Troubleshoot MST on Catalyst 9000 Switches

Contents

Introduction

This document describes basic concepts needed to understand how MST works in a topology with either PVST or other regions.

Prerequisites

Requirements

Cisco recommends that you have knowledge of these topics:

- **Rapid-PVST (Rapid Per VLAN Spanning Tree)**

Components Used

The information in this document is based on these software and hardware versions:

- Catalyst 9300.
- From 17.3 train onward.

The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, ensure that you understand the potential impact of any command.

Related Products

This document can also be used with these hardware:

- All Catalyst 9000 Family.

Background Information

Terminology

Before start and apply any kind of troubleshoot, please consider this terminology:

Concept	Description
STP Instance	An instance is one session that runs in your CPU: On PVST, one VLAN is an instance in. On MST an instance is a group of VLANs. This document would use the term instance bas this meaning.
IST	**IST (Internal Spanning Tree)** is also known as **Instance 0** or MSTI0: - This is a special instance. - MSTI 0 is used to create one single loop free topology in the entire L2 domain. - When MST communicates to other regions or switches that run other versions of **spannin tree**, the IST or MSTI0's settings are used to communicate. - MSTI 0 is the only BPDU and the switch elected root of MSTI 0 is either responsible to be root of all regions, or to carry information about regional roots inside a MST region The IST is the only **spanning tree** instance that sends and receives BPDUs. All of the othe **spanning tree** instance information is contained in M-records, which are encapsulated wit MSTP BPDUs. Because the MSTP BPDU carries information for all instances. This is the o instance that has timer related parameters.When MST communicates to other regions and versions of **spanning tree**, the IST or MSTI0's settings are what are used to communicate
MSTIs	**MSTIs** stands for **Multiple Spanning Tree Instances**. From 1 to 15 The Cisco implementation supports 16 instances: one IST (instance 0) and 15 MSTIs.
Region	A group of switches that run MST. All of them have the same MST configuration.
CIST and CST	- The **Common Spanning Tree** interconnects the MST regions and single spanning trees. - A **Common and Internal Spanning Tree** is a collection of the ISTs in each MST region a **Common Spanning Tree**.
Regional Root	This is the election process for each instance in a region with the exception of instance 0. It is possible to have a different root in a spanning tree region for each instance if needed. This is done if it is considered the information in the IST BPDU that has the information req

to perform a normal spanning tree election.
The CIST root bridge was called the IST master in the prestandard implementation. If the C
root bridge is in the region, the regional root is the CIST root bridge.
Otherwise, the regional root is the closest switch to the CIST root in the region. The regiona
acts as a root bridge for the IST.

M-Record

Since there is only one BPDU, and that BPDU reflects the information required to converge
instance 0, it is needed another mechanism to form roots for other instances.
This is called an M-Record. Inside each M-Record is all of the spanning tree information fo
individual instance.
This information is carried with TLVs in the IST BPDU.

Dispute

The **Dispute** mechanism is a built in unidirectional link detection mechanism. This is not available in the original version of 802.1d (RSTP was actually integrated into the 802.1d standard in 2004) or PVST.
The **dispute** mechanism is triggered on receipt of an inferior BPDU that has a designated s
and is in a learning and forwarding state..
This indicates a unidirectional link, and to prevent loops the port that receives blocks the lin

Proposal / Agreement

This **Proposal agreement** mechanism is one of the most important changes to RSTP.
This is what allows rapid spanning tree to actually be rapid.
A simplified explanation of the **proposal agreement** process is that when 2 neighbors com
both start with their BPDU transmission with a proposal bit.
Once one of the peer transitions to agreement (it states that the neighbor is accepted as th
superior path to the root) the links immediately transition to a forwarding state.
Start with both ports that sends BPDUs. They claim to be the root with designate and propo
bit set.
When the inferior switch recognizes this port is not a root bridge and has the best path to th
root, it no longer has the proposal bit set, and transitions to Root state and forwarding.

Shared Segments

RSTP / MST put a half duplex link in a “shared” state. This means that the **Proposal Agreement** process does not happen.
Since the sequence is meant to rapidly bring up P2P links, a premature transition to a forwa
state could case a loop. This can be seen in the show commands for spanning tree
You can enter spanning-tree link-type point-to-point on the interface to force it to be in P2P
state, please used it carefully.

Multiple Regions

•Multiple regions are determined when MST configurations do not match.
•The CIST is elected between Regions via the MSTI0 BPDU
•Multiple regions appear as one logical switch per region to other devices.

Boundary Port

These ports are on the limits of the Region, commonly on these ports non-MST BPDUs are
received, so MST is not possible on this port.

PVST Simulation

PVST Simulation is the way MST and PVST can work on the same network.
In certain scenarios, like migrations or changes in the topology of a network, more than one
Flavor are found together and an MST region is connected to another domain.
As an example, a network that changes from PVST+ to MST and all the switches cannot be
modified at the same time. Also, there is a need to work with MST and PVST+ together.
Since PVST+ cannot process MST BPUSs, there is a compatibility mechanism between th
so both protocols can interact. This compatibility mechanism is called PVST simulation.

PVST Simulation Failure

If the rules stated on PVST simulation are not met

Restrictions

- PVST+, Rapid PVST+, and MSTP are supported, but only one version can be active at any time. (For example, all VLANs run PVST+, all VLANs run Rapid PVST+, or all VLANs run MSTP.)
- VLAN Trunking Protocol (VTP) propagation of the MST configuration is not supported.

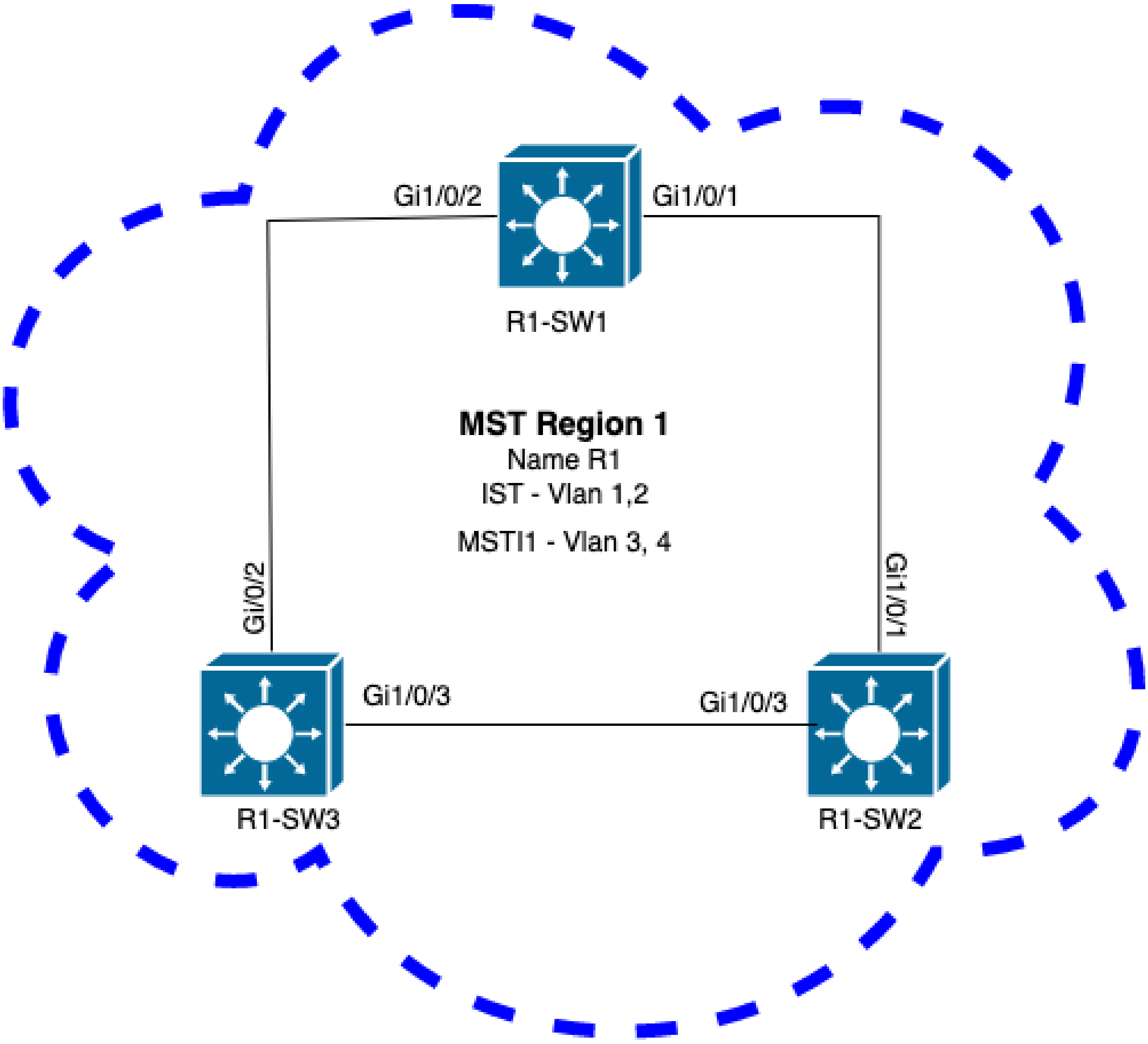
Troubleshoot

The goal is to have the MST region to behave like a virtual CST bridge, from the perspective outside the region.

Other switches, either in a different the region or in a PVST domain, see the MST region as only one switch because RootID and Root Path cost are left unchanged.

MST (single region)

Topology



Configuration

These three attributes must be configured in the same way on all switches under an MST region to converge properly. Commands are applied under MST configuration mode.

- Name
- Revision number
- VLAN to instance mapping

```
spanning-tree mst configuration
name <region name>
revision <number>
instance <number> vlan <vlan number>
```

Validate attributes configuration with this command:

```
show running-config | section span
```

Example: attributes configuration for switches 1, 2, and 3 in region 1

R1-SW1

```
R1-SW1#show running-config | section spann
spanning-tree mode mst
spanning-tree extend system-id
spanning-tree mst configuration
 name R1               <---
 revision 1            <---
 instance 1 vlan 3-4   <---
```

R1-SW2

```
R1-SW2#show running-config | section spann
spanning-tree mode mst
spanning-tree extend system-id
spanning-tree mst configuration
 name R1
 revision 1
 instance 1 vlan 3-4
```

R1-SW3

```
R1-SW3#show running-config | section spann
spanning-tree mode mst
spanning-tree extend system-id
spanning-tree mst configuration
 name R1
 revision 1
 instance 1 vlan 3-4
```

Validation

During MST migration, you can configure MST parameters without the need to change the STP mode yet.

Follow these recomendations to avoid possible network disruptions due to misconfiguration.

- Check MST configuration before commit.
- Check MST configuration after commit

Check MST configuration before commit.

This check is when **spanning-tree mode mst** has not been applied yet.

```
show spanning-tree mst
show current
show spanning-tree mst configuration digest
```

> **Note**: **show current** is only available under MST configuration mode (**spanning-tree mst configuration** submode)

Example: For switch 1 in region 1

Verify STP mode is not in MST mode yet

```
R1-SW1#show spanning-tree mst
% Switch is not in mst mode   <--
```

Verify current MST configuration

```
R1-SW1(config-mst)#show current
Current MST configuration
Name      [R1]
Revision  1     Instances configured 2

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
0         1-2,6-4094
1         3-4
-------------------------------------------------------------------------------
```

> **Note**: **show current** is only available under MST configuration mode.

> **Note**: **show span mst configuration** and **show current** are equivalent commands.

Verify digest hash

```
R1-SW1#show spanning-tree mst configuration digest
% Switch is not in mst mode                          <--
Name [R1]
Revision 1 Instances configured 2
Digest 0xA423B8DBB209CCF6560F55618AB58726            <--
Pre-std Digest 0x8C9BE88BBC9B84CB8AED635EE008436A
```

> **Note**: Digest output lets you know whether or not the switch is already in MST mode. Digest hash does not change, even if the MST mode has not been enabled yet.

> **Note**: Catalyst 9000 switches run the IEEE standard MST protocol. Therefore you must focus on the **Digest** hash instead of the **Pre-std Digest**

Check MST configuration after commit

```
show current
show pending
show spanning-tree mst configuration digest
abort
```

> **Note**: **show pending** (as well as **show current**) is only available under the MST configuration mode

The **show current** output shows you the MST configuration after exit the MST submode (which is when config change is applied) whereas the **show pending** output show you the MST configuration that has been recently configured, but not applied.

If for any reason you need to revert the config changes and you are still under the MST submode, then you can apply the **abort** command which exit from the MST submode without apply the changes.

> **Note**: **show pending** (as well as **show current**) is only available under the MST configuration mode

Example: For switch 1 in region 1

Notice that current and pending configurations are the same, this mean no changes have been made.

Digest hash is the same as one validated in the previous output.

```
R1-SW1(config)#spanning-tree mst configuration
R1-SW1(config-mst)#show current
Current MST configuration
Name      [R1]
Revision  1     Instances configured 2

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
0         1-2,5-4094
1         3-4
-------------------------------------------------------------------------------

R1-SW1(config-mst)#show pending
Pending MST configuration
Name      [R1]
Revision  1     Instances configured 2

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
0         1-2,5-4094
1         3-4
-------------------------------------------------------------------------------

R1-SW1(config-mst)#do show spanning-tree mst configuration digest
Name      [R1]
Revision  1     Instances configured 2
Digest          0xA423B8DBB209CCF6560F55618AB58726   <--
Pre-std Digest  0x8C9BE88BBC9B84CB8AED635EE008436A
```

New instance is created and VLAN 5 is mapped to it. This time the **show current** output does not show the new instance recently condigured, but **show pending** does. This is expected.

Notice that Digest hash has not changed. This is because new config only applies when you exit from the MST configuration mode (**spanning-tree mst configuration** submode)

```
 R1-SW1(config-mst)#instance 2 vlan 5       <--
R1-SW1(config-mst)#show current
Current MST configuration
Name      [R1]
Revision  1     Instances configured 2

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
0         1-2,5-4094
```

```
1         3-4
-------------------------------------------------------------------------------

R1-SW1(config-mst)#show pending
Pending MST configuration
Name      [R1]
Revision  1     Instances configured 3

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
0         1-2,6-4094
1         3-4
2         5     <--
-------------------------------------------------------------------------------

R1-SW1(config-mst)#do show spanning-tree mst configuration digest
Name      [R1]
Revision  1     Instances configured 2
Digest          0xA423B8DBB209CCF6560F55618AB58726     <--
Pre-std Digest  0x8C9BE88BBC9B84CB8AED635EE008436A
```

After exit from the MST configuration mode, changes are reflected. Digest hash is also re-calculated to match with the new changes made.

```
R1-SW1(config-mst)#exit
R1-SW1(config)#spanning-tree mst configuration
R1-SW1(config-mst)#show current
Current MST configuration
Name      [R1]
Revision  1     Instances configured 3

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
0         1-2,6-4094
1         3-4
2         5       <--
-------------------------------------------------------------------------------

R1-SW1(config-mst)#show pending
Pending MST configuration
Name      [R1]
Revision  1     Instances configured 3

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
0         1-2,6-4094
1         3-4
2         5     <--
-------------------------------------------------------------------------------


R1-SW1(config-mst)#do show spanning-tree mst configuration digest
Name      [R1]
Revision  1     Instances configured 3
Digest          0x083305551908B9A2CC50B482DC577B8F     <--
Pre-std Digest  0xA8AC09BDF2942058FAF4CE727C9D258F
```

These commands are helpful to validate MST parameters and convergency. Also they provide information related to MST timers, cost, and so on.

```
show spanning-tree pathcost method
show spanning-tree root
show spanning-tree summary
show spanning-tree mst
show spanning-tree interface <interface>
```

Note: **show spanning-tree mst** and **show spanning-tree** are equivalent

Example: For switch 1 in region 1

There are two methods to measure the path cost, short (legacy) and long. It is always preferable to be homogeneous along your layer 2 network. If you run long pathcost method, do it along all your switches wich run on STP.

```
R1-SW1#show spanning-tree pathcost method
Spanning tree default pathcost method used is long  <--
```

This output lets you now the path cost method, but also lets you know the switch run standard MST protocol and uses the extended system ID (which is a must when MST is used).

```
R1-SW1#show spanning-tree summary
Switch is in mst mode (IEEE Standard)               <--
Root bridge for: none
EtherChannel misconfig guard            is enabled
Extended system ID                      is enabled  <--
Portfast Default                        is disabled
PortFast BPDU Guard Default            is disabled
Portfast BPDU Filter Default           is disabled
Loopguard Default                      is disabled
UplinkFast                              is disabled
BackboneFast                            is disabled
Configured Pathcost method used is long             <--

Name                   Blocking Listening Learning Forwarding STP Active
---------------------- -------- --------- -------- ---------- ----------
MST0                          0         0        0          3          3
MST1                          0         0        0          3          3
---------------------- -------- --------- -------- ---------- ----------
2 msts                        0         0        0          6          6
```

Bridge and root IDs, priorities, costs, port roles and status as well as VLAN mapping can be observed in this output:

```
R1-SW1#show spanning-tree mst

##### MST0    vlans mapped:   1-2,5-4094
Bridge        address 3473.2db8.be80  priority      32768 (32768 sysid 0)
Root          address f04a.021e.9500  priority      24576 (24576 sysid 0)
              port    Gi1/0/2         path cost     0
Regional Root address f04a.021e.9500  priority      24576 (24576 sysid 0)
                                      internal cost 20000     rem hops 19
Operational   hello time 2 , forward delay 15, max age 20, txholdcount 6
Configured    hello time 2 , forward delay 15, max age 20, max hops    20

Interface                        Role Sts Cost      Prio.Nbr Type
```

```
----------------                 ---- --- --------- -------- --------------------------------
Gi1/0/1                          Desg FWD 20000     128.1    P2p
Gi1/0/2                          Root FWD 20000     128.2    P2p
Gi1/0/4                          Desg FWD 20000     128.4    P2p

##### MST1    vlans mapped:   3-4
Bridge        address 3473.2db8.be80  priority      32769 (32768 sysid 1)
Root          address f04a.021e.9500  priority      24577 (24576 sysid 1)
              port    Gi1/0/2         cost          20000     rem hops 19

Interface                        Role Sts Cost      Prio.Nbr Type
----------------                 ---- --- --------- -------- --------------------------------
Gi1/0/1                          Desg FWD 20000     128.1    P2p
Gi1/0/2                          Root FWD 20000     128.2    P2p
Gi1/0/4                          Desg FWD 20000     128.4    P2p
```

This command shows you the STP roles status, priority, and link type from interface perspective instead of per instance perspective.

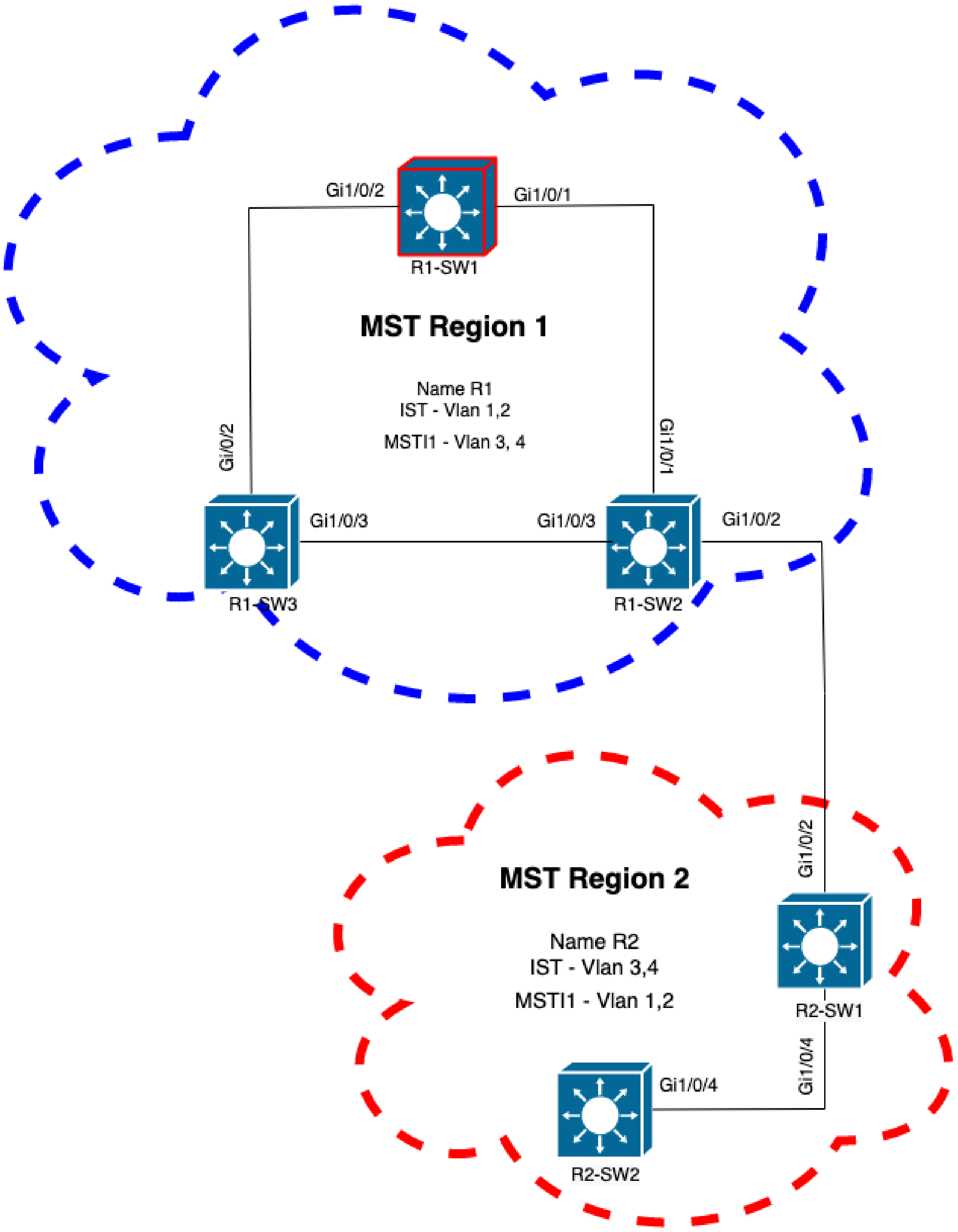
```
R1-SW1#show spanning-tree interface gigabitEthernet 1/0/1

Mst Instance        Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
MST0                Desg FWD 20000     128.1    P2p
MST1                Desg FWD 20000     128.1    P2p

R1-SW1#show spanning-tree interface gigabitEthernet 1/0/2

Mst Instance        Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
MST0                Root FWD 20000     128.2    P2p
MST1                Root FWD 20000     128.2    P2p
```

Synchronization between regions

Region 2 has been added to the topology. The purpose is to check the process of how two different regions interact and converge. Only the boundary switches take place in this communication.

Since both ends of the link have the same process of communication. This section focuses on the outputs of **show spanning-tree mst** of R1-SW2 and two BPDUs taken from a packet capture.

Topology



Validation

This is the initial communication between R1-SW2 from Region 1 and R2-SW1 from Region 2. As soon as a connection is established between both devices, they send a BPDU.

Focus on interface Gi1/0/2 from R2-SW1, which is blocking (BLK) as initial state. Remember that a switch port enters the BLK state at time of election process.

```
R2-SW1#show spanning-tree mst
```

```
MST0
! Output omitted for brevity Interface Role Sts Cost Prio.Nbr Type ------------------- ---- ---
--------- -------- -------------------------------- Gi1/0/2             Desg BLK 20000     128.2
P2p
Gi1/0/4             Root FWD 20000     128.4    P2p

MST1
! Output omitted for brevity Interface Role Sts Cost Prio.Nbr Type ------------------- ---- ---
--------- -------- -------------------------------- Gi1/0/2             Desg BLK 20000     128.2
P2p
Gi1/0/4             Root FWD 20000     128.4    P2p
```

In the packet capture it is observed this first BPDU, with the Port Role flags shown as Designated and the Proposal.

This means that the communication already started and both ports started the process of syncronization to establsh an agreement and set the port roles and states. All start with the proposal mechanism.

```
IEEE 802.3 Ethernet
    Destination: Spanning-tree-(for-bridges)_00 (01:80:c2:00:00:00)
    Source: Cisco_05:d6:02 (f0:4a:02:05:d6:02)
    Length: 121
Logical-Link Control
Spanning Tree Protocol
    Protocol Identifier: Spanning Tree Protocol (0x0000)
    Protocol Version Identifier: Multiple Spanning Tree (3)
    BPDU Type: Rapid/Multiple Spanning Tree (0x02)
    BPDU flags: 0x0e, Port Role: Designated, Proposal
        0... .... = Topology Change Acknowledgment: No
        .0.. .... = Agreement: No
        ..0. .... = Forwarding: No
        ...0 .... = Learning: No
        .... 11.. = Port Role: Designated (3)
        .... ..1. = Proposal: Yes
        .... ...0 = Topology Change: No
    Root Identifier: 24576 / 0 / f0:4a:02:1e:95:00
    Root Path Cost: 20004
    Bridge Identifier: 32768 / 0 / a0:f8:49:10:47:80
    Port identifier: 0x8002
    Message Age: 2
    Max Age: 20
    Hello Time: 2
    Forward Delay: 15
    Version 1 Length: 0
    Version 3 Length: 80
    MST Extension
```

After BPDUs exchange between switches, the state changes to learning (LRN).

After R2-SW1 receives the first BPDU previously shown, LRN state is the first transitional state after blocking state.

```
R2-SW1#show spanning-tree mst
```

```
MST0
! Output omitted for brevity

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/2             Desg LRN 20000     128.2    P2p
Gi1/0/4             Root FWD 20000     128.4    P2p

MST1
! Output omitted for brevity

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/2             Desg LRN 20000     128.2    P2p
Gi1/0/4             Root FWD 20000     128.4    P2p
```

Once one of the peer establish an agreement and the synchronization takes place (the neighbor is accepted as the superior path to the root), the links immediately transition to forwarding state.

Here you can observe the BPDU with the Flags set as learning, it also includes the topology change notification flag which is triggered as soon as the port transitions from LRN to forwarding (FWR).

In this state, MST determines whether the port participates in frame forwarding or not (state BLK).

```
IEEE 802.3 Ethernet
Logical-Link Control
Spanning Tree Protocol
    Protocol Identifier: Spanning Tree Protocol (0x0000)
    Protocol Version Identifier: Multiple Spanning Tree (3)
    BPDU Type: Rapid/Multiple Spanning Tree (0x02)
    BPDU flags: 0x3d, Forwarding, Learning, Port Role: Designated, Topology Change
        0... .... = Topology Change Acknowledgment: No
        .0.. .... = Agreement: No
        ..1. .... = Forwarding: Yes
        ...1 .... = Learning: Yes
        .... 11.. = Port Role: Designated (3)
        .... ..0. = Proposal: No
        .... ...1 = Topology Change: Yes
    Root Identifier: 24576 / 0 / f0:4a:02:1e:95:00
    Root Path Cost: 20004
    Bridge Identifier: 32768 / 0 / a0:f8:49:10:47:80
    Port identifier: 0x8002
    Message Age: 2
    Max Age: 20
    Hello Time: 2
    Forward Delay: 15
    Version 1 Length: 0
    Version 3 Length: 80
    MST Extension
```

Finally, Switch port enters to forwarding state after traverse all the states involved in creation of network topology.

This would be the last state of the port, with the role designated (Desg) and status FDW.

```
R2-SW1#show spanning-tree mst

MST0
! Output omitted for brevity

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/2             Desg FWD 20000     128.2    P2p
Gi1/0/4             Root FWD 20000     128.4    P2p


MST1
! Output omitted for brevity

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Gi1/0/2             Desg FWD 20000     128.2    P2p
Gi1/0/4             Root FWD 20000     128.4    P2p
```

Debugs

These bugs were enabled during communication between R2-SW1 and R1-SW2.

```
debug spanning-tree mstp roles
debug spanning-tree mstp tc
debug spanning-tree mstp boundary
```

Example:

```
R2-SW1#show debugging
Packet Infra debugs:

Ip Address                                               Port
------------------------------------------------------|----------

Multiple Spanning Tree:
  MSTP port ROLES changes debugging is on
  MSTP Topology Change notifications debugging is on
  MSTP port BOUNDARY flag changes debugging is on
```

Logs observed

```
%LINK-3-UPDOWN: Interface GigabitEthernet1/0/2, changed state to down
%LINK-3-UPDOWN: Interface GigabitEthernet1/0/2, changed state to up
MST[0]: Gi1/0/2 is now designated port
MST[0]: Gi1/0/2 becomes designated - clearing BOUNDARY flag
MST[1]: Gi1/0/2 is now designated port
MST[0]: port Gi1/0/2 received external tc
MST[0]: port Gi1/0/2 received external tc
MST[1]: port Gi1/0/2 received tc
MST[0]: port Gi1/0/2 received external tc
MST[0]: port Gi1/0/2 received external tc
MST[1]: port Gi1/0/2 received tc
```

```
MST[0]: port Gi1/0/2 received external tc
MST[0]: port Gi1/0/2 received external tc
MST[1]: port Gi1/0/2 received tc
MST[0]: port Gi1/0/2 initiating tc
MST[1]: port Gi1/0/2 initiating tc
MST[0]: port Gi1/0/2 received external tc
MST[0]: port Gi1/0/2 received external tc
MST[1]: port Gi1/0/2 received tcsho span
%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/0/2, changed state to up
MST[0]: port Gi1/0/3 received internal tc
MST[0]: port Gi1/0/3 received internal tc
MST[0]: port Gi1/0/3 received internal tc
```

PVST Simulation Failure

PVST simulation s the mechanism that MST uses to communicate to non MST switches.

PVST switches does not recognize MST BPDUs because they are simply different. This is why It is important to understand the differences between PVST and MST BPDUs.

PVST BPDUs vs MST BPDUs

Two BPDUs were captured, one for PVST and one for MST, look at the differences between them.

PVST

- PVST sends a BPDU for every VLAN configured on the switch. Therefore have 100 VLANS configured means 100 BPDUs are sent over all the ports to build its own loop free topology.
- PVST is based on the classic STP

```
Ethernet II, Src: Cisco_06:19:01 (f0:4a:02:06:19:01), Dst: PVST+ (01:00:0c:cc:cc:cd)
    Destination: PVST+ (01:00:0c:cc:cc:cd)
    Source: Cisco_06:19:01 (f0:4a:02:06:19:01)
    Type: 802.1Q Virtual LAN (0x8100)
802.1Q Virtual LAN, PRI: 7, DEI: 0, ID: 3
    111. .... .... .... = Priority: Network Control (7)
    ...0 .... .... .... = DEI: Ineligible
    .... 0000 0000 0011 = ID: 3
    Length: 50
Logical-Link Control
    DSAP: SNAP (0xaa)
    SSAP: SNAP (0xaa)
    Control field: U, func=UI (0x03)
    Organization Code: 00:00:0c (Cisco Systems, Inc)
    PID: PVSTP+ (0x010b)
Spanning Tree Protocol
    Protocol Identifier: Spanning Tree Protocol (0x0000)
    Protocol Version Identifier: Spanning Tree (0)
    BPDU Type: Configuration (0x00)
    BPDU flags: 0x01, Topology Change
        0... .... = Topology Change Acknowledgment: No
        .... ...1 = Topology Change: Yes
    Root Identifier: 32768 / 0 / 68:9e:0b:a0:f5:80
        Root Bridge Priority: 32768
        Root Bridge System ID Extension: 0
        Root Bridge System ID: Cisco_a0:f5:80 (68:9e:0b:a0:f5:80)
    Root Path Cost: 20000
    Bridge Identifier: 32768 / 0 / f0:4a:02:06:19:00
```

```
        Bridge Priority: 32768
        Bridge System ID Extension: 0
        Bridge System ID: Cisco_06:19:00 (f0:4a:02:06:19:00)
    Port identifier: 0x8001
    Message Age: 1
    Max Age: 20
    Hello Time: 2
    Forward Delay: 15
    Originating VLAN (PVID): 3
        Type: Originating VLAN (0x0000)
        Length: 2
        Originating VLAN: 3
```

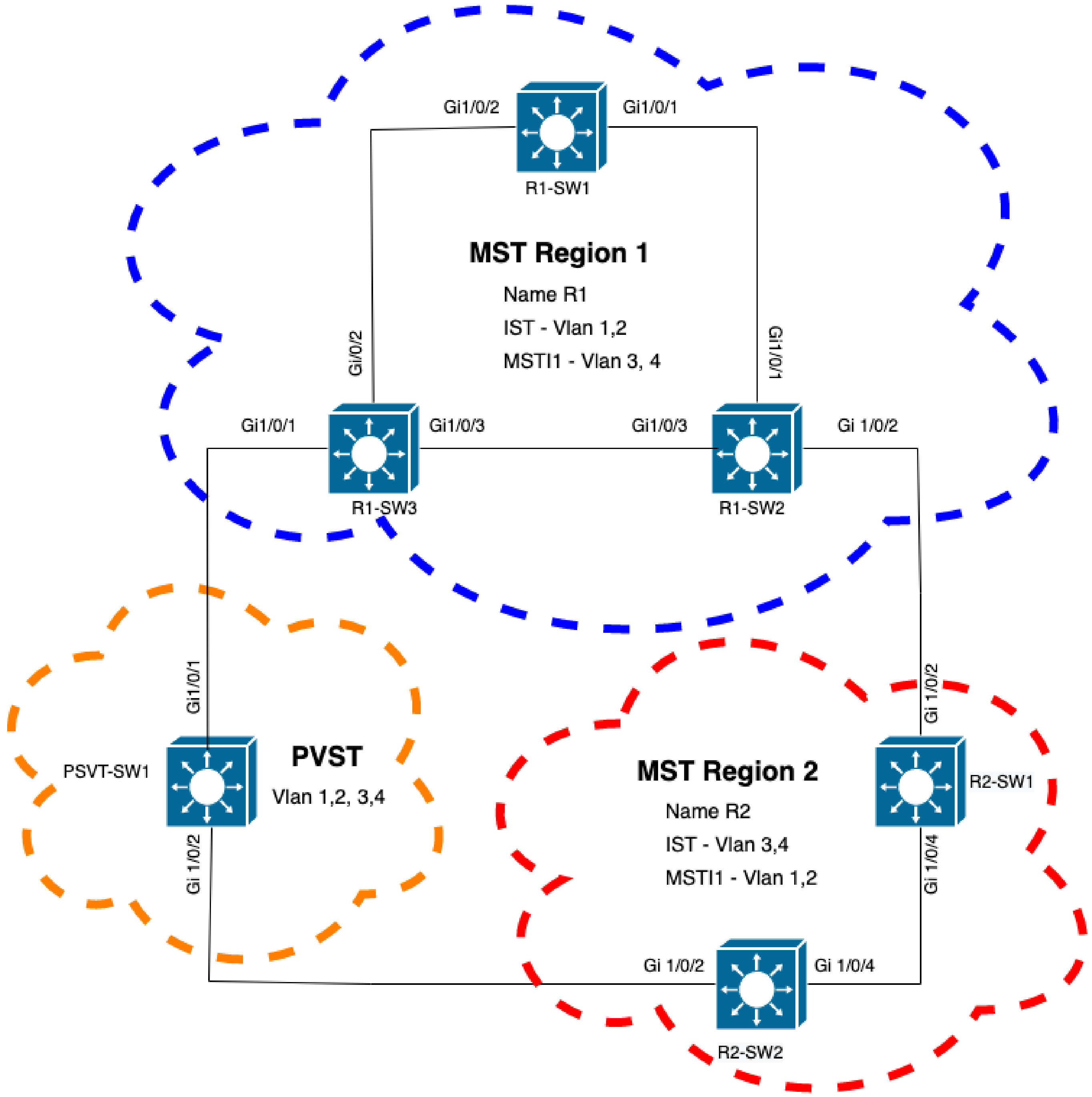
MST

- MST sends a single BPDU for all the MST instances configured on the switch. This is achieved thanks to the MST extension (M records) which haves the information of all instances.
- MST is based on RSTP, which means that all the intrinsic mechanisms of this protocol were inherited to MST.
- Timers are defined by the IST and affects all other instances within a region

```
IEEE 802.3 Ethernet
    Destination: Spanning-tree-(for-bridges)_00 (01:80:c2:00:00:00)
    Source: Cisco_b8:be:81 (34:73:2d:b8:be:81)
    Length: 121
Logical-Link Control
    DSAP: Spanning Tree BPDU (0x42)
    SSAP: Spanning Tree BPDU (0x42)
    Control field: U, func=UI (0x03)
Spanning Tree Protocol
    Protocol Identifier: Spanning Tree Protocol (0x0000)
    Protocol Version Identifier: Multiple Spanning Tree (3)
    BPDU Type: Rapid/Multiple Spanning Tree (0x02)
    BPDU flags: 0x0e, Port Role: Designated, Proposal
        0... .... = Topology Change Acknowledgment: No
        .0.. .... = Agreement: No
        ..0. .... = Forwarding: No
        ...0 .... = Learning: No
        .... 11.. = Port Role: Designated (3)
        .... ..1. = Proposal: Yes
        .... ...0 = Topology Change: No
    Root Identifier: 32768 / 0 / 34:73:2d:b8:be:80
        Root Bridge Priority: 32768
        Root Bridge System ID Extension: 0
        Root Bridge System ID: Cisco_b8:be:80 (34:73:2d:b8:be:80)
    Root Path Cost: 0
    Bridge Identifier: 32768 / 0 / 34:73:2d:b8:be:80
        Bridge Priority: 32768
        Bridge System ID Extension: 0
        Bridge System ID: Cisco_b8:be:80 (34:73:2d:b8:be:80)
    Port identifier: 0x8001
    Message Age: 0
    Max Age: 20
    Hello Time: 2
    Forward Delay: 15
    Version 1 Length: 0
    Version 3 Length: 80
    MST Extension
        MST Config ID format selector: 0
        MST Config name: R1
        MST Config revision: 1
        MST Config digest: a423b8dbb209ccf6560f55618ab58726
        CIST Internal Root Path Cost: 0
        CIST Bridge Identifier: 32768 / 0 / 34:73:2d:b8:be:80
            CIST Bridge Priority: 32768
            CIST Bridge Identifier System ID Extension: 0
            CIST Bridge Identifier System ID: Cisco_b8:be:80 (34:73:2d:b8:be:80)
        CIST Remaining hops: 20
        MSTID 1, Regional Root Identifier 32768 / 34:73:2d:b8:be:80
            MSTI flags: 0x0e, Port Role: Designated, Proposal
                0... .... = Topology Change Acknowledgment: No
                .0.. .... = Agreement: No
                ..0. .... = Forwarding: No
                ...0 .... = Learning: No
                .... 11.. = Port Role: Designated (3)
                .... ..1. = Proposal: Yes
                .... ...0 = Topology Change: No
            1000 .... = Priority: 0x8
            .... 0000 0000 0001 = MSTID: 1
            Regional Root: Cisco_b8:be:80 (34:73:2d:b8:be:80)
            Internal root path cost: 0
            Bridge Identifier Priority: 8
            Port identifier priority: 8
            Remaining hops: 20
```

Topology

Switch with PVST was added to the network. It interconnects region 1 and 2.



Validation

After PVST switch was connected, boundary port (gi1/0/1) of switch R1-SW3 from region 1 goes to PVST inconsistent and blocks the port.

```
R1-SW3#show spanning-tree mst

##### MST0    vlans mapped:   1-2,5-4094
Bridge        address f04a.021e.9500  priority      32768 (32768 sysid 0)
Root          address 689e.0ba0.f580  priority      16385 (16384 sysid 1)
              port    Gi1/0/1         path cost     20000
Regional Root this switch
Operational   hello time 2 , forward delay 15, max age 20, txholdcount 6
Configured    hello time 2 , forward delay 15, max age 20, max hops    20

Interface                          Role Sts Cost      Prio.Nbr Type
```

```
----------------                  ---- --- --------- -------- --------------------------------
Gi1/0/1                           Root BKN*20000     128.1    P2p Bound(PVST) *PVST_Inc
Gi1/0/2                           Desg FWD 20000     128.2    P2p
Gi1/0/3                           Desg FWD 20000     128.3    P2p

##### MST1    vlans mapped:   3-4
Bridge        address f04a.021e.9500  priority      32769 (32768 sysid 1)
Root          address 3473.2db8.be80  priority      32769 (32768 sysid 1)
              port    Gi1/0/2         cost          20000     rem hops 19

Interface                         Role Sts Cost      Prio.Nbr Type
----------------                  ---- --- --------- -------- --------------------------------
Gi1/0/1                           Mstr BKN*20000     128.1    P2p Bound(PVST) *PVST_Inc
Gi1/0/2                           Root FWD 20000     128.2    P2p
Gi1/0/3                           Altn BLK 20000     128.3    P2p
```

> **Note**: Similar outputs are observed on R2-SW2 from region 2, which is another boundary port.

.

This happened because any of these rules were broken

- If the root bridge for CIST is within a non-MST region, the spanning-tree priority of VLANs 2 onwards within that domain must be better (lesser) than that of VLAN 1.
- If the root bridge for CIST is within a MST region, VLANs 2 onwards defined in the non-MST domains must have their spanning-tree priorities worse (greater) than that of the CIST root.

Please take a look at the invalid configurations that were set up on the switch to face this issue:

Case 1. PVST switch is the root for VLANS 2-4, however VLANs 2-4 have a worse (greater) priority than VLAN 1. In this case all switches except PVST switch have the default STP priority (32768)

```
PVST-SW1# show run | inc span
spanning-tree mode pvst
spanning-tree extend system-id
spanning-tree vlan 1 priority 4096    <--
spanning-tree vlan 2-4 priority 16384 <--
spanning-tree mst configuration
```

Log observed:

```
%SPANTREE-2-PVSTSIM_FAIL: Blocking root port Gi1/0/1: Inconsitent inferior PVST BPDU received on
VLAN 2, claiming root 16386:689e.0ba0.f580
```

Case 2. PVST switch is not the root for VLANS 1, however VLANs 2-4 have a better(lesser) priority than the root. In this case, root has the default priority 24576. This means the root bridge is not the root for all VLANs

```
PVST-SW1#show run | inc span
spanning-tree mode pvst
spanning-tree extend system-id
spanning-tree vlan 1 prio 32768       <-- higher priority than the root
spanning-tree vlan 2-4 priority 16384 <--  lower priority than the root
spanning-tree mst configuration
```

Log observed:

```
%SPANTREE-2-PVSTSIM_FAIL: Blocking root port Gi1/0/1: Inconsistent inferior PVST BPDU received
on VLAN 2, claiming root 40962:689e.0ba0.f580
```

Once you consider the rules previously mentioned, you can use these valid configurations to delete this issue.

Case 1.

```
PVST-SW1# show run | inc span
spanning-tree mode pvst
spanning-tree extend system-id
spanning-tree vlan 1 priority 16384  <-- VLAN 1 has a higher priority than all other VLANs
spanning-tree vlan 2-4 priority 4096 <--
spanning-tree mst configuration
```

Log observed:

```
%SPANTREE-2-PVSTSIM_OK: PVST Simulation nconsistency cleared on port GigabitEthernet1/0/1.
```

Case 2.

```
PVST-SW1#show run | inc span
spanning-tree mode pvst
spanning-tree extend system-id
spanning-tree vlan 1 prio 32768       <-- higher priority than the root
spanning-tree vlan 2-4 priority 40960 <--  higher priority than the root
spanning-tree mst configuration
```

Log observed:

```
%SPANTREE-2-PVSTSIM_OK: PVST Simulation nconsistency cleared on port GigabitEthernet1/0/1.
```

Debugs

Verify the BPDUs with the BPDU debugs if packet capture is not possible.

```
debug spanning-tree mstp bpdu receive
debug spanning-tree mstp bpdu transmit
```

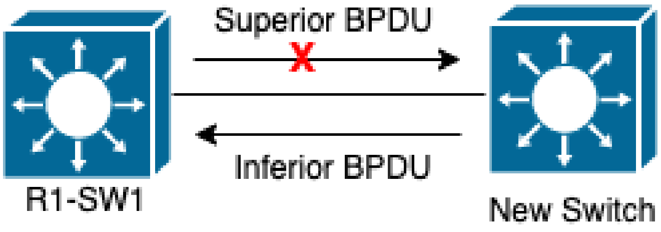
Example: For switch 2 in region 2 connected to PVST switch

```
R2-SW2#debug spanning-tree mstp bpdu receive
MSTP BPDUs RECEIVEd dump debugging is on
R2-SW2#debug spanning-tree mstp bpdu transmit
MSTP BPDUs TRANSMITted dump debugging is on
R2-SW2#debug condition interface gigabitEthernet 1/0/2 <-- interface facing PVST switch

R2-SW2#show logging
! Output omitted for brevity
%LINK-3-UPDOWN: Interface GigabitEthernet1/0/2, changed state to down
%LINK-3-UPDOWN: Interface GigabitEthernet1/0/2, changed state to up
MST[0]:-TX> Gi1/0/2 BPDU Prot:0 Vers:3 Type:2
MST[0]: Role :Desg Flags[P] Age:2 RemHops:19
MST[0]: CIST_root:16385.689e.0ba0.f580 Cost :40000
```

```
MST[0]: Reg_root :32768.f04a.0205.d600 Cost :20000
MST[0]: Bridge_ID:32768.a0f8.4910.4780 Port_ID:32770
MST[0]: max_age:20 hello:2 fwdelay:15
MST[0]: V3_len:80 region:R2 rev:1 Num_mrec: 1
MST[1]:-TX> Gi1/0/2 MREC
MST[1]: Role :Desg Flags[MAP] RemHops:20
MST[1]: Root_ID :32769.a0f8.4910.4780 Cost :0
MST[1]: Bridge_ID:32769.a0f8.4910.4780 Port_id:130
%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/0/2, changed state to up
MST[0]:-TX> Gi1/0/2 BPDU Prot:0 Vers:3 Type:2
MST[0]: Role :Desg Flags[P] Age:2 RemHops:19
MST[0]: CIST_root:16385.689e.0ba0.f580 Cost :40000
MST[0]: Reg_root :32768.f04a.0205.d600 Cost :20000
MST[0]: Bridge_ID:32768.a0f8.4910.4780 Port_ID:32770
MST[0]: max_age:20 hello:2 fwdelay:15
MST[0]: V3_len:80 region:R2 rev:1 Num_mrec: 1
MST[1]:-TX> Gi1/0/2 MREC
MST[1]: Role :Desg Flags[MAP] RemHops:20
MST[1]: Root_ID :32769.a0f8.4910.4780 Cost :0
MST[1]: Bridge_ID:32769.a0f8.4910.4780 Port_id:130
MST[0]:<RX- Gi1/0/2 superior designated BPDU Prot:0 Vers:2 Type:2
MST[0]: Role :Desg Flags[FLTc] Age:0
MST[0]: CIST_root:16385.689e.0ba0.f580 Cost :0
MST[0]: Bridge_ID:16385.689e.0ba0.f580 Port_ID:32770
MST[0]: max_age:20 hello:2 fwdelay:15
```

P2P Dispute

Topology



Explanation

In this section you can observe a problem with two devices that could not establish an agreement and set the status of the ports properly.

```
R1-SW1#show spanning-tree mst

##### MST0    vlans mapped:   1-2,5-4094
Bridge        address 3473.2db8.be80  priority      32768 (32768 sysid 0)
Root          address 689e.0ba0.f580  priority      4097  (4096 sysid 1)
              port    Gi1/0/2         path cost     20000
Regional Root address f04a.021e.9500  priority      24576 (24576 sysid 0)
                                      internal cost 20000     rem hops 19
Operational   hello time 2 , forward delay 15, max age 20, txholdcount 6
Configured    hello time 2 , forward delay 15, max age 20, max hops    20

Interface                        Role Sts Cost      Prio.Nbr Type
----------------                 ---- --- --------- -------- --------------------------------
Gi1/0/1                          Desg FWD 20000     128.1    P2p
Gi1/0/2                          Root FWD 20000     128.2    P2p
Gi1/0/4                          Desg BLK 20000     128.2    P2p Dispute
```

```
##### MST1    vlans mapped:   3-4
Bridge        address 3473.2db8.be80  priority      32769 (32768 sysid 1)
Root          address f04a.021e.9500  priority      24577 (24576 sysid 1)
              port    Gi1/0/2         cost          20000     rem hops 19

Interface                        Role Sts Cost      Prio.Nbr Type
----------------                 ---- --- --------- -------- --------------------------------
Gi1/0/1                          Desg FWD 20000     128.1    P2p
Gi1/0/2                          Root FWD 20000     128.2    P2p
Gi1/0/4                          Desg BLK 20000     128.2    P2p Dispute
```

R1-SW1 (root) noticed that a new devices was connected to it. So it sends its BPDU and defines itself as root.

It received a BPDU that specifies that, on the other side on the link, the flags are set as port role: designated, forwarding and learning.

This means that the new switch connected states that has better path to reach the root. However, this is not possible as R1-SW1 is the root and there is no better path to it.

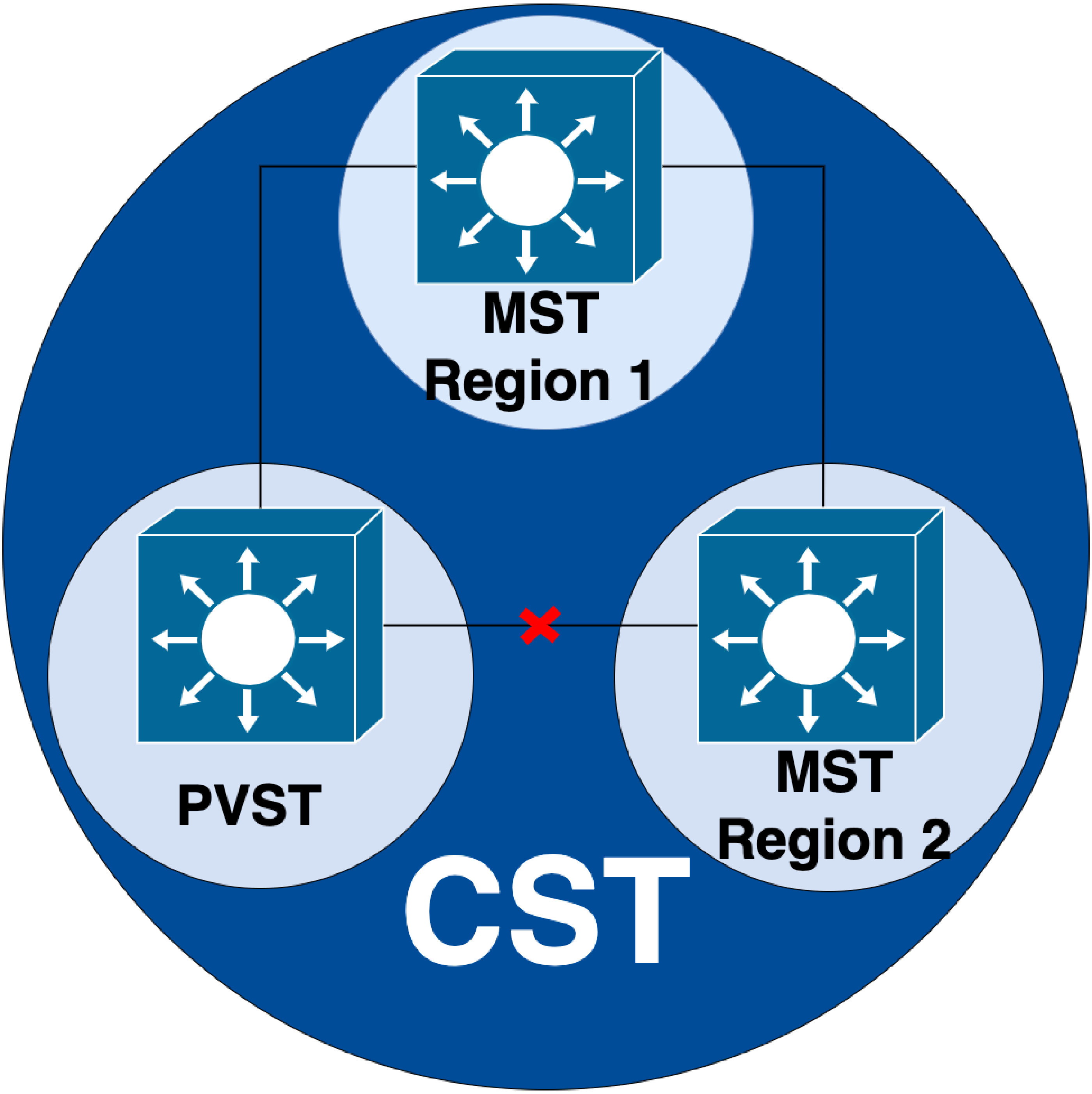
Because both switches could not establish the agreement and set the ports correctly (as both BPDUs show a better path to the root), R1-SW1 assumes that the new switch does not receive its BPDUs and sets the port status to P2P Dispute to avoid unidirectional scenarios that can cause loops.

MST approaches

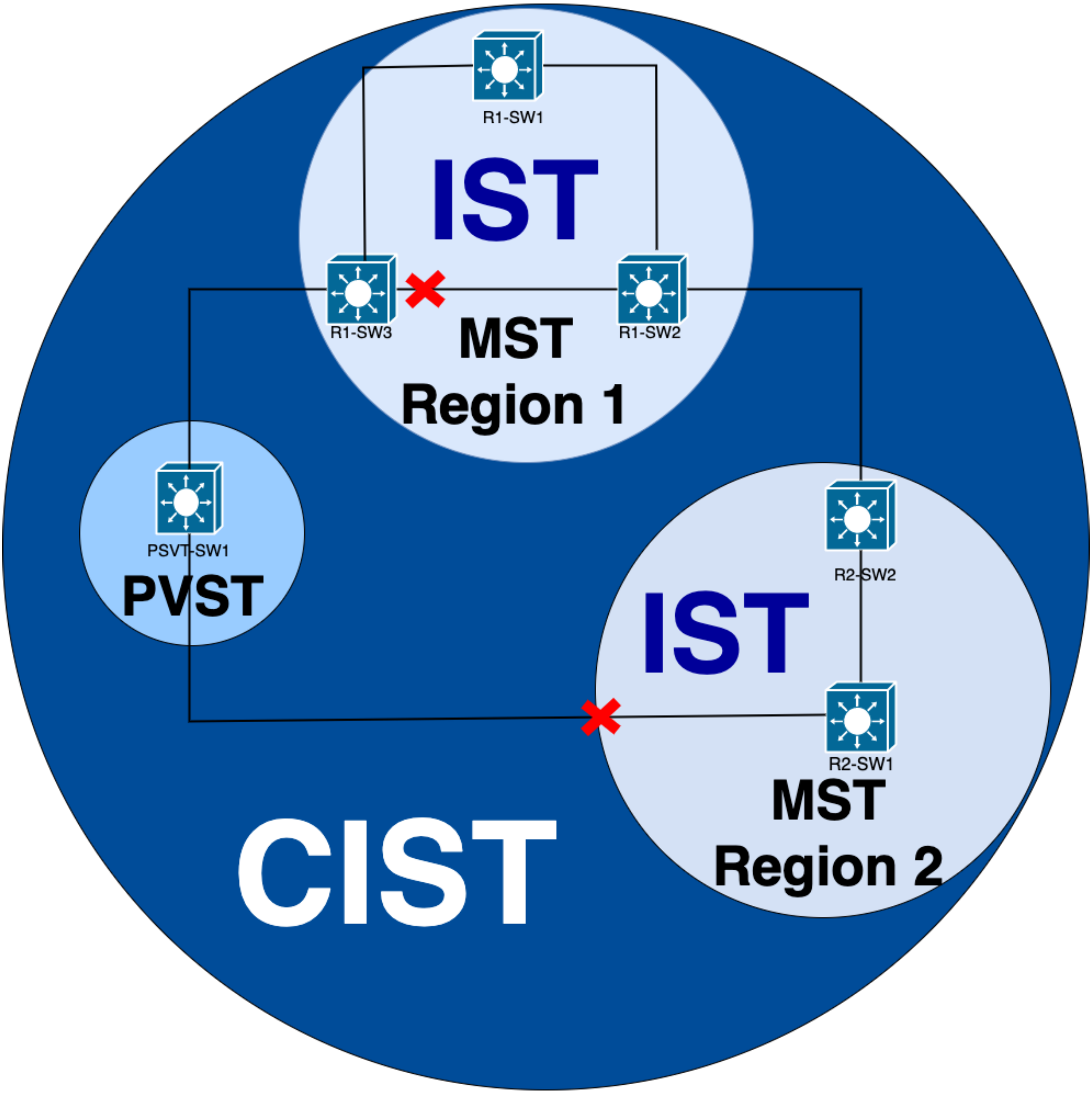
As observed in this document, MST can be more complicated as long as more switches are added to the network. Due to this, it is important to have different approaches to the same network.

Example:

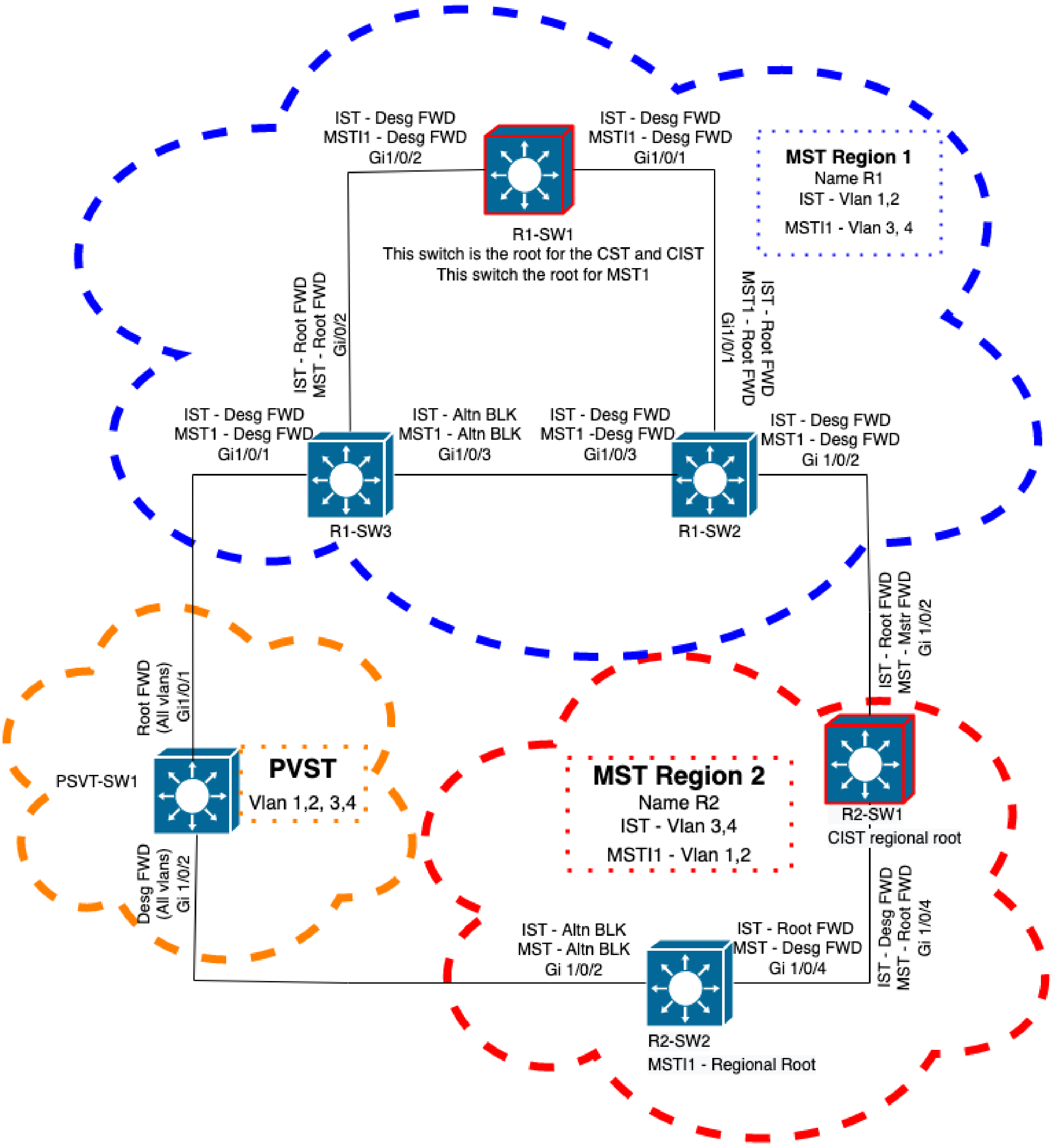
If the issue observed is not within MST region but in a PVST domain, you can have a wider picture and ignore anything inside the MST regions (CST perspective).



On the other hand if the issue is suspected to be either between MST regions or inside a region, then CIST provides a better perspective.



If needed, you can **focus** on the port roles and status of the switches



Related Information

- Understanding Multiple Spanning Tree Protocol (802.1s)
- Layer 2 Configuration Guide, Cisco IOS XE Amsterdam 17.3.x (Catalyst 9300 Switches)
- Layer 2 and Layer 3 Configuration Guide, Cisco IOS XE Everest 16.5.1a (Catalyst 9300 Switches)
- PVST Simulation n MST Switches
- Cisco bug ID CSCvy02075 - Switch forwards traffic received on ports in blocking BLK state