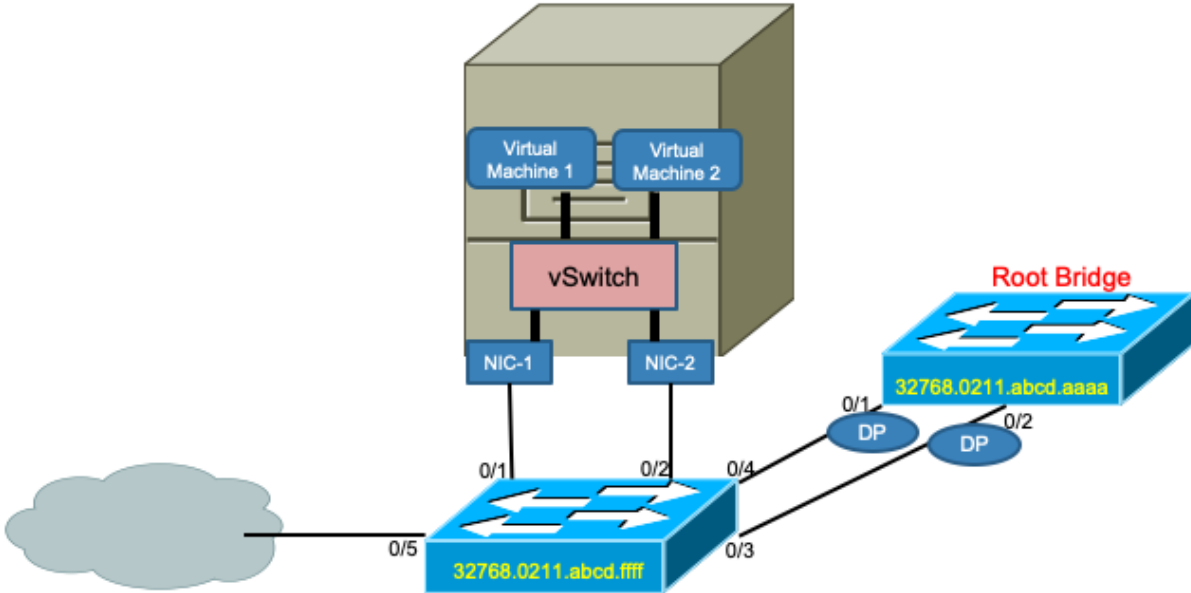
Non-Designated Ports

+ Ports that are neither Root Ports or Designated Ports become Non-Designated Ports
+ This port role is always "Discarding"
+ Two different types of Non-Designated Ports:
    + Alternate Port
        + Received superior BPDU on non-Root port
        + BPDU was received with a different sending Bridge-ID than local Bridge-ID
    + Backup Port
        + Received superior BPDU on non-Root port
        + BPDU was sent with a same sending Bridge-ID as local Bridge-ID

Discarding was formerly known in earlier versions of 802.1d as "Blocking" and I use the terms interchangeably in this series.
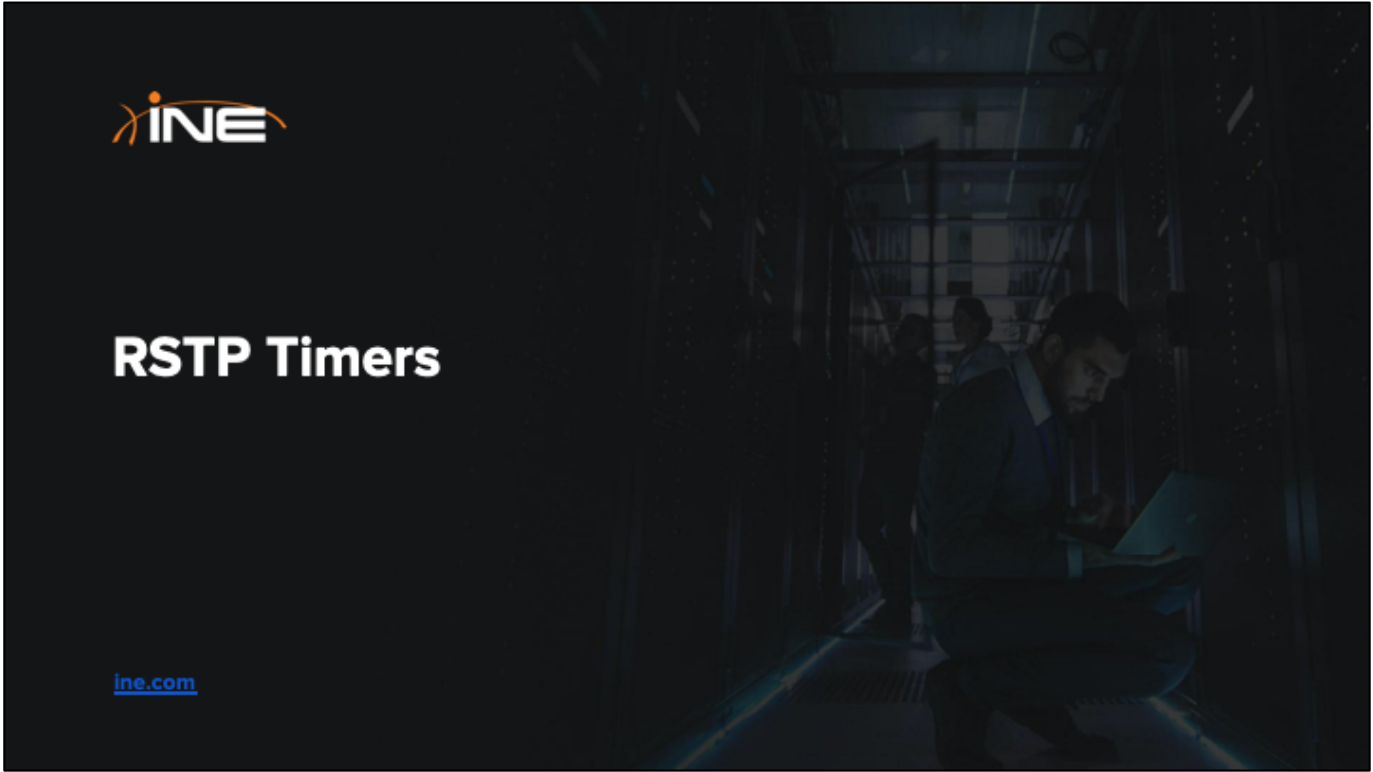
Alternate & Backup

Virtual Machine 1

Virtual Machine 2

vSwitch

NIC-1

NIC-2

Root Bridge

32768.0211.abcd.aaaa

0/1

DP

0/2

DP

0/1

0/2

0/4

0/5

32768.0211.abcd.ffff

0/3

RSTP Timers

Hello Timer & Forwarding Delay

+ Hello Timer
  + Dictates frequency of BPDU generation
  + 2-seconds (default)
  + Configurable
    + Switch(config)#spanning-tree vlan <vlan-id> hello-time <1-10 secs>
+ Forwarding Delay
  + Used for non-edge host ports to control transition delays
  + Used between RSTP switches on half-duplex connections to control transition delays
  + Configurable
    + Switch(config)#spanning-tree vlan <vlan-id> forward-time <4-30 secs>

A non-edge host port would be any switchport that is NOT configured for Portfast that is connected to a non-STP device (router, laptop, server, etc).

Message Age & Max_Age

+ ## Max_Age Timer
    + Not used for RSTP as a timer
    + Carryover from original 802.1d specification
    + 20-seconds by default
    + Switch(config)#spanning-tree vlan <vlan-id> max-age <6-40 secs>
+ ## Message Age
    + Used as a hop count for RSTP
    + Starts at zero (0) from Root Bridge and incremented by one (1) for each subsequent bridge that BPDU passes through
    + If BPDU received with Message_Age = Max_Age then BPDU is discarded

In theory, if a BPDU is received by an RSTP switch in which the max-age equals the message-age that BPDU is supposed to be discarded. In practice I have seen the receiving switch WILL accept it however that switch will transmit back (to the sending switch) its own BPDU with the Proposal flag set. So the two switches will in a constant cycle of proposal/agreement.

Portfast & Edge Ports

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The Benefits Of Portfast

+ Access Ports typically connect to hosts
  + Laptops/PCs
  + Servers
+ End users don't want to wait up to a minute to gain network connectivity
+ Portfast designed to speed up this process by placing an active port immediately into the STP "Forwarding" state
+ Not to be used on VLAN Trunk ports unless there is certainty about lack-of-loops

RSTP Edge Ports

+ RSTP sees interfaces configured with Portfast as "Edge" ports
  + These ports are not affected by the RSTP Topology Change process

```
Interface            Role Sts Cost      Prio.Nbr Type
-------------------- ---- --- --------- -------- --------
Gi0/1                Desg FWD 4          128.2    P2p Edge
Gi1/0                Desg FWD 4          128.5    P2p
Gi1/1                Desg FWD 4          128.6    P2p
Gi1/2                Desg FWD 4          128.7    P2p
Po2                  Desg FWD 3          128.65   P2p
```

Portfast Configuration

+ Configuration
    + (config-if)#spanning-tree portfast
    +   or...
    + (config)#spanning-tree portfast default

+ Verification
    + Switch#show spanning-tree interface <type/number> portfast