Chapter 11: STP

Contents

Chapter 11 STP

11.1 STP Overview

Spanning Tree Protocol (STP) is applied in loop network to block some undesirable redundantpaths with certain algorithms and prune the network into a loop-free tree, thereby avoiding theproliferation and infinite cycling of the packet in the loop network.

11.1.1   Protocol Packets of Spanning-Tree

STP uses bridge protocol data units (BPDUs), also known as configuration messages, as its protocol packets.

STP identifies the network topology by transmitting BPDUs between STP-compliant network devices. BPDUs contain sufficient information for the network devices to complete the spanning tree calculation.

In STP, BPDUs come in two types:

Configuration BPDUs, used for calculating spanning trees and Maintain the spanning treetopology. Topology change notification (TCN) BPDUs, used for notifying concerned devices of networktopology changes, if any.

11.1.1 Basic Concepts in Spanning-Tr

Root Bridge

A tree network must have a root; hence the concept of "root bridge" has been introduced in STP. There is one and only one root bridge in the entire network, and the root bridge can change alone with changes of the network topology. Therefore, the root bridge is not fixed.

Upon network convergence, the root bridge generates and sends out configuration BPDUs at a certain interval, and other devices just forward the BPDUs. This mechanism ensurestopological stability.

Root Port

On a non-root bridge device, the root port is the port nearest to the root bridge. The root port is responsible for communication with the root bridge. A non-root-bridge device has one and onlyone root port. The root bridge has no root port.

Designated Bridge

For a device, Designated Bridge is the device directly connected with this device and responsible for forwarding BPDUs; For a LAN, Designated Bridge is the device responsible forforwarding BPDUs to this LAN segment.

Designated Port

For a device, Designated Port is the port through which the designated bridge forwards BPDUs to this device; For a LAN, Designated Port is the port through which the designated bridge forwards BPDUs to this LAN segment.

Path cost

Path cost is a reference value used for link selection in STP. By calculating the path cost, STP

selects relatively "robust" links and blocks redundant links, and finally prunes the network into

loop-free tree structure.

11.1.2   Spanning-Tree Interface States

Each Layer 2 interface on a GPON using spanning tree exists in one of these states:

Disabled

The interface is not participating in spanning tree because of a shutdown port, no link on theport,

or no spanning-tree instance running on the port.

Blocking

The interface does not participate in frame forwarding.

Listening

The first transitional state after the blocking state when the spanning tree determines that theinterface

should participate in frame forwarding.

Learning

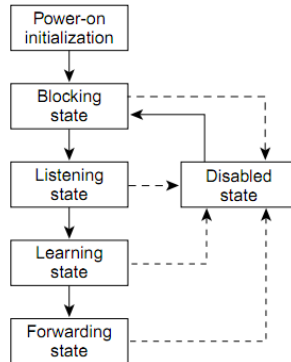The interface prepares to participate in frame forwarding.

Forwarding

The interface forwards frames.

An interface moves through these states:

• From initialization to blocking

• From blocking to listening or to disabled

• From listening to learning or to disabled

• From learning to forwarding or to disabled

• From forwarding to disabled

When you power up the GPON, spanning tree is enabled by default, and every interface in theGPON, VLAN, or network goes through the blocking state and the transitory states of listeningand learning. Spanning tree stabilizes each interface at the forwarding or blocking state.

When the spanning-tree algorithm places a Layer 2 interface in the forwarding state, this process occurs:

1) The interface is in the listening state while spanning tree waits for protocol information to transition the interface to the blocking state.

2) While spanning tree waits the forward-delay timer to expire, it moves the interface to the learning state and resets the forward-delay timer.

3) In the learning state, the interface continues to block frame forwarding as the GPON learns end-station location information for the forwarding database.

4) When the forward-delay timer expires, spanning tree moves the interface to the forwarding state, where both learning and frame forwarding are enabled.

11.2 How Spanning-Tree Works

Spanning-Tree identifies the network topology by transmitting configuration BPDUs between network devices. Configuration BPDUs contain sufficient information for network devices to complete the spanning tree calculation. Important fields in a configuration BPDU include: **Root bridge ID:** consisting of root bridge priority and MAC address.

Root path cost: the cost of the shortest path to the root bridge.

Designated bridge ID: designated bridge priority plus MAC address.

Designated port ID: designated port priority plus port name.

Message age: age of the configuration BPDU while it propagates in the network.

Max age: maximum age of the configuration BPDU maintained in the device.

Hello time: configuration BPDU interval.

Forward delay: forward delay of the port.

1) Specific calculation process of the STP algorithm

● Initial state

Upon initialization of a device, each port generates a BPDU with itself as the root bridge, in which the root path cost is 0, designated bridge ID is the device ID, and the designated port is the local port.

● Selection of the optimum configuration BPDU

Each device sends out its configuration BPDU and receives configuration BPDUs from other devices.

The process of selecting the optimum configuration BPDU is as follows:

Step	Description
1	Upon receiving a configuration BPDU on a port, the device performs the following processing: If the received configuration BPDU has a lower priority than that of the configuration BPDU generated by the port, the device will discard the received configuration BPDU without doing any processing on the configuration BPDU of this port. If the received configuration BPDU has a higher priority than that of the configuration BPDU generated by the port, the device will replace the content of the configuration BPDU generated by the port with the content of the received configuration BPDU.
2	The device compares the configuration BPDUs of all the ports and chooses the optimum configuration BPDU.

● Selection of the root bridge

At network initialization, each STP-compliant device on the network assumes itself to be the root bridge, with the root bridge ID being its own device ID. By exchanging configuration BPDUs, the devices compare one another's root bridge ID. The device with the smallest root bridge ID is elected as the root bridge.

● Selection of the root port and designated ports

The process of selecting the root port and designated ports is as follows:

Selection of the root port and designated ports

Step	Description
1	A non-root-ridge device regards the port on which it received the optimum configuration BPDU as the root port.

2	Based on the configuration BPDU and the path cost of the root port, the device calculates a designated port configuration BPDU for each of the rest ports.
	• The root bridge ID is replaced with that of the configuration BPDU of the root port.
	• The root path cost is replaced with that of the configuration BPDU of the root port plus the path cost corresponding to the root port.
	• The designated bridge ID is replaced with the ID of this device.
	• The designated port ID is replaced with the ID of this port.
3	The device compares the calculated configuration BPDU with the configuration BPDU on the port of which the port role is to be defined, and does different things according to the comparison result:
	• If the calculated configuration BPDU is superior, the device will consider this port as the designated port, and the configuration BPDU on the port will be replaced with the calculated configuration BPDU, which will be sent out periodically.
	• If the configuration BPDU on the port is superior, the device will block this port without updating its configuration BPDU, so that the port will only receive BPDUs, but not send any, and will not forward data.

Once the root bridge, the root port on each non-root bridge and designated ports have been unsuccessfully elected, the entire tree-shaped topology has been constructed.

2) The BPDU forwarding mechanism in spanning-tree

Upon network initiation, every GPON regards itself as the root bridge, generates configuration BPDUs with itself as the root, and sends the configuration BPDUs at a regular interval of hellotime.

● If it is the root port that received the configuration BPDU and the received configuration

BPDU is superior to the configuration BPDU of the port, the device will increase messageage carried in the configuration BPDU by a certain rule and start a timer to time the configuration BPDU while it sends out this configuration BPDU through the designated port.

- If the configuration BPDU received on the designated port has a lower priority than the configuration BPDU of the local port, the port will immediately send out its better configuration BPDU in response.

- If a path becomes faulty, the root port on this path will no longer receive new configuration BPDUs and the old configuration BPDUs will be discarded due to timeout. In this case, the device will generate a configuration BPDU with itself as the root and sends out the BPDU. This triggers a new spanning tree calculation process so that a new path is established to restore the network connectivity.

However, the newly calculated configuration BPDU will not be propagated throughout the network immediately, so the old root ports and designated ports that have not detected the topology change continue forwarding data along the old path. If the new root port anddesignated port begin to forward data as soon as they are elected, a temporary loop may occur.

3) STP timers

STP calculations need three important timing parameters: forward delay, hello time, and max age.

- Forward delay is the delay time for device state transition. A path failure will cause re-calculation of the spanning tree, and the spanning tree structure will change

10

accordingly. However, the new configuration BPDU as the calculation result cannot be propagated throughout the network immediately. If the newly elected root port and designated ports start to forward data right away, a temporary loop is likely to occur. For this reason, as a mechanism for state transition in STP, a newly elected root port or designated port requires twice the forward delay time before transitioning to the forwarding state, when the new configuration BPDU has been propagated throughout thenetwork.

● Hello time is the time interval at which a device sends hello packets to the surrounding devices to ensure that the paths are fault-free.

● Max age is a parameter used to determine whether a configuration BPDU held by the device has expired. A configuration BPDU beyond the max age will be discarded.

11.3 Implement RSTP on Ethernet GPON

The Ethernet GPON implements the Rapid Spanning Tree Protocol (RSTP), i.e., the enhancement of STP. The Forward Delay for the root ports and designated ports to enter forwarding state is greatly reduced in certain conditions, thereby shortening the time period forstabilizing the network topology.

To achieve the rapid transition of the root port state, the following requirement should be met: The old root port on this GPON has stopped data forwarding and the designated port in the upstream has begun forwarding data.

The conditions for rapid state transition of the designated port are:

- The port is an Edge port that does not connect with any GPON directly or indirectly. If the designated port is an edge port, it can GPON to forwarding state directly without immediately forwarding data.

- The port is connected with the point-to-point link, that is, it is the master port in aggregation ports or full duplex port. It is feasible to configure a point-to-point connection. However, errors may occur and therefore this configuration is not recommended. If the designated port is connected with the point-to-point link, it can enter the forwarding state right after handshakingwith the downstream GPON and receiving the response.

The GPON that uses RSTP is compatible with the one using STP. Both protocol packets can be identified by the GPON running RSTP and used in spanning tree calculation.

11.4 Configure RSTP

11.4.1   RSTP Configuration Task List

Configuration Task	Description	Detailed Configuration
Enable STP and Configure the working mode	Required	11.4.2
Configure STP bridge priority	Optional	11.4.3
Configure Time Parameter	Optional	11.4.4
Configure STP Path Cost	Optional	11.4.5
Configure STP Port Priority	Optional	11.4.6
Configure STP mcheck	Optional	11.4.7
Configure STP point-to-point mode	Optional	11.4.8
Configure STP portfast	Optional	11.4.9

Configure STP transit limit	Optional	11.4.10
RSTP Monitor and Maintenance	Optional	11.4.11

11.4.2　　Enable RSTP and Configure the Working Mode

After enabling STP globally, all ports will be defaulted to join the STP topology calculating by default. If some port is not allowed to take part in the STP calculation, administrator can use undo stp command in interface configuration mode to disable STP on this port.

Operation	Command	Remarks
Enter global configuration mode	**system-view**	
Enable STP globally	**stp**	
Select STP mode	**stp mode rstp**	
Enter interface configuration mode	**interface ethernet** *interface-num*	
Enable/disable STP on port	[**undo**] **stp**	

Note：

When enable STP globally, the system is working under RSTP mode.

11.4.3　　Configure STP Bridge Priority

The priority of bridge determines this GPON can be root or not. If this GPON is needed to be the root, the priority can be configured inferior.

By default, the GPON bridge priority is 32768.

Operation	Command	Remarks
Enter global configuration mode	**system-view**	
Configure STP priority	**stp priority** *bridge-priority*	

11.4.4   Configure Time Parameter

There are three time parameters: Forward Delay, Hello Time and Max Age.User

can configure these three parameters for RSTP calculation.

Operation	Command	Remarks
Enter global configuration mode	**system-view**	
Configure Hello-packet sending interval	**stp hello-time** *seconds*	
Configure STP forward-delay	**stp forward-time** *seconds*	
Configure STP max-age	**stp max-age** *seconds*	

Note:

Too long Hello Time may cause link failure thought by network bridge for losing packets of thelink to

restart accounting STP; too smaller Hello Time may cause network bridge frequently to send

configuration packet to strengthen the load of network and CPU. Hello Time ranges from1 to 10

seconds. It is suggested to use the default time of 2 seconds. Hello Time ≤ Forward Delay-2.

If Forward Delay is configured too small, temporary redundancy will be caused; if Forward Delay is

configured too large, network will not be restored linking for a long time. Forward Delay ranges from

4 to 30 seconds. The default forward delay time, 15 seconds is suggested to use. Forward

Delay≥Hello Time + 2.

Max Age is used to configure the longest aging interval of STP. Lose packet when over-timing.The

STP will be frequently accounts and take crowded network to be link fault, if the value is too small.

If the value is too large, the link fault cannot be known timely. Max Age is determinedby diameter of

network, and the default time of 20 seconds is suggested. $2*$(Hello Time + 1) ≤

Max Age ≤ 2*(ForwardDelay − 1) When enable STP globally, the system is working under RSTP mode.

11.4.5   Configure STP Path Cost

Configure interface STP path cost and choose the path with the smallest path cost to be the effective path.

The path cost is related to the link speed rate. The larger the speed rate is, the less the cost is.STP can auto-detect the link speed rate of current interface and converse it to be the cost.

Configure port path cost will make STP re-calculating. The value of the path cost is 1-65535. Itis suggested using the default vaule, which makes the STP to calculate the current port cost byitself.

By default, the path cost is determined by the current port speed.

When the port is 10M, the default cost is 200,000; when the port is 100M, the default cost is 20,000; 1000M, 2,000.

Operation	Command	Remarks
Enter global configuration mode	**system-view**	
Enter interface configuration mode	**interface ethernet** *interface-num*	
Configure STP path cost	**stp cost** *path-cost*	

11.4.6   Configure STP Port Priority

Specify specified port in STP by Configure port priority. Generally, the smaller the value is, the superior the priority is, and the port will be more possible to be included in STP. If the prioritiesare the same, the port number is considered.

The smaller the value is, the superior the priority is, and the port is easier to be the root

interface. Change the port priority may cause the re-calculating of the STP. The port priority ranges from 0 to 255. The default port priority is 128.

Operation	Command	Remarks
Enter global configuration mode	**system-view**	
Enter interface configuration mode	**interface ethernet** *interface-num*	
Configure STP port priority	**stp port-priority** *port-priority*	

11.4.7   Configure STP Mcheck

GPON working under RSTP mode can be connected to GPON with STP. But when the neighbor is working under RSTP, the two connected ports are still work under STP mode. Mcheck is for force port sending RSTP packet to make sure the two neighbor ports can be working under RSTP. If yes, the working mode will turn to be RSTP.

Operation	Command	Remarks
Enter global configuration mode	**system-view**	
Enter interface configuration mode	**interface ethernet** *interface-num*	
Configure STP mcheck	**stp mcheck**	

11.4.8   Configure STP Point-to-Point Mode

In rstp, the requirement of interface quickly in transmission status is that the interface must bepoint to point link not media sharing link. It can be specified interface link mode manually and can also judge it by network bridge.

Operation	Command	Remarks
Enter global configuration mode	**system-view**	

Enter interface configuration mode	**interface ethernet** *interface-num*	
Configure GPON auto-check the point-to-point	**stp point-to-point auto**	
Configure STP point-to-point mode forcetrue	**stp point-to-point forcetrue**	
Configure STP point-to-point mode forcefalse	**stp point-to-point forcefalse**	

11.4.9   Configure STP Portfast

Edge port is the port connecting to the host which can be in transmission status in very shorttime after linkup, but once the port receiving STP packet, it will shift to be non-edge port.

Operation	Command	Remarks
Enter global configuration mode	**system-view**	
Enter interface configuration mode	**interface ethernet** *interface-num*	
Configure STP portfast	**stp portfast**	

11.4.10 Configure STP Transit Limit

Restrict STP occupying bandwidth by restricting the speed of sending BPDU packet. Thespeed is determined by the number of BPDU sent in each hello time.

By default, port will send 3 BPDU packets in every Hello time interval.

Operation	Command	Remarks
Enter global configuration mode	**system-view**	
Enter interface configuration mode	**interface ethernet** *interface-num*	
Configure STP transit limit	**stp transit-limit** *transit-limit*	

11.1.1 RSTP Monitor and Maintenance

After finishing above configuration, user can check the configurations by command below.

Operation	Command	Remarks
Display STP interface	**display stp interface** [**brief** [**ethernet** *interface-num*]]	