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CCIE Routing & Switching

Multiple Spanning Tree (MST)

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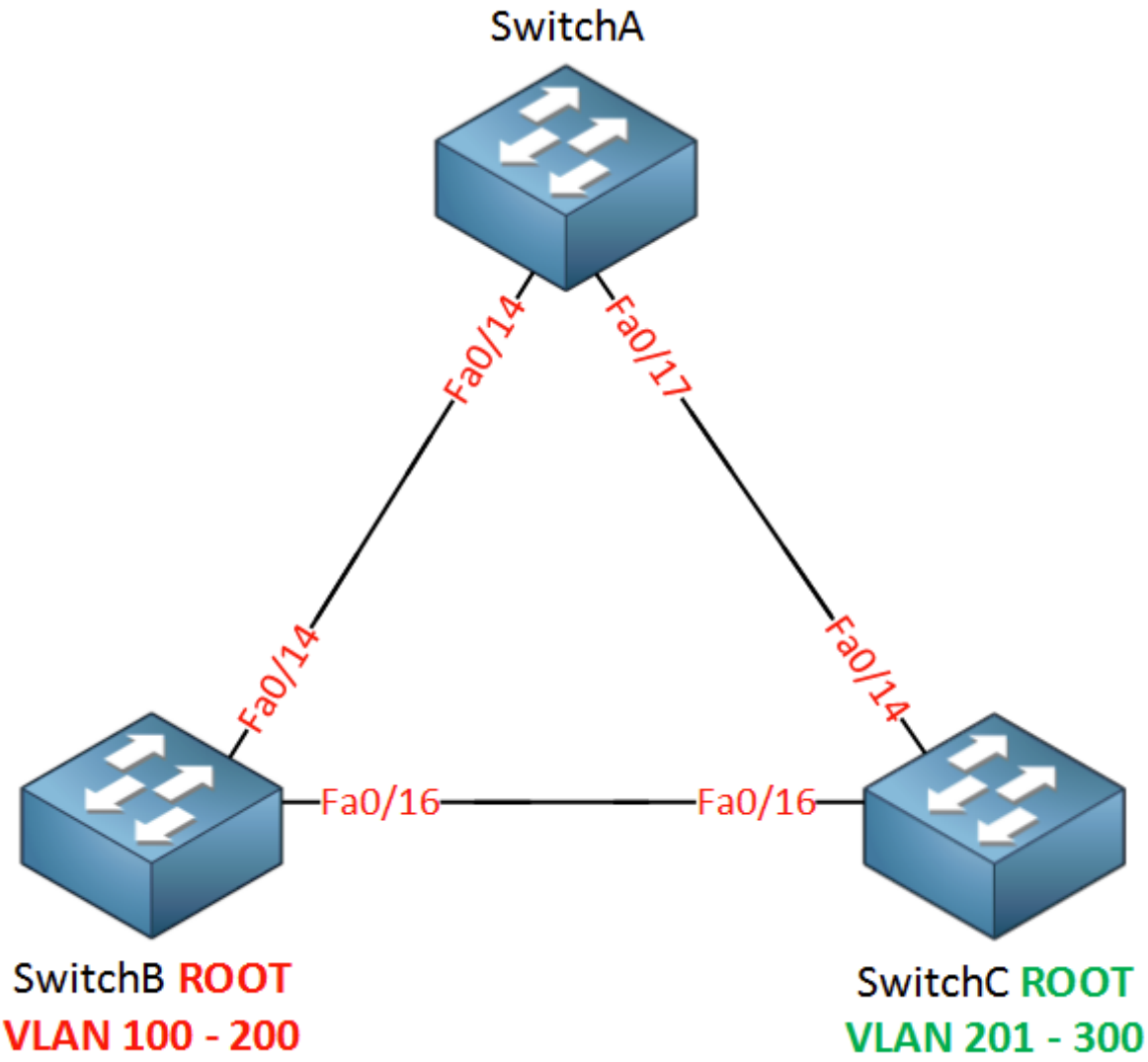
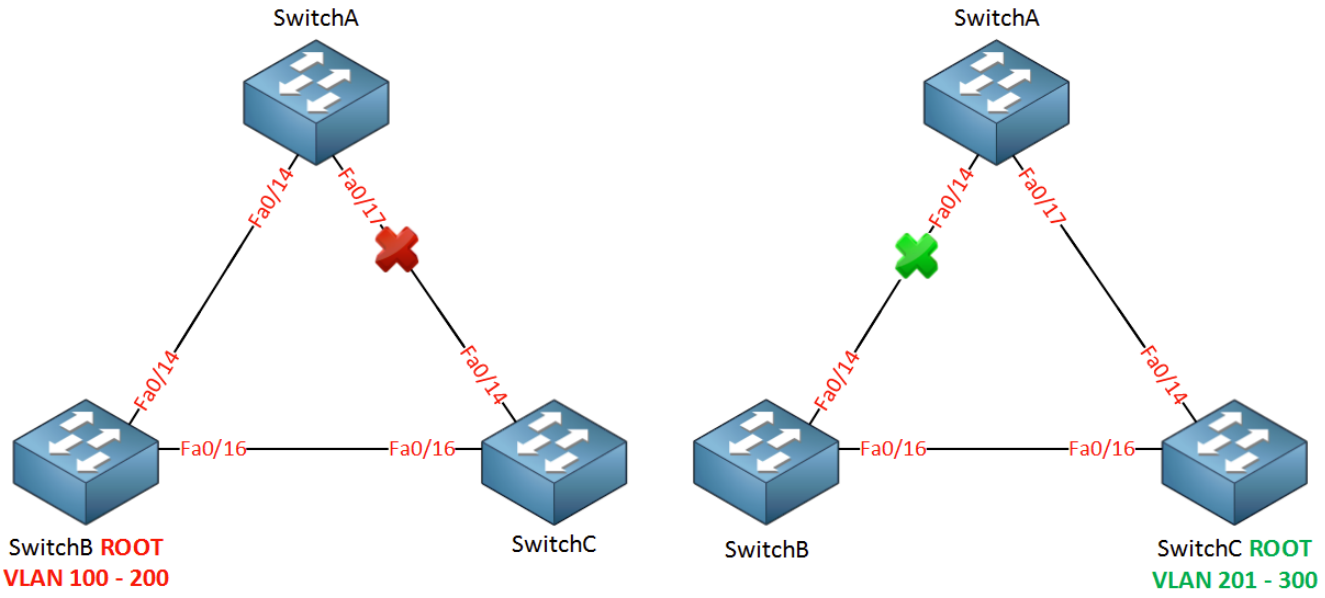
By default Cisco Catalyst Switches run PVST+ or Rapid PVST+ (Per VLAN Spanning Tree). This means that each VLAN is mapped to a single spanning tree instance. When you have 20 VLANs, it means there are 20 instances of spanning tree.

Is this a problem? Like always...it depends, let's take a look at an example:



Take a look at the topology above. We have three switches and a lot of VLANs. There's 199 VLANs in total. If we are running PVST or Rapid PVST this means that we have 199 different calculations for each VLAN. This requires a lot of CPU power and memory.

When SwitchB is the root bridge for VLAN 100 – 200 and SwitchC for VLAN 201 – 300 our spanning-tree topologies will look like this:



SwitchB is the root bridge for VLAN 100 up to VLAN 200. This means that the fa0/17 interface of SwitchA or the fa0/14 interface on SwitchC will be blocked. I'll have 100 spanning tree calculations but they all look the same for these VLANs...

The same thing applies for VLAN 201 – 300. SwitchC is the root bridge for VLAN 201 up to 300. The fa0/14 interface on SwitchA or SwitchB will be blocked for all these VLANs.

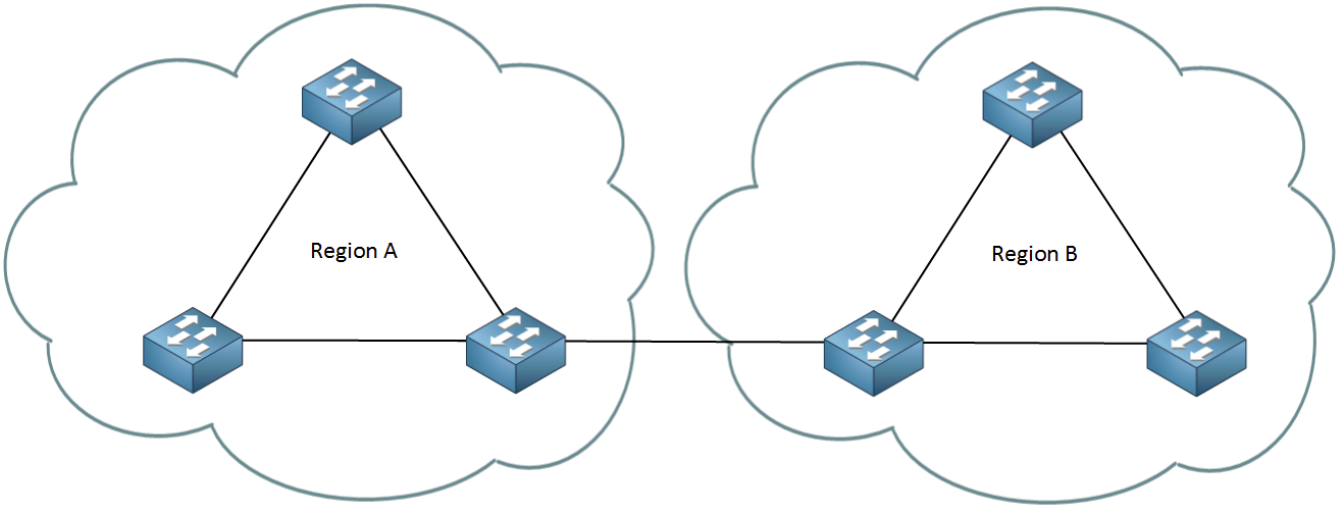
Two different outcomes but I still have 200 different instances of spanning tree running. That's a waste of CPU cycles and memory right?

MST (Multiple Spanning Tree) will solve this issue. Instead of calculating a spanning tree for each VLAN we can use **instances** and map VLANS to each instance. For the network above I could do something like this:

- Instance 1: VLAN 100 – 200
- Instance 2: VLAN 201 – 300

Sounds logical right? Only two spanning tree calculations (instances) are required for all these VLANs.

MST works with the concept of **regions.** Switches that are configured to use MST need to find out if their neighbors are running MST.



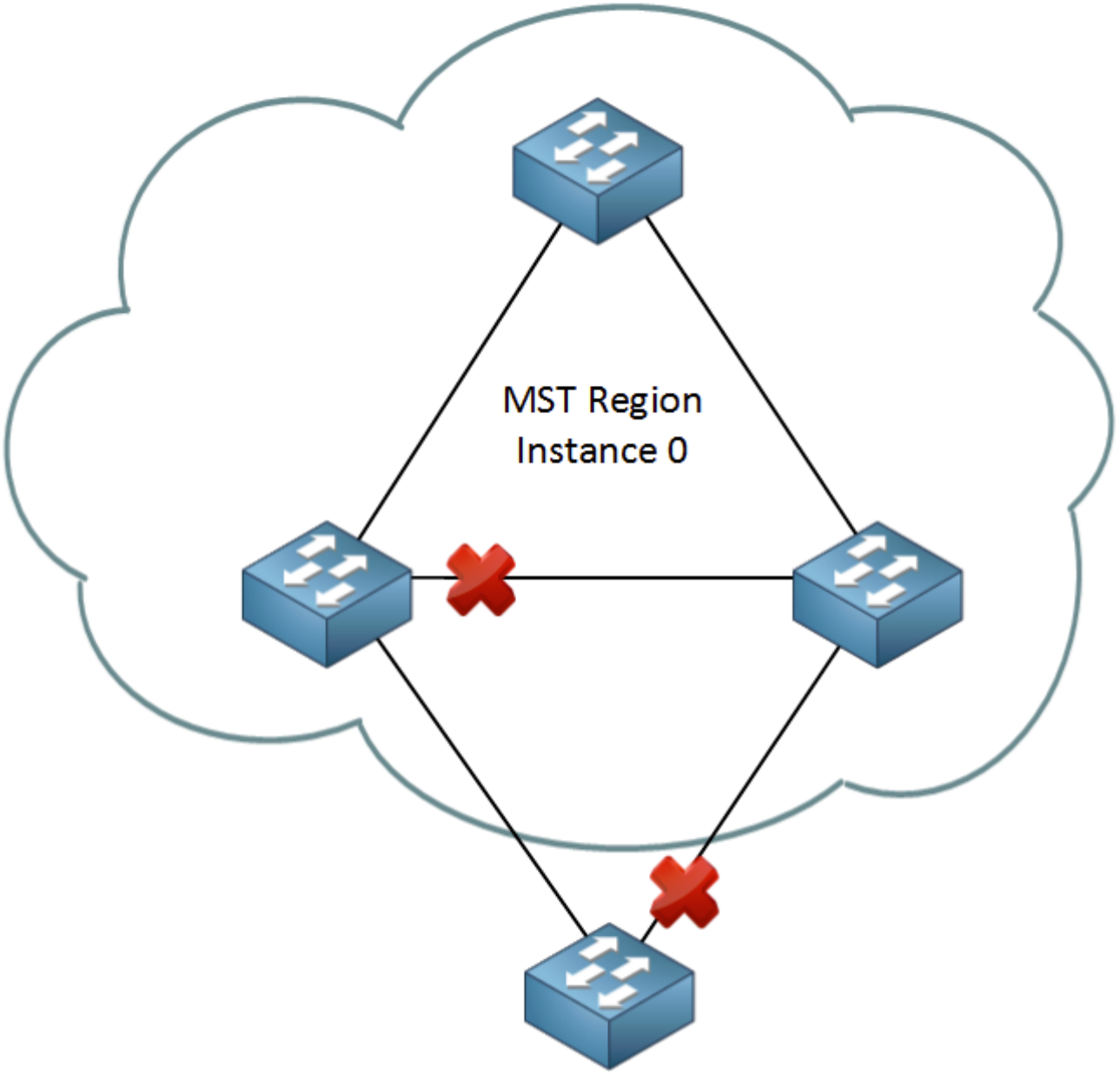
When switches have the **same attributes** they will be in the same region. It's possible to have one or more regions and here are the attributes that need to match:

- MST configuration name.
- MST configuration revision number.
- MST instance to VLAN mapping table.

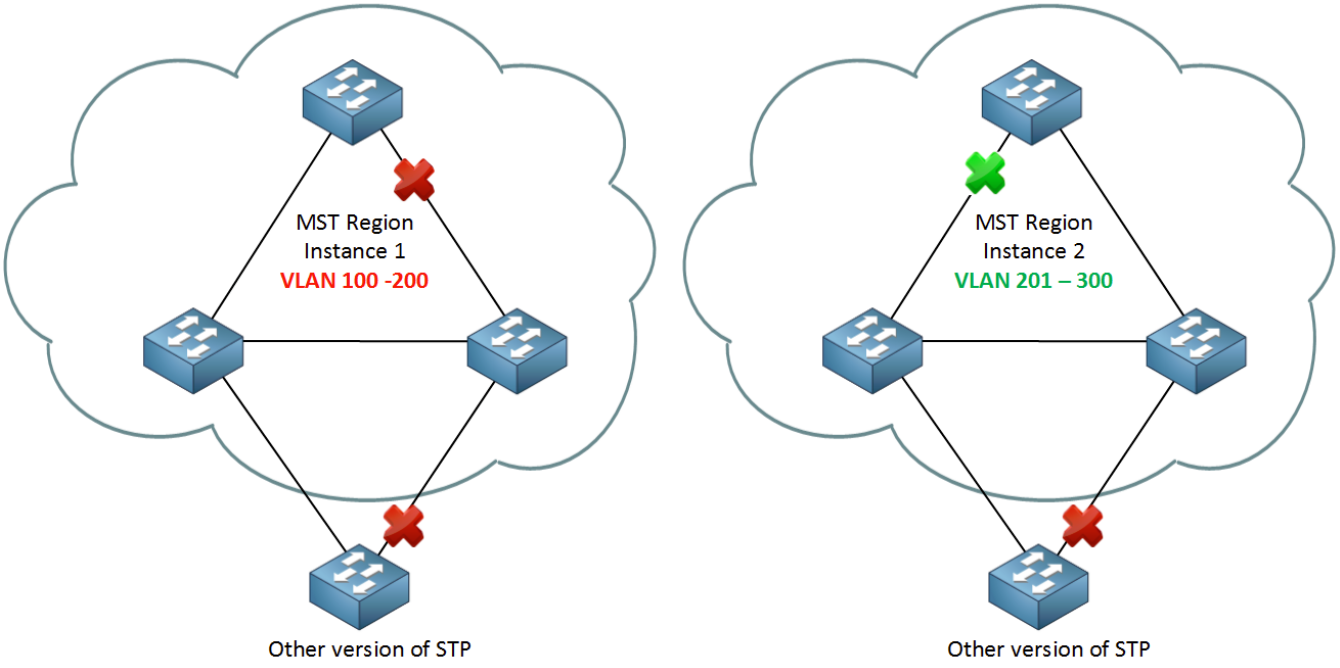
When switches have the **same attributes** configured they will be in the same region. If the attributes are not the same the switch is seen as being at the boundary of the region. It can be connected to another MST region but also talk to a switch running another version of spanning tree.

The **MST configuration name** is just something you can make up, it's used to identify the MST region. The **MST configuration revision number** is also something you can make up and the idea behind this number is that you can change the number whenever you change your configuration. It doesn't matter what you pick as long as it's the same on all switches within the MST region. VLANs will be mapped to an instance by using the **MST instance to VLAN mapping table**. This is something we have to do ourselves.

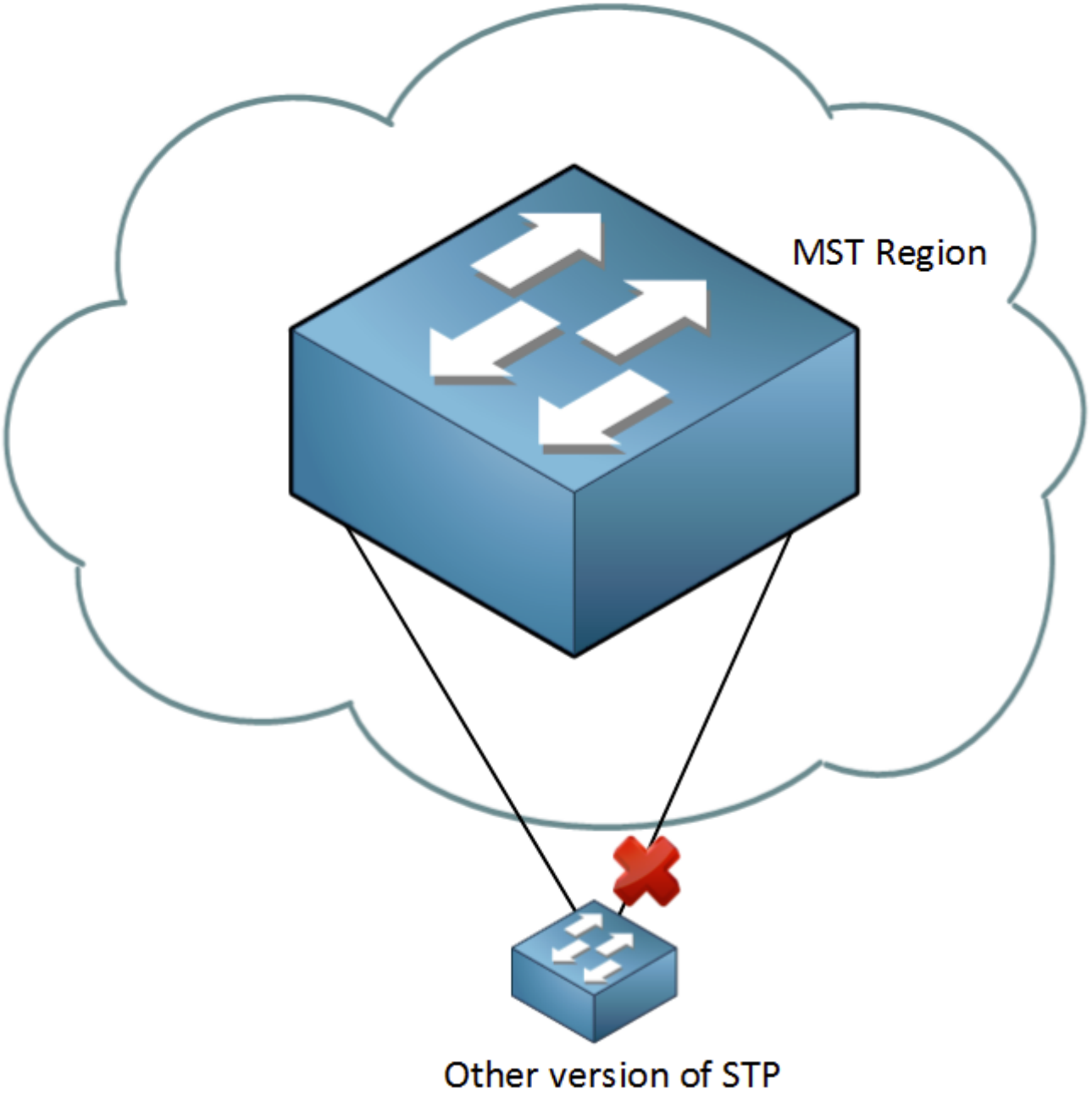
Within the MST region we will have one instance of spanning tree that will create a loop free topology **within the region.** When you configure MST there is always one default instance used to calculate the topology within the region. We call this the **IST (Internal Spanning Tree).** By default Cisco will use **instance 0** to run the IST. In case you were wondering...its rapid spanning tree that we run within the MST.



I could create instance 1 for VLAN 100 – 200 and instance 2 for VLAN 201 – 300. Depending on which switch will become root bridge for each instance a different port will be blocked. It could look like this:



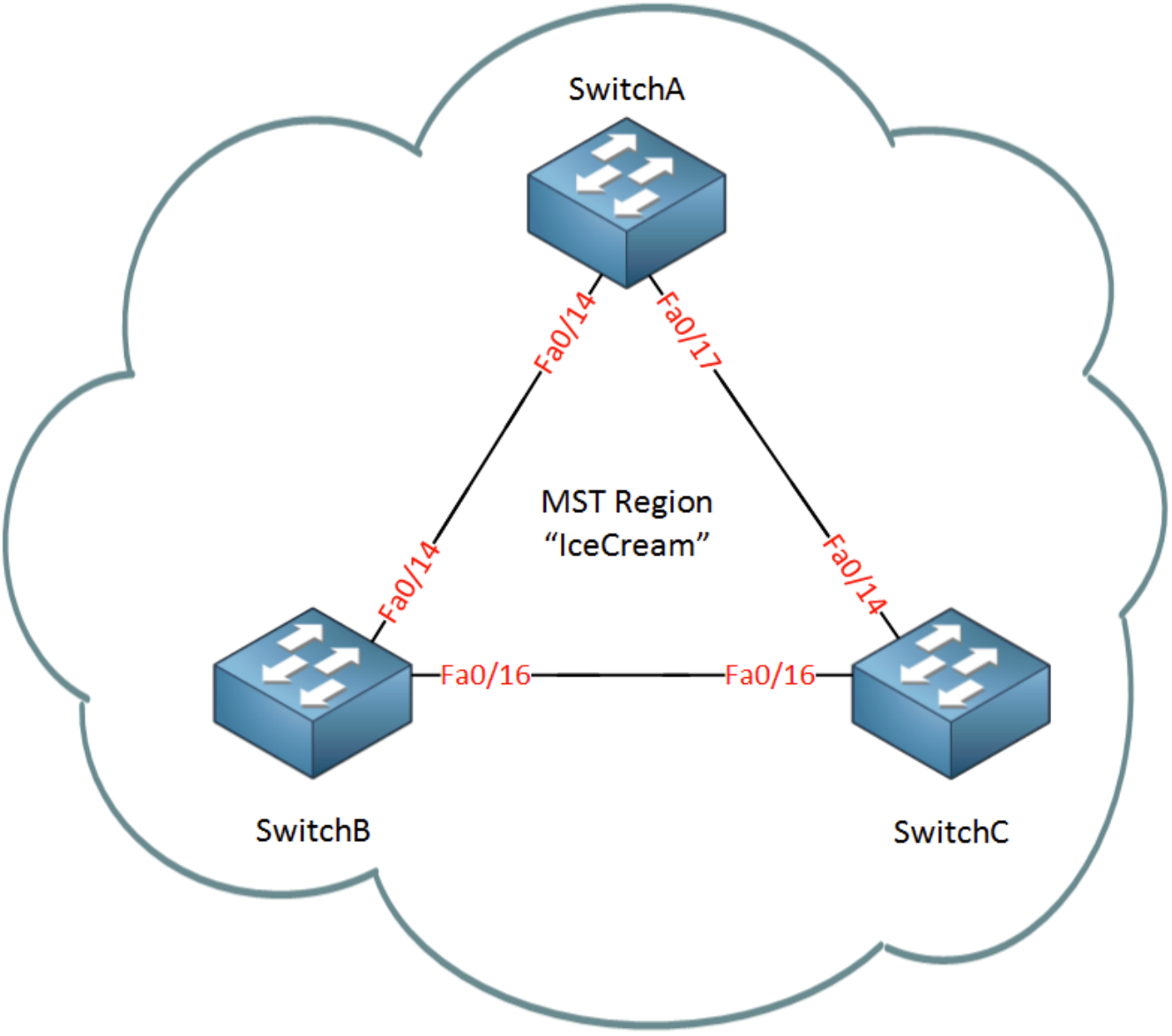
The switch outside the MST region doesn't see what the MST region looks like. For this switch it's like it's talking to one big switch or a 'black box':



Does this make sense so far? I hope so! Let's have some fun with the configuration.

MST Configuration

I will use the following topology:



We’ll start with a single MST region with the following attributes:

- MST configuration name: “IceCream”
- MST configuration revision number: 1 (this is just a number that I made up)
- MST instance to VLAN mapping table:
  - Instance 2: VLAN 10, 20 and 30.
  - Instance 3: VLAN 40, 50 and 60.

This is what we will do:

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

```
SwitchB(config)#spanning-tree mode mst
```

```
SwitchC(config)#spanning-tree mode mst
```

This is how we enable MST on our switches. Let's look at the default MST instance:

```
SwitchA#show spanning-tree mst configuration
Name      []
Revision  0     Instances configured 1

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
-
0         1-4094
---------------------------------------------------------------------------
-
```

```
SwitchB#show spanning-tree mst configuration
Name      []
Revision  0     Instances configured 1

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
-
0         1-4094
---------------------------------------------------------------------------
-
```

```
SwitchC#show spanning-tree mst configuration
Name      []
Revision  0     Instances configured 1

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
-
0         1-4094
---------------------------------------------------------------------------
-
```

We can use the **show spanning-tree mst configuration** command to see the MST instances. I haven't created any additional instances so only instance 0 is available. You can see that all VLANs are currently mapped to instance 0. Let's see what else we can find:

```
SwitchA#show spanning-tree mst

##### MST0    vlans mapped:   1-4094
Bridge        address 0011.bb0b.3600  priority      32768 (32768 sysid 0)
Root          address 000f.34ca.1000  priority      32768 (32768 sysid 0)
              port    Fa0/17          path cost     0
Regional Root address 000f.34ca.1000  priority      32768 (32768 sysid 0)
                                      internal cost 200000    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
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Desg FWD 200000    128.16   P2p
Fa0/17           Root FWD 200000    128.19   P2p
```

You can also use the show spanning-tree mst command. We can see the VLAN mapping but also information about the root bridge. Before we can add more instances we have to do our chores...time to add some VLANs and configure the links between the switches as trunks:

```
SwitchA(config)#interface fa0/14
SwitchA(config-if)#switchport trunk encapsulation dot1q
SwitchA(config-if)#switchport mode trunk
SwitchA(config)#interface fa0/17
SwitchA(config-if)#switchport trunk encapsulation dot1q
SwitchA(config-if)#switchport mode trunk
```

```
SwitchB(config)#interface fa0/14
SwitchB(config-if)#switchport trunk encapsulation dot1q
SwitchB(config-if)#switchport mode trunk
SwitchB(config)#interface fa0/16
SwitchB(config-if)#switchport trunk encapsulation dot1q
SwitchB(config-if)#switchport mode trunk
```

```
SwitchC(config)#interface fa0/14
SwitchC(config-if)#switchport trunk encapsulation dot1q
SwitchC(config-if)#switchport mode trunk
SwitchC(config)#interface fa0/16
SwitchC(config-if)#switchport trunk encapsulation dot1q
SwitchC(config-if)#switchport mode trunk
```

That takes cares of the trunks, and here are the VLANs:

```
SwitchA, B & C:
(config)#vlan 10
(config-vlan)#vlan 20
(config-vlan)#vlan 30
(config-vlan)#vlan 40
(config-vlan)#vlan 50
(config-vlan)#vlan 60
(config-vlan)#exit
```

Now we can configure MST and the instances:

```
SwitchA(config)#spanning-tree mst configuration
SwitchA(config-mst)#name IceCream
SwitchA(config-mst)#revision 1
SwitchA(config-mst)#instance 2 vlan 10,20,30
SwitchA(config-mst)#instance 3 vlan 40,50,60
SwitchA(config-mst)#exit
```

```
SwitchB(config)#spanning-tree mst configuration
SwitchB(config-mst)#name IceCream
SwitchB(config-mst)#revision 1
SwitchB(config-mst)#instance 2 vlan 10,20,30
SwitchB(config-mst)#instance 3 vlan 40,50,60
SwitchB(config-mst)#exit
```

```
SwitchC(config)#spanning-tree mst configuration
SwitchC(config-mst)#name IceCream
```

```
SwitchC(config-mst)#revision 1
SwitchC(config-mst)#instance 2 vlan 10,20,30
SwitchC(config-mst)#instance 3 vlan 40,50,60
SwitchC(config-mst)#exit
```

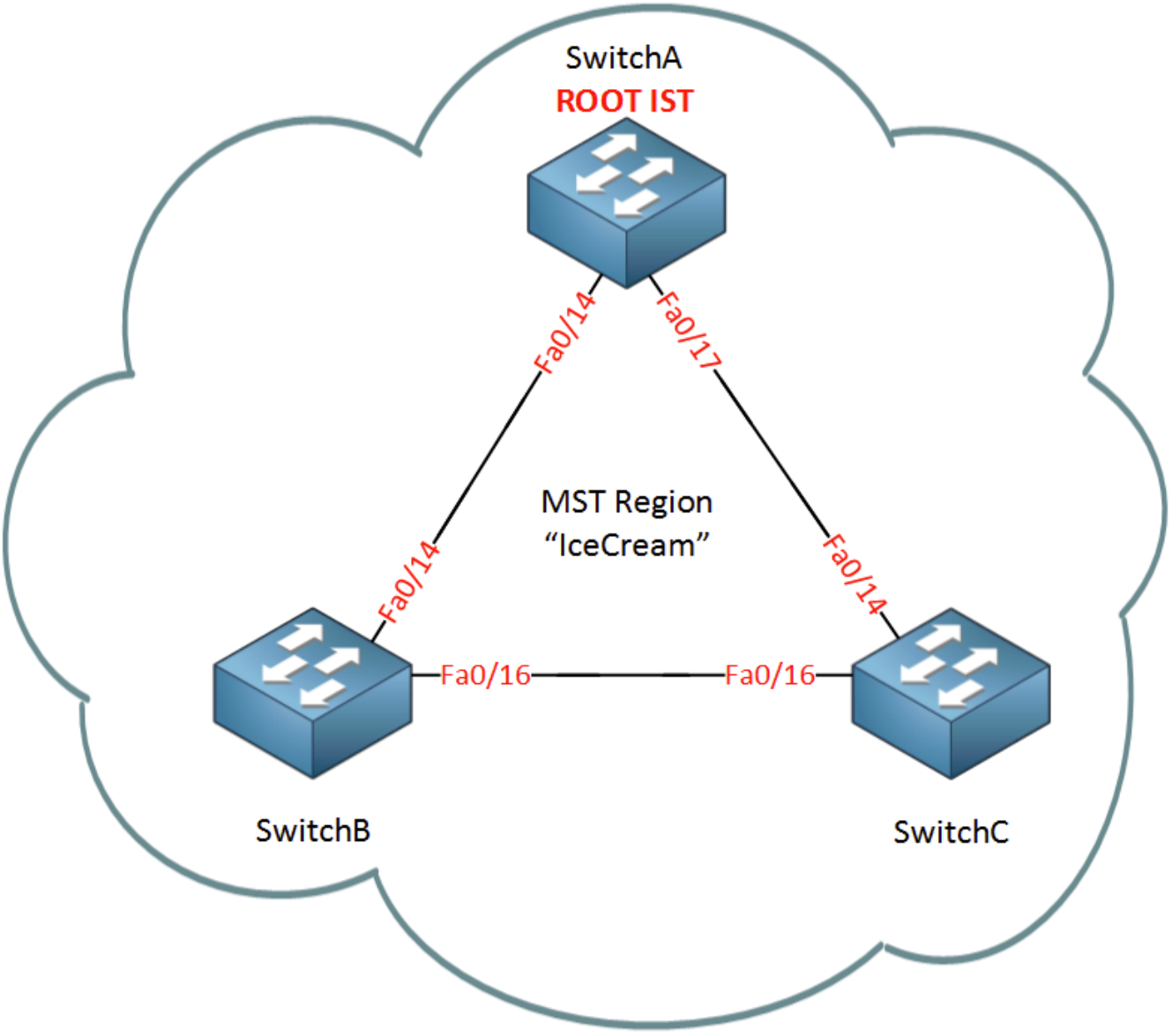
This is how we configure MST. First you need the **spanning-tree mst configuration** command to enter the configuration of MST. We set the name by using the **name** command. Don't forget to set a **revision number** and map the instances with the **instance** command. Let's verify our work:

```
SwitchA#show spanning-tree mst configuration
Name      [IceCream]
Revision  1     Instances configured 3

Instance  Vlans mapped
--------  ---------------------------------------------------------------------
-
0         1-9,11-19,21-29,31-39,41-49,51-59,61-4094
2         10,20,30
3         40,50,60
---------------------------------------------------------------------------
-
```

We can use the show spanning-tree mst configuration command to verify our configuration. You can see that we now have two instances. The VLANS are mapped to instance 2 and 3. All the other VLANs are still mapped to instance 0.

So far so good, let's play some more with MST and change the root bridge:



Within our region I want to make sure that SwitchA is the root bridge. We'll have to change the priority for the IST (Internal Spanning Tree):

```
SwitchA(config)#spanning-tree mst 0 priority 4096
```

This is how I change the priority for MST instance 0.

```
SwitchA#show spanning-tree mst

##### MST0    vlans mapped:   1-9,11-19,21-29,31-39,41-49,51-59,61-4094
Bridge        address 0011.bb0b.3600  priority      4096  (4096 sysid 0)
Root          this switch for the CIST
```

Here you can see that SwitchA is the root bridge for the IST. It says CIST which stands for Common and Internal Spanning Tree.

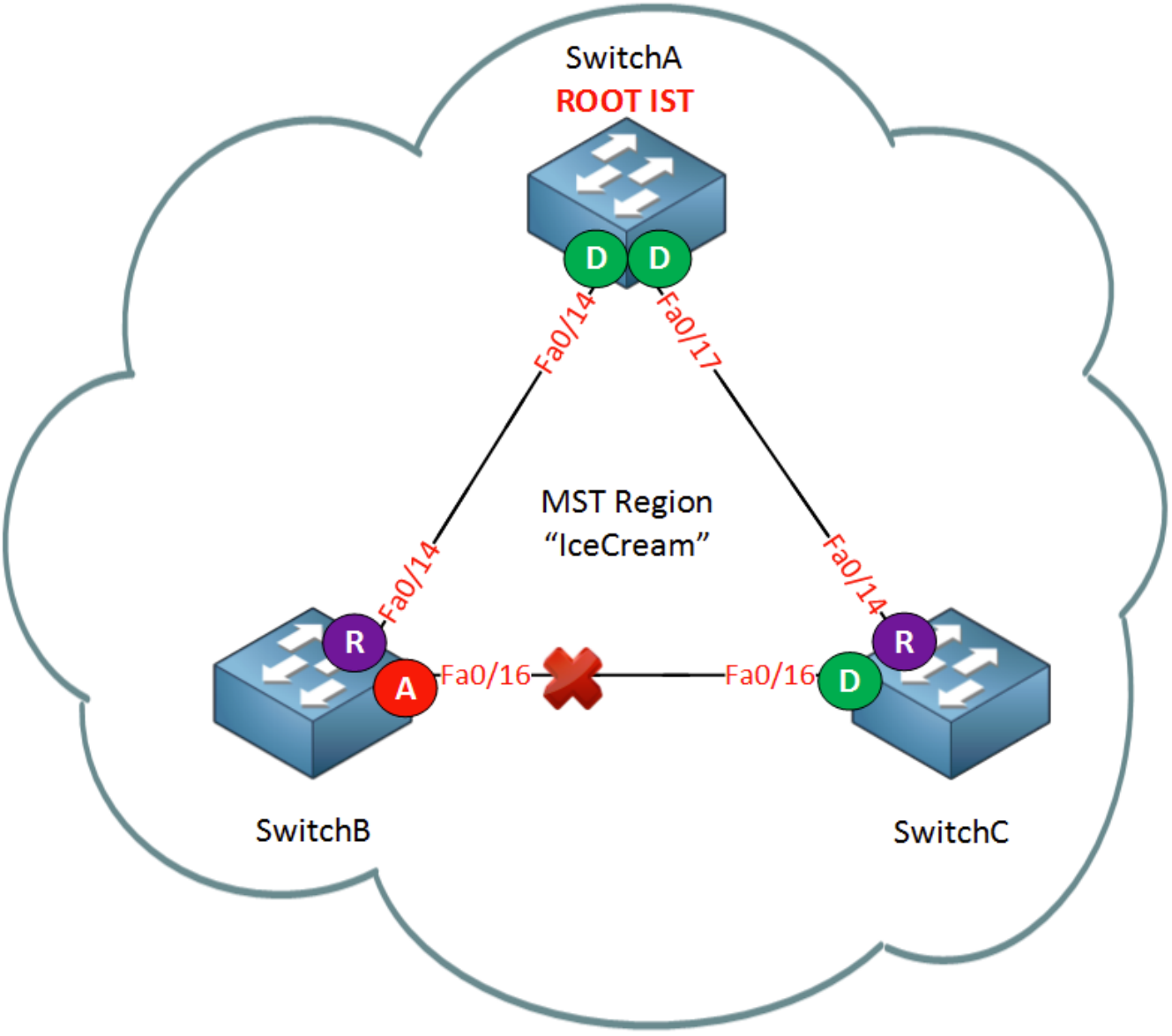
Let's take a look at the interfaces:

```
SwitchA#show spanning-tree mst 0 | begin Interface
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Desg FWD 200000    128.16   P2p
Fa0/17           Desg FWD 200000    128.19   P2p
```

```
SwitchB#show spanning-tree mst 0 | begin Interface
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Root FWD 200000    128.16   P2p
Fa0/16           Altn BLK 200000    128.18   P2p
```

```
SwitchC#show spanning-tree mst 0 | begin Interface
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Root FWD 200000    128.14   P2p
Fa0/16           Desg FWD 200000    128.16   P2p
```

Now we know the state of all interfaces. Let's draw a picture so we know what the IST looks like:



Now I want to make some changes to instance 2 so SwitchB will be root bridge:

```
SwitchB(config)#spanning-tree mst 2 priority 4096
```

We’ll change the priority on SwitchB for instance 2.

```
SwitchB#show spanning-tree mst 2

##### MST2    vlans mapped:   10,20,30
Bridge        address 0019.569d.5700  priority      4098  (4096 sysid 2)
Root          this switch for MST2
```

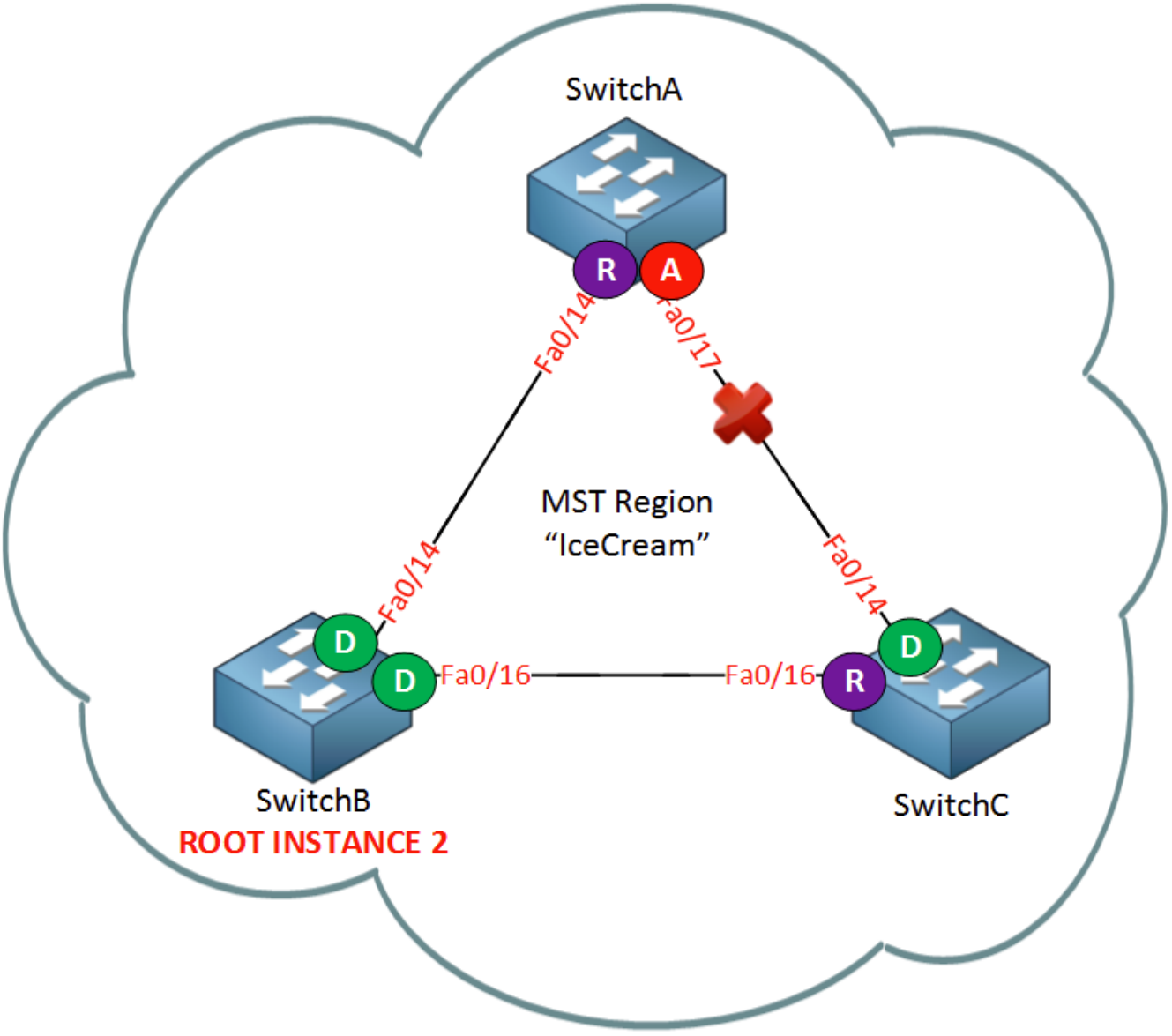
This command proves that SwitchB is the root bridge for instance 2. Let's check the interfaces:

```
SwitchA#show spanning-tree mst 2 | begin Interface
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Root FWD 200000    128.16   P2p
Fa0/17           Altn BLK 200000    128.19   P2p
```

```
SwitchB#show spanning-tree mst 2 | begin Interface
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Desg FWD 200000    128.16   P2p
Fa0/16           Desg FWD 200000    128.18   P2p
```

```
SwitchC#show spanning-tree mst 2 | begin Interface
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Desg FWD 200000    128.14   P2p
Fa0/16           Root FWD 200000    128.16   P2p
```

This is what instance 2 looks like. Let's turn that into a nice picture:



Here's a fancy picture of instance 2 to show you the port roles. Note that this topology looks different than the one for instance 0.

Last but not least I'm now going to make some changes for instance 3:

```
SwitchC(config)#spanning-tree mst 3 priority 4096
```

SwitchC will become the root bridge for instance 3.

```
SwitchC#show spanning-tree mst 3

##### MST3    vlans mapped:   40,50,60
Bridge        address 000f.34ca.1000  priority      4099  (4096 sysid 3)
Root          this switch for MST3
```

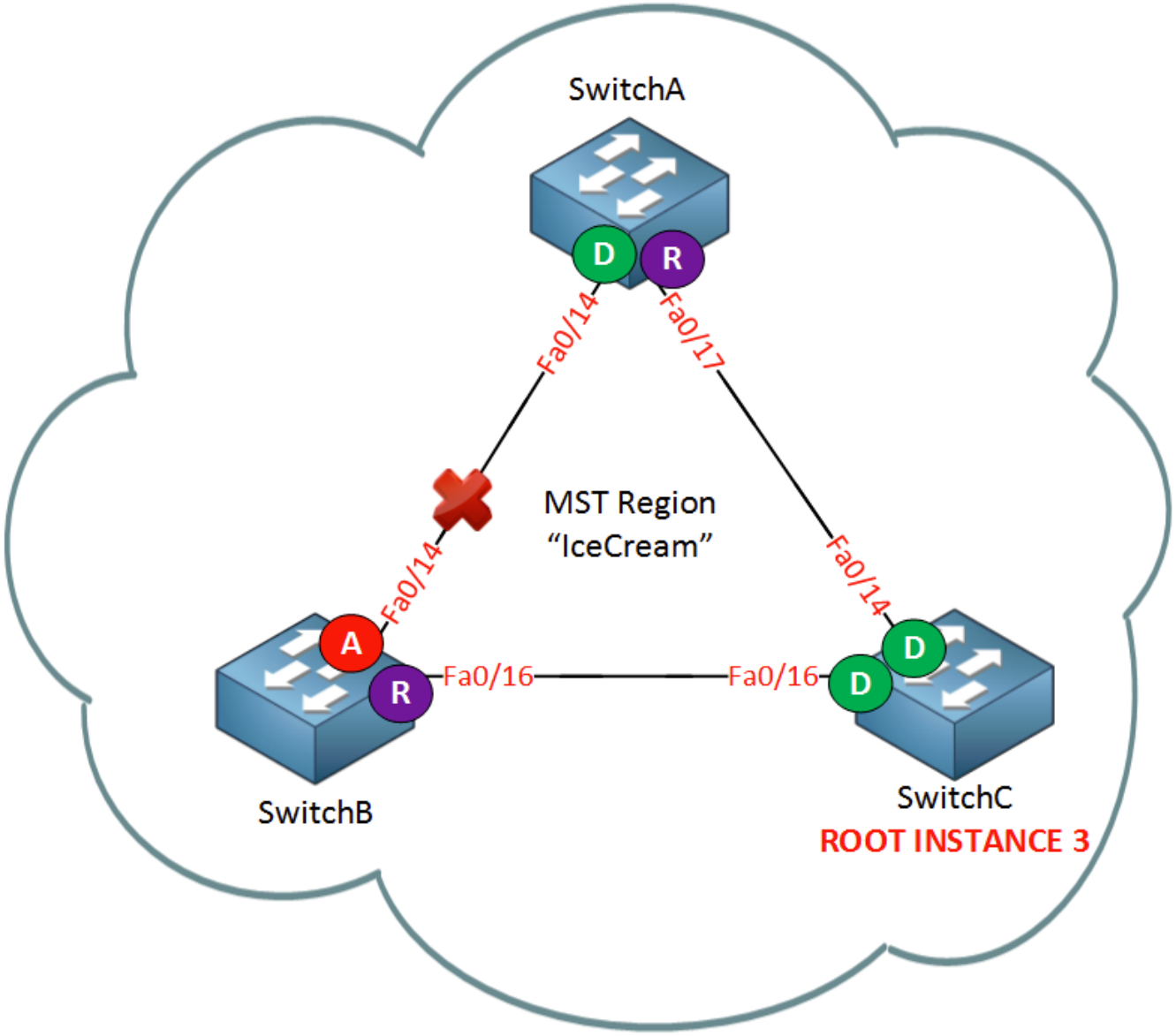
SwitchC is now the root bridge for instance 3. Let's look at the interfaces:

```
SwitchA#show spanning-tree mst 3 | begin Interface
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Desg FWD 200000    128.16   P2p
Fa0/17           Root FWD 200000    128.19   P2p
```

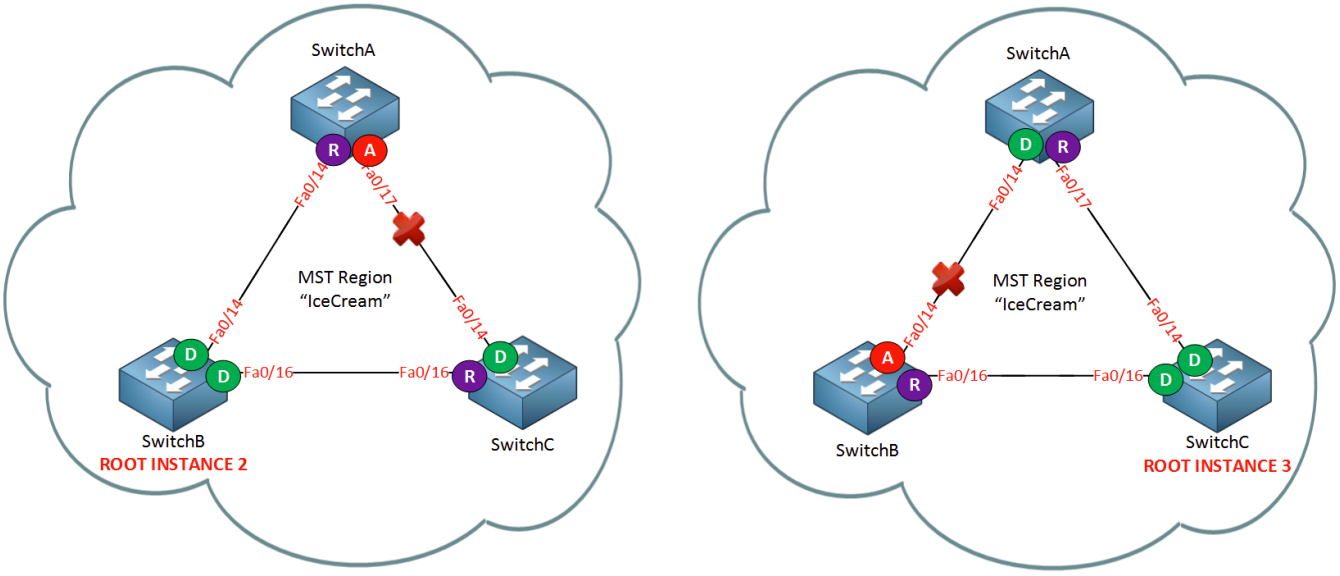
```
SwitchB#show spanning-tree mst 3 | begin Interface
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Altn BLK 200000    128.16   P2p
Fa0/16           Root FWD 200000    128.18   P2p
```

```
SwitchC#show spanning-tree mst 3 | begin Interface
Interface        Role Sts Cost      Prio.Nbr Type
---------------- ---- --- --------- -------- --------------------------------
Fa0/14           Desg FWD 200000    128.14   P2p
Fa0/16           Desg FWD 200000    128.16   P2p
```

And we can draw another topology picture:



Let's compare instance 2 and 3 next to each other:



On the left side you see instance 2 and on the right side is instance 3.

By changing the root bridge per instance we end up with different topologies:

- Instance 2: fa0/17 on SwitchA is blocked for VLAN 10, 20 and 30.
- Instance 3: fa0/14 on SwitchB is blocked for VLAN 40, 50 and 60.

Is this making sense so far? I sure hope so!

What happens when I add another switch that is running PVST to our topology? Let's find out!

```
SwitchD(config)#spanning-tree mode pvst
```

PVST is the default on most Cisco switches but I'm showing it here so you really know I'm running PVST.

```
SwitchD(config)#interface fa0/16
SwitchD(config-if)#switchport trunk encapsulation dot1q
SwitchD(config-if)#switchport mode trunk
SwitchD(config)#interface fa0/19
SwitchD(config-if)#switchport trunk encapsulation dot1q
SwitchD(config-if)#switchport mode trunk
```

```
SwitchD(config)#vlan 10
SwitchD(config-vlan)#vlan 20
SwitchD(config-vlan)#vlan 30
SwitchD(config-vlan)#vlan 40
SwitchD(config-vlan)#vlan 50
SwitchD(config-vlan)#vlan 60
SwitchD(config-vlan)#exit
```

I want to make sure that we have trunk to SwitchB and SwitchC and that SwitchD knows about all the VLANs. Let's see what switchD thinks of all this:

```
SwitchD#show spanning-tree vlan 1

VLAN0001
  Spanning tree enabled protocol ieee
  Root ID    Priority    4096
```

```
             Address     0011.bb0b.3600
             Cost        19
             Port        19 (FastEthernet0/19)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32769  (priority 32768 sys-id-ext 1)
             Address     0009.7c36.2880
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
--
Fa0/16              Altn BLK 19        128.16   P2p
Fa0/19              Root FWD 19        128.19   P2p
```

This is what SwitchD sees about VLAN 1. Keep in mind this VLAN was mapped to instance 0. It sees SwitchA as the root bridge and you can see which port is in forwarding and blocking mode.

```
SwitchD#show spanning-tree vlan 10

VLAN0010
  Spanning tree enabled protocol ieee
  Root ID    Priority    4096
             Address     0011.bb0b.3600
             Cost        19
             Port        19 (FastEthernet0/19)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32778  (priority 32768 sys-id-ext 10)
             Address     0009.7c36.2880
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
             Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
--
Fa0/16              Altn BLK 19        128.16   P2p
Fa0/19              Root FWD 19        128.19   P2p
```

Here's VLAN 10 which is mapped to instance 2. SwitchD sees SwitchA as the root bridge for this VLAN even though we configured SwitchB as the root bridge for instance 2. This is perfectly normal because **MST will only advertise BPDUs from the IST to the outside world**. We won't see any information from instance 2 or instance 3 on SwitchD.

```
SwitchD#show spanning-tree vlan 40

VLAN0040
  Spanning tree enabled protocol ieee
  Root ID     Priority    4096
              Address     0011.bb0b.3600
              Cost        19
              Port        19 (FastEthernet0/19)
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID   Priority    32808  (priority 32768 sys-id-ext 40)
              Address     0009.7c36.2880
              Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec
              Aging Time 300

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
--
Fa0/16              Altn BLK 19        128.16   P2p
Fa0/19              Root FWD 19        128.19   P2p
```

VLAN 40 is mapped to instance 3 but you can see that SwitchD sees SwitchA as the root bri SwitchD receives the same BPDU for all VLANS.

That's all I have about MST for now! I hope this tutorial was useful for you and that you learned something here.

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- January 22, 2015 at 15:51 #11805 Reply

Yevgeniy O
Participant
good

April 7, 2015 at 02:21 #11806 Reply

Philip W
Participant
Awesome explanation on this, really cleared things up for me

May 18, 2015 at 00:17 #11807 Reply

Michael M
Participant
Hi Rene.
So is IST0 just Vlans that have not been applied to an Instance? If so im just confused about the part in the article where you state that “MST will only advertise BPDUs from the IST to the

outside world".
If a region connects to a different region or another STP domain does that mean all VLANs are now mapped to IST0 just for that switch that is outside of the region?

May 18, 2015 at 11:41 #11808 Reply

Rene Molenaar
Keymaster
Hi Michael,

IST0 is called IST (Internal Spanning-Tree) and these are the VLANs that haven't been mapped to another instance.

PVST uses 1 STP for each VLAN, MST uses 1 STP for multiple VLANs so we have a mismatch here. To make the two compatible, here's what happens:

– Within the MST region we run multiple STPs (one for each instance).
– On the border links (switches that connect to PVST) our MST switch will detect PVST BPDUs (or another MST region) and marks these interfaces as "boundary".
– The MST switch won't send any BPDUs from the instances that we configured.
– The MST switch will copy its BPDU from the IST and sends this BPDU on all VLANs towards the "outside" switch (this is called PVST Simulation mode).

This is what allows switches outside of the MST region to see it as "1 big switch".

If you need some more detail, let me know. I can always do another write-up on MST…

Rene

May 18, 2015 at 12:54 #11809 Reply

Michael M
Participant
Ahh ok I think I get it. IST0 is purely a MST thing and has nothing to do with PVST or CST
Thank you Rene.

August 6, 2015 at 11:28 #11810 Reply

Hussein Samir
Participant
Hi Rene,

Can we use MST in ISL trunks ?
And what about MISTP implementation ?

August 6, 2015 at 20:26 #11811 Reply

Rene Molenaar
Keymaster
Hi Hussein,

MISTP is Cisco's pre-standard version which later became MST (which is a standard IEEE 802.1s). ISL trunks is no problem btw.

Rene

August 25, 2015 at 06:37 #11812 Reply

Alberto s
Participant
Hello, Rene.

Reference to the 2 instances, can I put one SW like root for the 2 instances?

August 25, 2015 at 20:54 #11813 Reply

Rene Molenaar
Keymaster
Hi Alberto,

Sure that's no problem. The advantage of using two root switches however is that you can have some load balancing. If you use the same root bridge for all VLANs then a single interface will become the blocked port for all VLANs.

Rene

September 10, 2015 at 23:08 #11814 Reply

Robert J
Participant
How would we configure a secondary root bridge in a four switch environment in case the primary root bridge went down? Would it be as simple as setting this on the secondary root bridge switch?

spanning-tree mst 1 priority 8192

September 11, 2015 at 16:52 #11815 Reply

Rene Molenaar
Keymaster
Hi Robert,

Yes that's it, just make sure you set the priority to be the "second best". By default all switches have a priority of 32768 so when the primary switch fails, this one fill becomes the new root bridge.

Rene

October 12, 2015 at 11:57 #18219 Reply

Frades
Participant
so the switch that running PVST that connects to the MST, that switch will only see the IST0 priority? in your example, you made the Switch A the root on Instance 0. so PVST switch will just see a one giant big switch on MST but the switch A is the root bridge?

so when you make the Switch B the root on Instance 0, PVTS switch that have the directly connected interface to switch B will become the root port?

October 13, 2015 at 18:48 #18837 Reply

Rene Molenaar

Keymaster
Hi John,

That's right, the PVST switch doesn't know what the MST regions looks like. The MST region will replicate IST BPDUs on all VLANs to "simulate" a PVST neighbor. If you make SwitchB the root then the PVST switch(es) will use their interface(s) connected to switchB as the root port.

Rene

June 11, 2016 at 14:14 #24818 Reply

sze jie k
Participant
Hi Rene,

Absolutely fantastic, just when I encountered 2 switches in my office environment (with 1 as MST)
and another PVST) and wonder how they will work, this lesson came to the rescue.

However, I still have some doubts and hope you can clarify them ->

q1) Beside reducing cpu and memory by having less instances,
does MST reduce the amount of BPDUs that travel down the trunk link ?

e.g. with MST, 1 instance for 20 VLANs = 1 BPDU down the trunk each time.
with PVST, 20 VLANs = 20 BPDUs down the trunk each time

q2) In the diagram, it is illustrated that a switch (e.g. SwitchD) running a different spanning tree protocol will treat the MST region as a black box.

Does the same apply for communication between different MST region ?

q3) During "show spanning-tree VLAN10" on switch D -> It is mentioned that "MST will only advertise BPDUs from the IST to the outside world"
But VLAN10 is not part of the IST instance in the ICECREAM region, wouldn't that cause any issue ?

q4) The reason for having different instances in a MST region is so that
we can assign different root switch for each instances so that we can even out
utilization of the physical links between switches ?

Regards,
Alan

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