MEAPS Configuration

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Chapter 1 MEAPS Introduction

1.1 MEAPS Overview

EAPS is a protocol specially applied on the link layer of the Ethernet ring. When the Ethernet ring is complete, you should prevent the broadcast storm from occurring on the data loopback. But when a link of an Ethernet ring is broken, you should enable the backup link rapidly to resume the communication of different nodes in the ring. The role of switch is specified by you through configuration.

MEAPS, an expansion on the basis of EAPS, can support not only the single ring but also the level-2 multi-ring structure. The later structure consists of the aggregation layer in the middle, constructed by aggregation equipment through the Ethernet ring for fast switching, and the access layer at the outside, connected by the access equipment. Different levels of rings are connected through the tangency or intersection mode. See the specific topology in the following figure:
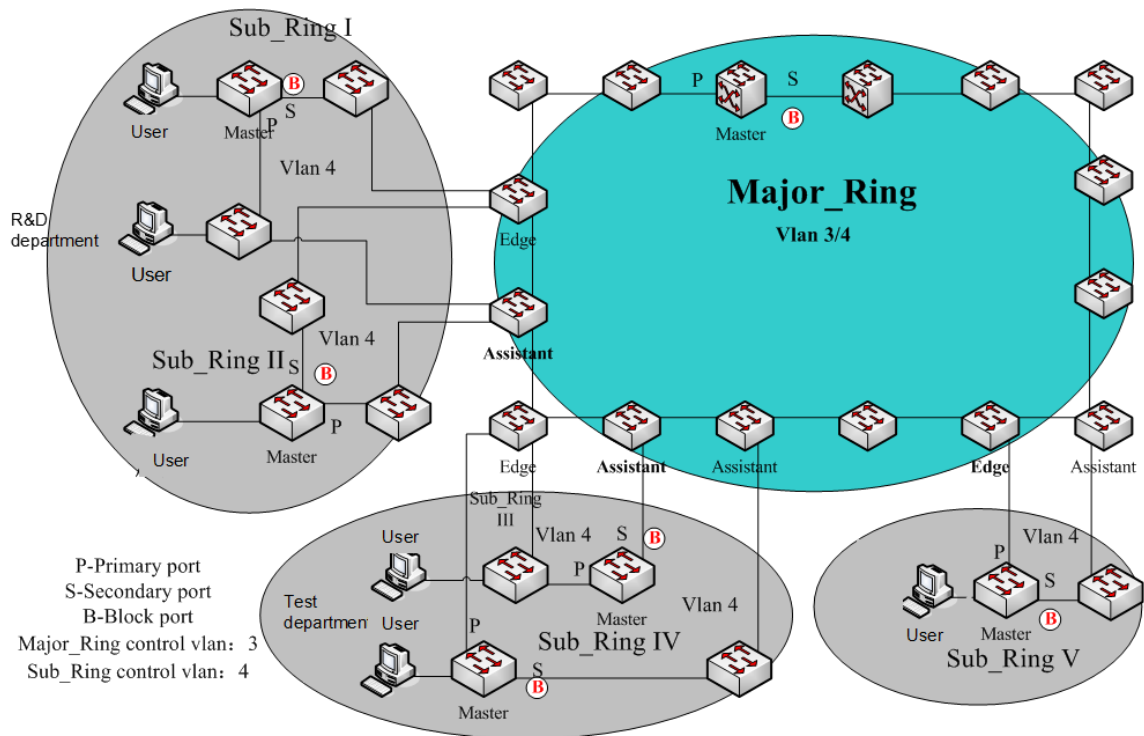
Figure 1 MEAPS Structure

The ring protection protocol and STP are both used for topology control on the link layer. STP is suitable for all kinds of complicated networks, which transmits the change of network topology hop by hop. The ring protection protocol is used for ring topology and adopts the pervasion mechanism to transmit the change of network topology. Therefore, the convergence of the ring protection protocol in the ring network is better than STP. In a sound network, the ring protection protocol can resume network communication within less than 50ms.

1.2 Basic Concepts of MEAPS

1.2.1 Domain

The domain specifies the protection range of the Ethernet loopback protection protocol and is marked by ID, which consists of integers; A group of switches that support the same protection data and have the same control VLAN can form a domain after they are connected with each other. One domain may include only one ring or multiple rings that intersect each other. See Figure-2.

One MEAPS domain has the following factors: MEAPS ring, control VLAN, master node, transit node, edge node and assistant edge node.

Figure-2 Simple MEAPS model

1.2.2 Ring

One ring corresponds to a ring Ethernet topology physically, which is a group of switches that are connected each other into a ring. One MEAPS domain may include only one MEAPS ring or multiple rings that intersect each other.
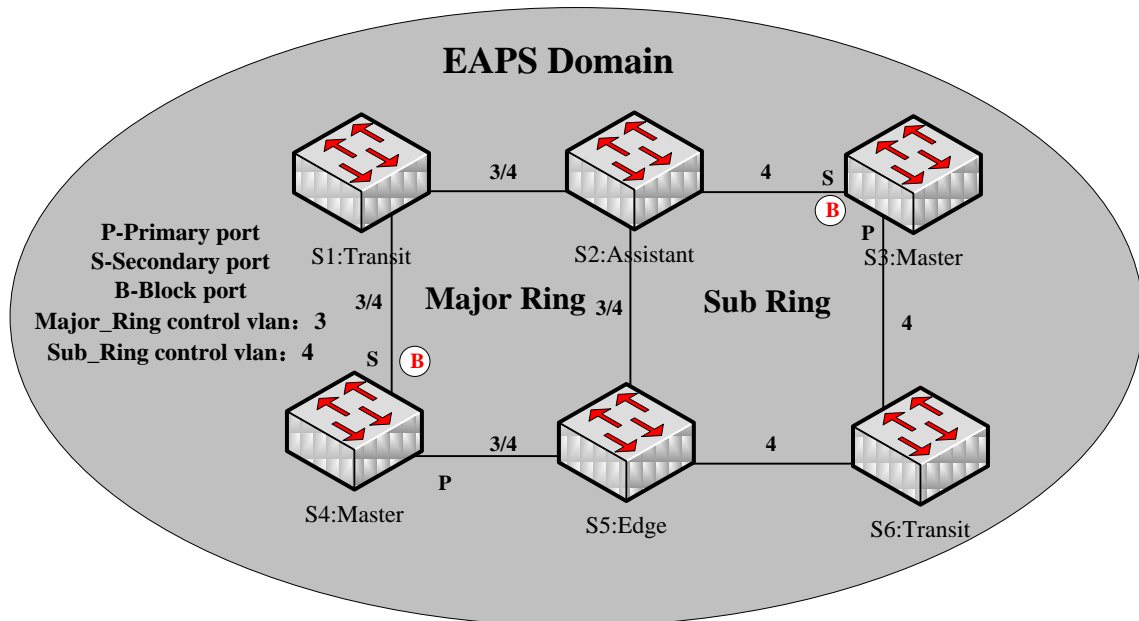
1.2.3 Major Ring

When a domain includes many rings, the included rings except the major ring are called as sub rings. The primary and secondary ports of each node on the major ring should be added into the main control VLAN and the sub control VLAN at the same time. See Figure-2.

1.2.4 Sub Ring

When a domain includes many rings, you should choose one ring from them as a major ring. The primary and secondary ports of each node on the sub ring should be added into the sub control VLAN. See Figure-2.

1.2.5 Control VLAN

The control VLAN is a concept against the data VLAN, and in MEAPS, the control VLAN is just used to transmit the MEAPS packets. Each MEAPS has two control VLANs, that is, the main control VLAN and the sub control VLAN.

You need to specify the main control VLAN when configuring the major ring or the sub ring. During configuration you just need to specify the main control VLAN and take the VLAN which is 1 more than the ID of the main control VLAN as the sub control VLAN. The major ring will be added to the main control VLAN and the sub control VLAN at the same time, while the sub ring will only be added to the sub control VLAN. See number 3 and number 4 beside each port on the following figure.

The main-ring protocol packets are transmitted in the main control VLAN, while the sub-ring protocol packets are transmitted in the sub control VLAN. The sub control VLAN on the major ring is the data VLAN of the major ring. The ports of a switch that access the Ethernet ring belong to the control VLAN, and only those ports that access the Ethernet ring can be added into the control VLAN.

Note:
The MEAPS port of the major ring should belong to both the main control VLAN and the sub control VLAN; the MEAPS port of the sub ring only belongs to the sub control VLAN. The major ring is regarded as a logical node of the sub ring and the packets of the sub ring are transparently transmitted through the major ring; the packets of the major ring are transmitted only in the major ring.

1.2.6   Data VLAN

Appearing against the control VLAN, the data VLAN is used to transmit data packets. The data VLAN can also include the MEAPS port and the non-MEAPS port. Each domain protects one or multiple data VLANs. The topology that is calculated by the ring protection protocol in a domain is effective only to the data VLAN in this domain.

Whether the data VLAN is created or not has no influence on the work of the ring state machine, where the MEAPS port is controlled by the MEAPS module and the non-MEAPS port is controlled by the STP module.

Note:
The processing methods which are similar to that of the MSTP module can be used, that is, the status of a port in the default STP instance is decided by the link status of the port, no matter what the VLAN configuration of a port is.

1.2.7   Master Node

The master node works as policy making and control of a ring. Each ring must possess only one master node. The master node takes active attitude to know whether the ring's topology is complete, removes loopback, control other switches to update topology information. See the following figure, where S3 is the master node of the sub ring and S4 is the master node of the major ring.

1.2.8   Transit Node

All switches on the Ethernet except the master node can be called as the transit nodes. The transit node only checks the state of the local port of the ring, and notifies the master node of the invalid link. See the following figure, in which S1, S2, S5 and S6 are all transit nodes.

1.2.9   Edge Node and Assistant Node

When the sub ring and the major ring are intersected, there are two intersection points, two switches beside which are called as the edge node for one and the assistant node for the other. The two nodes are both the nodes of the sub ring. There are no special requirements as to which switch will be set to be the edge node or the assistant node if their configurations can distinguish themselves. However, one of them must be set as the edge node and the other must be set as the assistant node. The edge node or the assistant node is a role that a switch takes on the sub ring, but the switch takes a role of the transit node or the master node when it is on the major ring. See the following figure, in which S2 is the assistant node and S5 is the edge node.

1.2.10   Primary Port and Secondary Port

The two ports through which the master node accesses the Ethernet ring are called as the primary port and the secondary port. The roles of the two ports are decided by the clients.

The primary port is in forwarding state when it is up. Its function is to forward the packets of the data VLAN on the master node and to receive and forward the control packets on the control VLAN. The master node will transmit the loopback detection packets from the primary port to the control VLAN. If the link of the primary port is resumed from the invalid status, the master node requires to send the address aging notification to the control VLAN promptly and then starts to transmit the loopback detection packets from the primary port.

The secondary port is in forwarding or blocking state when it is up. The master node receives the ring detection packets from the secondary port and judges whether the topology of the ring network is complete. In complete topology, the master node blocks the data packets on the secondary port, and prevents loopback from occurring; after a link on the ring network is interrupted, the master node will open the secondary port to forwarding the data packets.

Note:
A port can be set as the primary port or the secondary port of a node and it cannot be set to be both the primary port and the secondary port.

1.2.11   Transit Port

The two ports for the transit node to access the Ethernet ring are both transit ports. Users can decide the role of the two ports through configuration.

The transit port is in forwarding or preforwarding state when it is up. A transit port receives the control packets from the control VLAN and at the same time forwards these packets to other ports in the control VLAN. After the transit port resumes from the invalid state, it first enters the pre-forwarding state, receives and forwards only the control packets, and blocks the data VLAN. After the transit node receives the notification of the aging address table, it enters the forwarding state.

Note:
A port can be set as the primary port or the transit port of a node and it cannot be reset.

1.2.12   Common Port and Edge Port

The edge node and the assistant node are the places where the sub ring and the major ring intersect. As to the two ports that access the Ethernet, one is a common port, which is the public port of the sub ring and the major ring; the other is the edge port in the sub ring. The roles of the two ports are decided by users through configuration.

The common port is on the main-ring port and so its state is decided by the state of the main-ring port. The common port itself has no operations or notifications. When the link, connecting the common port, changes, the sub-ring node where the common port lies will not be notified. The existence of the common port just guarantees the completeness of the ring.

The edge port of the edge node is in forwarding or preforwarding state when it is up. Its basic characteristics are consistent with those of the transit port except one function. The exceptional function is that when the edge port is up and its corresponding main-ring port is also up, it will transmit the edge-hello packets from the main-ring port to detect the completeness of the major ring.

The edge port of the assistant node is in forwarding, preforwarding or EdgePreforwarding state when it is up. Besides the same characteristics of the transit port, it also has one more state, the Edge Preforwarding state. If the edge port is in forwarding state and the main-ring port that the edge port corresponds to has not received the edge-hello packets, the state of the edge port is changed into the EdgePreforwarding state, and it only receives and forwards the control packets and blocks the data VLAN until the corresponding main-ring port receives the Edge-hello packets again.

The edge port of the edge node and the assistant node is to help detect the completeness of the major ring. For more details, see the channel status checkup mechanism of the sub-ring protocol packets on the major ring in the following chapter.

Note:
Each port can be set as the only edge port of a node and it cannot be configured again; the common port can be borne only on a port of the major ring and it cannot be configured on a port without a corresponding main-ring port.

1.2.13   Aging of the MAC Address Table (FLUSH MAC FDB)

The Ethernet ring protection protocol can transmit data packets to the correct link by controlling the aging of the switch's MAC address table when the topology changes. In general, the time for a MAC address to age in the MAC address table is 300 seconds. The ring protection protocol can control the aging of the MAC address table in a short time.

1.2.14　Complete Flag of Ring

Both the master node and the transit node can show whether the current ring network is complete through the state symbol "COMPLETE". On the master node, only when all links of the ring network are normal, the primary port is in forwarding state and the secondary port is in blocking state can the "COMPLETE" symbol be real; on the transit node, only when its two transit ports are in forwarding state can the "COMPLETE" symbol be true. On the master node, only when all links of the ring network are normal, the primary port is in forwarding state and the secondary port is in blocking state can the "COMPLETE" symbol be real; on the transit node, only when its two transit ports are in forwarding state can the "COMPLETE" symbol be true.

The state symbol of the ring network helps user to judge the topology state of the current network.

1.3　Types of EAPS Packets

Table 1.1 Types of EAPS packets

Type of the packet	Description
Ring Detection (HEALTH)	It is transmitted by the master node to detect whether the topology of the ring network is complete.
link interruption (LINK-DOWN)	Indicates that link interruption happens in the ring. This kinds of packets are transmitted by the transit node.
MAC address aging table of the transit node (RING-DOWN-FLUSH-FDB)	It is transmitted by the master node after interruption of the ring network is detected and the packets show the MAC address aging table of the transit node.
Ring resume aging address table (RING-UP-FLUSH-FDB)	It is transmitted by the master node after interruption of the ring network is resumed and the packets show the MAC address aging table of the transit node.
Ring completeness detection (EDGE-HELLO)	It is decided by the edge port of the edge node, transmitted by the main-ring port that the edge node corresponds to, and detects whether the major ring is complete.

1.4　Fast Ethernet Ring Protection Mechanism

1.4.1　Polling mechanism

The primary port transmits the HEALTH packets to the control VLAN. In normal case, the HEALTH packets will pass through all other nodes of the ring and finally arrive at the secondary port of the master node.

The secondary port blocks all data VLANs in primitive condition. When receiving the HEALTH packets continuously, the secondary port keeps blocking data VLANs and blocking the loop. If the secondary port does not receive the HEALTH packets from the primary port in a certain time (which can be configured), it will regard the ring network is out of effect. Then the master node removes the blocking of data VLANs on the secondary port, ages the local MAC address table, and transmits the RING-DOWN-FLUSH-FDB packets to notify other nodes.

If the master node receives the HEALTH packets at the secondary port that is open to data VLANs, the ring network is resumed. In this case, the master node immediately blocks data VLANs on the secondary port, updates the local topology information and reports other nodes to age the MAC address table through RING-UP-FLUSH-FDB packets.

As shown in the following figure, the master node, S4, transmits the HELLO packets periodically. If the loopback has no troubles, the HELLO packets will arrive at the secondary port of the master node, and the master node will block data forwarding of the data VLAN that the secondary port belongs to, preventing the loopback from happening.
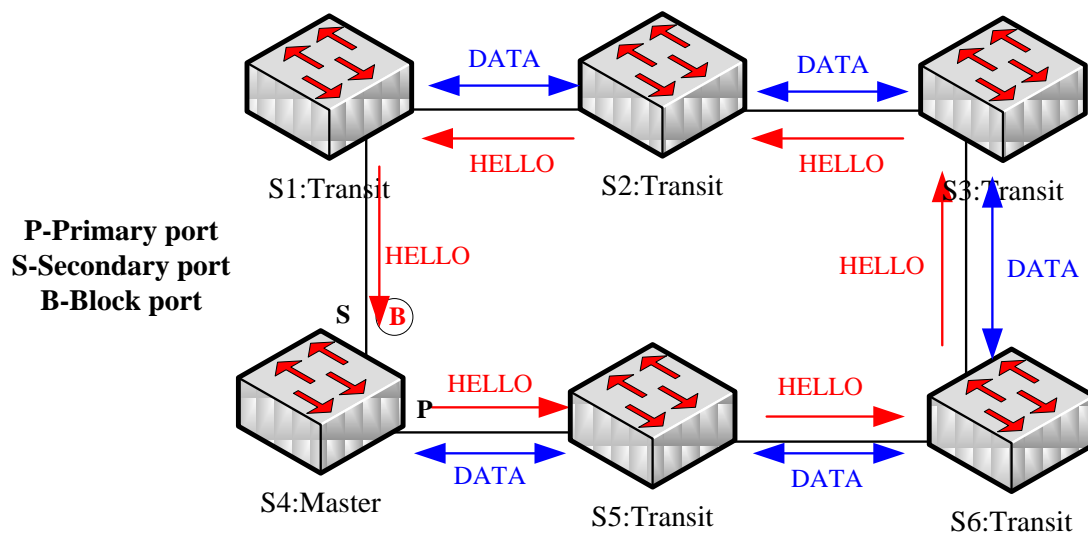

Figure 3 Polling mechanism

Note:
You can configure related commands on the Hello-time node and the Fail-time node to modify the interval for the primary port to transmit the HEALTH packets and the time limit for the secondary port to wait for the HEALTH packets.

1.4.2   Notification of Invalid Link of Transit Node

The link state change notification mechanism provides a faster processing mechanism for ring network topology changes than the polling mechanism:

After the transit port of the transit node is out of effect, the LINK-DOWN packet will be immediately transmitted by the other transit port to notify other nodes. In normal case, the packet passes through other transit nodes and finally arrives at one port of the master node.

After the master node receives the LINK-DOWN packet, it thinks that the ring network is invalid. In this case, the master node removes the blocking of data VLANs on its secondary port, ages the local MAC address table, transmits the RING-DOWN-FLUSH-FDB packet and notifies other nodes. As shown in the following figure, trouble occurs on the link between node S3 and node S6. After node S3 and node S6 detect that trouble has already occurred on the link, they block the ports that the troubled link corresponds to and transmit the LINK-DOWN packets respectively from the other port; when the master node receives the LINK-DOWN packets, holds that the trouble occurs on the loopback, and decides not to wait for the fail-time any more.
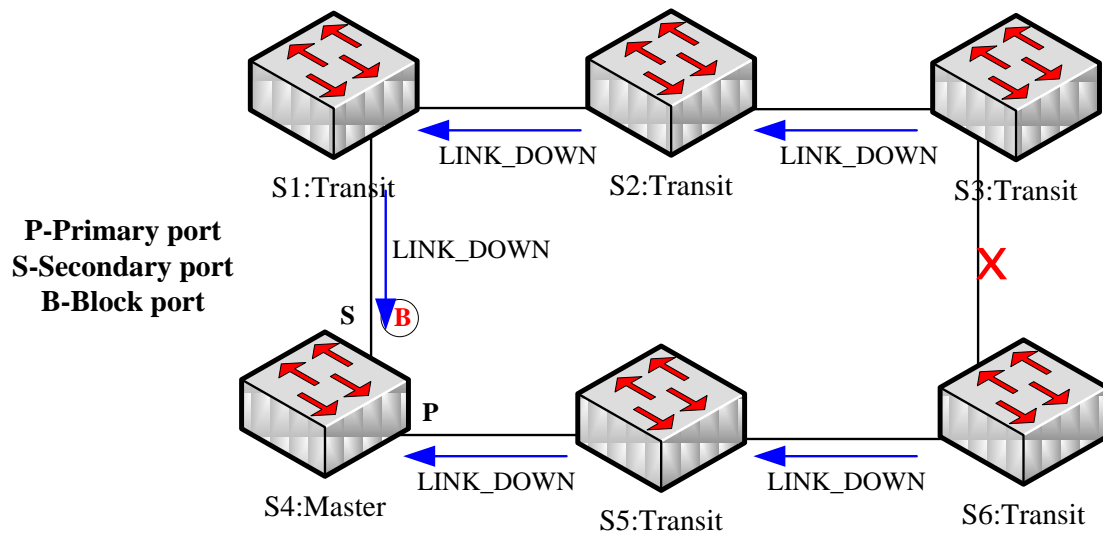
Figure 4 Link status change's notification

After the transit port is resumed, it does not immediately transmit the packets of data VLANs, but enters the Pre-Forwarding state. A transit port in pre-forwarding state only transmits and receives the control packets from the control VLAN.

If there is only one transit port invalid in the ring network and when the port enters the pre-forwarding state, the secondary port of the master node can receive the HEALTH packet from the primary port again. In this case, the master node blocks data VLANs on the secondary port again and transmits the notification of ageing

address table outside. After the node with a transit port in pre-forwarding state receives the notification of aging address table, the node will first modify the pre-forwarding port to the forwarding port and then ages the local MAC address table.

If a transit mode does not receives the notification of aging address table from the master node, it thinks that the link connecting the master node is already out of effect, and the transit node will automatically set the pre-forwarding port to be a forwarding one.

Note:
You can configure the related commands through the pre-forward-time node to modify the time for the transit port to keep the pre-forwarding state.

1.4.3   Channel Status Checkup Mechanism of the Sub-Ring Protocol Packet on the Major ring

The ports on the major ring are simultaneously added to the control VLAN of the major ring and the control VLAN of the sub ring. Hence, the protocol packets of the sub ring should be broadcast among the edge ports of the edge node and the assistant node through the channel, provided by the major ring. In this case, the whole major ring is just like a node of the sub ring (similar as a virtual transit node), as shown in the following figure:
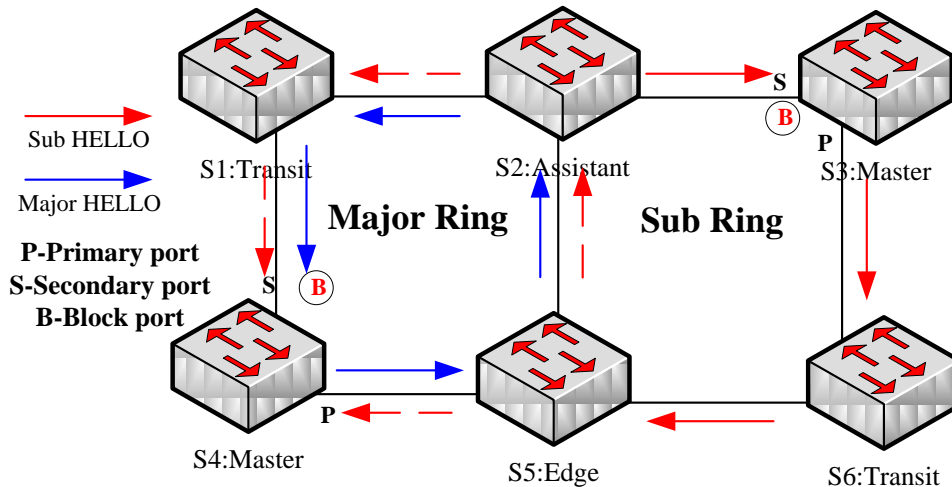
Figure 5 Intersection of the major ring and the sub ring

When trouble occurs on the link of the major ring, and when the channel of the sub-ring protocol packets between the edge node and the assistant node are interrupted, the master node of the sub ring cannot receive the HELLO packets that the master node itself transmits. In this case, the Fail Time times out, and the master node of the sub ring changes to the Failed state and opens its secondary port.

The above-mentioned processes have an effective protection towards general networking, guaranteeing not only the prevention of the broadcast loopback but also the corresponding functions of the backup link. The dual homing networking mode is always used in actual networking, as shown in the following figure. The two sub rings in the dual homing networking, sub ring I and sub ring II, interconnect through the edge node and assistant node, and forms a big ring. When the major ring has troubles, the secondary ports of the master nodes of all sub rings open and forms the broadcast loop (marked by the arrow) in the big ring.
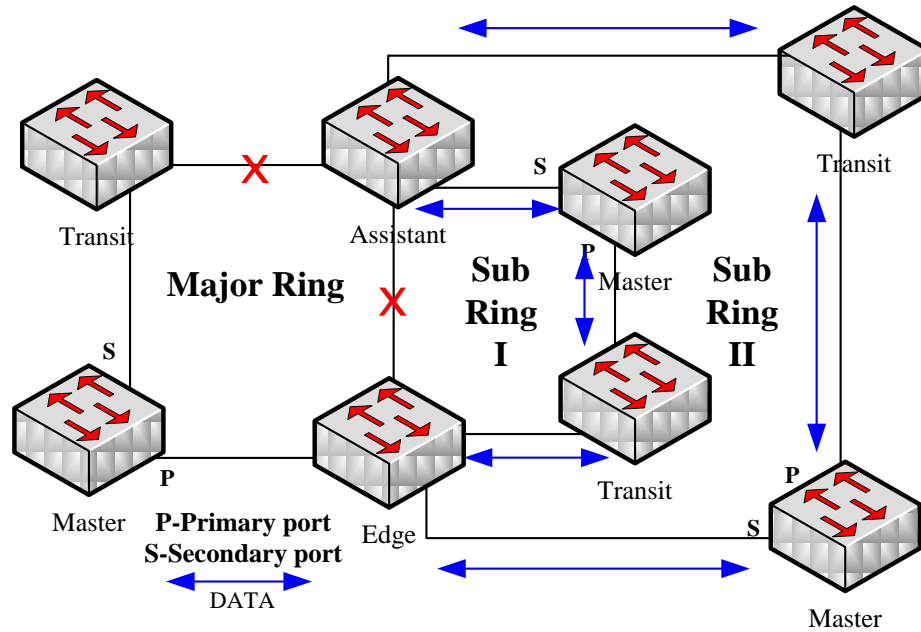

Figure 6 Broadcast storm triggered by the dual homing networking mode

The channel status checkup mechanism of the sub-ring protocol packet on the major ring is introduced to solve the problem about the dual homing ring. This mechanism is to monitor the status of the channel link on the major ring between the edge node and the assistant node, which requires the help of the edge node and the assistant node. The purpose of this mechanism is to keep the data loop from happening by blocking the edge port of the edge node before the secondary port of the master node on the sub ring opens. The edge node is the trigger of the mechanism, while the assistant node is the listener and decider of this mechanism. Once the notification message from the edge node cannot be received, the edge node will instantly be in blocked state until this notification message is received again. The results of the mechanism, which bring about after the troubles on the major ring, are shown in the following figure:
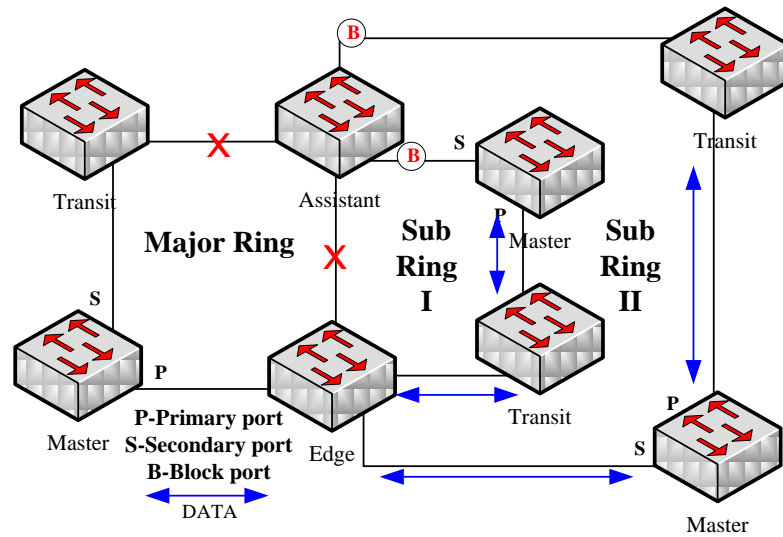
Figure 7 Results of the channel status checkup mechanism

But you should pay special attention to this point that the edge port of the assistant node must be blocked before the secondary port of the master node on the sub ring opens. Otherwise, the broadcast storm will happen.

The whole procedure of this mechanism is described as follows:

1. Check the channel status on the major ring between the edge node and the assistant node.

The edge node of the sub ring periodically transmits the Edge-Hello packets to the major ring through the two ports of the major ring, and these packets pass through all nodes on the major ring in sequence and finally arrive the assistant node, as shown in the following figure. If the assistant node can receive the edge-hello packet in the regulated time, it indicates that the channel of this packet is normal; if not, it indicates that the channel is interrupted. The edge-hello packet is the control packet of the sub ring, but is transmitted and received by the ports on the major ring and is transferred to the sub ring for processing.
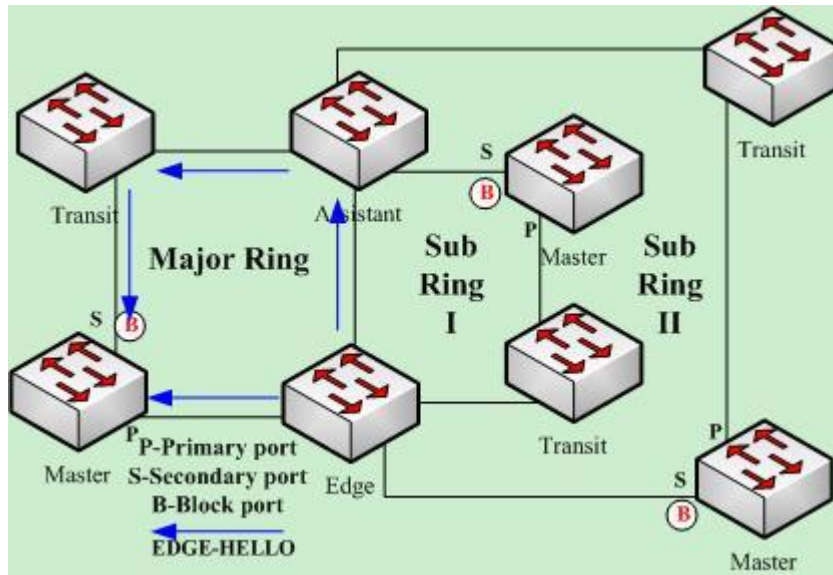
Figure 8 Checking the channel status on the major ring between the edge node and the assistant node

2. The edge node blocks the edge port at the interruption of the channel.

If the assistant node cannot receive the edge-hello packet during Edge Fail Time, the assistant holds that the channel of the sub-ring protocol packet - the edge-hello packet - is interrupted, changes its edge port's status into the Edge-Preforwarding status instantly, blocks the forwarding of the data packets (though still receives and forwards the control packet), and immediately transmits the LINK-DOWN packet to the master node for the master node to open the secondary port to avoid communication interruption among all nodes on the ring.

Note:
In order to guarantee that the edge port first changes into the edge-preforwarding status and then the master node opens the secondary port, you shall be sure that the cycle for the edge node to transmit the edge-hello packet, Edge Hello Time, is smaller than the cycle for the master node to transmit the Hello packet, Hello Time; similarly, the Edge Fail Time of the assistant node should be smaller than Fail Time. At the same time, Fail Time is generally the triple of Hello Time, and Edge Fail Time is also the triple of Edge Hello Time.
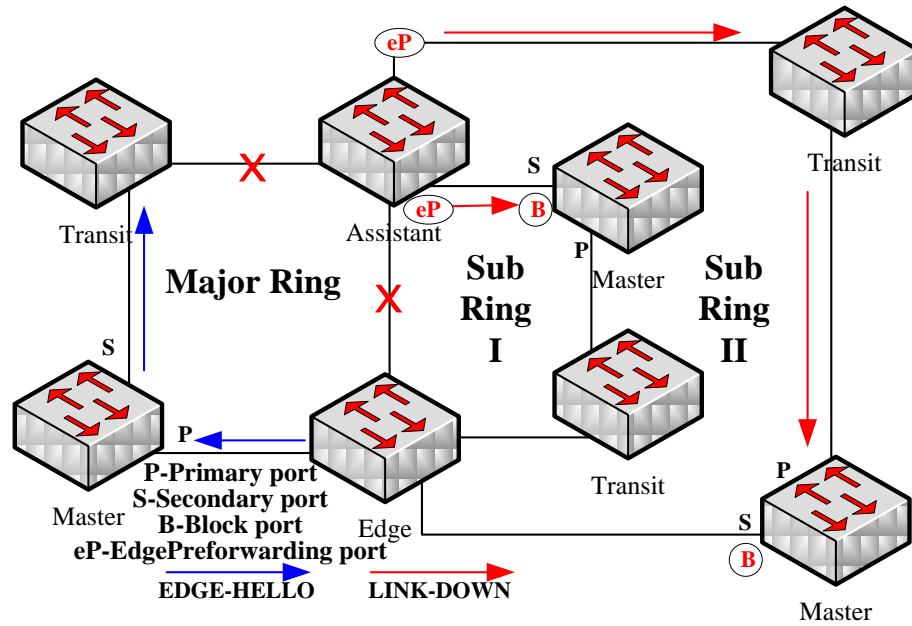
Figure 9 The edge port being blocked by the edge node at the interruption of the channel

3. Channel recovery

When the link of the major ring and the communication between the edge node and the assistant node resumes, the channel of the sub-ring protocol packet resumes to the normal function. In this case, the master node of the sub ring receives the Hello packet again, which is transmitted by the master node itself, and therefore it switches to the Complete status, blocks the secondary port and transmits the RING-UP-FLUSH-FDB packet to the ring. At the same time, the status of the edge port of the assistant node changes from Edge-Preforwarding to Forwarding, guaranteeing a smooth communication among all nodes on the ring. The following figure shows that the channel is resumed and then the communication on the ring is also resumed.

Note:
Before the edge node opens the blocked edge port, the secondary port of the master node on the sub ring should be blocked to prevent the broadcast storm from happening.

Figure 10 Channel recovery

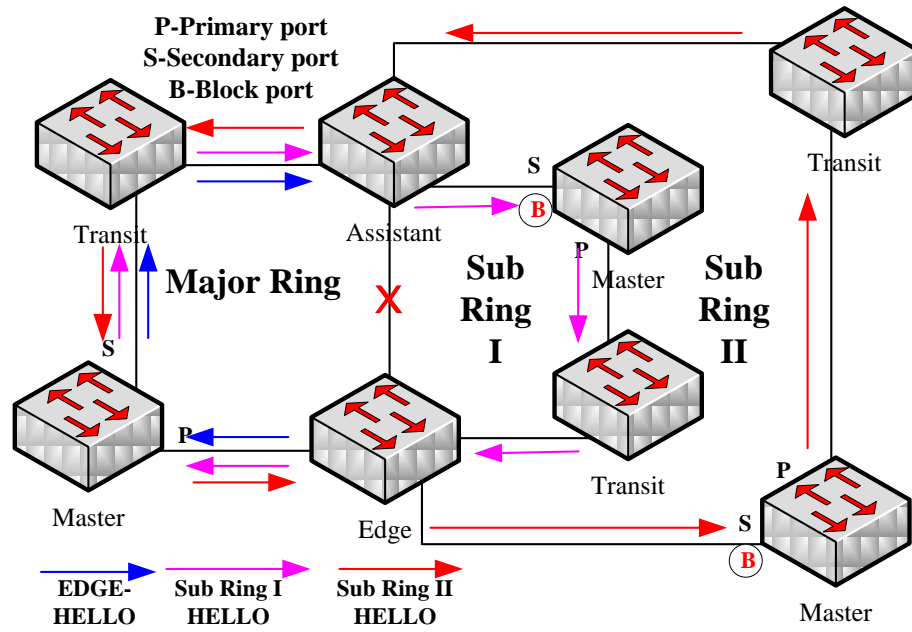# Chapter 2 Fast Ethernet Ring Protection Configuration

2.1   Requisites before Configuration

Before configuring MEAPS, please read the following items carefully:

- One of important functions of the ring protection protocol is to stop the broadcast storm, so please make sure that before the ring link is reconnected all ring nodes are configured. For example, when EAPS is configured, after the master node and all transit nodes are configured, connect the network cable and the secondary port of the master node; when configuring ERPS, please keep at least one link disconnected until all ring nodes are configured.

- Enable the ring protection protocol to be compatible with the STP of a switch through relative configurations. The users are allowed to set "no spanning-tree", SSTP, RSTP PVST or MSTP mode.

- After an instance of the ring's node is set, users are forbidden to change the basic information of the node (excluding the time parameters) unless the current ring's node is deleted and then reset.

- If you run show to browse the configured node and find its **state** is **init**, it shows that the node's configuration is unfinished and therefore the node cannot be started. In this case, you are required to change or add basic information to complete the configuration of the node.

- The ring protection protocol supports a switch to configure multiple ring networks.

- The configuration of the control VLAN of the ring automatically leads to the establishment of the corresponding VLAN without requiring users' manual configuration.

- The port of each ring can forward the packets from the control VLAN of the ring, while other ports, even in the Trunk mode, cannot forward the packets from the control VLAN.

- By default, Fail-time of the master node is triple longer than Hello-time, so that packet delay is avoided from shocking the ring protection protocol. After Hello-time is modified, Fail-time need be modified accordingly.

- By default, Pre-Forward-Time of the transit node is triple longer than Hello-time of the master node so that it is ensured that the master node can detect the recovery of the ring network before the transit port enters the pre-forwarding state. If Hello-time configured on the master node is longer than Fre-Forward-Time of the transit node, loopback is easily generated and broadcast storm is then triggered.

- Users cannot set Edge Hello Time and Edge Fail Time, and their default values are decided by Hello Time and Fail Time respectively for their values are 1/3 of Hello Time and Fail Time respectively.

- The physical interface, the fast-Ethernet interface, the gigabit-Ethernet interface and the aggregation interface can all be set to be the ring's interfaces. If link aggregation, 802.1X or port security has been already configured on a physical interface, the physical interface cannot be set to be a ring's interface any more.

- This protocol is similar with the original EAPS in functions, but its ring's topology has more expansibility and flexibility. Hence, MEAPS and EAPS are partially compatible, and the intersection configuration can be done on the MEAPS ring and the EAPS ring.

2.2   MEAPS Configuration Tasks

- Configuring the Master Node

- Configuring the Transit Node

- Configuring the Edge Node and the Assistant Node

- Configuring the Ring Port

- Browsing the State of the Ring Protection Protocol

2.3   Fast Ethernet Ring Protection Configuration

2.3.1   Configuring the Master Node

Configure a switch to be the master node of a ring network according to the following steps:

Command	Purpose
Switch#**config**	Enters the switch configuration mode.
Switch_config#**mether-ring** *id1* **domain** *id2*	Sets a node and enters the node configuration mode. id1: instance ID of a node id2: instance ID of a domain (omitted when it is 0)
Switch_config_ring1#**master-node**	Compulsory. Configures the node type to be a master node.
Switch_config_ring1#**major-ring[sub-ring]**	Compulsory. Sets the node's level to be one of the major or sub ring node.
Switch_config_ring1#**control-vlan** *vlan-id*	Compulsory. Sets the control VLAN and establishes VLAN "id" and VLAN "id+1".

	vlan-id: control vlan ID
Switch_config_ring1#**hello-time** value	Optional. Configures the cycle for the master node to transmit the HEALTH packets. Value: It is a time value ranging from 1 to 10 seconds and the default value is 3 seconds.
Switch_config_ring1#**fail-time** value	Optional. Configures the time for the secondary port to wait for the HEALTH packets. Value: It is a time value ranging from 3 to 30 seconds and the default value is 9 seconds.
Switch_config_ring1#**exit**	Saves the current settings and exits the node configuration mode.
Switch_config#	

Note:
The *no mether-ring id domain id2* command is used to delete the node settings and the node's port settings of the ring.

Note:
The major ring and the sub-ring must configure with the same vlan- the major ring control vlan. After configuration, the major ring control vlan and the sub-ring control vlan will be established on the major ring simultaneously. The sub-ring control vlan will be created on the sub-ring and forbid the major ring to control vlan.

2.3.2   Configuring the Transit Node

Configure a switch to be the transit node of a ring network according to the following steps:

Command	Purpose
Switch# config	Enters the switch configuration mode.
Switch_config#**mether-ring** id1 **domain** id2	Sets a node and enters the node configuration mode. id1: ID of the node; id2: instance ID of a domain (omitted when it is 0)
Switch_config_ring1# **transit -node**	Compulsory. Configures the node type to be a transit node.
Switch_config_ring1#**major-ring[sub-ring]**	Compulsory. Sets the node's level to be one of the major or sub ring node.

Switch_config_ring1#**control-vlan** *vlan-id*	Compulsory. Sets the control VLAN and establishes VLAN "id" and VLAN "id+1". *vlan-id:* control vlan ID
Switch_config_ring1#**pre-forward-time** *value*	Optional. Configures the time of maintaining the pre-forward state on the transit port. Value: It is a time value ranging from 3 to 30 seconds and the default value is 9 seconds.
Switch_config_ring#exit	Saves the current settings and exits the node configuration mode.
Switch_config#	

2.3.3   Configuring the Edge Node and the Assistant Node

Configure a switch to be the master node of a ring network according to the following steps:

Command	Purpose
Switch# **config**	Enters the switch configuration mode.
Switch_config#**mether-ring** *id1* **domain** *id2*	Sets a node and enters the node configuration mode. id1: instance ID of a node id2: instance ID of a domain (omitted when it is 0)
Switch_config_ring1#**edge-node[assistant-node]**	Compulsory. Sets the node type to be an edge node.
Switch_config_ring1#**sub-ring**	This step can be omitted. The edge node must be the sub-ring node.
Switch_config_ring1#**control-vlan** *vlan-id*	Compulsory. Sets the control VLAN and establishes VLAN "id" and VLAN "id+1" *vlan-id*: control vlan ID.
Switch_config_ring1#**pre-forward-time** *value*	Optional. Configures the time of maintaining the pre-forwarding state of the edge port. *Value:* It is a time value ranging from 3 to 30 seconds and the default value is 9 seconds.
Switch_config_ring1#**exit**	Saves the current settings and exits the node configuration mode.
Switch_config#	

2.3.4   Configuring Sub-ring Networking Mode

Configure a switch to be the master node of a ring network according to the following steps:

Command	Purpose
Switch# **config**	Enters the switch configuration mode.
Switch_config#**mether-ring** *id1* **domain** *id2*	Sets a node and enters the node configuration mode. id1: instance ID of a node id2: instance ID of a domain (omitted when it is 0)
Switch_config_ring1#**edge-node[assistant-node]**	Compulsory. Sets the node type to be an edge node.
Switch_config_ring1#**sub-ring**	This step can be omitted.The edge node must be the sub-ring node.
Switch_config_ring1#**control-vlan** *vlan-id*	Compulsory. Sets the control VLAN and establishes VLAN "id" and VLAN "id+1". *vlan-id*: control vlan ID
Switch _config_ring2#**single-subring-mode**	Compulsory. The ring configuration can be finished without configuring the command, but the sub-ring networking mode is not available. In the sub-ring networking mode, the sub-ring protocol packet channel detection mechanism cannot work on the major ring and there must no dual homing networking. The command is effective only for the edge node and the assistant node.
Switch_config_ring1#**pre-forward-time** *value*	Optional. Configures the time of maintaining the pre-forwarding state of the edge port. Value: It is a time value ranging from 3 to 30 seconds and the default value is 9 seconds.
Switch_config_ring1#**exit**	Saves the current settings and exits the node configuration mode.
Switch_config#	

2.3.5 Configuring the Ring Port

Configure a port of a switch to be the port of Ethernet ring according to the following steps:

Command	Purpose
Switch# config	Enters the switch configuration mode.
Switch_config#interface *intf-name*	Enters the interface configuration mode.
Switch_config_intf#mether-ring *id1* **domain** *id2* **primary-port [secondary-port	transit-port	common-port	edge-port]**	Configures the type of the port of Ethernet ring. id1: instance ID of a node id2: instance ID of a domain (omitted when it is 0)

Switch_config_intf#exit	Exits from interface configuration mode.

Note:
Run **no mether-ring** *id1* **domain** *id2* **primary-port [secondary-port | transit-port | common-port | edge-port]** to delete the ring port configuration.

2.3.6   Browsing the State of the Ring Protection Protocol

Run the following command to browse the state of the ring protection protocol:

Command	Purpose
show mether-ring	Browses the summary information about the ring protection protocol and the ports of ring.
show mether-ring *id1* **domain** *id2*	Browses the summary information about the designated ring protection protocol and the ports of ring. id1: instance ID of a node id2: instance ID of a domain (omitted when it is 0)
show mether-ring *id1* **domain** *id2* **detail**	Browses the detailed information about the designated ring protection protocol and the port of Ethernet ring.
show mether-ring *id1* **domain** *id2* **interface** *intf-name*	Browses the states of the designated ring ports or those of the designated common ports.

Chapter 3 Appendix

3.1 Working Procedure of MEAPS

MEAPS adopts three protection mechanisms to support the single-ring or level-2 multi-ring structure. The following sections shows, from the complete state to the link-down state, then to recovery and finally to the complete state again, the details of MEAPS running and the change of the MEAPS topology by typical examples.

3.1.1 Complete State

The complete state of the ring, which is advocated for only one ring, is monitored and maintained by the polling mechanism. In complete status, all links on the whole ring are in UP state, which finds expression in the state of the master node. In order to prevent the broadcast storm from occurring, the master node will block its secondary port. At the same time, the master node will periodically transmit the Hello packets from its primary port. These hello packets will pass through the transit node in sequence and finally return to the master node from its secondary port. The ring in complete state is shown in the following figure. The major ring and two sub rings are all in complete state. The hello packet of the major ring is only broadcast in the major ring, while the hello packet of the sub ring can be transparently transmitted through the major ring, then return to the sub ring, and finally get the secondary port of the master node on the sub ring.
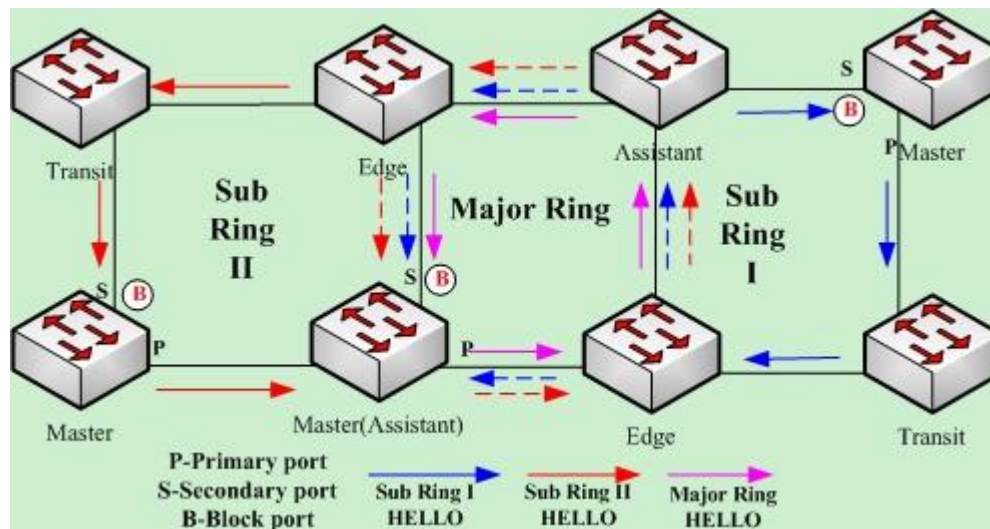

Figure 11 Complete state

3.1.2　Link-Down

　　　　The link-down state of the ring is decided by the polling mechanism, the notification of the link state change and the channel status checkup mechanism of the sub-ring protocol packet. Surely the link-down state of the ring is also advocated as to only one ring. When some link in the ring is in link-down state, the ring changes from the compete state to the troubled state, that is, the link-down state.

　　　　If link-down occurs on a link, the polling mechanism and the link status change notification mechanism will both function. The transit node, on which link-down occurs, will transmit the link-down packet to the master node through the Up port at its other side; at the same time, the polling mechanism will monitor and change promptly the state of the ring through Fail Time. When a trouble occurs on the sub-ring protocol channel, the trouble will be handled by the channel status checkup mechanism of the sub-ring protocol packet on the major ring. As shown in the following figure, the trouble notification message on the link of the major ring and on the common link is only transmitted on the major ring and finally transmitted to the master node; the trouble notification message on the link of sub ring 2 will be transmitted to the master node of the sub ring, which can be transparently transmitted through the major ring.
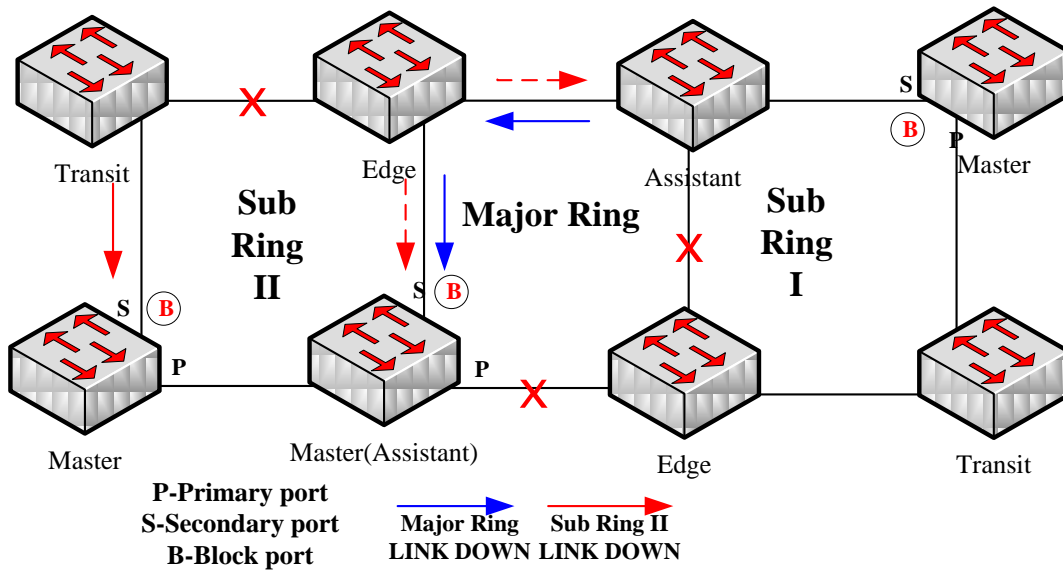

Figure 12 Ring transmitting the trouble and notifying the master node

　　　　After the master node receives the link-down packet, its state will be changed to the Failed state and at the same time the secondary port will be opened, the FDB table will be refreshed, and the RING-DOWN-FLUSH-FDB packets will be transmitted from two ports for notifying all nodes. As shown in the following figure, the master node on the major ring notifies the transit node on the major ring of refreshing FDB; sub ring 1 has troubles on its channel, so the edge port of the assistant node will be blocked; the master node of sub ring 2 notifies the transit nodes on the sub ring to refresh FDB and then the transparent transmission will be conducted on the major ring.
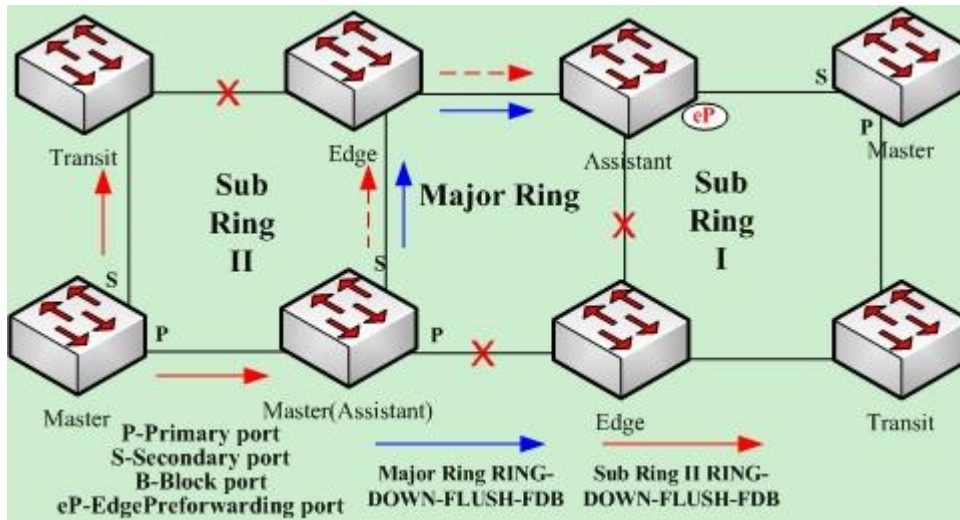
Figure 13 Ring transmitting troubles and refreshing FDB

3.1.3　Recovery

When the port on the transit node is recovered, the transit node will shift to its Preforwarding state. The processing procedure when the port of the transit node is recovered is shown in the following figure. The link of the major ring will recover, while the transit node, which connects the link of the major ring, changes into the Preforwarding state, blocks the data packets but allows the Hello packets of the control packet to pass through; similarly, the transit node on sub ring 2 also changes into the Preforwarding state; when the hello packet on sub ring 1 arrives the edge node, due to the fact that the resumed transit node only allows the control packet of the major to pass through and that the hell packet of sub ring 1 is just like the data packet of the major ring, the hello packet cannot be forwarded.
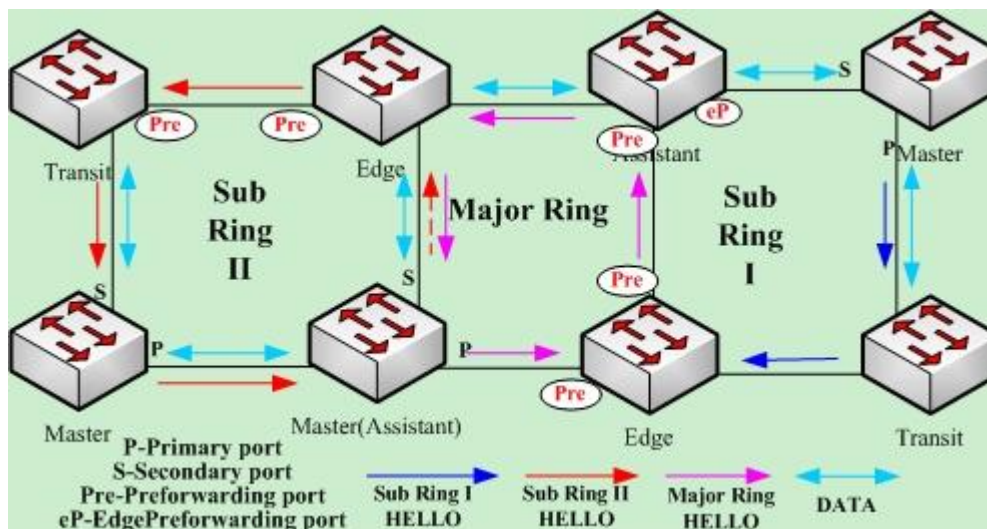
Figure 14 Recovery of the ring's link and the shift of the transit node to preforwarding

The transit port can transmit the control packet in preforwarding state, so the secondary port of the master node can receive the hello packet from the primary port. Hence, the master node shifts its state to Complete, blocks the secondary port and transmits the RING-UP-FLUSH-FDB packet from the primary port. After the transit node receives the RING-UP-FLUSH-FDB packet, the transit node will shift back to the Link-Up state, open the blocked port and refresh the FDB table. The procedure of ring recovery is shown in the following figure. The master node on the major ring changes into the complete state, blocks the secondary port, transmits the RING-UP-FLUSH-FDB packet to all transit nodes on the major ring and makes these transit nodes to shift back to their link-up state, to open the blocked port and to refresh the FDB table; similarly, the transit node and the master node on sub ring 2 also take on the corresponding change; due to the sub-ring protocol packet's channel recovery on sub ring 1, the secondary port of the master node can receive the hello packet from the primary port, and the master node shifts its state back to the complete state, blocks the secondary port, transmits the RING-UP-FLUSH-FDB packet and makes the assistant node open the edge port and sub ring 1 resume to its complete state.
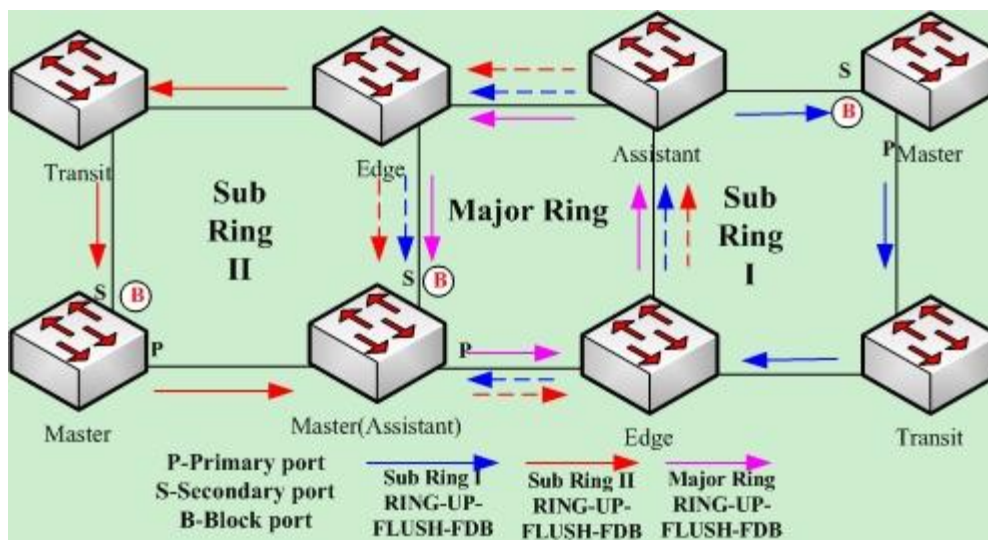

Figure 15 Recovery of the ring

Of course, if the transit node in Preforwarding state does not receive the RING-UP-FLUSH-FDB packet and Fail Time also exceeds, the transit node will open the blocked transit port and resume data communication.

3.2   MEAPS Configuration Examples
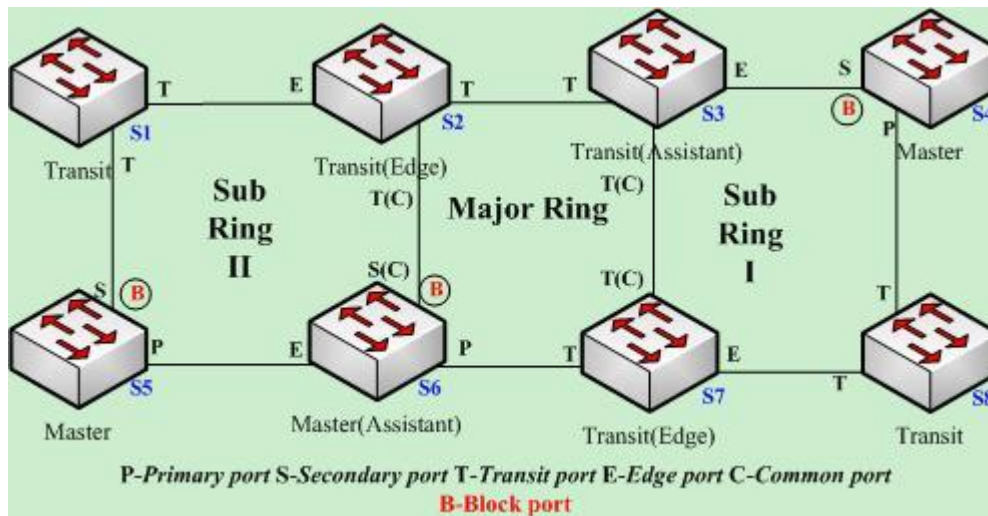
3.2.1   Configuration Examples

Figure 2.1 MEAPS Configuration Examples

As shown in figure 2.1, master node S1 and transit node S2 are configured as follows. As to the settings of other nodes, they are same to S2's settings.

Configuring switch S1:

The following commands are used to set the sub-ring transit node, node 2:

Switch_config#mether-ring 2 domain 1
Switch_config_ring2#transit-node
Switch_config_ring2#sub-ring
Switch_config_ring2#control-vlan 2

The following commands are used to set the time parameter:

Switch_config_ring2#pre-forward-time 12

Exits from the node configuration mode:

Switch_config_ring2#quit

The following commands are used to set the transit port of node 2:

Switch_config#interface gigaEthernet 0/1
Switch_config_g0/1#mether-ring 2 domain 1 transit-port
Switch_config_g0/1#switchport mode trunk

Switch_config_g0/1#quit

Switch_config#interface gigaEthernet 0/2

Switch_config_g0/2#mether-ring 2 domain 1 transit-port

Switch_config_g0/2#switchport mode trunk

Switch_config_g0/2#quit

Configuring switch S2:

The following commands are used to set the major-ring transit node, node 1:

Switch_config#mether-ring 1 domain 1

Switch_config_ring1#transit-node

Switch_config_ring1#major-ring

Switch_config_ring1#control-vlan 2

The following commands are used to set the time related parameters:

Switch_config_ring1#pre-forward-time 12

Exits from the node configuration mode:

Switch_config_ring1#quit

The following commands are used to set the transit port of node 1:

Switch_config#interface gigaEthernet 0/1

Switch_config_g0/1#mether-ring 1 domain 1 transit-port

Switch_config_g0/1#switchport mode trunk

Switch_config_g0/1#quit

Switch_config#interface gigaEthernet 0/2

Switch_config_g0/2#mether-ring 1 domain 1 transit-port

Switch_config_g0/2#switchport mode trunk

Switch_config_g0/2#quit

The following commands are used to set the sub-ring edge node, node 2:

Switch_config#mether-ring 2 domain 1

Switch_config_ring2#edge-node

Switch_config_ring2#sub-ring *(This step can be omitted.)*

Switch_config_ring2#control-vlan 2

The following commands are used to set the time related parameters:

Switch_config_ring2#pre-forward-time 12

Exits from the node configuration mode:

Switch_config_ring2#quit

The following commands are used to set the common port and edge port of node 2:

Switch_config#interface gigaEthernet 0/2

Switch_config_g0/2#mether-ring 2 domain 1 common-port

Switch_config_g0/2#quit

Switch_config#interface gigaEthernet 0/3

Switch_config_g0/3#mether-ring 2 domain 1 edge-port

Switch_config_g0/3#switchport mode trunk

Switch_config_g0/3#quit

Configuring switch S3:

The following commands are used to set the transit port of node 1:

Switch_config#mether-ring 1 domain 1

Switch_config_ring1#transit-node

Switch_config_ring1#major-ring

Switch_config_ring1#control-vlan 2

The following commands are used to set the time related parameters:

Switch_config_ring1#pre-forward-time 12

Exits from the node configuration mode:

Switch_config_ring1#quit

The following commands are used to set the transit port of node 1:

Switch_config#interface gigaEthernet 0/1

Switch_config_g0/1#mether-ring 1 domain 1 transit-port

Switch_config_g0/1#switchport mode trunk

Switch_config_g0/1#quit

Switch_config#interface gigaEthernet 0/2

Switch_config_g0/2#mether-ring 1 domain 1 transit-port

Switch_config_g0/2#switchport mode trunk

Switch_config_g0/2#quit

The following commands are used to set the sub-ring assistant node, node 4:

Switch_config#mether-ring 4 domain 1

Switch_config_ring4#assistant-node

Switch_config_ring4#sub-ring *(This step can be omitted.)*

Switch_config_ring4#control-vlan 2

The following commands are used to set the time related parameters:

Switch_config_ring4#pre-forward-time 12

Exits from the node configuration mode:

Switch_config_ring4#quit

The following commands are used to set the common port and edge port of node 2:

Switch_config#interface gigaEthernet 0/2

Switch_config_g0/2#mether-ring 4 domain 1 common-port

Switch_config_g0/2#quit
Switch_config#interface gigaEthernet 0/3
Switch_config_g0/3#mether-ring 4 domain 1 edge-port
Switch_config_g0/3#switchport mode trunk
Switch_config_g0/3#quit

Configuring switch S4:

The following commands are used to set the sub-ring master node, node 4:

Switch_config#mether-ring 4 domain 1
Switch_config_ring4#master-node
Switch_config_ring4#sub-ring
Switch_config_ring4#control-vlan 2

The following commands are used to set the time related parameters:

Switch_config_ring4#hello-time 4
Switch_config_ring4#fail-time 12

Exits from the node configuration mode:

Switch_config_ring4#quit

The following commands are used to set the primary port and secondary port of node 4:

Switch_config#interface gigaEthernet 0/1
Switch_config_g0/1#mether-ring 4 domain 1 primary-port
Switch_config_g0/1#switchport mode trunk
Switch_config_g0/1#quit
Switch_config#interface gigaEthernet 0/2
Switch_config_g0/2#mether-ring 4 domain 1 secondary-port
Switch_config_g0/2#switchport mode trunk
Switch_config_g0/2#quit

Configuring switch S5:

The following commands are used to set the sub-ring master node, node 2:

Switch_config#mether-ring 2 domain 1
Switch_config_ring2#master-node
Switch_config_ring2#sub-ring
Switch_config_ring2#control-vlan 2

The following commands are used to set the time related parameters:

Switch_config_ring2#hello-time 4
Switch_config_ring2#fail-time 12

Exits from the node configuration mode:

Switch_config_ring2#quit

The following commands are used to set the primary port and secondary port of node 2:

    Switch_config#interface gigaEthernet 0/1
    Switch_config_g0/1#mether-ring 2 domain 1 primary-port
    Switch_config_g0/1#switchport mode trunk
    Switch_config_g0/1#quit
    Switch_config#interface gigaEthernet 0/2
    Switch_config_g0/2#mether-ring 2 domain 1 secondary-port
    Switch_config_g0/2#switchport mode trunk
    Switch_config_g0/2#quit

Configuring switch S6:

The following commands are used to set the major-ring master node, node 1:

    Switch_config#mether-ring 1 domain 1
    Switch_config_ring1#master-node
    Switch_config_ring1#major-ring
    Switch_config_ring1#control-vlan 2

The following commands are used to set the time related parameters:

    Switch_config_ring1#hello-time 4
    Switch_config_ring1#fail-time 12

Exits from the node configuration mode:

    Switch_config_ring1#quit

The following commands are used to set the transit port of node 1:

    Switch_config#interface gigaEthernet 0/1
    Switch_config_g0/1#mether-ring 1 domain 1 primary-port
    Switch_config_g0/1#switchport mode trunk
    Switch_config_g0/1#quit
    Switch_config#interface gigaEthernet 0/2
    Switch_config_g0/2#mether-ring 1 domain 1 secondary-port
    Switch_config_g0/2#switchport mode trunk
    Switch_config_g0/2#quit

The following commands are used to set the sub-ring assistant node, node 2:

    Switch_config#mether-ring 2 domain 1
    Switch_config_ring2#assistant-node
    Switch_config_ring2#sub-ring *(This step can be omitted.)*
    Switch_config_ring2#control-vlan 2

The following commands are used to set the time related parameters:

    Switch_config_ring2#pre-forward-time 12

Exits from the node configuration mode:

Switch_config_ring2#quit

The following commands are used to set the common port and edge port of node 2:

Switch_config#interface gigaEthernet 0/2
Switch_config_g0/2#mether-ring 2 domain 1 common-port
Switch_config_g0/2#quit
Switch_config#interface gigaEthernet 0/3
Switch_config_g0/3#mether-ring 2 domain 1 edge-port
Switch_config_g0/3#switchport mode trunk
Switch_config_g0/3#quit

Configuring switch S7:

The following commands are used to set the major-ring transit node, node 1:

Switch_config#mether-ring 1 domain 1
Switch_config_ring1#transit-node
Switch_config_ring1#major-ring
Switch_config_ring1#control-vlan 2

The following commands are used to set the time related parameters:

Switch_config_ring1#pre-forward-time 12

Exits from the node configuration mode:

Switch_config_ring1#quit

The following commands are used to set the transit port of node 1:

Switch_config#interface gigaEthernet 0/1
Switch_config_g0/1#mether-ring 1 domain 1 transit-port
Switch_config_g0/1#switchport mode trunk
Switch_config_g0/1#quit
Switch_config#interface gigaEthernet 0/2
Switch_config_g0/2#mether-ring 1 domain 1 transit-port
Switch_config_g0/2#switchport mode trunk
Switch_config_g0/2#quit

The following commands are used to set the secondary port of node 4:

Switch_config#mether-ring 4 domain 1
Switch_config_ring4#edge-node
Switch_config_ring4#sub-ring *(This step can be omitted.)*
Switch_config_ring4#control-vlan 2

The following commands are used to set the time related parameters:

Switch_config_ring4#pre-forward-time 12

Exits from the node configuration mode:

Switch_config_ring4#quit

The following commands are used to set the common port and edge port of node 2:

Switch_config#interface gigaEthernet 0/2
Switch_config_g0/2#mether-ring 4 domain 1 common-port
Switch_config_g0/2#quit
Switch_config#interface gigaEthernet 0/3
Switch_config_g0/3#mether-ring 4 domain 1 edge-port
Switch_config_g0/3#switchport mode trunk
Switch_config_g0/3#quit

Configuring switch S8:

The following commands are used to set the sub-ring transit node, node 4:

Switch_config#mether-ring 4 domain 1
Switch_config_ring4# transit -node
Switch_config_ring4#sub-ring
Switch_config_ring4#control-vlan 2

The following commands are used to set the time related parameters:

Switch_config_ring4#pre-forward-time 12

Exits from the node configuration mode:

Switch_config_ring4#quit

The following commands are used to set the transit port of node 4:

Switch_config#interface gigaEthernet 0/1
Switch_config_g0/1#mether-ring 4 domain 1 transit -port
Switch_config_g0/1#switchport mode trunk
Switch_config_g0/1#quit
Switch_config#interface gigaEthernet 0/2
Switch_config_g0/2#mether-ring 4 domain 1 transit -port
Switch_config_g0/2#switchport mode trunk
Switch_config_g0/2#quit

3.3   Unfinished Configurations (to be continued)

- Unfinished basic information configuration: there is one of the ring's role, the ring's grade and the control VLAN unset. One exceptional case is that when a node's role has configured to be the edge node or assistant node, the default ring's grade is sub-ring.

● Contradiction of basic information: When a node's role is edge-node or assistant-node, the default ring's grade is sub-ring; when the ring's grade is major-ring, prompt information will appear.

● Sub ring having no corresponding major-ring node: When a node's role is edge-node or assistant-node, this node is borne on the major-ring node; if there is no corresponding major-ring node to compulsorily create the sub-ring edge node or sub-ring assistant node, prompt information will appear (in this case, you can use the show command to browse the MEAPS state; if you find the basic information is complete but the state is init, it indicates that the configuration of the ring's node has not finished).

● Conflicts arising during control VLAN configuration: If the control VLAN, which is configured by a node, conflicts with other configured nodes, prompt information will appear (in this case, you can use the show command to browse the MEAPS state; if you find the basic information is complete but the state is init, it indicates that the configuration of the ring's node has not finished).

● When configuring the sub-ring node according to the major ring node, the id of the sub-ring node must be greater than the ID of the major ring node. Otherwise, here pops up a prompt.