



High-availability Seamless Redundancy

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High-availability Seamless Redundancy

High-availability Seamless Redundancy overview

HSR is defined in International Standard IEC 62439-3-2016 clause 5. HSR is similar to Parallel Redundancy Protocol (PRP) but is designed to work in a ring topology. Instead of two parallel independent networks of any topology (LAN-A and LAN-B), HSR defines a ring with traffic in opposite directions. Port-A sends traffic counter clockwise in the ring, and Port-B sends traffic clockwise in the ring.

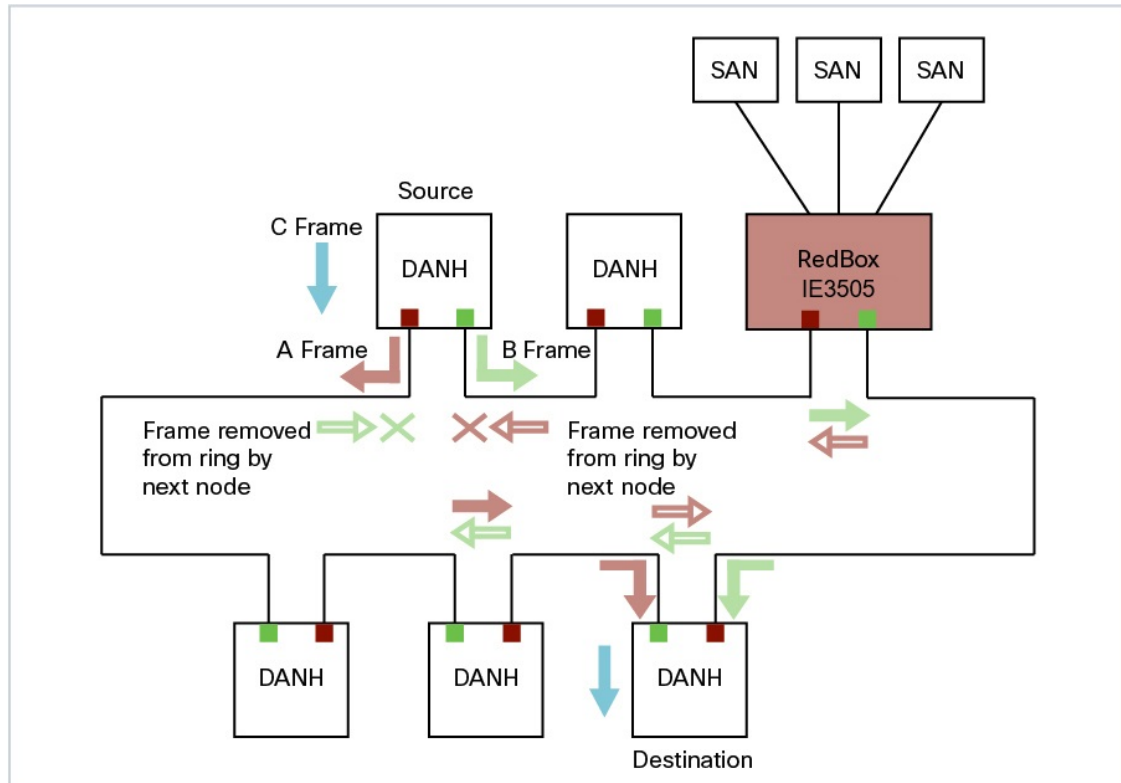
The HSR packet format is also different from PRP. To allow the switch to determine and discard duplicate packets, additional protocol specific information is sent with the data frame. For PRP, this is sent as part of a trailer called the redundancy control trailer (RCT), whereas for HSR this is sent as part of the header called the HSR header. Both the RCT and HSR header contain a sequence number, which is the primary data used to determine if the received frame is the first instance or a duplicate instance.

In this release, the switch supports only HSR-singly attached node (SAN) and only one HSR instance. If you have created a PRP instance, no HSR instance can be created.

The non-switching nodes with two interfaces attached to the HSR ring are referred to as Doubly Attached Nodes implementing HSR (DANHs). Similar to PRP, Singly Attached Nodes (SANs) are attached to the HSR ring through a device called a RedBox (Redundancy Box). The RedBox acts as a DANH for all traffic for which it is the source or the destination. The switch implements RedBox functionality using Gigabit Ethernet port connections to the HSR ring.

The following figure shows an example of an HSR ring as described in IEC 62439-3.

Figure 1: Example of HSR Ring Carrying Unicast Traffic



Devices that do not support HSR out of the box (for example, laptops and printers) cannot be attached to the HSR ring directly because all HSR capable devices must be able to process the HSR header on packets received from the ring and add the HSR header to all packets sent into the ring. These nodes are attached to the HSR ring through a RedBox. As shown in the figure above, the RedBox has two ports on the DANH side. Non-HSR SAN devices are attached to the upstream switch ports. The RedBox generates the supervision frames on behalf of these devices so that they are seen as DANH devices on the ring. Because the RedBox emulates these as DANH, they are called Virtual Doubly Attached Nodes (VDAN).

Switches that Support HSR

Table 1: The following Advanced base modules SKUs (PIDs) supports HSR.

Switch	PID
Cisco IE3505 Rugged Series Switch	IE-3505-8P3S
	IE-3505-8T3S
Cisco IE3505 Heavy-Duty Series Switch	IE-3505H-16T

Support for HSR is available on Network Essentials and Network Advantage licenses.

Supported HSR Features

IE-3505-8P3S, IE-3505-8T3S, and IE-3505H-16T switches support the following HSR features.

Maximum of one HSR ring is supported as shown in the following table:

Table 2: HSR Support for Cisco IE3505 Series Switch and Expansion Models

Switch	FPGA Profile	Number of Rings
Cisco IE3505 Rugged Series without expansion module	Default	1
	Redundancy	1
Cisco IE3505 Rugged Series with expansion module	Default	1
	Redundancy	1
IE-3505H-16T	Default	1
	Redundancy	1

Loop Avoidance

Each node in the HSR ring forwards frames received from one port to the other port of the HSR pair. To avoid loops and use network bandwidth effectively, the RedBox does not transmit frames that are already transmitted in same direction. When a node injects a packet into the ring, the packet is handled as follows to avoid loops:

- Unicast packet with destination inside the ring: When the unicast packet reaches the destination node, the packet is consumed by the respective node and is not forwarded.
- Unicast packet with destination not inside the ring: Because this packet does not have a destination node in the ring, it is forwarded by every node in the ring until it reaches the originating node. Because every node has a record of the packet it sent, along with the direction in which it was sent, the originating node detects that packet has completed the loop and drops the packet.
- Multicast packet: A multicast packet is forwarded by each node because there can be more than one consumer of this packet. For this reason a multicast packet always reaches the originating node. However, every node will check whether it has already forwarded the received packet through its outgoing interface. Once the packet reaches the originating node, the originating node determines that it already forwarded this packet and drops the packet instead of forwarding it again.

HSR RedBox Modes of Operation

The most basic mode of operation is HSR-SAN mode (single RedBox mode). In this mode, the RedBox is used to connect SAN devices to the HSR ring. The Redbox's responsibility in this mode is to represent SAN devices as VDANs on the ring.

HSR SAN Mode

In HSR-SAN mode, the RedBox inserts the HSR tag on behalf of the host and forwards the ring traffic, except for frames sent by the node itself, duplicate frames, and frames for which the node is the unique destination. In this mode, packets are handled as follows:

- A source DANH sends a frame passed from its upper layers (C frame), prefixes it with an HSR tag to identify frame duplicates, and sends the frame over each port (A frame and B frame).

- A destination DANH receives two identical frames from each port within a certain interval. The destination DANH removes the HSR tag of the first frame before passing it to its upper layers and discards any duplicate.
- Each node in the HSR ring forwards frames received from one port to the other port of the HSR pair. A node will not forward frames received on one port to the other under the following conditions:
 - The received frame returns to the originating node in the ring.
 - The frame is a unicast frame with a destination MAC address of a node upstream of the receiving node.
 - The node had already sent the same frame in the same direction. This rule prevents a frame from spinning in the ring in an infinite loop.

HSR-SAN interfaces

HSR-SAN mode is supported on interfaces GigabitEthernet 1/1-2 and GigabitEthernet 1/4-5. HSR ring 1 is configured as a pair of ports: Gi1/1 and Gi1/2 or Gi1/4 and Gi1/5.

Table 3: The supported HSR-SAN channel interfaces for IE3505 Rugged Series Switch

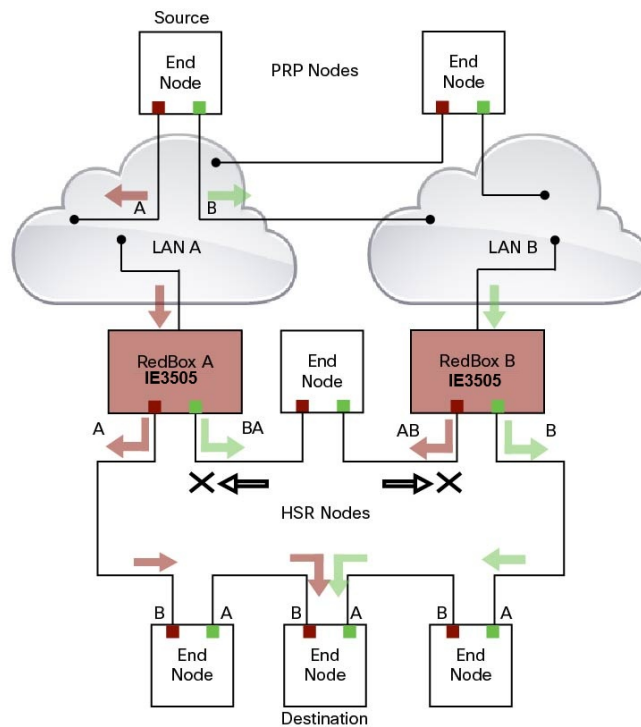
Mode	Module	Port Interface
HSR-SAN ring 1	Base Module	GigabitEthernet1/1 and 1/2 or GigabitEthernet1/4 and 1/5

HSR-PRP (Dual RedBox Mode)

HSR-PRP mode, also called Dual RedBox mode, is used to bridge HSR and PRP networks. Dual RedBox mode is supported on the Cisco IE3505 Series Switch.

In this mode, two different RedBoxes connect to LAN A and LAN B of the PRP network. Two ports connect to the HSR ring and one port connects to one of the two PRP LANs. The traffic on the upstream interlink port connecting the RedBox to the PRP network is PRP-tagged. In HSR-PRP mode, the RedBox extracts data from the PRP frame and generates the HSR frame using this data, and performs the reverse in the opposite direction. To avoid loops and use network bandwidth effectively, the RedBox does not transmit frames already transmitted in same direction (see [Loop Avoidance, on page 3](#)).

The following figure shows an HSR ring connected to a PRP network through two RedBoxes, one for each LAN. In this example, the source frame originates in the PRP network. RedBoxes are configured to support PRP traffic on the interlink ports and HSR traffic on the ring ports. Nodes connected to the HSR-PRP Redbox act as a SAN to the PRP Redbox and a VDAN to the HSR-PRP Dual Redbox.

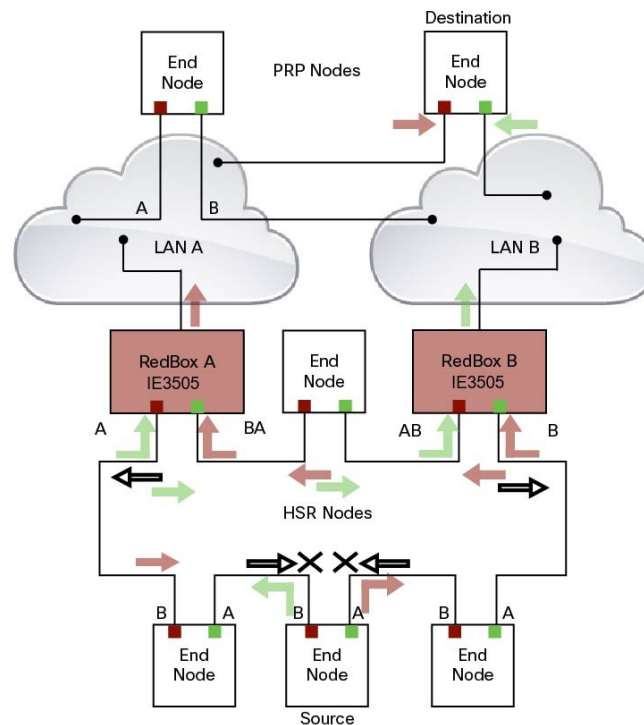


The sequence number from the PRP RCT is reused for the HSR tag and vice versa to allow frame identification from one redundancy network to the other and to identify the pairs and duplicates on either network. In the figure above, RedBox A and RedBox B send the same frame (A and AB and B and BA, respectively), but a RedBox does not transmit a frame that it already received.

Every DANH device generates its own sequence number, which is incremented for each outgoing frame. When a packet is switched from HSR to PRP or PRP to HSR, the sequence number is taken from the incoming packet so the same sequence number is used. Any node, whether it is an intermediate or final destination in the HSR or PRP network, uses the source MAC address and sequence number as the key for duplicate packet detection. Because the source address is expected to be unique for each node, there are no overlapping sequence numbers between different nodes.

Multicast frames or unicast frames without a receiver in the ring (arrows with the black outline in the figure) are removed by the RedBox that inserted them into the ring, if they originated from outside the ring. For this purpose, the frames carry a LAN identifier that is also the RedBox identifier.

The following figure shows an HSR ring coupled to a PRP network, where the source frame originates in the HSR ring.



To prevent frames from being reinjected into the PRP network through the other RedBox, each HSR frame carries the 4-bit PathId, which identifies the PRP network from which the frame came originally. RedBoxes are configured and identified by the PathId of the PRP LAN to which they are attached.

Different PathIds can be used to bridge more than one PRP network to an HSR ring. Likewise, more than one HSR ring can be bridged to a PRP network.

PRP is not needed for HSR-PRP to function in the IE3500 Rugged Series Switches. Any third port can be connected to PRP LAN A or LAN B network without PRP or any specific configurations.

PRP Supervision frames are sent toward PRP LAN A or LAN B from conversion of HSR Supervision Frames originated from DANHs and VDANs of HSR RedBoxes in the HSR ring. The HSR-PRP Redbox does not generate them but passes them along.

Packet flow in HSR-PRP

Packets coming from PRP network in the coupled PRP LAN-A or LAN-B are expected to have an RCT (Redundancy Control Trailer) tag. The switch removes the RCT and transfers the information to the HSR header using the programmed Net ID and LAN ID, recalculates the CRC, and sends the modified packet out to both ring A and ring B. If the packets originate from a SAN in the coupled PRP network, the switch treats it similarly as a VDAN to the HSR ring.

Egress Data Path—Packets coming from a SAN or PRP LAN A or LAN B to the HSR ring:

- For PRP packets, the switch converts the PRP RCT to an HSR tag for all packets (transfers Sequence Number and LAN ID from PRP to HSR).
- For SAN packets, the switch just inserts the HSR tag as is done in HSR-SAN RedBox mode.

- The switch needs to learn the MAC source address and add it to the Proxy Node table (VDAN table) with a new additional bit that allows the switch to distinguish between DANP or SAN. This allows the ingress path to determine whether to include the RCT trailer or not.

Ingress Data Path—Packets coming from the HSR ring to a SAN or PRP LAN A or LAN B:

- If the Proxy Node table or VDAN table lookup of the MAC destination address returns DANP, the switch converts the HSR tag to PRP RCT for accepted packets (transfers Sequence Number and LAN ID from HSR to PRP RCT).
- If the Proxy Node table or VDAN table lookup of the MAC destination address returns SAN, the switch strips the HSR tag and sends the packet without the RCT.

HSR-PRP Interfaces

In HSR-PRP Dual RedBox mode, two ports are connected to the HSR ring, and one port is connected to the PRP LAN A or LAN B network. The two ports that connect to the HSR ring are fixed (Gi1/1 and Gi1/2). When set to HSR-PRP mode, the two ports that connect to the HSR ring (Gi1/1 and Gi1/2) are automatically configured to HSR.

Table 4: The supported HSR-PRP channel interfaces for IE3505 Rugged Series Switch

Mode	Module	Port Interface
HSR-PRP	Base Module	GigabitEthernet1/1 and 1/2

The port connected to PRP LAN A or LAN B can be any other port from the base module or expansion module. All remaining ports of the HSR-PRP RedBox (base module or expansion module ports) can be used for any other purpose, for example, to connect a DHCP server.

These ports act as non-HSR/PRP nodes (SANs/VDANs) in the topology. The HSR-PRP RedBox can use all remaining ports (base module or expansion module ports) for other purposes, such as connecting a DHCP server. These non-PRP and non-HSR ports must be in the same VLAN as the HSR and PRP ports to achieve SAN/VDAN behavior.

Connecting Multiple PRP Networks to an HSR Ring

A maximum of six PRP networks, identified by the PathId, can be connected to the same HSR ring. The 4-bit PathId consists of the following:

- The 3-bit NetId (1 to 6), which identifies a PRP network and the two RedBoxes that connect the PRP network to an HSR ring.
- The 1-bit LanId (LAN A = 0 and LAN B = 1)

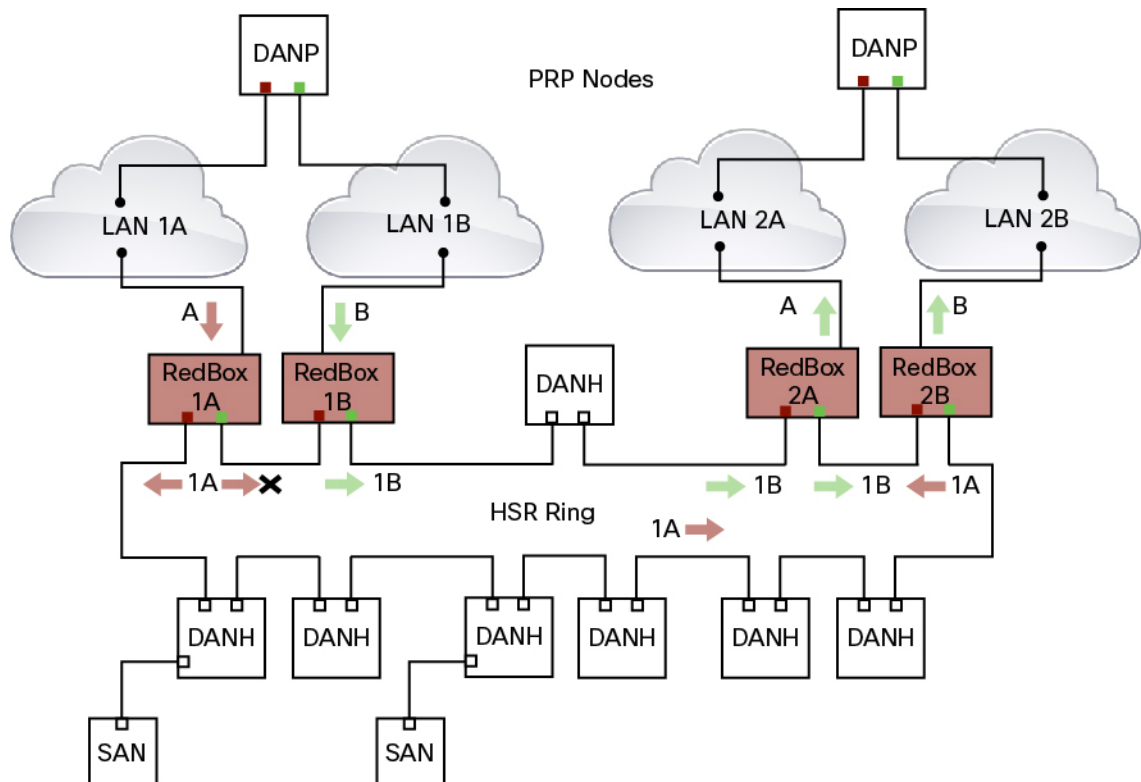
NetId values are as follows:

- 0 for regular HSR frames
- 1 to 6 for frames originating from a PRP network
- 7 is reserved

The following table lists the combinations of NetIds and LanIds for Redbox-A and Redbox-B.

PathId		
NetId	LanId	
	RedBox-A	RedBox-B
001	0	1
010	0	1
011	0	1
100	0	1
101	0	1
110	0	1
000	Used for Local HSR Ring	
111	Reserved	

The following figure shows an example of an HSR ring connected to two PRP networks.



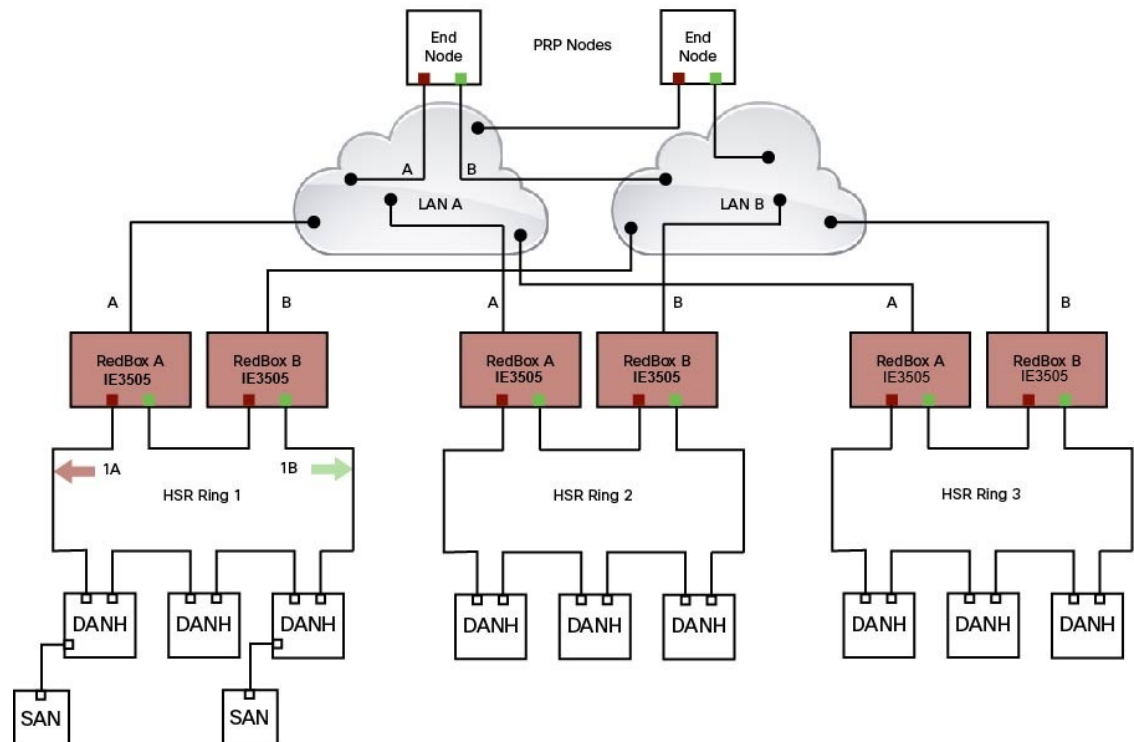
To prevent reinjection of frames coming from one PRP network into another PRP network or from the other LAN of the same PRP network, a RedBox only forwards frames that do not carry its own PathId from the HSR ring.

When a PRP frame from LAN A or from LAN B of a PRP network with a given NetId is inserted to the HSR ring, a RedBox inserts its own NetId and the LanId “A” or “B” into the PathId of the HSR tag.

When forwarding a frame from the HSR ring to a PRP network, the RedBox inserts the LanId “A” or “B” into the RCT.

Connecting Multiple HSR Rings to a PRP Network

A PRP network can be connected to any number of HSR rings, but these rings cannot be connected to each other because this would create loops. The following figure shows an example of three HSR rings connected to one PRP LAN.



HSR Alarms

An HSR ring can generate the following two alarms:

- **Partial Ring Fault:** This fault is generated by an HSR RedBox when one of its physical ring ports/links is down. Because the packets can be sent using the redundant path, this is considered as a partial fault. However, this fault still requires user intervention to restore the ring. This is a minor fault and cannot be associated with an external hardware alarm relay.
- **Full Ring Fault:** This fault is generated by an HSR RedBox when both of its physical ring ports/links are down. This is a catastrophic failure and needs immediate attention. This is a major fault and can be associated with an external hardware alarm relay.

When an event that raises an alarm is generated, it can be associated with one or more of the following actions to notify the user:

- Syslog: A syslog is generated when the Alarm is raised/cleared.
- SNMP Notification: SNMP notification is sent when the alarm is raised/cleared.
- Relay output: External relay contacts can be asserted/de-asserted in response to the alarm. Relays are activated by major faults only.

See [Enabling HSR Alarms, on page 25](#) for steps to configure HSR alarms.

The following table lists the HSR events and their representations.

Event Number	Event Description	System Log (Level)	Alert/Alarm Log	Alarm LED and Output relay
1	Ring goes from UP to DOWN state.	2	2	Major Alarm/Assert
2	Ring goes from DOWN to UP state.	6	6	De-assert
3	One ring port goes DOWN, the other ring port and the ring itself is UP.	3	3	
4	Both ring ports are UP again.	6	6	

You can view currently active alarms using the **show facility alarm status** command. The following example shows alarm status for minor and major HSR alarms:

```
Switch#show facility-alarm status
Source          Severity    Description                                Relay    Time
Switch          MINOR      34 HSR ring is partially down             MAJ      Oct 24 2017 10:16:10

-----
Switch# show facility-alarm status
Source          Severity    Description                                Relay    Time
Switch          MAJOR      33 HSR ring is down                       MAJ      Oct 24 2017 10:17:07
```

The following examples show the syslog entries that are generated for each HSR alarm event assertion and clear event (if configured):

- Syslog generated on occurrence of Partial fault:

```
Oct 24 11:07:13.952 IST: %HSR_ALARM-3-HSR_PARTIALFAULT: The HSR ring in now in PARTIAL
FAULT state
```

- Syslog generated when the Partial fault is cleared:

```
Oct 24 11:07:38.032 IST: %HSR_ALARM-3-HSR_PARTIALFAULT: The HSR ring in now in PARTIAL
FAULT state - event cleared
```

- Syslog generated on occurrence of Full fault:

```
Oct 24 11:07:38.036 IST: %HSR_ALARM-2-HSR_RINGFAULT: The HSR ring in now in FAULT state
```

- Syslog generated when the Full fault is cleared:

```
Oct 24 11:08:19.082 IST: %HSR_ALARM-2-HSR_RINGFAULT: The HSR ring is now in FAULT state  
- event cleared
```

CDP and LLDP for HSR

HSR supports the Cisco Discovery Protocol (CDP) and Link Layer Discovery Protocol (LLDP). CDP and LLDP are Layer 2 neighbor discovery protocols. Both CDP and LLDP can provide information about nodes directly connected to the device. They also provide additional information such as the local and remote interface and device names.

When CDP or LLDP is enabled, you can use the CDP or LLDP information to find the adjacent nodes on an HSR ring and their status. You can then use the neighbor information from each node to determine the complete HSR network topology and debug and locate ring faults.

CDP and LLDP are configured on physical interfaces only.

For more information, see [Configuring an HSR Ring and Verifying Configuration](#).

PTP over HSR

PTP over HSR is a network synchronization capability that allows PTP packets to bypass standard HSR duplicate or discard logic to maintain timing accuracy across redundant paths.

PTP over HSR:

- Supports the PTP Power profile on Cisco Catalyst IE9300 Rugged, IE3500 Rugged and IE3500H Heavy Duty Series Switches.
- Utilizes a designated time recipient port for synchronization while maintaining a passive port for redundancy.
- Operates automatically without requiring additional interface-specific PTP configuration.

PTP over HSR operational details

The PTP grandmaster in an HSR network can be a RedBox, a VDAN, a SAN, or a DANH. Because the PTP 1588 standard does not account for clocks synchronized over redundant, simultaneously active paths, HSR handles PTP packets differently than other traffic types.

Supported PTP profiles and modes

This reference provides the HSR support matrix for PTP profiles, clock modes, and RedBox types as defined by IEC 62439-3.

PTP over HSR is supported only for the PTP Power Profile. For unsupported PTP profiles, PTP traffic flows over HSR port-A only.

Table 5: HSR support for PTP profiles

PTP Profile	Clock Mode	Supported	HSR RedBox Type as per IEC 62439-3
Power Profile	Boundary Clock (BC)	Yes	HSR RedBox as doubly attached BC (DABC) with P2P
	P2P Transparent Clock (TC)	Yes	HSR RedBox as doubly attached TC (DATC) with P2P
	Grandmaster Clock (GMC)-BC	No	Not applicable
	Forward	No	Not applicable
Default Profile	BC	No	Not applicable
	End-to-End (E2E) TC	No	Not applicable

Operating HSR RedBox as Doubly Attached BC (DABC) with P2P

This section describes the operation of PTP over HSR using an example where RedBox Primary and RedBox Secondary are configured to run in Power Profile as Boundary Clocks that use the Peer-to-Peer delay measurement mechanism.

Summary

Assume for this example that SAN-1 is the GMC. All the clocks are configured to run Peer-to-Peer Delay measurement and the peer delay is regularly calculated and maintained on every link shown in the figure. The BMCA on RedBox Primary determines the port to SAN-1 to be connected to the time source. The PTP protocol running on RedBox Primary will forward Sync and Follow_Up messages on ports RedBox Primary A and B.

On RedBox Secondary, the regular BMCA operation determines RedBox Secondary port A to be time recipient and RedBox Secondary port B to be `PASSIVE`. However, with the knowledge that ports RedBox Secondary A and B are part of the same HSR ring, RedBox Secondary port B is forced into `PASSIVE_SLAVE` state and RedBox Secondary port A becomes active for PTP.

RedBox Secondary port A works as a regular time recipient port. It uses the Sync and Follow_Up messages along with their correction field to calculate the delay and offset from time source and synchronize the local clock.

RedBox Secondary port B, which is in `PASSIVE_SLAVE` state operates in this way:

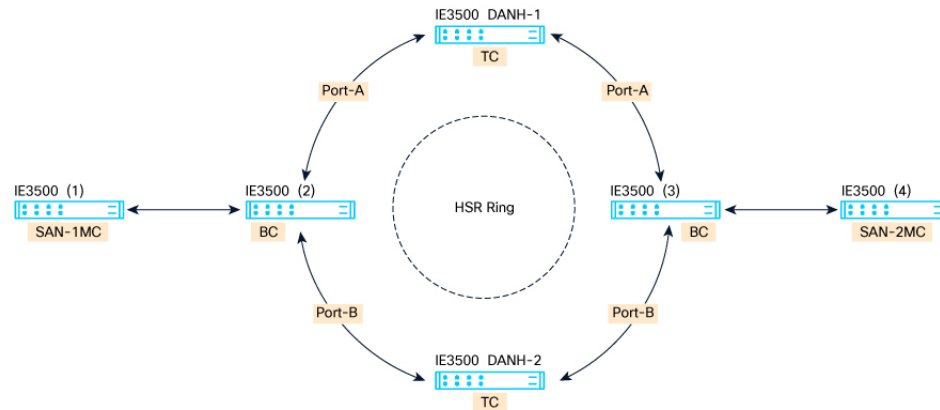
Just like RedBox Secondary port A, it maintains the delay and offset from time source, but does not perform any operation on the local clock. Having all the synchronization information available enables it to seamlessly take over as the new time recipient in case RedBox Secondary port A loses communication with the GMC.

The given image uses these device mappings:

- SAN-1MC: IE3500 (1)
- RedBox Primary: IE3500 (2)

- RedBox Secondary: IE3500 (3)
- SAN-2MC: IE3500 (4)
- DANH-1: IE3500 configured as a Transparent Clock
- DANH-2: IE3500 configured as a Transparent Clock

Workflow



These stages describe the PTP operation and synchronization logic for RedBox Primary (IE3500 (2)) and RedBox Secondary (IE3500 (3)).

1. RedBox Primary (IE3500 (2)) performs BMCA to identify the time source and distribute synchronization messages.
 - BMCA identifies the port connected to SAN-1MC (IE3500 (1)) as the time-receiver port.
 - Sync and Follow_Up messages are forwarded through RedBox Primary Port A toward DANH-1 and through RedBox Primary Port B toward DANH-2.
2. RedBox Secondary (IE3500 (3)) manages its port states to maintain synchronization and redundancy.
 - RedBox Secondary Port A, connected to DANH-1, functions as the active time-receiver port.
 - RedBox Secondary Port B, connected to DANH-2, remains in the `PASSIVE_SLAVE` state while maintaining synchronization information for failover.

Configure HSR RedBox as DABC with P2P

Configure the PTP power profile on SAN, RedBox, and DANH nodes in an HSR doubly attached boundary clock topology with P2P delay measurement.

This procedure applies to resilient industrial Ethernet deployments that use SAN or RedBox boundary clocks and DANH transparent clocks. These clocks must synchronize with the same grandmaster while maintaining redundancy and accurate peer-delay measurements.

Procedure

Step 1 Use the **configure terminal** command to enter global configuration mode.

Example:

```
Switch# configure terminal
```

Step 2 Use the **interface range** *interface-id* command to create the HSR ring interface and assign the ports to the HSR ring.

Example:

```
Switch(config)# interface range GigabitEthernet 1/1-2
```

Note

Select the pair that matches the physical ring connections in your deployment. Both interfaces in the selected pair must use the same settings and VLAN configuration. Configure these settings before assigning the interfaces to the HSR ring.

For channel and interface details, see [HSR-Ring 1](#)

Step 3 Use the **hsr-ring** *ring-id* command to create an HSR ring.

Example:

```
Switch(config-if-range)# hsr-ring 1
```

Step 4 Use the **no shutdown** command to turn on the HSR interface.

Example:

```
Switch(config-if-range)# no shutdown
```

For more details on the HSR ring configuration, see [HSR Ring Configuration](#)

Step 5 Use the **exit** command to return to global configuration mode.

Example:

```
Switch(config-if-range)# exit
```

Step 6 Configure PTP

- a) Use the **ptp clock boundary domain** *domain-number* **profile power** command to configure the boundary type PTP clock, which stops the PTP session from the grandmaster clock and acts as a PTP server or client clock downstream.

Example:

```
Switch(config)# ptp clock boundary domain 0 profile power
```

- b) Use the **allow-without-tlv** command to permit PTP message processing without TLVs.

Example:

```
Switch(config-ptp-clk)# allow-without-tlv
```

- c) Use the **clock-port** *port-name* command to define a new clock port for ethernet multicast interface Gi1/0/21.

Example:

```
Switch(config-ptp-clk)# clock-port dyn1
```

- d) Use the **transport ethernet multicast interface** *interface-id* command to specify the transport method for clocking traffic.

Example:

```
Switch(config-ptp-port)# transport ethernet multicast interface Gi1/0/21
```

- e) Use the **clock-port** *port-name* command to define a new clock port for ethernet multicast interface Gi1/0/22.

Example:

```
Switch(config-ptp-clk)# clock-port dyn2
```

- f) Use the **transport ethernet multicast interface** *interface-id* command to specify the transport method for clocking traffic.

Example:

```
Switch(config-ptp-port)# transport ethernet multicast interface Gi1/0/22
```

- g) (Optional) Use the **vlan** *vlan-id* command to configure VLAN for tagged packets.

Example:

```
Switch(config-ptp-port)# vlan 100
```

Step 7 Configure DANH-1 as a TC

In this example, DANH-1 is an IE3500 and IE3500H switch configured as a TC. The PTP commands apply to supported switches. HSR interface assignments are platform-specific so you can use the supported interface pair for your switch model.

- a) Use the **configure terminal** command to enter global configuration mode of the switch that operates as DANH-1.

Example:

```
DANH-1# configure terminal
```

- b) Use the **ptp clock transparent domain** *domain-number* **profile power** command to configure the device as a Transparent Clock, which accounts for packet residence time to maintain PTP synchronization accuracy without terminating the PTP session.

Example:

```
DANH-1(config)# ptp clock transparent domain 0 profile power
```

- c) Use the **allow-without-tlv** command to permit PTP message processing without TLVs.

Example:

```
DANH-1(config)# allow-without-tlv
```

See Step 8a to 8c to configure DANH-2.

See [Verification](#) commands to verify the configuration.

Note

When RedBox Primary and RedBox Secondary are configured for HSR, Boundary Clock (BC) must be enabled on both the HSR-capable ring ports and the ports connected to SANH devices.

HSR RedBox as Doubly Attached TC (DATC) with P2P

This process assumes SAN-1 functions as the Grandmaster Clock (GMC). All clocks are configured to run Peer-to-Peer Delay measurement, with peer delay regularly calculated and maintained on every link.

Summary

These components participate in the synchronization process:

- RedBox Primary: Performs BMCA to determine the time source connection and forwards Sync and Follow_Up messages.
- RedBox Secondary: Operates with one port as the time recipient and the other as a passive slave to ensure seamless failover.

Workflow

These stages describe the operational behavior of the RedBox devices during PTP synchronization.

1. RedBox Primary determines the time source and manages message forwarding.
 - The BMCA on RedBox Primary identifies the port connected to SAN-1 as the time source.
 - RedBox Primary forwards all Sync and Follow_Up messages received on port C out of ports A and B.
2. RedBox Secondary manages port roles to maintain synchronization and redundancy.

When	And	Then	And
Port A receives Sync/Follow_Up	Active state	Calculate delay and offset	Forward messages out of port C
Port B receives Sync/Follow_Up	Passive state	Maintain delay and offset	Drop messages

Result

The network maintains synchronization information, allowing port B to seamlessly take over as the time recipient if port A loses communication with the GMC.

Configure HSR RedBox as DATC with P2P

Configure PTP power profile and clock modes across SAN, RedBox, and DANH nodes to establish deterministic time synchronization in an HSR DATC topology using P2P delay measurement.

This procedure applies to resilient industrial Ethernet deployments where SAN or RedBox TCs and DANH TCs must converge to the same grandmaster with redundancy and accurate peer-delay timing.

Procedure

-
- Step 1** To configure SAN-1, SAN-2, RedBox with PTP, see [PTP configuration](#).

Step 2 Use the **interface range** *interface-id* command to create the HSR ring interface and assign ports to the HSR ring.

Example:

```
Switch(config)# interface range GigabitEthernet 1/1/1-2
```

For channel and interface details, see [HSR-Ring 1](#).

Step 3 Use the **hsr-ring** *ring-id* command to create HSR ring.

Example:

```
Switch(config-if-range)# hsr-ring 1
```

Step 4 Use the **no shutdown** command to turn on the HSR interface.

Example:

```
Switch(config-if-range)# no shutdown
Switch(config-if-range)# exit
```

For more details on the HSR ring configuration, see [HSR Ring Configuration](#).

Step 5 Configure DANH-1 as a TC

In this example, DANH-1 is an IE3500 and IE3500H switch configured as a TC. The PTP commands also apply to supported switches. HSR interface assignments are platform-specific so you can use the supported interface pair for your switch model.

- a) Use the **configure terminal** command to enter global configuration mode of the switch that operates as DANH-1.

Example:

```
DANH-1# configure terminal
```

- b) Use the **ptp clock transparent domain** *domain-number* **profile power** command to configure the device as a TC, which accounts for packet residence time to maintain PTP synchronization accuracy without terminating the PTP session.

Example:

```
DANH-1(config)# ptp clock transparent domain 0 profile power
```

- c) Use the **allow-without-tlv** command to permit PTP message processing without TLVs.

Example:

```
DANH-1(config)# allow-without-tlv
```

See Step 5a to 5c to configure TC for DANH-2, RedBox Primary, and RedBox Secondary.

See [Verification](#) commands to verify the configuration.

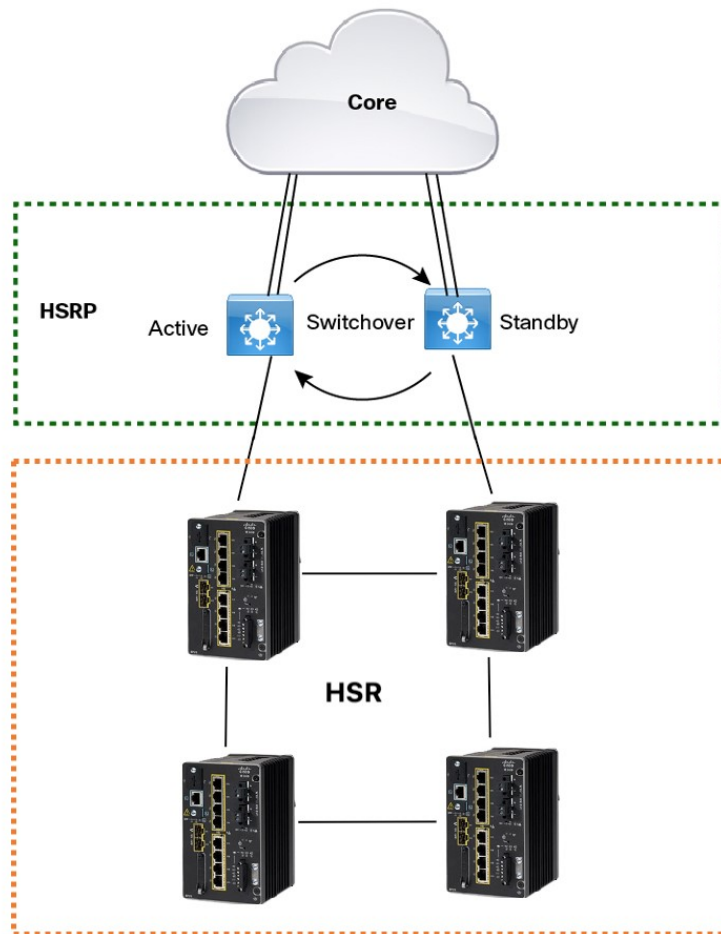
Note

On each RedBox, verify that PTP is enabled on both HSR ring interfaces and on the interfaces connected to singly attached nodes (SANs). Apply the same PTP settings to both HSR ring interfaces to support uninterrupted synchronization if the active timing path changes.

HSR Uplink Redundancy Enhancement

The HSR Uplink Redundancy Enhancement feature allows for flexible designs that enable two separate interfaces to connect upstream from the HSR ring through two separate HSR RedBoxes. This ensures there is no single point of failure exiting the HSR ring. Examples of protocols that can leverage this feature to improve high availability include HSRP, VRRP and REP. Prior to this enhancement, if these protocols were utilized on redundant uplinks, undesirable results could occur, such as next-hop split-brain conditions or slow REP failover times.

The following diagram shows an example network with HSR and HSRP that allows uplink next-hop gateway redundancy out of the HSR ring.



To implement HSR Uplink Redundancy, ensure that the **fpgamode-DualUplinkEnhancement** feature is not disabled. This feature is required to support the connectivity to a dual router (HSRP in this case) on the distribution layer:

```
Switch#show hsr ring 1 detail | include fpgamode
fpgamode-DualUplinkEnhancement: Enabled
```

If the output shows *fpgamode-DualUplinkEnhancement,:Disabled* issue the following command:

```
Switch# conf t
Enter configuration commands, one per line. End with CNTL/Z.
```

```
Switch(config)# hsr-ring 1 fpgamode-DualUplinkEnhancement
Switch(config)# end
```

HSRP Configuration

The following example HSRP configuration applies to the two distribution switches Active & Standby in the above figure. In the following configuration, HSRP is configured in a Switch Virtual Interface (SVI).

```
Active# conf t
Enter configuration commands, one per line. End with CNTL/Z.
Active(config)# interface vlan 10
Active(config-if)# ip address 30.30.30.2 255.255.255.0
Active(config-if)# standby 1 ip 30.30.30.1
Active(config-if)# standby 1 priority 120
Active(config-if)# end
```

```
Standby# conf t
Enter configuration commands, one per line. End with CNTL/Z.
Standby(config)# interface Vlan10
Standby(config-if)# ip address 30.30.30.4 255.255.255.0
Standby(config-if)# standby 1 ip 30.30.30.1
Standby(config-if)# end
```

```
Active# show standby
Vlan10 - Group 1
  State is Active
    8 state changes, last state change 00:03:55
    Track object 1 (unknown)
    Virtual IP address is 30.30.30.1
    Active virtual MAC address is 0000.0c07.ac01 (MAC In Use)
    Local virtual MAC address is 0000.0c07.ac01 (v1 default)
    Hello time 200 msec, hold time 750 msec
    Next hello sent in 0.176 secs
    Preemption enabled, delay min 5 secs, reload 5 secs, sync 5 secs
    Active router is local
    Standby router is 30.30.30.4, priority 100 (expires in 0.656 sec)
    Priority 120 (configured 120)
    Group name is "hsrp-Vl10-1" (default)
    FLAGS: 0/1
```

```
Active# show standby brief
          P indicates configured to preempt.
          |
Interface  Grp  Pri  P State   Active        Standby        Virtual IP
Vl10       1    120 P Active  local         30.30.30.4     30.30.30.1
```

```
Standby# show standby
Vlan10 - Group 1
  State is Standby
    13 state changes, last state change 00:04:17
    Track object 1 (unknown)
    Virtual IP address is 30.30.30.1
    Active virtual MAC address is 0000.0c07.ac01 (MAC Not In Use)
    Local virtual MAC address is 0000.0c07.ac01 (v1 default)
    Hello time 200 msec, hold time 750 msec
    Next hello sent in 0.064 secs
    Preemption enabled, delay min 5 secs, reload 5 secs, sync 5 secs
    Active router is 30.30.30.2, priority 120 (expires in 0.816 sec)
    Standby router is local
    Priority 100 (default 100)
    Group name is "hsrp-Vl10-1" (default)
    FLAGS: 0/1
Standby# show standby brief
```

```

P indicates configured to preempt.
|
Interface  Grp  Pri P State  Active  Standby  Virtual IP
v110      1    100 P Standby 30.30.30.2  local  30.30.30.1

```

Guidelines and Limitations

- HSR is supported only in a standalone deployment.
- Only one HSR instance is supported. Note that the switch supports only one HSR or one PRP instance, so if a PRP instance has been created, no HSR instance can be created.
- HSR ring 1 can only be configured as a pair of ports: Gi1/1 and Gi1/2 or Gi1/4 and Gi1/5. Using these port pairs, you can configure 1 HSR ring.
- The HSR feature requires the Network Essentials license.
- The HSR feature is not enabled by default and you must explicitly configure the HSR rings.
- HSR is disabled automatically if the required firmware image is not available on the system.
- Once a port is part of a ring, the media-type, speed, and duplex settings of the port cannot be changed. We recommend that you apply those settings before configuring ring membership.
- If mode of HSR interfaces is changed from access to trunk mode or vice-versa after configuring the ring, we recommended that you flap the HSR ring.
- The recommended maximum number of nodes in the node table is 512. Nodes are all the DANH and VDAN devices that can be connected to the ring at same time. This number is not an absolute limit, but higher numbers of entries may increase the number of duplicate packets received by the end devices.
- HSR ring ports can only be configured in L2 mode.
- HSR is supported on following port types:
 - 100 mbps, Full Duplex. Half duplex is not supported.
 - 1000 mbps, Full Duplex. Half duplex is not supported.
 - HSR is not supported on the uplink ports.
- Both ports of one ring must be of same speed and type (that is, both can be SFPs or both can be copper)
- The following protocols and features are mutually exclusive with HSR on the same port:
 - PRP
 - EtherChannels
 - Link Aggregation Control Protocol (LACP)
 - Port Aggregation Protocol (PAgP)
 - Resilient Ethernet Protocol (REP)
- MACsec, HSR, and PRP are not allowed together.
- HSR supports an MTU size of up to 1998 bytes of Ethernet payload.

- STP is not supported on the HSR ring. By default, all modes of Spanning Tree Protocol (STP) will be disabled on the ring ports.
- Switched Port Analyzer (SPAN) and Remote SPAN (RSPAN) are not supported on HSR. That is, SPAN and RSPAN should not be used to monitor the traffic on an HSR ring. In addition, traffic that has been monitored using RSPAN should not be transferred over an HSR ring.
- It is important for all interfaces in an HSR ring to have the same speed and duplex settings. It is recommended to apply those settings before configuring ring membership.
- Once a port is part of ring, the port cannot be shut down.

For example, if Gi1/4 and Gi1/5 are part of an HSR ring and you try to shut down Gi1/4 or Gi1/5, the operation will not be permitted:

```
Switch(config)# interface gi1/4
Switch(config-if)#shutdown
%Interface GigabitEthernet1/4 is configured in a HSR ring shutdown not permitted!
Switch(config-if)#
```

You can perform a shutdown of the HSR ring. For example:

```
Switch# conf t
Switch(config)#int hs1
Switch(config-if)#shut
```

- VLAN configuration such as trunk and access mode must be the same on both the ports participating in the ring. For example, if Gi1/4 and Gi1/5 in an HSR ring are in trunk mode and you attempt to change the mode of one port to access, the ports in the ring will not be bundled:

```
Switch(config)#interface range gi1/4
Switch(config-if)#switchport mode access
Jul 27 22:00:27.809 IST: %EC-5-CANNOT_BUNDLE2: Gi1/4 is not compatible with Gi1/5 and
will be suspended (trunk mode of Gi1/4 is access, Gi1/5 is dynamic)
```

- After an interface is added in the HSR ring, only the primary interface counters are updated. You should not need to configure and check the status of individual physical interfaces after they are added to the HSR ring.
- As soon as you configure an HSR ring on two ports of a switch, MAC flaps will be observed on other switches where the HSR configuration is yet to be applied. We recommend that you shut down the newly created HSR ring on the switch before configuring the ring on all switches, and then re-enable them one by one as shown below. For example, if there are four switches in the ring, disable the HSR ring interfaces on each switch:

```
Switch1(config)#interface range gi1/1-2
Switch1(config-if)#shutdown
Switch1(config-if)#hsr-ring hs1
Creating a HSR-ring interface hs1
Switch1(config-if)#int hs1
Switch1(config-if)#shutdown
Switch1(config-if)#end
```

After all four switches are configured with the ring, re-enable the HSR ports on each switch:

```
Switch1#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch1(config)#int hs1
Switch1(config-if)#no shutdown
Switch1(config-if)#end
Switch1#
```

This prevents interim MAC flapping during HSR ring configuration in member switches.

Default Settings

Table 6: HSR Ring Parameters

Parameter	Description	Range	Default Value
entryForgetTime	Time for clearing an inactive entry from duplicate discard table.	0-65535	400 ms
fpgamode-DualUplinkEnhancement	Set FPGA register for source mac filtering.	enable or disable	enable
nodeForgetTime	Time to clear an inactive entry from the node table.	0-65535	60000 ms
nodeRebootInterval	Time after which the RedBox must start sending supervision frames after bootup.	0-65535	500 ms
pauseFrameTime	Time interval between HSR pause frames.	0-65535	25 ms
proxyNodeTableForgetTime	Time to clear an inactive entry from the proxy node table or vdan table.	0-65535	60000 ms
supervisionFrameLifeCheckInterval	Life check interval value for supervision frames.	0-65535	1600 ms
supervisionFrameOption			
mac-da	The last bytes of the destination MAC address of supervision frames (01:15:4E:00:01:00). The last 00 is replaced by the value of this parameter.	1-255 MAC DA last eight bits option value	No default
vlan-cfi	Enable Canonical Format Indicator (CFI) for the VLAN tagged frame.	enable or disable	disable
vlan-cos	Class of Service (COS) value to be set in the VLAN tag of the Supervision frame.	0-7	0

Parameter	Description	Range	Default Value
vlan-id	The VLAN tag of the supervision frame.	0-4095	0
vlan-tagged	Set VLAN tagging option.	enable or disable	disable
supervisionFrameRedboxMacaddress	The RedBox MAC address in the supervision frames.	48-bit RedBox MAC address	The interface HSR ring MAC address
supervisionFrameTime	Time interval between supervision frames.	0-65535	3 ms

Configure an HSR Ring

Follow these steps to configure an HSR ring:

Before you begin

- Read and understand the [Guidelines and Limitations, on page 20](#) section of this chapter.
- Ensure that the member interfaces of a HSR ring are not participating in any redundancy protocols such as FlexLinks, EtherChannel, REP, and so on before configuring a HSR ring.

Procedure

-
- Step 1** Enter global configuration mode:
- ```
Switch# configure terminal
```
- Step 2** (Optional) Globally enable CDP to provide information about HSR ring nodes:
- ```
Switch(config)# cdp run
```
- Step 3** (Optional) Globally enable LLDP to provide information about HSR ring nodes:
- ```
Switch(config)# lldp run
```
- Step 4** Enter interface configuration mode and disable PTP on the ports to be assigned to the HSR ring:
- ```
Switch(config)# interface range g1/1-2  
Switch(config-if-range)# no ptp enable
```
- Step 5** (Optional) Enable CDP on the ports to be assigned to the HSR ring:
- ```
Switch(config-if-range)# cdp enable
```
- Step 6** (Optional) Enable LLDP on the ports to be assigned to the HSR ring:
- ```
Switch(config-if-range)# lldp transmit  
Switch(config-if-range)# lldp receive
```
- Step 7** Shut down the ports before configuring the HSR ring:
- ```
Switch(config-if-range)# shutdown
```

**Step 8** Create the HSR ring interface and assign the ports to the HSR ring:

```
Switch(config)# interface range gigabitEthernet 1/1-2
Switch(config-if-range)# hsr-ring 1
```

**Step 9** (Optional) If required, configure HSR ring optional parameters. See the Default Settings section for the parameter descriptions, ranges and default values.

```
Switch(config-if-range)# hsr 1 supervisionFrameLifeCheckInterval 10000
```

**Step 10** Turn on the HSR interface:

```
Switch(config-if-range)# no shutdown
Switch(config-if)# end
```

### Example

```
Switch# conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)# interface range gigabitEthernet 1/1-2
Switch(config-if-range)# no ptp enable
Switch(config-if-range)# shutdown
Switch(config-if-range)# hsr-ring 1
Switch(config-if-range)# hsr-ring 1 supervisionFrameLifeCheckInterval 10000
Switch(config-if-range)# no shutdown
Switch(config-if-range)# end
```

## Configuring HSR-PRP

Follow these steps to enable HSR-PRP Redbox mode on the switch. Enabling HSR-PRP mode creates an HSR ring and bridges the the HSR ring to a PRP network.

### Before you begin

- See [Guidelines and Limitations](#), on page 20.

### Procedure

**Step 1** Enter global configuration mode:

```
switch# configure terminal
```

**Step 2** Enable HSR-PRP mode and select LAN A or LAN B and the optional PRP Net ID:

```
hsr-prp-mode enable {prp-lan-a | prp-lan-b} [1-6]
```

- prp-lan-a: Redbox is connected to LAN A.
- prp-lan-b: Redbox is connected to LAN B.
- 1-6: PRP Net ID value from 1 to 6.

The default is 1.

**Note**

Be sure to configure the same Net ID in Redbox A and B that is part of the same PRP network.

**Example:**

```
switch(config)#hsr-prp-mode enable prp-lan-a
```

To disable HSR-PRP Redbox mode, use the command **no hsr-prp-mode enable**.

---

## Enabling HSR Alarms

To enable alarms for HSR, follow these steps:

**Before you begin**

Alarms and actions can be enabled/disabled at the facility level only. You cannot enable only partial faults or full faults; either all alarms for given facility are enabled or all are disabled.

See [HSR Alarms, on page 9](#) for details about HSR alarms.

**Procedure**

---

- |               |                                                                                                                                                                 |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Step 1</b> | Enter global configuration mode:<br><pre>Switch# configure terminal</pre>                                                                                       |
| <b>Step 2</b> | Enable the HSR alarm facility:<br><pre>Switch(config)# alarm facility hsr enable</pre> <p>To disable HSR alarms, enter <b>no alarm facility hsr enable</b>.</p> |
| <b>Step 3</b> | (Optional) Enable SNMP notification for HSR alarms:<br><pre>Switch(config)# alarm facility hsr notifies</pre>                                                   |
| <b>Step 4</b> | (Optional) Associate HSR alarms with the Major Relay:<br><pre>Switch(config)# alarm facility hsr relay major</pre>                                              |
| <b>Step 5</b> | (Optional) Send HSR alarms to a syslog server:<br><pre>Switch(config)# alarm facility hsr syslog</pre>                                                          |
| <b>Step 6</b> | (Optional) Enable logging of informational HSR alarm messages:<br><pre>Switch(config)# logging alarm informational</pre>                                        |
| <b>Step 7</b> | Exit global configuration mode:<br><pre>Switch(config)# end</pre>                                                                                               |
| <b>Step 8</b> | Verify the configuration:                                                                                                                                       |

```
Switch# show facility-alarm status
```

## Clear All Node Table and VDAN Table Dynamic Entries

### Procedure

- Step 1** To clear all dynamic entries in the node table, enter the following command: **clear hsr node-table**
- Step 2** To clear all dynamic entries in the VDAN table, enter the following command; **clear hsr vdan-table**

## Verifying the Configuration

| Command                                                                                                                    | Purpose                                                                                                                                            |
|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>show hsr ring 1 [detail ]</b>                                                                                           | Displays configuration details for the specified HSR ring.                                                                                         |
| <b>show hsr statistics {egressPacketStatistics   ingressPacketStatistics   nodeTableStatistics   pauseFrameStatistics}</b> | Displays statistics for HSR components.<br><br><b>Note</b><br>To clear HSR statistics information, enter the command <b>clear hsr statistics</b> . |
| <b>show hsr node-table</b>                                                                                                 | Displays HSR node table.                                                                                                                           |
| <b>show hsr vdan-table</b>                                                                                                 | Displays HSR Virtual Doubly Attached Node (VDAN) table.<br><br><b>Note</b><br>The VDAN table and Proxy node table are the same.                    |
| <b>show cdp neighbors</b>                                                                                                  | Displays CDP neighbor information for an HSR ring.                                                                                                 |
| <b>show lldp neighbors</b>                                                                                                 | Displays LLDP neighbor information for an HSR ring.                                                                                                |

## Configuration Examples

### HSR-SAN

This example shows the configuration of an HSR ring (Ring 1) using Gi1/1 and Gi1/2 ports between four devices.

```

Switch-1# conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch-1(config)#interface range gigabitEthernet 1/1-2
Switch-1(config-if-range)#shutdown
Switch-1(config-if-range)#hsr-ring 1
Creating a HSR-ring interface HSR-ring 1

Switch-1(config-if-range)#no shutdown
Switch-1(config-if-range)#exit
Switch-1(config)#exit
Switch-1#
Switch-2# conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch-2(config)#interface range gigabitEthernet 1/1-2
Switch-2(config-if-range)#shutdown
Switch-2(config-if-range)#hsr-ring 1
Creating a HSR-ring interface HSR-ring 1

Switch-2(config-if-range)#no shutdown
Switch-2(config-if-range)#exit
Switch-2(config)#exit
Switch-2#
Switch-3# conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch-3(config)#interface range gigabitEthernet 1/1-2
Switch-3(config-if-range)#shutdown
Switch-3(config-if-range)#hsr-ring 1
Creating a HSR-ring interface HSR-ring 1

Switch-3(config-if-range)#no shutdown
Switch-3(config-if-range)#exit
Switch-3(config)#exit
Switch-3#
Switch-4# conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch-4(config)#interface range gigabitEthernet 1/1-2
Switch-4(config-if-range)#shutdown
Switch-4(config-if-range)#hsr-ring 1
Creating a HSR-ring interface HSR-ring 1

Switch-4(config-if-range)#no shutdown
Switch-4(config-if-range)#exit
Switch-4(config)#exit
Switch-4#
Switch-1# show hsr ring 1 detail
HSR-ring: HS1

Layer type = L2
Operation Mode = mode-H
Ports: 2 Maxports = 2
Port state = hsr-ring is In use
Protocol = Enabled Redbox Mode = hsr-san
Ports in the ring:
 1) Port: Gi1/1
 Logical slot/port = 1/1 Port state = In use
 Protocol = Enabled
 2) Port: Gi1/2
 Logical slot/port = 1/2 Port state = In use
 Protocol = Enabled

Ring Parameters:
Redbox MacAddr: 9433.d845.2a81
Node Forget Time: 60000 ms

```

```

Node Reboot Interval: 500 ms
Entry Forget Time: 400 ms
Proxy Node Forget Time: 60000 ms
Supervision Frame COS option: 0
Supervision Frame CFI option: 0
Supervision Frame VLAN Tag option: Disabled
Supervision Frame MacDa: 0x00
Supervision Frame VLAN id: 0
Supervision Frame Time: 3 ms
Life Check Interval: 1600 ms
Pause Time: 25 ms
fpgamode-DualUplinkEnhancement: Enabled

```

## HSR-HSR QuadBox

### HSR-HSR QuadBox

High-availability Seamless Redundancy (HSR)-HSR QuadBox is a quadruple port specialized device used to interconnect two independent HSR networks. This network redundancy feature:

- provides enhanced protection against a failure on one QuadBox device,
- utilizes four specific ports to bridge traffic between two HSR domains for seamless failover, and
- ensures continuous network operation with minimal packet loss even during link or node failures.

The HSR-HSR QuadBox mode is a specialized configuration that enables the system to interconnect two independent HSR rings. This functionality explicitly supports HSR port assignments across both base and expansion modules, overriding general HSR limitations that typically restrict a system to a single HSR ring or HSR ports to base modules only.

The QuadBox connects multiple HSR rings by linking two rings through four dedicated ports without causing any learning or forwarding delays. It is designed for industrial networks that demand zero downtime, high fault tolerance, and reliability. The HSR-HSR QuadBox mode is a specialized switch configuration with fixed port assignments that vary based on the module type, ensuring seamless and efficient bridging of the two HSR rings.



**Note** The interface assignment for HSR-HSR QuadBox is fixed and cannot be changed.

**Table 7: Interface assignment for HSR-HSR QuadBox**

| Port Pair        | Module                            | Ring 1 ports   | Ring 2 ports     |
|------------------|-----------------------------------|----------------|------------------|
| Copper           | Base Module                       | Gig1/4, Gig1/5 | Gig1/6, Gig1/7   |
| Mixed (SFP + Cu) | Base Module                       | Gig1/1, Gig1/2 | Gig1/6, Gig1/7   |
| SFP              | Base + 8P SFP Expansion Module    | Gig1/1, Gig1/2 | Gig2/1, Gig2/2   |
|                  | Base + 8P Mixed Expansion Module  | Gig1/1, Gig1/2 | Gig2/7, Gig2/8   |
|                  | Base + 16P Mixed Expansion Module | Gig1/1, Gig1/2 | Gig2/15, Gig2/16 |

The port pair option is chosen via CLI and in case of SFP, based on the expansion module attached too.

## Guidelines and limitations for configuring HSR-HSR QuadBox

### Activation, configuration, and management limitations and restrictions

- Activate a new FPGA profile and reload the box to enable HSR QuadBox.
- The feature is available in Network Essentials license.
- When you enable HSR-HSR QuadBox mode, only the four HSR-HSR ports stay active. All other ports shut down, and their features stop working. You receive a warning for this mode change.
- You can manage the switch through interfaces such as the device manager, CLI, or SNMP, using an in-band Switched Virtual Interface (SVI) over the HSR Ring, but expect a temporary loss of connection when you enable or disable QuadBox mode.

So, we strongly recommend you to use a console connection when switching into or out of HSR-HSR mode.

- Disabling HSR-HSR mode resets all physical interfaces to their default configuration and erases settings on non-QuadBox ports.
- Set the same native VLAN on both QuadBox rings and all connected ports.

### Functional limitations and restrictions

- QuadBox disables MAC address learning.
- When the topology has more than one QuadBox, the VLAN and multicast filter configuration must match on all the QuadBoxes and both the HSR rings.
- HSR-HSR mode restricts switchport access.
- HSR-HSR mode sets MTU to 2020 and you cannot change it.
- QuadBox disables PTP.
- HSR-HSR FPGA profile does not support show and clear commands for Node and VDAN tables, HSR ring proxyNodeTableForgetTime, HSR ring nodeforgetTime, or creation of independent HSR ring interfaces.
- Multicast filters drop only multicast MAC addresses. They do not drop unicast MAC addresses

## HSR-HSR QuadBox workflow

### Summary

A HSR QuadBox, or quadruple port device, connects two HSR rings to each other. Two of these ports connect to the first ring, and the other two connect to the second ring, while any other ports on the device remain inactive.

To segregate traffic between the two rings, you can configure the QuadBox with VLAN and multicast filters. This allows you to restrict the specified VLAN and multicast groups from crossing the rings. VLAN filtering uses the VLAN allowed list to restrict VLANs. Multicast filtering matches packets with the same MAC

destination address (MACDA) and optional mask as configured in the filters. If there is a match, the packets are dropped.

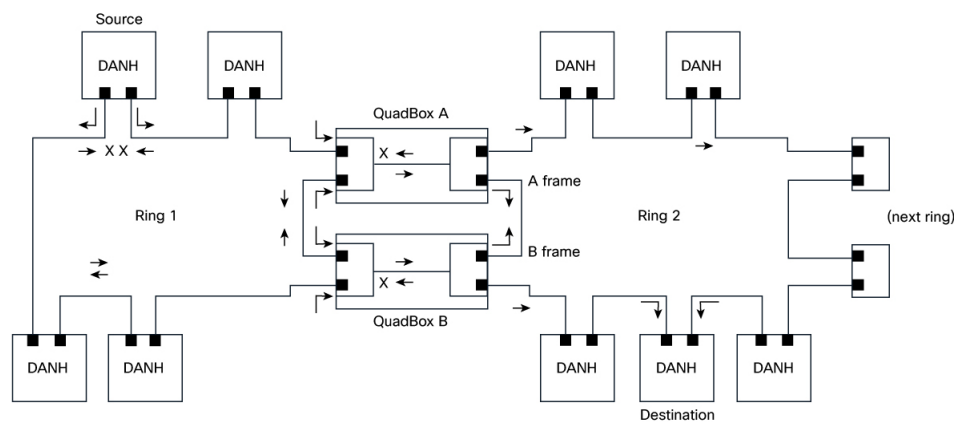
A QuadBox manages duplicate information. If two QuadBoxes are on the same ring and both try to send the same data from the first ring to the second, the system prevents it. If a QuadBox receives a piece of information that it has already sent, or the another QuadBox on the same ring has already sent, it recognizes the duplicate and do not forward it further. This prevents four copies to be circulated on the second ring.

The key components involved in the process are:

- Doubly Attached Node for HSR (DANH) source node: Duplicates each outgoing frame and injects the copies into the ring in opposite directions.
- Ring 1: Redundant path that carries the two counter-rotating frame copies and continues service even when a link is broken.
- QuadBox A: Interconnect device that receives frames from Ring 1 and forwards a copy to Ring 2 or vice versa.
- QuadBox B: Interconnect device that receives frames from Ring 1 and forwards a copy to Ring 2 or vice versa.
- Ring 2: Second redundant ring that transports both frame copies (labeled as A frame and B Frame as per HSR-HSR QuadBox workflow figure) toward destination nodes and onward to the next ring if present.
- DANH destination node: Accepts the first-arriving frame and discards the duplicate to avoid loops and duplicates.
- Next ring: Downstream ring link that can receive forwarded traffic for extended topologies.

## Workflow

Figure 2: HSR-HSR QuadBox workflow



The process involves these stages:

1. The DANH source node sends a data frame and immediately creates two copies, injecting those copies into Ring 1 in opposite directions.
2. The two frame copies propagate around Ring 1. If a link is broken (as indicated by the cross marks), the intact path still carries the frames to the interconnects.

3. QuadBox A receives the Ring 1 frame traveling in one direction (clockwise) and forwards a copy to Ring 2, preserving redundancy.
4. QuadBox B receives the Ring 1 frame traveling in the opposite direction (counter-clockwise) and forwards a copy to Ring 2, ensuring both directions of Ring 2 carry the duplicated frames.
5. On Ring 2, the A frame and B frame travel in opposite directions, so that all attached DANH nodes can receive at least one copy.
6. The DANH destination node takes the first-arriving frame, processes it, and discards the second copy to prevent duplicate delivery.
7. If the topology includes a downstream link, Ring 2 forwards traffic toward the next ring to extend connectivity.

### Result

The switch provides seamless interconnection between two HSR rings, ensuring redundancy and network resilience in industrial environments.

## Enable HSR-HSR QuadBox mode

You can activate HSR-HSR QuadBox mode to bridge two HSR rings using four dedicated ports on an IE3505 or IE3505H switch.

Use this task when you need to interconnect two HSR rings for redundancy.

### Procedure

- Step 1** Use the **fpga-profile activate hsr-quadbox** command to activate FPGA profile for QuadBox.

**Example:**

```
Switch# fpga-profile activate hsr-quadbox
```

Use the **reload** command to reload the device to apply the new profile.

- Step 2** Use the **configure terminal** command to enter configuration mode.

**Example:**

```
Switch# configure terminal
```

- Step 3** Use the **hsr-hsr-mode enable pair [copper | sfp | mixed]** command to enable HSR-HSR QuadBox based on the port pair option mentioned in the *Interface configuration for HSR-HSR QuadBox* table.

**Example:**

```
Switch(config)# hsr-hsr-mode enable pair sfp
PLEASE READ THE FOLLOWING INFORMATION ABOUT THE HSR-HSR MODE:
```

By enabling this mode, Ethernet ports that are not part of the feature will no longer be operational.

When operating in this mode note the following:

1. When this mode is configured and enabled, all other ports apart from the mode ports, will be shut down. Any feature running on these Ethernet ports will no longer function.

2. The only means to manage the Switch will be available through the Serial Console.
3. IP management of the Switch will be restored once "inband access via HTTP/HTTPS" is configured and Device Manager will not be accessible until inband IP management is operational.
4. Make sure Native VLAN is same on both the Quadboxes.
5. Make sure Vlan allowed list configuration and Multicast filters configured are same on both quadboxes
6. The CLI switchport mode access will be disabled when quadbox is enabled
7. Switchport access mode will be disabled when HSR-HSR is configured.
8. MTU size is restricted to 2020.

```
ACCEPT? (yes/[no]): yes
Creating a HSR-ring interface HSR-ring 1
```

```
Creating a HSR-ring interface HSR-ring 2
```

```
Interface GigabitEthernet1/1 set to default configuration
Interface GigabitEthernet1/2 set to default configuration
Interface GigabitEthernet1/3 set to default configuration
Interface GigabitEthernet1/8 set to default configuration
Interface GigabitEthernet1/9 set to default configuration
```

Confirm acceptance of the mode change and acknowledge the warning about port shutdown and management changes.

**Table 8: Syntax description**

| Keyword       | Description                                                                 |
|---------------|-----------------------------------------------------------------------------|
| <b>copper</b> | Configures both HSR rings to use built-in copper ports.                     |
| <b>sfp</b>    | Configures both HSR rings to use SFP ports.                                 |
| <b>mixed</b>  | Configures one HSR ring to use SFP ports and the other to use copper ports. |

Refer to *Interface assignment for HSR-HSR QuadBox* table for additional ports information.

**Step 4** (Optional) Use the **hsr-ring ring\_number multicast-filter deny group multicast\_group\_number\_with\_mask [multicast\_group\_number\_without\_mask] address multicast address [mask multicast\_address\_mask]** command to configure multicast filtering for the QuadBox.

**Example:**

```
Switch(config)# hsr-ring 1 multicast_filter_deny_group 1 0000.0100.0a00 ffff.ffff.ffff
Switch(config)# hsr-ring 2 multicast_filter_deny_group 5 0000.0100.0b00
```

Table 9: Syntax description

| Keyword                                    | Description                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>multicast_group_number_with_mask</i>    | The multicast group number configured with a mask. Configure the 48-bit multicast address and mask. The MAC destination address (MACDA) of a frame is matched with the configured 48-bit match-pattern up to the number of bits configured in the 48-bit mask. Once a match is found between the frame's MACDA and the mask/match-pattern setting, the frame is dropped and not forwarded from the QuadBox. It ranges from 1 to 4. |
| <i>multicast_group_number_without_mask</i> | The multicast group number configured without a mask. These 256 filters allow you to specify a single group that can be blocked. Because there is no mask, each filter can block only one multicast group. Any packets with a MACDA matching the configured MAC addresses are then dropped by the QuadBox. It ranges from 5 to 260.                                                                                                |
| <i>multicast_address_mask</i>              | The 48-bit MAC destination address written as a dotted triple of four-digit hexadecimal numbers. The ones bits in the mask are the bits to be ignored in the MAC Address.                                                                                                                                                                                                                                                          |

**Step 5** (Optional) Perform these steps to configure VLAN filtering for HSR ring interface 1 or 2.

- a) Use the **interface hsr-ringring\_number** command to configure the interface for HSR ring.

**Example:**

```
Switch(config)# interface hsr-ring 1
```

- b) Use the **switchport mode trunk allowed vlan vlan\_num** command to configure the switch mode.

**Example:**

```
Switch(config-if)# switchport mode trunk allowed vlan 1
```

The allowed *vlan\_num* value on the HSR ring ranges from 1 to 4096. All other VLANs are dropped.

- c) Use the **exit** command to exit from the configuration mode.

**Example:**

```
Switch(config-if)# exit
```

**Step 6** Use the **show hsr ring [multicast-filter | allowed-vlan | vlan-filter-drop-count | multicast-filter-drop]** command to monitor the information.

**Example:**

```
Switch# show hsr ring multicast-filter
 HSR-ring listing:

HSR-ring: HS1

Filter No. Address Mask
=====
2 0000.0100.0a00 ffff.ffff.ffff

HSR-ring: HS2

Filter No. Address Mask
```

```

=====
5 0000.0100.0b00 0000.0000.0000
Switch#

Switch# show hsr ring allowed-vlan
 HSR-ring listing:

HSR-ring: HS1

Vlan allowed list

0-4094

HSR-ring: HS2

Vlan allowed list

0-4094

Switch# show hsr ring vlan-filter-drop-count
 HSR-ring listing:

HSR-ring: HS1

VLAN filter drop count : 0
 HSR-ring: HS2

VLAN filter drop count : 0

Switch# show hsr ring multicast-filter-drop
 HSR-ring listing:

HSR-ring: HS1

Multicast filter drop count: 0
HSR-ring: HS2

Multicast filter drop count: 0

Switch# show hsr ring detail
 HSR-ring listing:

HSR-ring: HS1

Layer type = L2
Operation Mode = mode-H
Ports: 2 Maxports = 2
Port state = hsr-ring is In use
Protocol = Enabled Redbox Mode = hsr-hsr
Ports in the ring:
 1) Port: Gi1/1
 Logical slot/port = 1/1 Port state = In use
Protocol = Enabled
 2) Port: Gi1/2
 Logical slot/port = 1/2 Port state = In use
Protocol = Enabled

Ring Parameters:
Redbox MacAddr: 9433.d845.5002
Node Forget Time: 60000 ms
Node Reboot Interval: 500 ms
Entry Forget Time: 400 ms
Proxy Node Forget Time: 60000 ms
Supervision Frame COS option: 0
Supervision Frame CFI option: 0
Supervision Frame VLAN Tag option: Disabled

```

```

Supervision Frame MacDa: 0x00
Supervision Frame VLAN id: 0
Supervision Frame Time: 3 ms
Life Check Interval: 1600 ms
Pause Time: 25 ms
fpgamode-DualUplinkEnhancement: Enabled

HSR-ring: HS2

Layer type = L2
Operation Mode = mode-H
Ports: 2 Maxports = 2
Port state = hsr-ring is In use
Protocol = Enabled Redbox Mode = hsr-hsr
Ports in the ring:
 1) Port: Gi2/7
 Logical slot/port = 1/19 Port state = In use
Protocol = Enabled
 2) Port: Gi2/8
 Logical slot/port = 1/20 Port state = In use
Protocol = Enabled

Ring Parameters:
Redbox MacAddr: 9433.d845.5013
Node Forget Time: 60000 ms
Node Reboot Interval: 500 ms
Entry Forget Time: 400 ms
Proxy Node Forget Time: 60000 ms
Supervision Frame COS option: 0
Supervision Frame CFI option: 0
Supervision Frame VLAN Tag option: Disabled
Supervision Frame MacDa: 0x00
Supervision Frame VLAN id: 0
Supervision Frame Time: 3 ms
Life Check Interval: 1600 ms
Pause Time: 25 ms
fpgamode-DualUplinkEnhancement: Enabled

```

## Feature History

**Table 10: Feature history**

| Feature Name    | Releases            | Description                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| HSR-HSR QuadBox | Cisco IOS XE 26.1.1 | This feature enables you to interconnect two distinct High-availability Seamless Redundancy (HSR) rings, providing continuous, fault-tolerant communication between them. This capability is crucial in industrial and critical infrastructure environments where zero packet loss and high network availability are paramount. It allows for robust network segmentation and enhanced resilience on IE3505 and IE3505H platforms. |

