

Understand AVB in Catalyst 3K and Catalyst 9000 Series Switches

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Introduction

This document describes how to configure and troubleshoot Audio Video Bridging (AVB) in the Catalyst 3650, 3850, 9300, and 9500 platforms.

Background Information

Audio and Video (AV) equipment deployments have traditionally been analog, single-purpose, point-to-point, one-way links. As deployments migrated to digital transmission, they continued to retain the point-to-point, one-way link architecture. This dedicated connection model resulted in a mass of cabling in professional and consumer applications that was hard to manage and operate.

Multiple mechanisms were identified to solve this problem, but all of them were nonstandard, difficult to operate and deploy, or expensive and inflexible. Migration to an Ethernet infrastructure was seen as a means of addressing the needs of professional AV equipment in addition to lowering Total Cost of Ownership (TCO) and enabling transparent integration of new services. However, the deployment mechanism lacked flexibility and interoperability.

To accelerate the adoption of Ethernet-based AV and provide a deployment that is more flexible, IEEE developed the IEEE 802.1 Audio Video Bridging (AVB) standard. This standard defines a mechanism whereby endpoints and the network function as a whole to enable high-quality AV streaming across consumer applications to professional AV deployments over an Ethernet infrastructure.

Hardware/Software Support

AVB is supported on the Cat3K platforms starting from software version Cisco IOS® XE Denali 16.3.x. In Cat9k, the AVB feature was introduced in Fuji-16.8.1a. There have been significant improvements throughout time, so newer software versions include enhancements for the AVB feature.

These platforms support AVB:

	Catalyst 3650/3850	Catalyst 9300	Catalyst 9400	Catalyst 9500
Supported SKUs/PIDs	<ul style="list-style-type: none">• WS-C3650-24PDM• WS-C3650-48FQM• WS-C3650-8X24PD• WS-C3650-8X24UQ• WS-C3650-12X48FD• WS-C3650-12X48UQ• WS-C3650-12X48UR• WS-C3650-12X48UZ• WS-C3850-12x48U• WS-C3850-24XU	<ul style="list-style-type: none">• Supported on all models	<ul style="list-style-type: none">• PTPv2/ gPTP supported on 17.2 software• AVB is not supported yet*	<ul style="list-style-type: none">• C9500-24Q• C9500-12Q• C9500-40X• C9500-16X

- WS-C3850-12XS
- WS-C3850-16XS
- WS-C3850-24XS
- WS-C3850-32XS
- WS-C3850-48XS

Note: At the present time, AVB is supported only on fixed/standalone platforms and not in stacking configuration. Support for modular platforms, like Cat9400, is on the roadmap.

AV Analog Technologies

	AVB	DANTE	CobraNet
Standard	IEEE802.1 (Audio/Video over Ethernet)	Proprietary (Audio over IP)	Proprietary (Audio over Ethernet)
Channel Capacity	Highest channel capacity at ≥ 10 Gbps network	Higher channel capacity at 1Gbps network	Low channel capacity 100Mbps network
Clock Synchronization	IEEE802.1AS gPTP All devices (switch, AVB end point) need to be gPTP capable	IEEE1588 DANTE enabled devices need to be IEEE1588 capable	Proprietary
Latency	<2ms	<2ms	<5.33ms High for many applications
Frame/Package Format	Layer2 Ethernet frame	Layer3 IP packet but not routable	Layer2 Ethernet frame
Configuration & Installation	Simple (Controller software from different vendors)	Simple (controller software from DANTE)	complex
License Fee	N/A	Expensive Standard switch	Expensive
Network Switch/Router	Switch needs to support AVB QoS is automatically setup Better QoS feature	QoS is manually setup use of standard Voice over IP (VoIP) Quality of Service (QoS) switch features	Standard switch QoS is manually setup

AVB IEEE Standards

IEEE 802.1 Audio Video Bridge (AVB) actually encompasses these four IEEE standards. This means that whenever there is an AVB issue, we have to take into account each of the standards and troubleshoot accordingly:

IEEE802.1AS (gPTP)

- Generalized Precision Time Protocol (gPTP).
- Timing and Synchronization for Time-Sensitive Applications Layer 2 devices.

IEEE802.1Qat (MSRP)

- Multiple Stream Reservation Protocol (MSRP).
- End-to-end traffic admission control system for resource reservation.

IEEE802.1Qav(QoS)

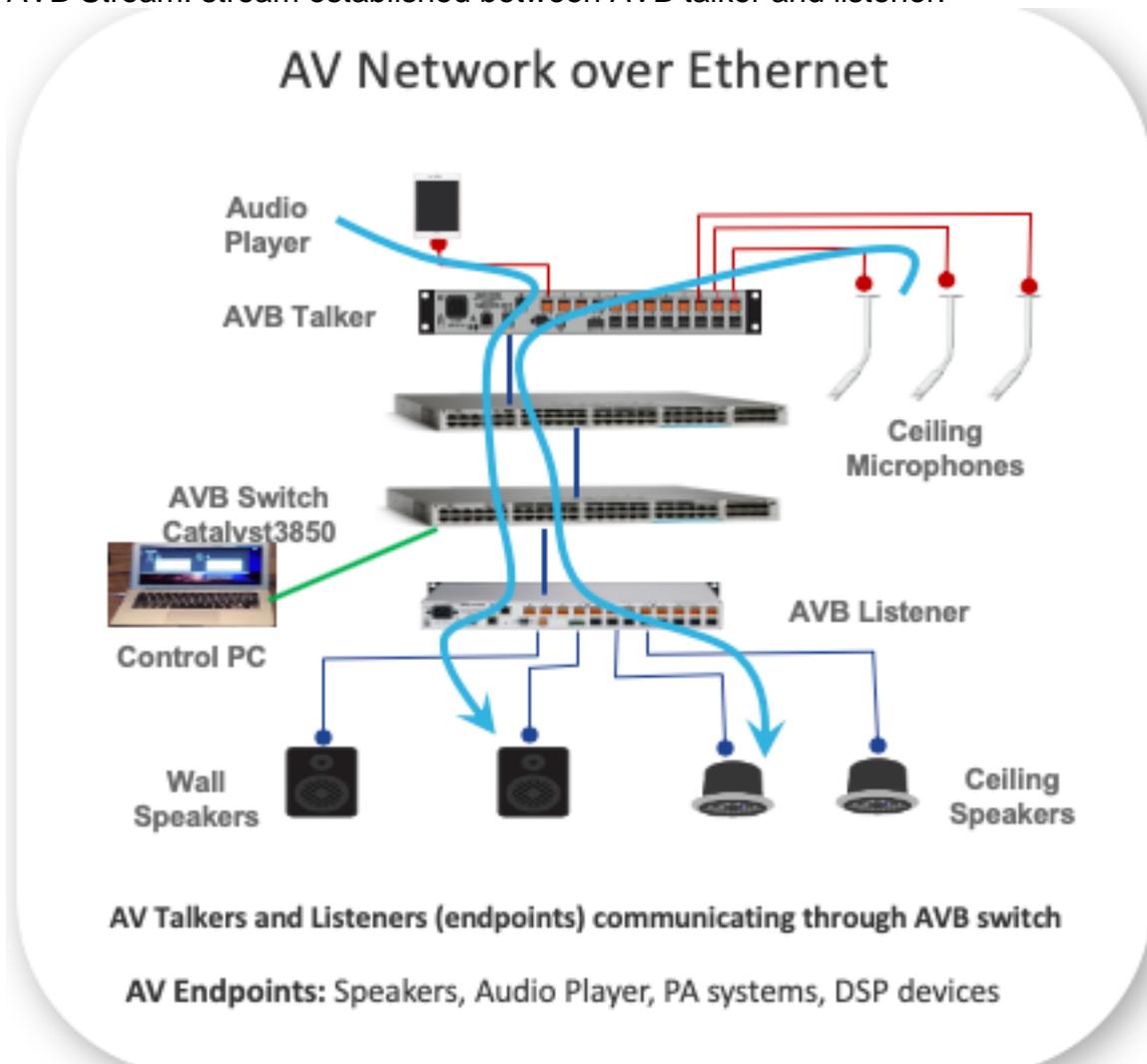
- Forwarding and Queuing for Time-Sensitive Streams (FQTSS).
- AV traffic scheduling and shaping.

IEEE802.1Qak(MVRP)

- Multiple VLAN Registration Protocol.
- Dynamic configuration and sharing of vlan information.

AVB Network Terminology

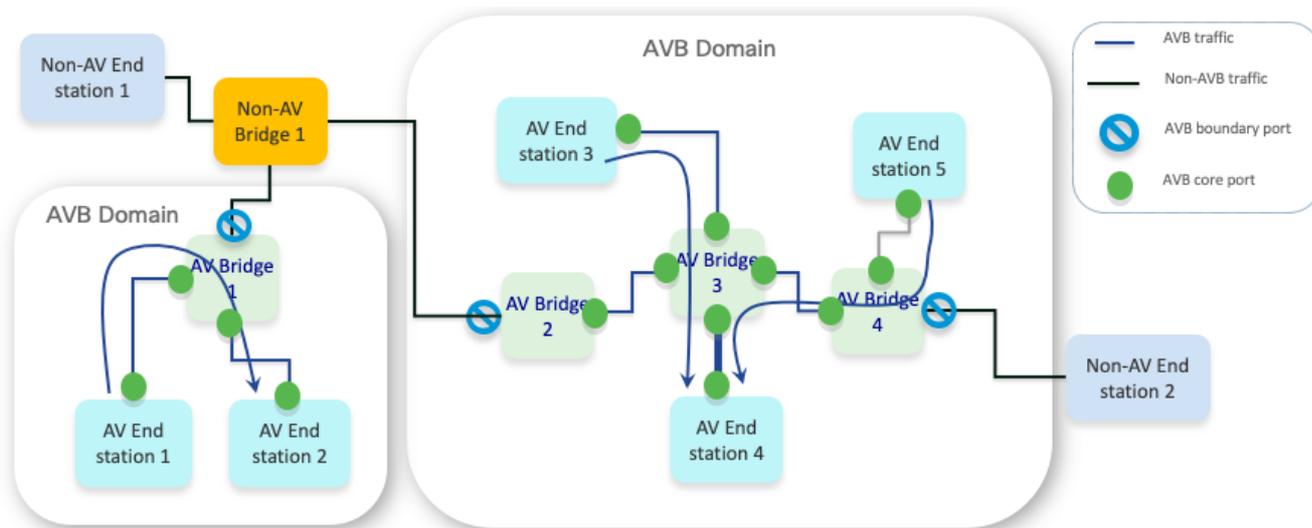
- AVB Talker: source of AVB stream.
- AVB Bridge/Switch.
- AVB Listener: consumer of AVB stream.
- AVB Stream: stream established between AVB talker and listener.



Note: Some AVB end-points can simultaneously act as AVB talker and AVB listener.

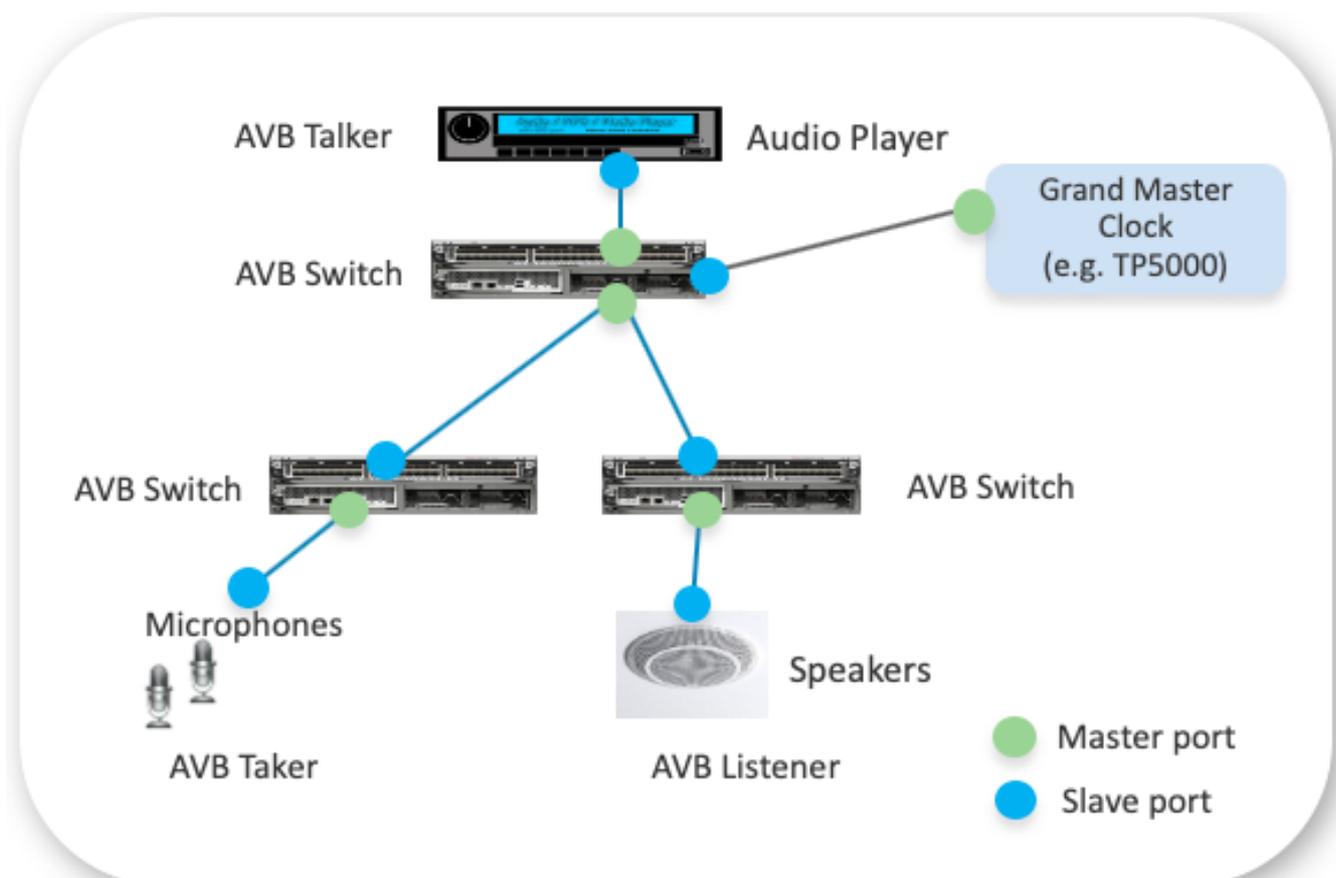
AVB Topologies

AVB Domain



Note: Only one AVB domain is supported per switch.

AVB PTP Domain



Note: gPTP only supports one domain.

The **BMCA** is used to select the primary clock on each link, and it ultimately selects the grandmaster clock for the whole gPTP domain. The grandmaster clock is in charge of providing

the timing and synchronization for the entire domain. BMCA is used to select the primary and subordinate states of the ports on each link using announce messages. The best clock selected as the primary depends on the quality of the clock (stability) and configurations such as gPTP priority. It runs locally on each port to compare its own local data sets with the received data sets on the announce messages from the neighboring device to determine the best clock on the link.

- Primary: This port is the source of the time on the path.
- Subordinate: This port synchronizes with the device on the path that is in the subordinate state.

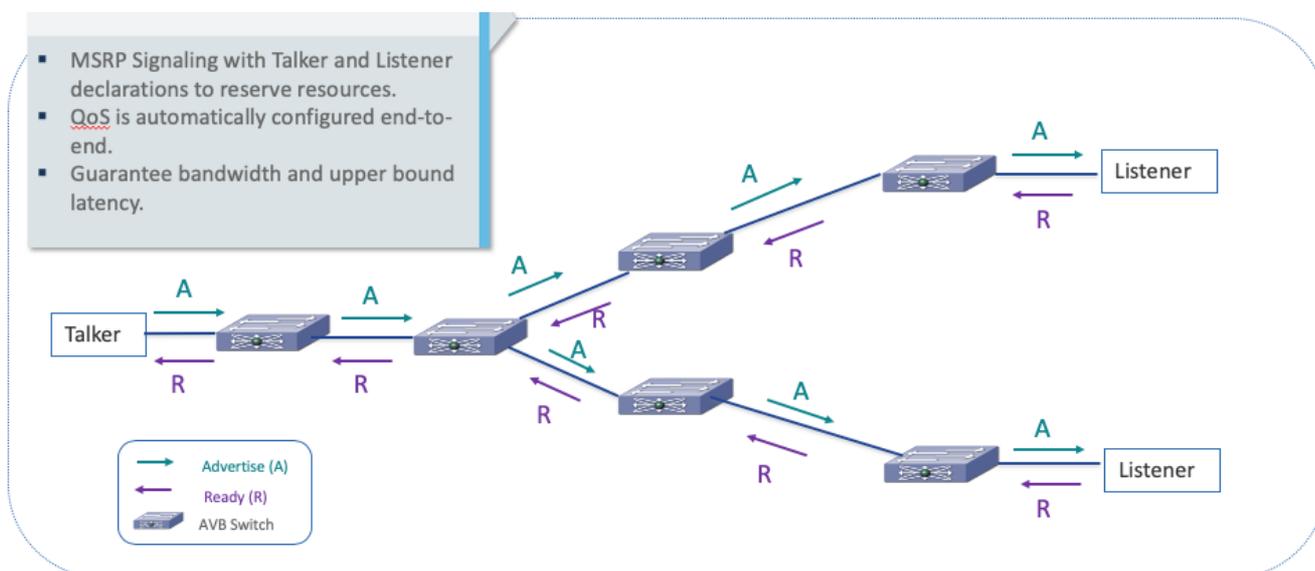
A gPTP capable switch determines if a peer is also gPTP capable by measuring **peer-to-peer delay** which is a delay between directly connected ports with no intervening switch. This delay measurement mechanism uses message types **Pdelay_Req**, **Pdelay_Resp**, and **Pdelay_Resp_Follow_Up**. Based on those message exchanges, the port gPTP capability is decided. Once the primary-subordinate clock hierarchy is established, the clock synchronization process starts.

gPTP is based on IEEE1588v2

- It is similar to BMCA specified in 1588v2, with few simplifications in the state machine
- There is **no Pre-primary state** (before reaching to **Primary** state).
- There is **no foreign-primary qualification period**.
- There is **no Uncalibrated state** (before reaching to **Subordinate** state).

	gPTP	IEEE1588v2
Transport	L2 only	L2/L3
Mix of systems	Only time-aware gPTP devices can be in-network	Can work with a mix of PTP time aware time unaware devices
Domain	Only one allowed	Can be multiple
Best Primary Clock Selection Algorithm	Simplified state machine	Pre-primary and Uncalibrated states are present
Types of devices	AVB endpoints and AVB switches	Ordinary, Boundary, and Transparent C

AVB MSRP Domain (QoS)

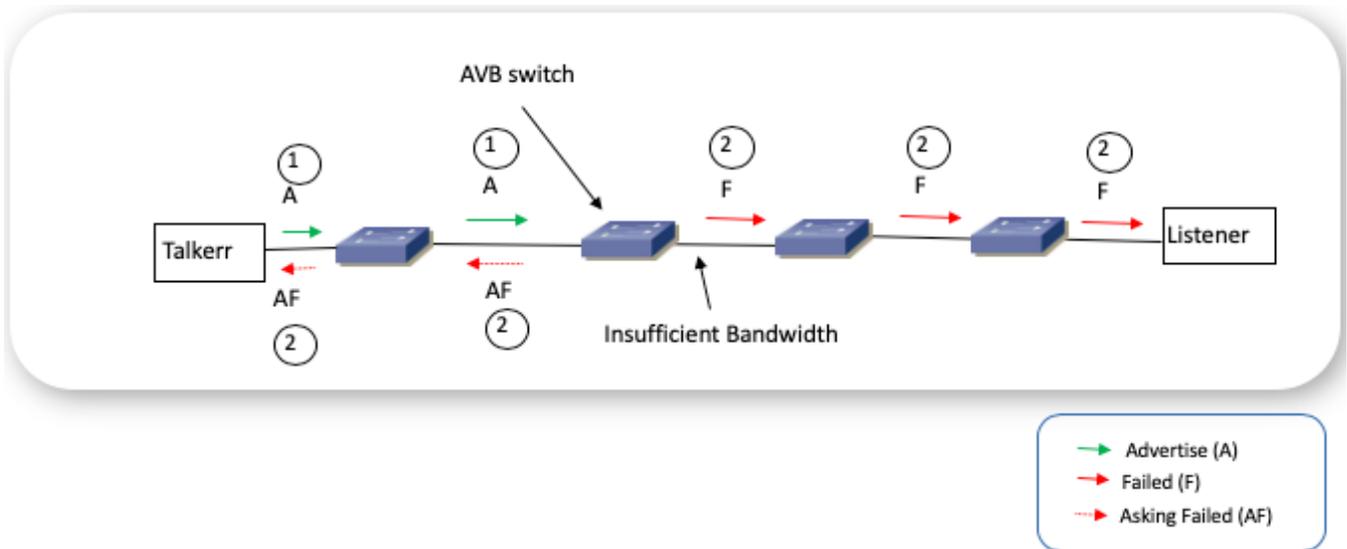


A Talker declaration is forwarded over output ports that can potentially lead to the destination MAC address of the reservation. **Listener declarations** are only propagated to the port with the associated Talker declaration (that is... based on the matching stream ID). If there is no associated

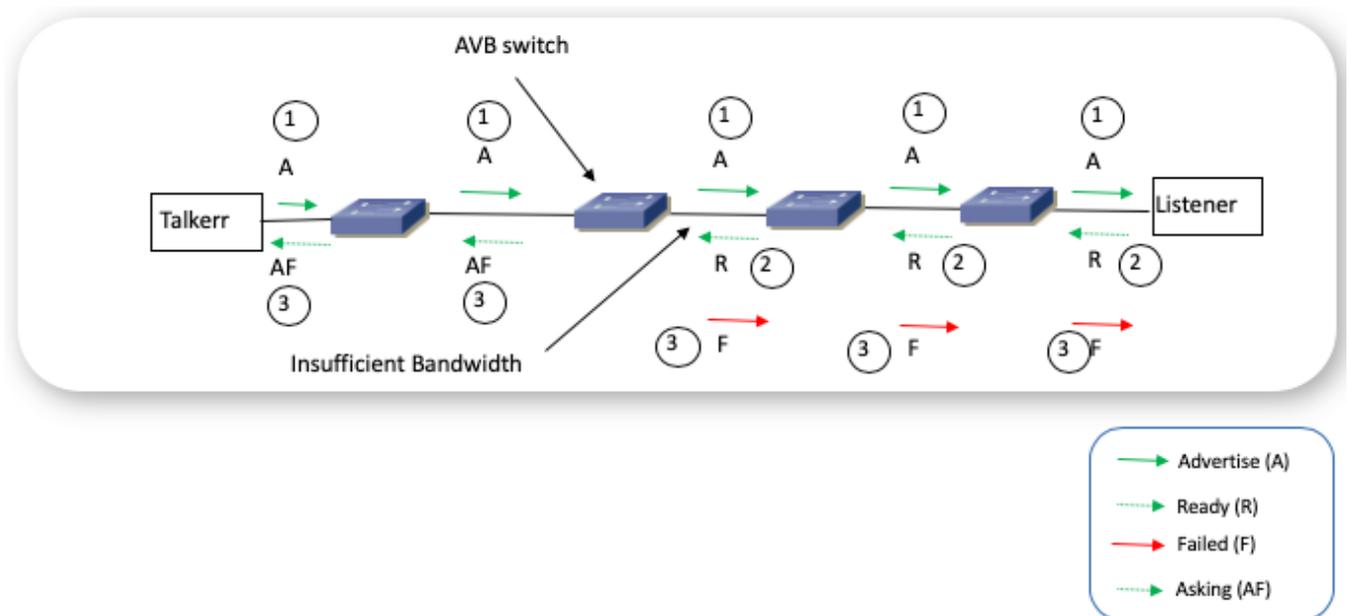
Talker declaration registered on any switch port then Listener declaration is not propagated.

Note: MSRP-aware switches automatically generate de-registration of stale registrations to tear down the AVB sessions.

MSRP – Reservation Failure during Advertise Registration



MSRP – Reservation Failure during Ready Registration



MSRP – Talkers States

Talker Advertise: An advertisement for a Stream that has not encountered any bandwidth or other network constraints along the network path from the Talker.

Talker Failed: An advertisement for a Stream that is not available to the Listener because of bandwidth constraints or other limitations somewhere along the path from the Talker.

MSRP – Listener States

Ready: This subtype indicates that there is at least one Listener that both intends to listen and has successfully reserved resources and that there are no Listeners that intend to listen but were unable to reserve resources.

Ready Failed: This subtype indicates that there is at least one Listener that both intends to listen and has successfully reserved resources, but at least one other Listener intends to listen but was unable to reserve resources.

Asking Failed: This subtype indicates that there is at least one Listener that intends to listen but was unable to reserve resources, but there were no Listeners that both intended to listen and were successful at reserving resources.

AVB Architecture – QoS Class of Traffic

8Q policy is supported. Cat3K/Cat9K does not support per-port ingress queueing. Internal queues are fine-tuned for AVB to provide end-to-end preferential treatment for SR class traffic within the switch (low latency).

Control traffic examples: OAM, Signaling, Network Control, InterNetwork Control

Stream Reservation (SR) Class A	Stream Reservation (SR) Class B	Control Traffic	VoIP
Highest priority worst-case latency 2 milliseconds COS 3	2nd Highest priority worst-case latency 50 milliseconds COS 2	COS 6,7	COS 5
Multimedia	Transactional Data	Bulk/Scavenger Data	Best Effort
COS 4	COS -	COS 1	COS 0

IEEE802.1Qav – QoS Ingress Remarking

- AVB stream data packets are classified into SRP traffic classes using the PCP (priority control point) of the incoming frame.
- To protect reserved flows, an AVB switch cannot allow a non-AVB participant port to forward best-effort traffic into an SRP class queue.
- To accomplish this protection, ingress re-marking must be done on all non-AVB participant ports (SRP domain Edge ports) to change incoming PCP matching any SRP class into a best-effort PCP.
- Any time any port's SRP Domain status changes (edge vs core) this re-marking must be added or removed.

IEEE802.1Qav – QoS Egress Queue

- SR class traffic is mapped onto egress priority queue that supports credit-based traffic shaper algorithm
- Dynamic configuration of Egress Shaper Rate (for bandwidth reservation) on per class and per port basis for AVB core ports
- For Cat3k, switch generated control traffic (that is... gPTP, MSRP) is in best effort queue in

16.3.1 release. They are in the priority queue in the 16.3.2 release and onwards.

AVB Architecture – Bandwidth Allocation Design

- A maximum of 75% of bandwidth is allocated for SR Class A + SR Class B.
- SR Class A reserves up to 75% of bandwidth.
- SR Class B reserves bandwidth that is not used by SR Class A.
- Bandwidth is allocated on a first come first served basis for AV stream.
- Hardware credit-based shaper to schedule AVB traffic evenly.

AVB MVRP Domain

What is MVRP?

- Multiple VLAN Registration Protocol (MVRP) is an application based on MRP (Multiple Registration Protocol) that supports dynamic registration and de-registration of VLANs on ports in a VLAN-bridged network. It uses MRP to declare the Attributes to be registered in a database on each port of each bridge in a bridged network. The actual Attribute used by MVRP is the VLAN ID. Stations or configured Bridge Ports make (withdraw) declarations if they do (not) need to receive frames for a given VLAN ID. If a VLAN ID is registered on a Bridge Port by MVRP, the Bridge knows that frames for that VLAN ID must be transmitted on that Bridge Port.
- MVRP allows AVB endpoints to make declarations if they need to receive frames for a given VLAN ID.
- MVRP allows AVB endpoints to withdraw declarations if they do not need to receive frames for a given VLAN ID.

When MVRP is Enabled on the Switch

- MVRP VLAN declaration from the end-point triggers VLAN creation on the switches.
- There are three different MVRP registration modes for a port:
 - Normal** - VLANs are dynamically registered/de-registered based on device declarations. This is the default mode for the ports when MVRP is globally enabled (mvrp registration normal).
 - Fixed** - Port ignores all MVRP declarations. VLANs that are statically configured are not dynamically pruned by MVRP. This mode can be configured on a per-port basis on interfaces that are connected to network devices that are not MVRP-aware (mvrp registration fixed).
 - Forbidden** - Port ignores all incoming MVRP messages and prunes VLANs (mvrp registration forbidden).

Note: VTP must be in disabled mode or transparent mode for MVRP to work.

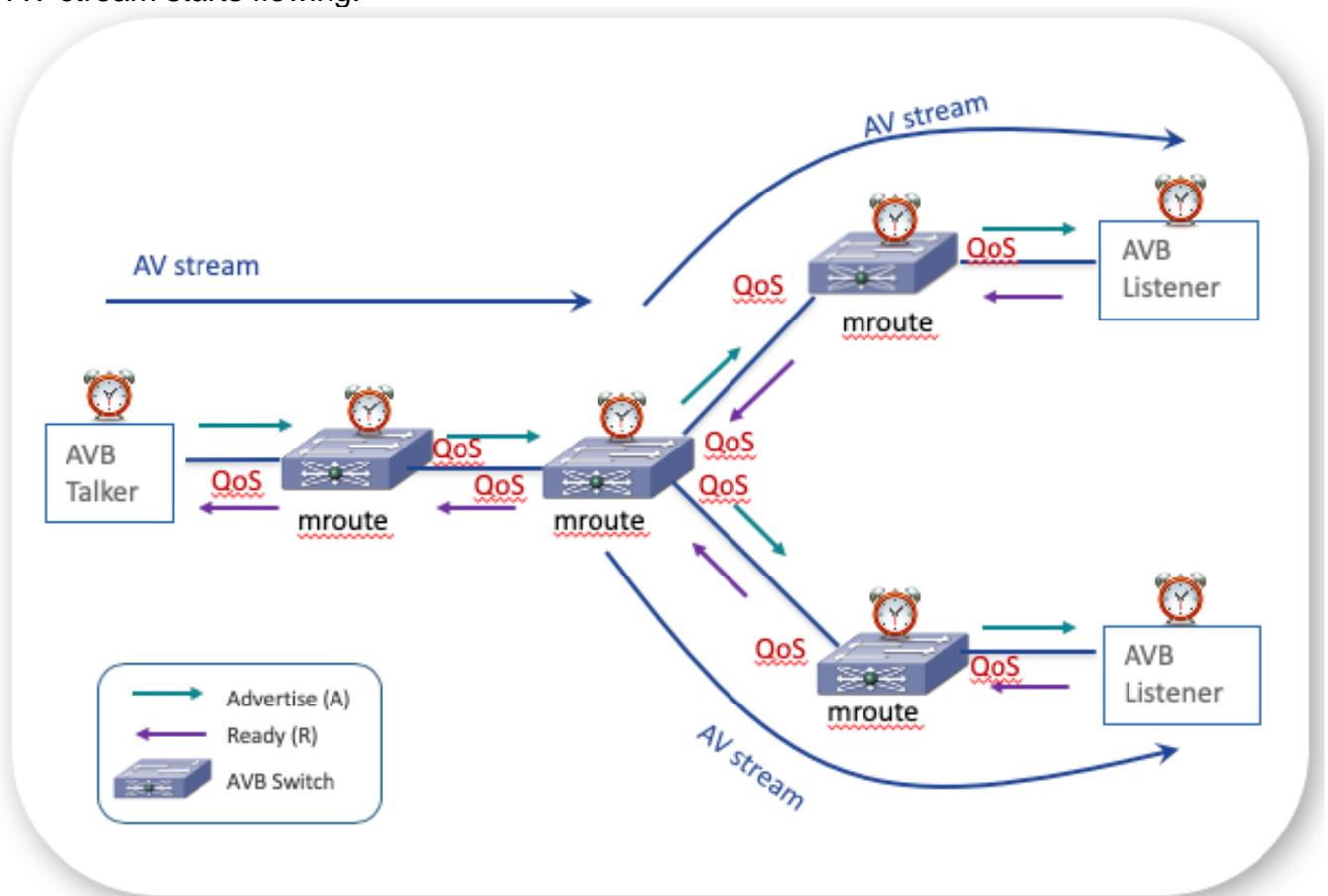
Note: MVRP works with Declaration and Registration events in a bidirectional way, which means that end-points and neighboring bridges in that domain would also need to be MVRP-aware if this feature gets enabled on one of the devices, otherwise the bridge where MVRP is enabled can prune some of the VLANs if it doesn't receive a Declaration/Registration for them, which can lead to potential connectivity issues.

When MVRP is not enabled on the Switch

Manually configure the switches in trunk mode allowing all range of VLANs that are expected to be used by the AVB streams.

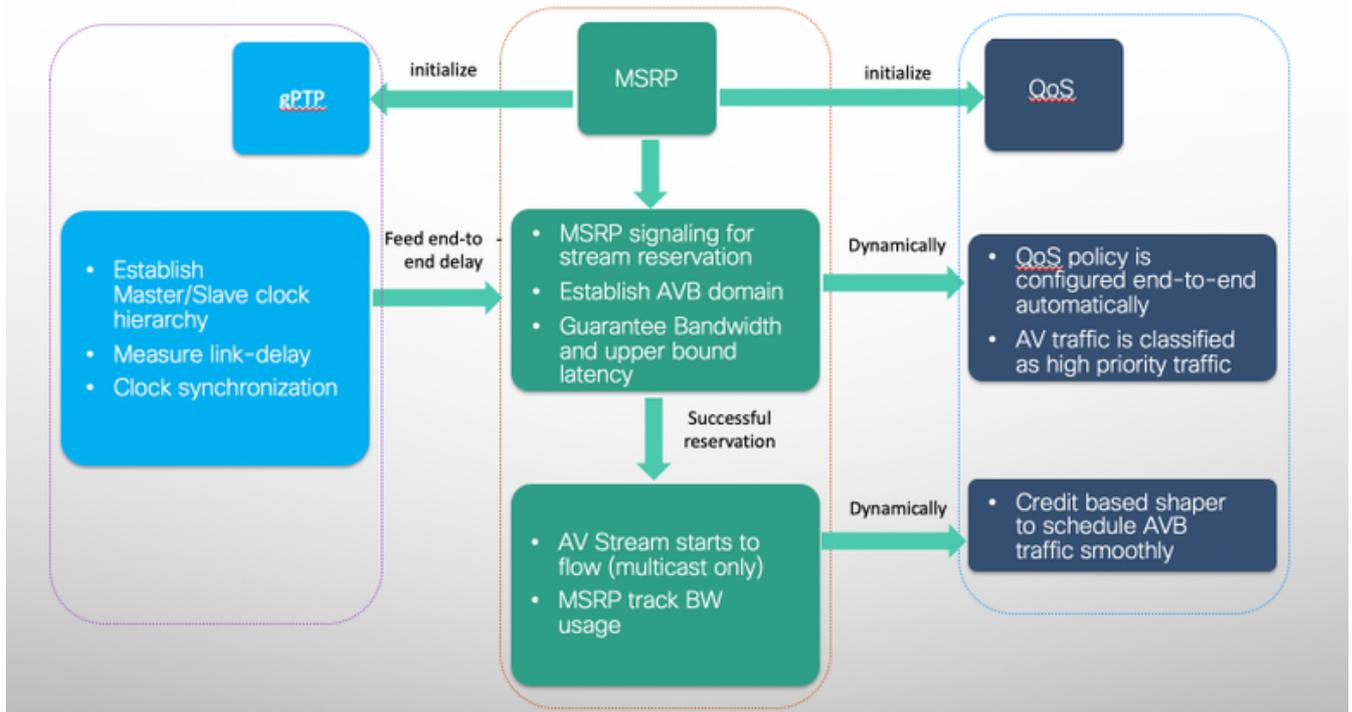
AVB Flow – Put Together

1. MSRP initializes gPTP for time synchronization.
2. MSRP initializes QoS policy on AVB switchport.
3. MSRP Signaling with Talker and Listener declarations to check resources. Guarantee bandwidth and upper bound latency.
4. QoS (shaper) is dynamically adjusted. Up to 75% of bandwidth is allocated for SR Class A + SR Class B.
5. MSRP adds layer2 multicast entry.
6. AV stream starts flowing.



AVB Components Interaction

AVB ARCHITECTURE – COMPONENTS INTERACTION



Troubleshoot AVB in Cat3k and Cat9k Switches

AVB Configuration

How to configure AVB

Step 1. Enable the AVB feature and its corresponding VLAN:

```
Cat3850# configure terminal
Cat3850(config)# avb
Cat3850(config)# vlan 2
Cat3850(config)# end
```

Note: Standard VLAN-ID used by AVB is VLAN 2. A different VLAN-ID can be set in the switch for the AVB VLAN using cli **avb vlan <vlan-id>**. This configuration serves the function of specifying the VLAN to which AVB specific QoS settings are applied via MSRP. If there is a need to use a non-standard VLAN (other than VLAN 2 which is the default) that needs to be set on AVB end-device controller as well so that the AVB end-devices declare to the switch the correct VLAN that is desired for AVB, otherwise, the AVB end-devices can advertise their streams on a different VLAN than the one configured on the switch.

Step 2. Configure the switch interfaces along the AVB connectivity path as dot1q trunk ports:

```
Cat3850# configure terminal
Cat3850(config)# interface GigabitEthernet1/0/3
Cat3850(config-if)# switchport mode trunk
Cat3850(config-if)# end
Cat3850#
```

Step 3 (Optional). Enable MVRP on the switch to enable dynamic VLAN propagation.

```
Cat3850# configure terminal
Cat3850(config)# mvrp global
Cat3850(config)# vtp mode transparent
Cat3850(config)# mvrp vlan create
Cat3850(config)# end
Cat3850#
```

Step 4 (Optional). Adjust PTP priority on the switch.

```
Cat3850#configure terminal
Cat3850(config)# ptp priority1 <0-255>
Cat3850(config)# ptp priority2 <0-255>
Cat3850(config)# end
Cat3850#
```

Configuration Automatically Added by MSRP

Support for hierarchical QoS for AVB was introduced on Cisco XE Denali 16.3.2. AVB Hierarchical QoS policy is a two-level Parent-Child Policy. AVB Parent policy segregates audio, video traffic streams (SR-Class A ,SR-Class B) and Network Control packets from standard best-effort ethernet traffic (Non-SR) and manages streams accordingly.

Note: QoS policies for AVB are automatically created and controlled by MSRP.

Note: The end-user has complete control over child policies that contain Non-SR class attributes and can modify only these child policies, that is...: **policy-map AVB-Output-Child-Policy** and **policy-map AVB-Input-Child-Policy**. AVB HQoS child policy configurations are retained even after reload.

Different types of Ingress Policies

Core port for SR Class A and Boundary port for SR Class B (This means that on this port, MSRP received an advertisement only for a class A stream, so all traffic for B is remarked to COS 0, whereas marking for class A stream is preserved).

```
interface GigabitEthernet1/0/3
  service-policy input AVB-Input-Policy-Remark-B
  service-policy output AVB-Output-Policy-Gi1/0/3

policy-map AVB-Input-Policy-Remark-B
  class AVB-SR-B-CLASS <<< Parent Policy dynamically generated (not user
  editable)
  set cos 0 (set 0 for boundary & SR class B PCP value for core port)
  class class-default
    service-policy AVB-Input-Child-Policy <<< Child Policy (user editable)
```

Core port for SR Class B and Boundary port for SR Class A (This means that on this port, MSRP received an advertisement only for a class B stream, so all traffic for A is remarked to COS 0, whereas marking for class B stream is preserved).

```
interface GigabitEthernet1/0/4
  service-policy input AVB-Input-Policy-Remark-A
  service-policy output AVB-Output-Policy-Gil/0/4
```

```
policy-map AVB-Input-Policy-Remark-A
```

```
  class AVB-SR-A-CLASS <<< Parent Policy dynamically generated (not user
  editable)
```

```
  set cos 0 (set 0 for boundary & SR class A PCP value for core port)
```

```
  class class-default
```

```
    service-policy AVB-Input-Child-Policy <<< Child Policy (user editable)
```

Core port for SR Class A and SR Class B (This means that on this port, MSRP received advertisements for class A and B streams, so the ingress marking for both stream types is preserved).

```
interface GigabitEthernet1/0/2
  service-policy input AVB-Input-Policy-Remark-None
  service-policy output AVB-Output-Policy-Gil/0/2
```

```
policy-map AVB-Input-Policy-Remark-None
```

```
class class-default
```

```
  service-policy AVB-Input-Child-Policy <<< Child Policy (user editable)
```

Boundary port for SR Class A and SR Class B (This means that on this port, MSRP did not receive advertisements for any streams, neither class A nor class B streams, so the ingress marking for both stream types is remarked to COS 0).

```
interface GigabitEthernet1/0/1
  service-policy input AVB-Input-Policy-Remark-AB
  service-policy output AVB-Output-Policy-Gil/0/1
```

```
policy-map AVB-Input-Policy-Remark-AB
```

```
  class AVB-SR-A-CLASS <<< Parent Policy dynamically generated (not user
  editable)
```

```
  set cos 0 (set 0 for boundary & SR class A PCP value for core port)
```

```
  class AVB-SR-B-CLASS <<< Parent Policy dynamically generated (not user
  editable)
```

```
  set cos 0 (set 0 for boundary & SR class B PCP value for core port)
```

```
  class class-default
```

```
    service-policy AVB-Input-Child-Policy <<< Child Policy (user editable)
```

Input Child Policy (User editable)

```
policy-map AVB-Input-Child-Policy
```

```
class VOIP-DATA-CLASS
```

```
  set dscp EF
```

```
class MULTIMEDIA-CONF-CLASS
```

```
  set dscp AF41
```

```
class BULK-DATA-CLASS
```

```
  set dscp AF11
```

```
class TRANSACTIONAL-DATA-CLASS
```

```
  set dscp AF21
```

```
class SCAVENGER-DATA-CLASS
```

```
  set dscp CS1
```

```
class SIGNALING-CLASS
```

```
  set dscp CS3
```

```
class class-default
```

```
  set dscp default
```

Different types of Egress Policies

The egress policy is also dynamically configured by MSRP on a port basis. MSRP can dynamically reserve a max. of 75% of the port bandwidth for classes A and B. The other 15% is statically reserved for control management traffic and the rest can be assigned on-demand to the different traffic types defined on the AVB-Output-Child-Policy:

```
policy-map AVB-Output-Policy-Gix/y/z
  class AVB-SR-A-CLASS
    priority level 1 (Shaper value based on stream registration)
  class AVB-SR-B-CLASS
    priority level 2 (Shaper value based on stream registration)
  class CONTROL-MGMT-QUEUE
    priority level 3 percent 15
class class-default
bandwidth remaining percent 100
queue-buffers ratio 80
  service-policy AVB-Output-Child-Policy <<< Child Policy (user editable)
```

```
policy-map AVB-Output-Child-Policy
class VOIP-PRIORITY-QUEUE
bandwidth remaining percent 30
queue-buffers ratio 10
class MULTIMEDIA-CONFERENCING-STREAMING-QUEUE
bandwidth remaining percent 15
queue-limit dscp AF41 percent 80
queue-limit dscp AF31 percent 80
queue-limit dscp AF42 percent 90
queue-limit dscp AF32 percent 90
queue-buffers ratio 10
class TRANSACTIONAL-DATA-QUEUE
bandwidth remaining percent 15
queue-limit dscp AF21 percent 80
queue-limit dscp AF22 percent 90
queue-buffers ratio 10
class BULK-SCAVENGER-DATA-QUEUE
bandwidth remaining percent 15
queue-limit dscp AF11 percent 80
queue-limit dscp AF12 percent 90
queue-limit dscp CS1 percent 80
queue-buffers ratio 15
class class-default
bandwidth remaining percent 25
queue-buffers ratio 25
```

In this example, **Gi1/0/6** is a **Core port for SR Class A** and **Boundary port for SR Class B** (this means that on this port, we are only receiving advertisements for class A streams). The bandwidth allocated for AV streams is limited to a maximum **75 percent of the total port bandwidth**. Since in this case, the port is auto-negotiating a link speed of **1 Gbps**, then max 75% of this bandwidth - 750 Mbps - can be reserved for class A and B streams. In this case, MSRP dynamically reserved 71% for class-A (approx 701 Mbps) and 0% for class-B.

However, when we check the actual QoS-Policy attached to the interface, we can notice that from that 75% of reservable BW, 71% was effectively assigned to Class-A (priority level 1) but in reality, also a small portion of the BW - **1% - was assigned to Class-B (priority level 2)**. As expected, 15% was assigned to control-mgmt traffic (priority level 3), and the **remaining bandwidth** got assigned to the **user-editable egress child policy**:

```
show msrp port interface Gi1/0/6
Port: Gi1/0/6    Admin: admin up    Oper: up
```

MTU: 1500 **Bandwidth: 1000000 Kbit/s** DLY: 0 us mode: Trunk

gPTP status: Enabled, asCapable

Residence delay: 20000 ns

Peer delay: 84 ns (Updated Wed Nov 18 17:35:18.823)

AVB readiness state: Ready

Per-class value	Class-A	Class-B

Tx srClassVID	2	2
Rx srClassVID	2	0
Domain State	Core	Boundary
VLAN STP State	FWD	FWD
Reservable BW (Kbit/s)	750000	0
Reserved BW (Kbit/s)	701504	0
Applied QOS BW (percent)	71	0

show policy-map interface Gi1/0/6

Service-policy output: **AVB-Output-Policy-Gi1/0/6**

<snip>

Class-map: **AVB-SR-CLASS-A** (match-any)

0 packets

Match: cos 3

Priority: 701504 kbps, burst bytes 17537600, <<< **71% of the reservable BW**

Priority Level: 1

Class-map: **AVB-SR-CLASS-B** (match-any)

0 packets

Match: cos 2

Priority: 10000 kbps, burst bytes 250000, <<< **1% of the reservable BW**

Priority Level: 2

Class-map: **AVB-CONTROL-MGMT-QUEUE** (match-any)

0 packets

Match: ip dscp cs2 (16)

0 packets, 0 bytes

5 minute rate 0 bps

Match: ip dscp cs3 (24)

0 packets, 0 bytes

5 minute rate 0 bps

Match: ip dscp cs6 (48)

0 packets, 0 bytes

5 minute rate 0 bps

Match: ip dscp cs7 (56)

0 packets, 0 bytes

5 minute rate 0 bps

Match: ip precedence 6

0 packets, 0 bytes

5 minute rate 0 bps

Match: ip precedence 7

0 packets, 0 bytes

5 minute rate 0 bps

Match: ip precedence 3

0 packets, 0 bytes

5 minute rate 0 bps

Match: ip precedence 2

0 packets, 0 bytes

5 minute rate 0 bps

Match: cos 6

0 packets, 0 bytes

```
5 minute rate 0 bps
Match: cos 7
0 packets, 0 bytes
5 minute rate 0 bps
Priority: 15% (150000 kbps), burst bytes 3750000, <<<< 15% of the total BW
Priority Level: 3
```

```
Class-map: class-default (match-any)
0 packets
Match: any
Queueing

(total drops) 0
(bytes output) 81167770686
bandwidth remaining 100% <<< all remaining BW got assigned to child policy
queue-buffers ratio 70

Service-policy : AVB-Output-Child-Policy
<snip>
```

Verify AVB Works Properly

You have to break down troubleshooting into five pieces:

1. Did we configure AVB properly in all the switches involved?
2. Check AVB
3. Check MSRP (QoS)
4. Check gPTP
5. Check MVRP

AVB Considerations

<< show avb domain >>

- Number and type of ports for each AVB Stream (Class-A and Class-B)
- Core for a certain class means that a stream advertisement for that SR class was received on that port.
- Boundary means that an advertisement for that SR class was not received on that port.
- Not **asCapable** means that PTP is not supported on that port
- A port can be Core for both classes at the same time.
- PCP = QoS Priority Code Point
- VID = VLAN-ID used for AVB

```
Switch#show avb domain
```

AVB Class-A

```
Priority Code Point : 3
VLAN : 2
Core ports : 2
Boundary ports : 31
```

AVB Class-B

```

Priority Code Point      : 2
VLAN                    : 2
Core ports              : 0
Boundary ports          : 33

```

```

-----
Interface      State      Delay      PCP  VID  Information
-----
    Te1/0/1      up      300ns
Class-  A      core          3    2
Class-  B      boundary       0    0
-----
    Te1/0/2      up      N/A          Port is not asCapable
-----
    Te1/0/3      up      284ns
Class-  A      core          3    2
Class-  B      boundary       0    0
-----
    Te1/0/4      down     N/A          Oper state not up
-----
    Te1/0/5      down     N/A          Oper state not up
-----
    Te1/0/6      down     N/A          Oper state not up
-----

```

<< show avb stream >>

- Relevant info about the stream (stream ID, actual bandwidth, Incoming and Outgoing interfaces).
- A port can simultaneously be sender for some streams and receiver for some others, depending on the AV-endpoint connected to that port.

----- show avb stream -----

```

Stream ID:      0090.5E15.965A:65434   Incoming Interface:  Te1/0/1
Destination   : 91E0.F000.3470   <<<< AVB works with layer-2 multicast (least-significant bit
of the first octet is on)
Class         : A
Rank         : 1
Bandwidth    : 8192 Kbit/s

```

Outgoing Interfaces:

```

-----
Interface      State      Time of Last Update      Information
-----
    Te1/0/3      Ready      Wed Jun 13 16:32:36.224

```

```

Stream ID:      0090.5E15.96D5:65436   Incoming Interface:  Te1/0/3
Destination   : 91E0.F000.0770
Class         : A
Rank         : 1
Bandwidth    : 5120 Kbit/s

```

Outgoing Interfaces:

```

-----
Interface      State      Time of Last Update      Information
-----
    Te1/0/1      Ready      Wed Jun 13 16:28:45.114

```

MSRP Considerations

<< show msrp streams >>

<< show msrp streams brief >>

<< show msrp streams stream-id # >>

- Relevant info for each MSRP phase during MSRP reservation for each stream (Advertise, Fail, Ready, ReadyFail, and so on.).

----- show msrp streams -----

Legend: R = Registered, D = Declared.

Stream ID	Talker				Listener					
	Advertise		Fail		Ready		ReadyFail		AskFail	
	R	D	R	D	R	D	R	D	R	D
0090.5E15.965A:65434	1	1	0	0	1	1	0	0	0	0
0090.5E15.96D5:65436	1	1	0	0	1	1	0	0	0	0
0090.5E15.96D5:65534	1	1	0	0	1	1	0	0	0	0

----- show msrp streams brief -----

Legend: R = Registered, D = Declared.

Stream ID	Destination Address	Bandwidth (Kbit/s)	Talkers		Listeners		Fail
			R	D	R	D	
0090.5E15.965A:65434	91E0.F000.3470	8192	1	1	1	1	No
0090.5E15.96D5:65436	91E0.F000.0770	5120	1	1	1	1	No
0090.5E15.96D5:65534	91E0.F000.0770	3584	1	1	1	1	No
0090.5E1A.33E2:65534	0000.0000.0000	0	0	0	1	0	Yes <<< Listener is requesting for this stream but no Talker transmit

show msrp streams stream-id 65534 <<< non-working one (ASK Failed).

Legend: R = Registered, D = Declared.

Stream ID	Talker				Listener				
	Advertise		Fail		Ready	ReadyFail	AskFail		
	R	D	R	D	R	D	R	D	
0090.5E1A.33E2:65534	0	0	0	0	0	0	1	0	<<< Listener request for the stream, but such stream is not transmitted by any talker

<snip>

<< show msrp port bandwidth >>

- How much of the 75% reservable bandwidth that can be used by AV-Streams was actually assigned to the port based on the MSRP negotiation (in this case only 2% for SR-Class A stream).

----- show msrp port bandwidth -----

```
-----
```

Ethernet Interface	Capacity (Kbit/s)	Assigned		Available		Reserved	
		A	B	A	B	A	B
Tel/0/1	1000000	75	0	73	73	2	0
Tel/0/2	1000000	75	0	75	75	0	0
Tel/0/3	1000000	75	0	73	73	2	0
Tel/0/4	1000000	75	0	75	75	0	0

```
-----
```

<< show msrp port interface >>

```
Switch# sh msrp port int tel/0/1
Port: Tel/0/1 Admin: admin up Oper: up
MTU: 1500 Bandwidth: 1000000 Kbit/s DLY: 0 us mode: Trunk
gPTP status: Enabled, asCapable
Residence delay: 20000 ns
Peer delay: 295 ns (Updated Thu Apr 27 16:49:05.574)
AVB readiness state: Ready
Per-class value Class-A Class-B
-----
Tx srClassVID 2 2
Rx srClassVID 2 0
Domain State Core Boundary
VLAN STP State FWD FWD
Reservable BW (Kbit/s) 750000 0
Reserved BW (Kbit/s) 14720 0
Applied QOS BW (percent) 2 0
```

```
Switch# show msrp port interface gi 1/0/40 det
Port: Gi1/0/40 Admin: admin down Oper: down
Intf handle: 0x30 Intf index: 0x30
Location: 1/40, Handle: 0x1001000100000027
MTU: 1500 Bandwidth: 1000000 Kbit/s DLY: 0 us mode: Other
LastRxMAC: 0:90:5E:1A:F5:92
gPTP status: Enabled
AVB readiness state: Oper state not up
Per-class value Class-A Class-B
-----
Tx srClassVID 2 2
Rx srClassVID 2 0
Domain State Boundary Boundary <<< Interface is Down hence Boundary.
VLAN STP State BLK BLK
Reservable BW (Kbit/s) 750000 0
Reserved BW (Kbit/s) 0 0
Applied QOS BW (percent) 0 0
Registered Talker: count 0
Declared Talker: count 0
Registered Listener: count 1
Handle 0x1001000100001F97
Registered Listener, Listener Fail
Stream: 0090.5E1B.048D:65534, handle 1001000100001F96
Port handle 0x1001000100000027, vlan: 0
MRP: 0/0/60207669/0/0
```

<< show tech msrp >>

- To collect all relevant MSRP outputs

```
Switch#show tech msrp
```

```
----- show clock -----
```

*10:32:56.410 UTC Thu Jun 13 2017

----- show version -----

Cisco IOS Software [Denali], Catalyst L3 Switch Software (CAT3K_CAA-UNIVERSALK9-M), Version 16.3.2, RELEASE SOFTWARE (fc4)

Technical Support: <http://www.cisco.com/techsupport>

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<snip>

QoS Considerations

- AVB networks guarantee bandwidth and minimum bounded latency for time-sensitive audio and video streams.
- AVB defines Class A and Class B as the time-sensitive streams, based on the worst-case latency targets of the traffic from talker to listener (the priority code points to map the traffic to the specific stream, **COS 3 for Class A and COS 2 for Class B**).
- The latency targets for the two streams are listed here: **SR-Class A: 2ms SR-Class B: 50ms**

Note: The sum of the worst-case latency contributions per hop results in an overall end-to-end latency of 2 ms or less for SR-Class A and 50ms or less for SR-Class B. A typical AVB deployment of 7 hops from talker to listener meets these latency requirements.

Note: gPTP is not supported for speeds of 100Mbps or less on mGig platforms. Reason: 100Mbps speed introduces a jitter of more than 50ms.

PTP Considerations

- Check where the Grandmaster Clock is located and run (be aware that Grandmaster clock can be an external device):

<< show ptp brief >>

- In this output **Master** means that this port is the source of the time (Primary) and **Subordinate** means that it is receiving the timing from the other end (**Faulty** means that nothing is connected or the other end does not support PTP). If all the AVB-ports on a switch are **Primary**, then the switch is the **Grandmaster Clock**.

Switch#show ptp brief

Interface	Domain	PTP State
FortyGigabitEthernet1/1/1	0	FAULTY
FortyGigabitEthernet1/1/2	0	FAULTY
TenGigabitEthernet1/0/1	0	MASTER
TenGigabitEthernet1/0/2	0	MASTER
TenGigabitEthernet1/0/3	0	MASTER
TenGigabitEthernet1/0/4	0	FAULTY
TenGigabitEthernet1/0/5	0	FAULTY
TenGigabitEthernet1/0/6	0	FAULTY
TenGigabitEthernet1/0/7	0	FAULTY
TenGigabitEthernet1/0/8	0	FAULTY
TenGigabitEthernet1/0/9	0	FAULTY

<snip>

<< show ptp clock >>

- This output provides Local PTP info.

```
Switch#show ptp clock
PTP CLOCK INFO
  PTP Device Type: Boundary clock
  PTP Device Profile: IEEE 802/1AS Profile
Clock Identity: 0x2C:86:D2:FF:ED:AD:A6:0
  Clock Domain: 0
  Number of PTP ports: 34
  PTP Packet priority: 4
Priority1: 2
Priority2: 2
  Clock Quality:
    Class: 248
    Accuracy: Unknown
    Offset (log variance): 16640
  Offset From Master(ns): 0
  Mean Path Delay(ns): 0
  Steps Removed: 0
```

<< show ptp parent >>

- Provides info about Grandmaster clock identity:

```
Switch# show ptp parent
PTP PARENT PROPERTIES
  Parent Clock:
Parent Clock Identity: 0x2C:86:D2:FF:ED:AD:A6:0
  Parent Port Number: 0
  Observed Parent Offset (log variance): 16640
  Observed Parent Clock Phase Change Rate: N/A

  Grandmaster Clock:
Grandmaster Clock Identity: 0x2C:86:D2:FF:ED:AD:A6:0 <<< Local switch is the Grandmaster
Clock of the domain
  Grandmaster Clock Quality:
    Class: 248
    Accuracy: Unknown
    Offset (log variance): 16640
    Priority1: 2
    Priority2: 2
```

<< show ptp port >>

<< show platform software fed switch active ptp interface >>

- These outputs display detailed PTP port info, like Neighbor Propagation Delay.
- At first, the Neighbor Propagation Delay is checked, and only if this value is within the permissible range, the link is promoted as AVB capable and the rest of the processes would follow. Else, the link is set to **not asCapable** state and AVB won't work.
- Based on network design/requirement the neighbor propagation delay can be manually configured:

ptp neighbor-propagation-delay-threshold

Non-Working Port:

```
switch#show ptp port gi1/0/32
```

```
PTP PORT DATASET: GigabitEthernet1/0/32
```

```
Port identity: clock identity: 0xB0:90:7E:FF:FE:28:3C:0
```

```
Port identity: port number: 32
```

```
PTP version: 2
```

Port state: DISABLED

```
Delay request interval(log mean): 0
```

```
Announce receipt time out: 3
```

```
Neighbor prop delay(ns): -10900200825022 <<< The is an erroneous reading. Default to 800ns.
```

```
Announce interval(log mean): 0
```

```
Sync interval(log mean): -3
```

```
Delay Mechanism: Peer to Peer
```

```
Peer delay request interval(log mean): 0
```

```
Sync fault limit: 500000000
```

```
switch# show platform software fed switch active ptp interface gi1/0/32
```

```
Displaying port data for if_id 28
```

```
=====
```

```
Port Mac Address B0:90:7E:28:3C:20
```

```
Port Clock Identity B0:90:7E:FF:FE:28:3C:00
```

```
Port number 32
```

```
PTP Version 2
```

```
domain_value 0
```

```
Profile Type: : DOT1AS
```

```
dot1as capable: FALSE
```

```
sync_recpt_timeout_time_interval 375000000 nanoseconds
```

```
sync_interval 125000000 nanoseconds
```

```
compute_neighbor_rate_ratio: TRUE
```

```
neighbor_rate_ratio 0.999968
```

```
compute_neighbor_prop_delay: TRUE
```

```
neighbor_prop_delay 9223079830310536030 nanoseconds <<< Error reading
```

```
port_enabled: TRUE
```

```
ptt_port_enabled: TRUE
```

```
current_log_pdelay_req_interval 0
```

```
pdelay_req_interval 1000000000 nanoseconds
```

```
allowed_pdelay_lost_responses 3
```

```
is_measuring_delay : TRUE
```

```
neighbor_prop_delay_threshold 800 nanoseconds
```

```
Port state: : DISABLED
```

```
sync_seq_num 29999
```

```
num sync messages transmitted 903660
```

```
num followup messages transmitted 903628
```

```
num sync messages received 0
```

```
num followup messages received 0
```

```
num pdelay requests transmitted 161245
```

```
num pdelay responses received 161245
```

```
num pdelay followup responses received 161245
```

```
num pdelay requests received 161283
```

```
num pdelay responses transmitted 161283
num pdelay followup responses transmitted 160704
```

Working Port:

```
switch#show ptp port gil/0/7
PTP PORT DATASET: GigabitEthernet1/0/7
Port identity: clock identity: 0xB0:90:7E:FF:FE:28:3C:0
Port identity: port number: 7
PTP version: 2
PTP port number: 7
PTP slot number: 1
Port state: MASTER
Delay request interval(log mean): 0
Announce receipt time out: 3
Neighbor prop delay(ns): 154
Announce interval(log mean): 0
Sync interval(log mean): -3
Delay Mechanism: Peer to Peer
Peer delay request interval(log mean): -3
Sync fault limit: 500000000
```

```
switch#sh platform software fed switch active ptp interface gil/0/7
```

```
Displaying port data for if_id f
```

```
=====
Port Mac Address B0:90:7E:28:3C:07
Port Clock Identity B0:90:7E:FF:FE:28:3C:00
Port number 7
PTP Version 2
domain_value 0
Profile Type: : DOT1AS
dot1as capable: TRUE
sync_recpt_timeout_time_interval 375000000 nanoseconds
sync_interval 125000000 nanoseconds
compute_neighbor_rate_ratio: TRUE
neighbor_rate_ratio 1.000000
compute_neighbor_prop_delay: TRUE
neighbor_prop_delay 146 nanoseconds
port_enabled: TRUE
ptt_port_enabled: TRUE
current_log_pdelay_req_interval -3
pdelay_req_interval 0 nanoseconds
allowed_pdelay_lost_responses 3
is_measuring_delay : TRUE
neighbor_prop_delay_threshold 800 nanoseconds
Port state: : MASTER
sync_seq_num 41619
num sync messages transmitted 2748392
num followup messages transmitted 2748387
num sync messages received 0
num followup messages received 35
num pdelay requests transmitted 2746974
num pdelay responses received 2746927
num pdelay followup responses received 2746926
num pdelay requests received 2746348
num pdelay responses transmitted 2746348
num pdelay followup responses transmitted 2746345
```

MVRP Considerations

- MVRP is optional. Manual configuration of VLANs on the switches is sufficient for AVB (ports in trunk mode, vlan 2 is normally used for AVB).

- If **MVRP is enabled** on the switch, then VTP must be in disabled or transparent mode for MVRP to work.

```
!
mvrp global
mvrp vlan create
!
!
<snip>
!! vlan 2
avb
!
!
vtp mode transparent
<< show mvrp interface >>
```

- In this example, we manually configured vlan 17 on **switch1**. We can see that right after that, we start sending MVRP declarations for that vlan over the trunk interface Gi1/0/1, which is connected to Te1/0/2 of **switch2**:

```
switch1(config)#vlan 17
switch1(config-vlan)#exit
```

```
switch1(config)#interface vlan 17
switch1(config-if)#
```

```
*Nov 10 10:48:40.155: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan17, changed state to up >>> configured vlan with interface.
```

```
switch1(config)#do sh mvrp interface Gi1/0/1
```

```
Port      Status      Registrar State
Gi1/0/1   on          normal
```

```
Port      Join Timeout      Leave Timeout      Leaveall Timeout      Periodic
Gi1/0/1   20                60                1000                 Timeout
100
```

```
Port      Vlans Declared    >>> Switch is sending Declarations for VLAN 17 over Gi1/0/1
Gi1/0/1   1,8,17
```

```
Port      Vlans Registered >>> MVRP Registration available only for VLAN 1 and 8
Gi1/0/1   1,8
```

```
Port      Vlans Registered and in Spanning Tree Forwarding State
Gi1/0/1   1,8
```

```
switch1(config)#do show interfaces trunk
```

```
Port      Mode      Encapsulation      Status      Native vlan
Gi1/0/1   on        802.1q             trunking    1
```

```
Port      Vlans allowed on trunk
Gi1/0/1   1-4094
```

```
Port      Vlans allowed and active in management domain
Gi1/0/1   1-2,8,17,21-33,35-62,64-72,74-82,84-86,88-91,94-95,97-110,112-198,531-544,800-802,900-1000
```

```
Port          Vlans in spanning tree forwarding state and not pruned
Gi1/0/1      1,8 >>> Vlan 17 is Pruned because we have not received any Declaration from the
neighboring device, hence this vlan is not registered in MVRP yet.
```

- In the outputs shown previously, we can see that **switch1** is sending MVRP Declarations for the recently created vlan 17, but the vlan is not registered in MVRP for that interface yet, hence it is being pruned on that port by the switch. The Registration event for that vlan hasn't been completed on **switch1** likely because the neighboring device **switch2** is not sending MVRP Declarations for that vlan (either because that vlan doesn't exist on that device or because **switch2** is not running MVRP).
- In our case, the neighboring device **switch2** is already running MVRP, but SVI for vlan 17 was not created there yet, so it was not sending MVRP Declarations for that vlan. As soon as we created SVI for vlan 17 on **switch2**, it started sending Declarations for this vlan and the vlan got registered in MVRP on **switch1**

switch2

```
switch2(config)#do show mvrp interface Te1/0/2
```

```
Port          Status      Registrar State
Te1/0/2       on          normal
```

```
Port          Join Timeout      Leave Timeout      Leaveall Timeout      Periodic
Te1/0/2       20                60                1000                 Timeout
100
```

```
Port          Vlans Declared
Te1/0/2       1,8 >>> we are not sending Declarations for vlan 17 to switch1
```

```
Port          Vlans Registered
Te1/0/2       1,8,17 >>> we see the vlan getting registered and hence in forwarding state on this
switch.
```

```
Port          Vlans Registered and in Spanning Tree Forwarding State
Te1/0/2       1,8,17
```

```
switch2(config)#do show interfaces trunk
```

```
Port          Mode          Encapsulation      Status      Native vlan
Te1/0/2       on           802.1q             trunking    1
```

```
Port          Vlans allowed on trunk
Te1/0/2       1-4094
```

```
Port          Vlans allowed and active in management domain
Te1/0/2       1,8,17
```

```
Port          Vlans in spanning tree forwarding state and not pruned
Te1/0/2       1,8,17 >>> vlan 17 is in forwarding state on switch2
```

```
switch2(config)#int vlan 17
```

```
switch2(config-if)#
```

```
*Nov 10 11:32:55.539: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan17, changed state to
up
```

switch1

```
switch1(config)#do sh mvrp interface Gi1/0/1
```

```

Port          Status      Registrar State
Gi1/0/1      on          normal

Port          Join Timeout      Leave Timeout      Leaveall Timeout      Periodic
Gi1/0/1      20                60                 1000                  Timeout
100

Port          Vlans Declared
Gi1/0/1      1,8,17

Port          Vlans Registered
Gi1/0/1      1,8,17 >>> vlan 17 is now registered on switch1

Port          Vlans Registered and in Spanning Tree Forwarding State
Gi1/0/1      1,8,17 >>> and in FWD state

```

```
switch1(config)#do show interfaces trunk
```

```

Port          Mode          Encapsulation      Status          Native vlan
Gi1/0/1      on            802.1q             trunking        1

Port          Vlans allowed on trunk
Gi1/0/1      1-4094

Port          Vlans allowed and active in management domain
Gi1/0/1      1-2,8,17,21-33,35-62,64-72,74-82,84-86,88-91,94-95,97-110,112-198,531-544,800-
802,900-1000

Port          Vlans in spanning tree forwarding state and not pruned
Gi1/0/1      1,8,17 >>> vlan 17 is in FWD state and no longer pruned

```

Tip: If the neighboring device does not run or support MVRP, then, on the switch that is already running MVRP, you can configure this line on the port where the neighbor that doesn't support MVRP is connected: 'mvrp registration fixed'. This config ignores all MVRP declarations on that port and all VLANs that are statically configured on that switch won't be dynamically pruned by MVRP on that interface.

List of Commands

--- AVB verification commands ---

#gptp

```

show ptp brief
show ptp clock
show ptp parent
show ptp port <int_name>
show platform software fed switch active ptp interface <int_name>

```

#avb

```

show avb domain
show avb stream

```

#msrp

```

show msrp streams
show msrp streams brief show msrp streams detail
show msrp streams stream-id <stream-id> show msrp port bandwidth

```

```
show msrp port interface <int_name>
show tech msrp #mvrp
show mvrp summary
show mvrp interface <int_name> #QoS
show policy-map interface <int_name>
show interface <int_name> counter errors show platform hardware fed switch active qos queue
config interface <int_name> show platform hardware fed switch active qos queue stats interface
<int_name>
show platform hardware fed switch active fwd-asic resource tcam utilization
show tech qos
```

!!! Starting from Cisco IOS XE Denali 16.3.2, 'show running-config interface' command does not display any details of the AVB policy attached.

!!! You must use 'show policy-map interface' command to display all the details of the AVB policy attached to that port. #FED QoS

```
show platform software fed switch active qos policy summary
show platform software fed switch active qos policy target interface <int_name>
```

Related Information

- Cisco Audio Video Bridging Design and Deployment for Enterprise Networks (White Paper)
<https://www.cisco.com/c/dam/en/us/products/collateral/switches/catalyst-3850-series-switches/white-paper-c11-736890.pdf>
- Audio Video Bridging on Cat3K Switches
<https://www.cisco.com/c/dam/en/us/products/collateral/switches/q-and-a-c67-737896.pdf>
- AVB Product Page
<https://www.cisco.com/c/en/us/products/switches/avb.html>
- AVB Configuration Guide on Denali 16.3.x
https://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst3650/software/release/16-3/configuration_guide/b_163_consolidated_3650_cg/b_163_consolidated_3650_cg_chapter_010.html
- AVB Configuration Guide on Everest 16.6.x
https://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst3850/software/release/16-6/configuration_guide/avb/b_166_avb_3850_cg/b_165_avb_3850_cg_chapter_00.html
- AVB Configuration Guide on Fuji 16.9.x
https://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst9300/software/release/16-9/configuration_guide/avb/b_169_avb_9300_cg/audio_video_bridging.html
- AVB Configuration Guide on Gibraltar 16.10.x
https://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst9300/software/release/16-10/configuration_guide/avb/b_1610_avb_9300_cg/audio_video_bridging.html
- Biamp Systems - Enabling AVB on Cisco Catalyst Switches
https://support.biamp.com/Tesira/AVB/Enabling_AVB_on_Cisco_Catalyst_Switches