LLDP

Technical White Paper

Issue 01

Date 2012-10-31

HUAWEI TECHNOLOGIES CO., LTD.

HUAWEI

Trademarks and Permissions

Notice

The purchased products, services and features are stipulated by the contract made between Huawei and the customer. All or part of the products, services and features described in this document may not be within the purchase scope or the usage scope. Unless otherwise specified in the contract, all statements, information, and recommendations in this document are provided "AS IS" without warranties, guarantees or representations of any kind, either express or implied.

The information in this document is subject to change without notice. Every effort has been made in the preparation of this document to ensure accuracy of the contents, but all statements, information, and recommendations in this document do not constitute a warranty of any kind, express or implied.

Huawei Technologies Co., Ltd.

Address: Huawei Industrial Base
Bantian, Longgang
Shenzhen 518129
People's Republic of China

Website: http://enterprise.huawei.com

About This Document

Change History

Changes between document issues are cumulative. The latest document issue contains all changes made in previous issues.

Changes in Issue 01 (2012-10-31)

Initial commercial release.

Contents

1 Introduction to LLDP

Definition

The Link Layer Discovery Protocol (LLDP) is a Layer 2 discovery protocol defined in the IEEE 802.1ab. Using LLDP, the Network Management System (NMS) can rapidly obtain the Layer 2 network topology and topology changes when the network scale expands.

Purpose

To facilitate WLAN maintenance and monitoring, the NMS must show all the wireless and wired connections on the network, including the connections between APs and directly connected switches. The displayed connections are the AP neighbor relationships. APs comply with standard LLDP protocols and periodically send LLDP TLVs containing the local LLDP information to neighbors in multicast mode. If a neighboring AP is enabled with LLDP, the neighbor relationship is established. If the AP connects to an LLDP-enabled switch, the switch is the AP's neighbor. The AP sends LLDP information to the switch and receives the LLDP multicast packets from the switch. The Simple Network Management Protocol (SNMP) enables the NMS to receive the AP's LLDP information from the AC and maintain local topology information.

LLDP defines a standard SNMP MIB on each interface. An SNMP MIB stores the status information including the chassis ID, port ID, and management address. Each device sends local status and status changes to neighboring nodes. The neighboring nodes then store the received information in the standard SNMP MIB so that the NMS can obtain the information.

The NMS collects topology information from the LLDP local system MIB and LLDP remote system MIB on all managed devices, analyzes the Layer 2 network topology, and finds defects.

Benefits

LLDP enables enterprises and carriers to know the topology of the entire network so that they can manage network devices and locate faults easily. This function facilitates network management and reduces manual workload.

2 Principles

About This Chapter

2.1 Basic Concepts

MIB is short for the management information base. MIBs are classified into LLDP local system MIBs and LLDP remote system MIBs.

- An LLDP local system MIB stores information about the local device, including the device ID, port ID, system name, system description, port description, system capability, and management address.
- An LLDP remote system MIB stores information about neighboring nodes, including the device ID, port ID, system name, system description, port description, system capability, and management address.

An LLDP agent manages LLDP operations for a port. The LLDP agent performs the following operations:

- Maintains information in the LLDP local system MIB.
- Obtains and sends LLDP local system MIB information to neighboring nodes when the status of the local device changes. An LLDP agent also obtains and sends LLDP local system MIB information to neighboring nodes at intervals when the status of the local device does not change.
- Identifies and processes received LLDP packets.
- Maintains information in the LLDP remote system MIB.
- Sends LLDP traps to the NMS when information in the LLDP local system MIB or the LLDP remote system MIB changes.

The LLDP management address (short for management address) is used by the NMS to identify the devices and implement network management. A management address identifies a device, facilitating the network topology layout and network management. The management address is carried in the Management Address TLV field of an LLDP packet to be transmitted to neighboring nodes.

When information in the LLDP local system MIB or the LLDP remote system MIB changes, the device sends trap messages to the NMS for updating the topology. The information changes include:

- LLDP is enabled or disabled globally.
- The local management address is changed.
- The neighbor information is changed, for example, a neighbor is added, deleted, or aged.

The following LLDP working modes are available:

- TxRx: The device sends and receives LLDP packets.
- Tx: The device only sends but does not receive LLDP packets.
- Rx: The device only receives but does not send LLDP packets.
- Disable: The device does not send or receive LLDP packets.

When the LLDP working mode on a port changes, the port initiates the protocol state machine. You can set an initialization delay for a port to avoid frequent initialization operations when the working mode frequently changes. After the delay is set, the initialization operation is not performed immediately after the working mode of a port changes.

- Sending mechanism: When a port works in TxRx or Tx mode, the device periodically sends LLDP packets to neighboring nodes. If the local configuration of the device changes, the device sends LLDP packets to notify neighboring nodes of the local information change. To prevent the device from sending a large number of LLDP packets due to frequent local information change, the device sends each LLDP packet at an interval.

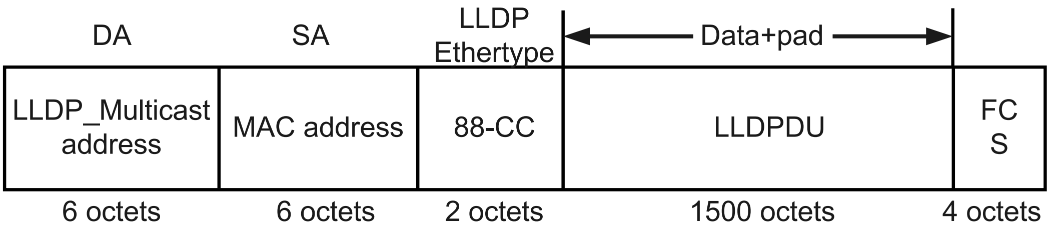
- Receiving mechanism: When a port works in TxRx or Rx mode, the device checks validity of TLVs carried in received LLDP packets and stores neighbor information locally. According to the TTL value in TTL TLVs, the device sets the aging time of a neighbor. If the TTL value is 0, the device immediately ages out information about this neighbor.

2.2 LLDP Frame Format

LLDP Frame Format Introduction

Figure 2-1 shows the LLDP frame format.

Figure 2-1 LLDP frame format



The meanings of fields in an LLDP frame are as follows:

- DA: indicates the destination address of the LLDP frame. It is the multicast address 01-80-C2-00-00-0E.
- SA: indicates the bridge MAC address of the neighboring node.
- LLDP Ethertype: indicates the LLDP frame type. A frame with this field is an LLDP frame and is sent to the LLDP module. The value of this field is 0x88CC.
- LLDPDU: indicates the LLDP data unit. It is the major content of an LLDP frame.
- FCS: indicates the frame check sequence.

LLDPDU

In LLDP, all device information is encapsulated in LLDPDUs, which are then sent to neighboring nodes. An LLDPDU contains a variety of type length values (TLVs). In a TLV, T indicates the information type, L indicates the information length, and V indicates the value or the content to be sent.

Devices send LLDPDUs with different TLVs to advertise their local information and receive LLDPDUs to obtain neighbor information.

Table 2-1 describes TLVs carried in LLDPDUs.

Table 2-1 TLVs carried in LLDPDUs

TLV Type	TLV Name	Usage in LLDPDU
0	End of LLDPDU	Mandatory
1	Chassis ID	Mandatory
2	Port ID	Mandatory
3	Time to live	Mandatory
4	Port description	Optional
5	System name	Optional
6	System description	Optional
7	System capabilities	Optional
8	Management address	Optional
9-126	Reserved	-
127	Organizationally specific TLVs	Optional

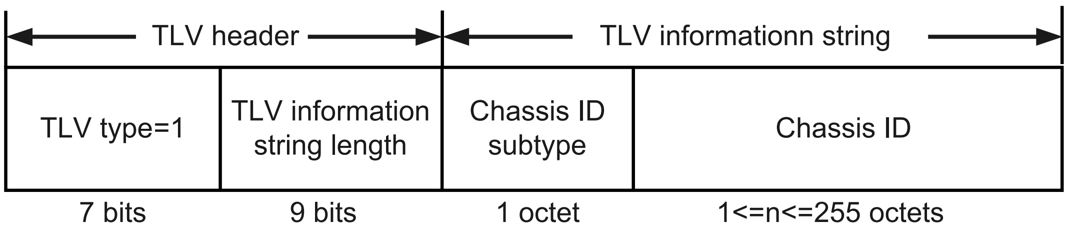
Different TLVs have different types and names. The field Usage in LLDPDU specifies whether an LLDPDU is mandatory or optional.

In general, an LLDPDU contains nine types of TLVs, among which 9-126 are reserved and 127 indicates some special TLVs. The Chassis ID TLV, Port ID TLV, and Time to live TLV are mandatory. The End of LLDPDU TLV identifies the ending of an LLDPDU and is mandatory. The other five TLVs are optional.

The following describes the mandatory TLVs:

- **Figure 2-2** shows the format of a Chassis ID TLV.

Figure 2-2 Format of a Chassis ID TLV



The type value of a Chassis ID TLV is 1 and occupies 7 bits. The field TLV information string length indicates the TLV length and occupies 9 bits. The first byte of the TLV information string indicates the TLV subtype, and the others indicate the TLV content.

The chassis ID varies depending on the subtype, as described in **Table 2-2**.

Table 2-2 Subtype of a chassis ID

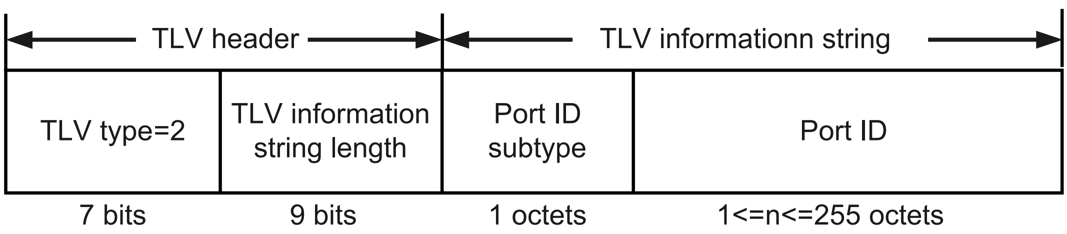
ID Subtype	ID Basis	Reference
0	Reserved	-
1	Chassis component	EntPhysicalAlias when entPhysClass has a value of 'chassis(3)' (IETF RFC 2737)
2	Interface alias	IfAlias (IETF RFC 2863)
3	Port component	EntPhysicalAlias when entPhysicalClass has a value of 'port(10)' or 'backplane(4)' (IETF RFC 2737)
4	MAC address	MAC address (IEEE Std 802-2001)
5	Network address	networkAddress
6	Interface name	ifName (IETF RFC 2863)
7	Locally assigned	local
8-255	Reserved	-

The subtype field occupies 1 byte and its value ranges from 0 to 255. Values from 8 to 255 are reserved, and the other values indicate TLV information of different subtypes and the corresponding standard documentation.

On Huawei devices, the chassis ID is the bridge MAC address of a device (subtype 4).

- **Figure 2-3** shows the format of a Port ID TLV.

Figure 2-3 Format of a Port ID TLV



The type value of Port ID TLV is 2 and occupies 7 bits. The field TLV information string length indicates the TLV length and occupies 9 bits. The first byte of the TLV information string indicates the TLV subtype, and the others indicate the TLV content of 1 to 255 bytes.

The port ID varies depending on the subtype, as described in **Table 2-3**.

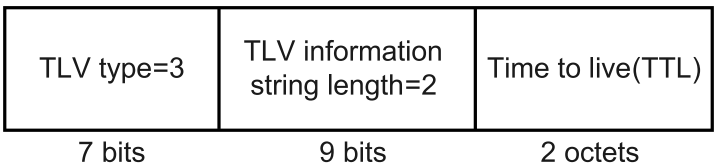
Table 2-3 Subtype of a port ID

ID Subtype	ID Basis	Reference
0	Reserved	-
1	Interface alias	IfAlias (IETF RFC 2863)
2	Port component	EntPhysicalAlias when entPhysicalClass has a value of 'port(10)' or 'backplane(4)' (IETF RFC 2737)
3	MAC address	MAC address (IEEE Std 802-2001)
4	Network address	NetworkAddress
5	Interface name	ifName (IETF RFC 2863)
6	Agent circuit ID	Agent circuit ID (IETF RFC 3046)
7	Locally assigned	Local
8-255	Reserved	-

On Huawei devices, the port ID is the port name (subtype 5).

- **Figure 2-4** shows the format of a Time to Live TLV.

Figure 2-4 Format of a Time to Live TLV

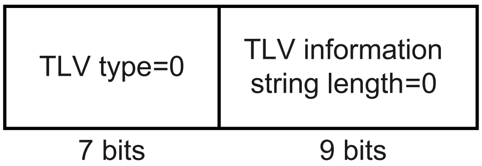


The type value of Time to Live TLV is 3 and occupies 7 bits. The field TLV information string length indicates the TLV length and occupies 9 bits. The Time to Live TLV has no subtype. The value of TLV information string ranges from 0 to 65535, in seconds. It occupies only 2 bytes and notifies the receive end of the information validity period. If the transmit end does not update the TLV information string for a period, the receive end discards the TLV information string; upon receiving the TLV information string, the receive end updates the information aging time of the neighboring node.

The following describes the End of LLDPDU TLV:

- The End of LLDPDU TLV identifies the ending of an LLDPDU. **Figure 2-5** shows the format of an End of LLDPDU TLV.

Figure 2-5 Format of an End of LLDPDU TLV

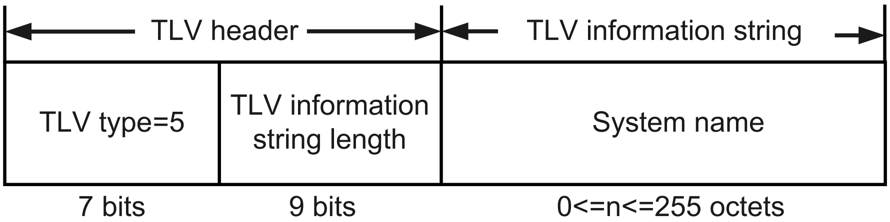


When the port status changes, for example, LLDP is disabled or the port is shut down, the port sends an LLDPDU with the TTL value of the Time to Live TLV set to 0 to the neighboring nodes. This LLDPDU is a shutdown packet. An End of LLDPDU TLV has only the type and length fields and does not have the field TLV information string. The type value of End of LLDPDU TLV is 0 and occupies 7 bits. The length of End of LLDPDU TLV is 0 and occupies 9 bits.

There are five optional TLVs: System Name TLV, System Description TLV, Port Description TLV, System Capability TLV, and Management Address TLV.

- **Figure 2-6** shows the format of a System Name TLV.

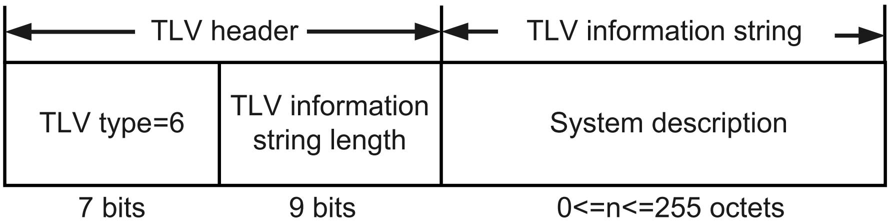
Figure 2-6 Format of a System Name TLV



A System Name TLV contains TLV type, TLV length, and TLV information string, without a subtype. A System Name TLV identifies the complete domain name of the local device. If the LLDP agent complies with IETF RFC 3418, the System Name TLV value is the same as the sysName value in IETF RFC 3418. An LLDPDU contains only one System Name TLV.

- **Figure 2-7** shows the format of a System Description TLV.

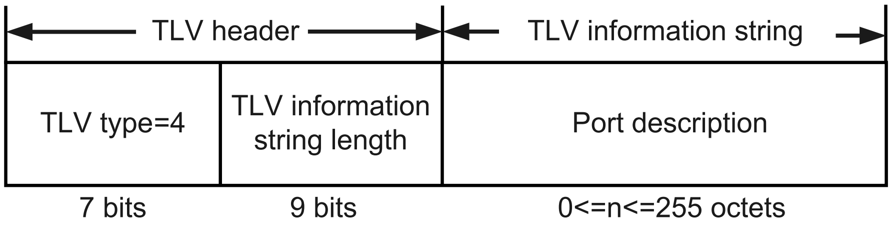
Figure 2-7 Format of a System Description TLV



A System Description TLV contains the fields TLV type, TLV length, and TLV information string, without a subtype. The System Description TLV identifies the full name, system hardware version, operating system, and network software of the local device. If the LLDP agent complies with IETF RFC 3418, the System Description TLV value is the same as the sysDesc value in IETF RFC 3418. An LLDPDU contains only one System Description TLV.

- **Figure 2-8** shows the format of a Port Description TLV.

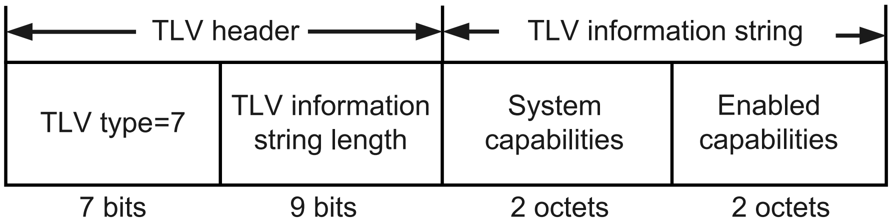
Figure 2-8 Format of a Port Description TLV



A Port Description TLV contains TLV type, TLV length, and TLV information string, without a subtype. The Port Description TLV identifies the description of a port on the local device. If the LLDP agent complies with IETF RFC 2863, the Port Description TLV value is the same as the ifDesc in IETF RFC 2863. An LLDPDU contains only one Port Description TLV.

- **Figure 2-9** shows the format of a System Capability TLV.

Figure 2-9 Format of a System Capability TLV



A System Capability TLV describes the functions that the system supports and has enabled. The TLV header of a System Capability TLV is similar to those of other TLVs. The resting fields of the System Capability TLV map different functions. **Table 2-4** describes the bits identifying the functions.

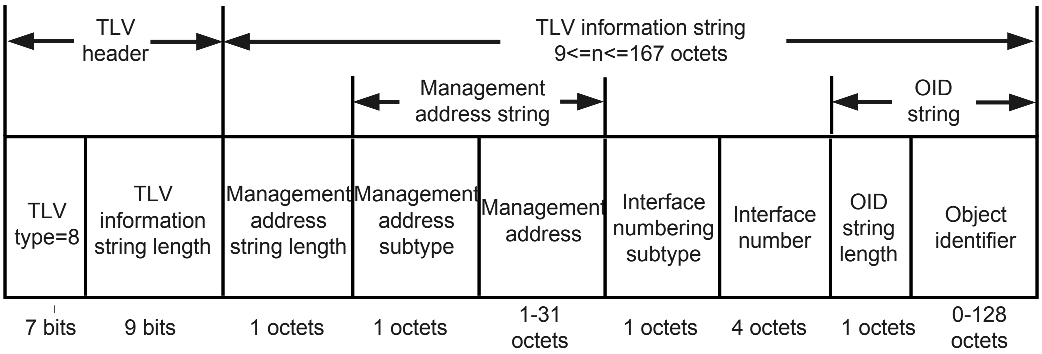
Table 2-4 Bits of a System Capability TLV

Bit	Capability	Reference
0	Other	-
1	Repeater	IETF RFC 2108
2	Bridge	IETF RFC 2674
3	WLAN access point	IETF 802.11 MIB
4	Router	IETF RFC 1812
5	Telephone	IETF RFC 2011
6	DOCSIS cable device	IETF RFC 2669 and IETF RFC 2670
7	Station only	IETF RFC 2011

Bit	Capability	Reference
8-15	Reserved	-

- Figure 2-10 shows the format of a Management Address TLV.

Figure 2-10 Format of a Management Address TLV



A Management Address TLV is used to advertise the management address of the local device. The value of TLV information string indicates the available type and value of the management address.

Based on the NMS and device configurations, the management address is determined as follows:

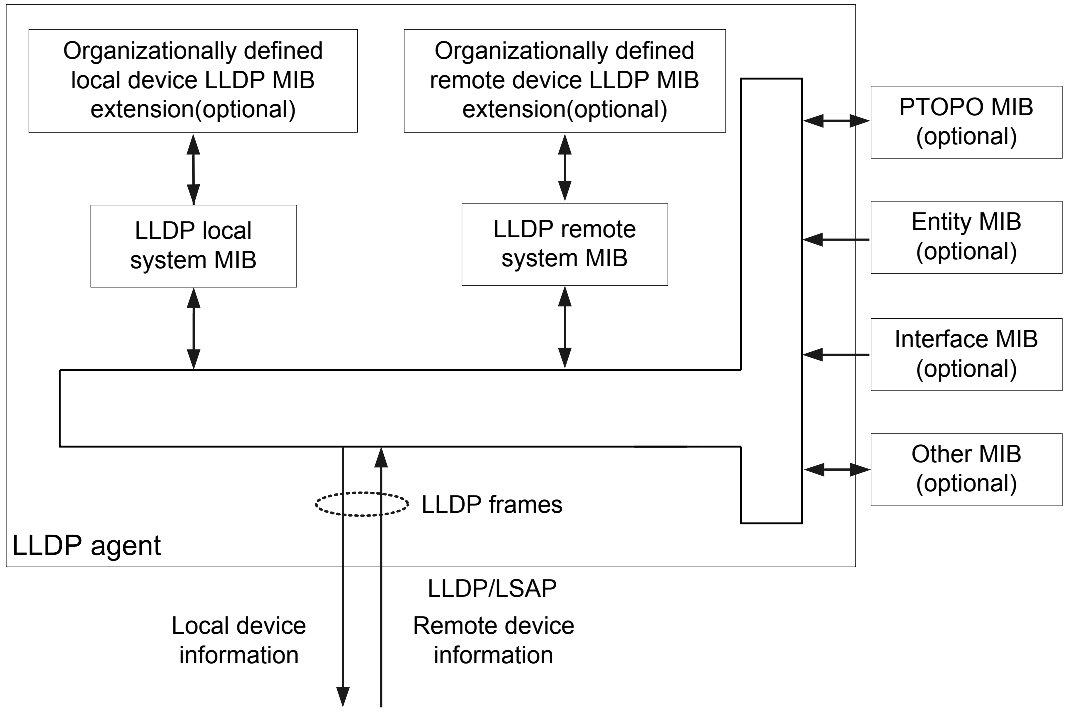
1. Configure a management IP address. An existing IP address on the local device can be configured as the management IP address. It can be the address of a loopback interface, management network interface, or VLANIF interface.
2. If no management IP address is configured, the system selects an IP address by default. The loopback IP address is preferentially used and if it does not exist, the smallest IP address in the IP address list is used.
3. If no default management IP address is found, the system uses the bridge MAC address.

2.3 Implementation

LLDP is a Layer 2 discovery protocol. After a device is enabled with LLDP, the device notifies neighboring nodes of its status that is stored in each port on the device. If the status of the local device changes, the device notifies the directly connected neighbor of the update so that the neighbor stores the updated status information in its standard SNMP MIB. The NMS can obtain the link layer information from the SNMP MIB. However, LLDP is only a protocol for discovering remote device status. LLDP cannot perform functions such as configuring network devices and controlling ports.

Figure 2-11 shows the LLDP architecture for better illustrating LLDP implementation.

Figure 2-11 LLDP architecture



Four MIBs are used for information exchange with the LLDP module, including PTOPO MIB, Entity MIB, Interface MIB, and Other MIB. The LLDP module exchanges information with these MIBs to update its LLDP local system MIB and define the organizationally defined local device LLDP MIB extension. The LLDP module then sends LLDPDUs to the peer device to notify it of the local device information.

Upon receiving the LLDP packets from the peer device, the LLDP module updates the LLDP remote system MIB stored on the local device. In this way, the device can update or maintain the LLDP remote system MIB stored on the local device through all interface connecting to neighboring nodes. The MIB allows the device to obtain the neighbor information, including the remote interface connected to the local device and the bridge MAC address of the peer device. The MIB organizes the information sending and receiving on the LDP module.

In general, LLDP is responsible for the following tasks:

1. Initialize and maintain information in the local MIB.
2. Extract information from the local MIB, encapsulate the information into LLDP frames, and send the LLDP frames to neighboring nodes at a certain interval or upon device status changes.
3. Verify and process the received LLDP frames.
4. Maintain the LLDP remote system MIB based on the received LLDP frames.
5. Report changes in LLDP local system MIB or remote system MIB to the NMS.

2.4 LLDP Parameters

You can adjust LLDP parameters to help the NMS discover the topology quickly and save network resources. LLDP parameters include:

- Interval at which LLDP packets are sent
- Delay in sending LLDP packets
- Time multiplier of device information held on neighboring nodes
- Delay in re-enabling LLDP on an interface
- Delay in sending LLDP traps

Interval at Which LLDP Packets Are Sent

A device sends LLDP packets to neighboring nodes at a specified interval when the device information does not change.

After the interval is configured on a device, all the LLDP-enabled interfaces on the device send LLDP packets to the neighboring nodes at the interval. However, the interface may send LLDP packets at different time points. By adjusting the interval value, you can change the speed of topology discovery on the entire network.

Adjust the interval based on the network load:

- A long delay reduces the LLDP packet exchange frequency, which saves system resources. If the value is too large, however, the device cannot notify neighboring nodes of its status in a timely manner, and the NMS cannot discover network topology changes in real time.
- A short delay increases the frequency of sending local status information to the neighboring nodes. This helps the NMS quickly discover network topology changes. If the interval is too short, however, LLDP packets are exchanged frequently, increasing the system load.

Delay in Sending LLDP Packets

When the local status changes, the AP immediately sends LLDP packets to neighboring nodes and starts the delay timer.

- If the local status changes within the delay time, the AP waits until the delay timer expires and sends LLDP packets to neighboring nodes. The AP then resets the delay timer.
- If the local status does not change within the delay time, the AP sends LLDP packets to neighboring nodes when the next interval starts.

If the device status changes frequently, increase the delay value to lower the LLDP packet sending frequency. Adjust the delay value based on the network load:

- A long delay reduces the LLDP packet exchange frequency, which saves system resources. If the value is too large, however, the device cannot notify neighboring nodes of its status in a timely manner, and the NMS cannot discover network topology changes in real time.
- A short delay increases the frequency of sending local status information to the neighboring nodes. This helps the NMS quickly discover network topology changes. If the delay is too short, however, LLDP packets are exchanged frequently, increasing the system load.

The interval at which LLDP packets are sent must be larger than or equal to four times the delay in sending LLDP packets. **Figure 2-12** and **Figure 2-13** show the relationship between the interval and delay in sending LLDP packets.

Figure 2-12 Relationship between the LLDP packet sending interval and delay

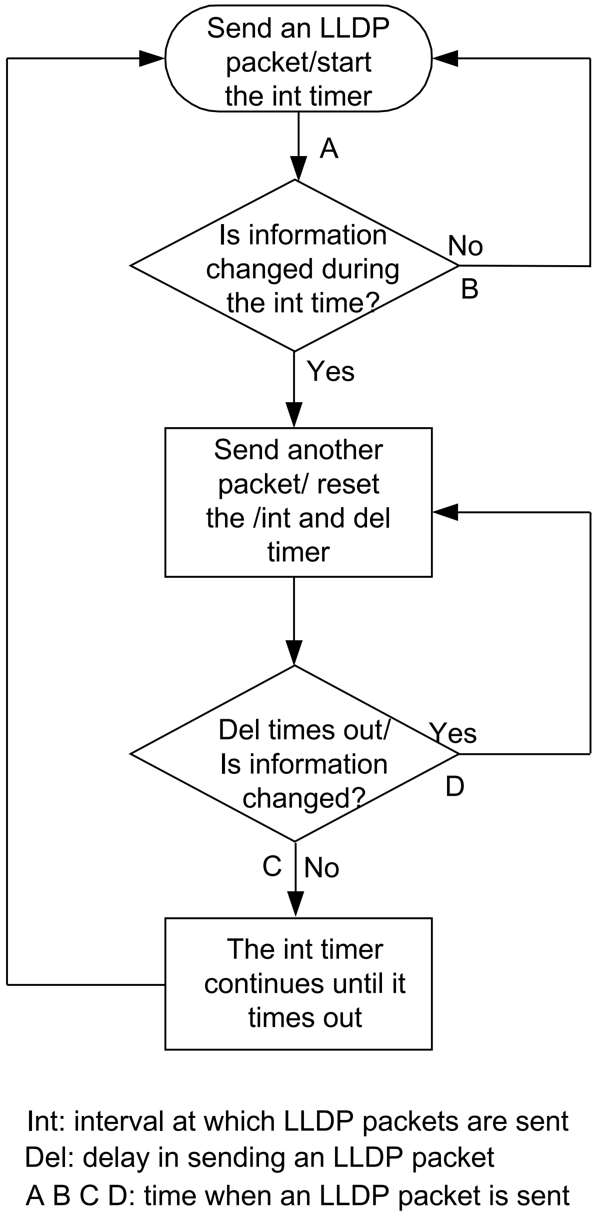
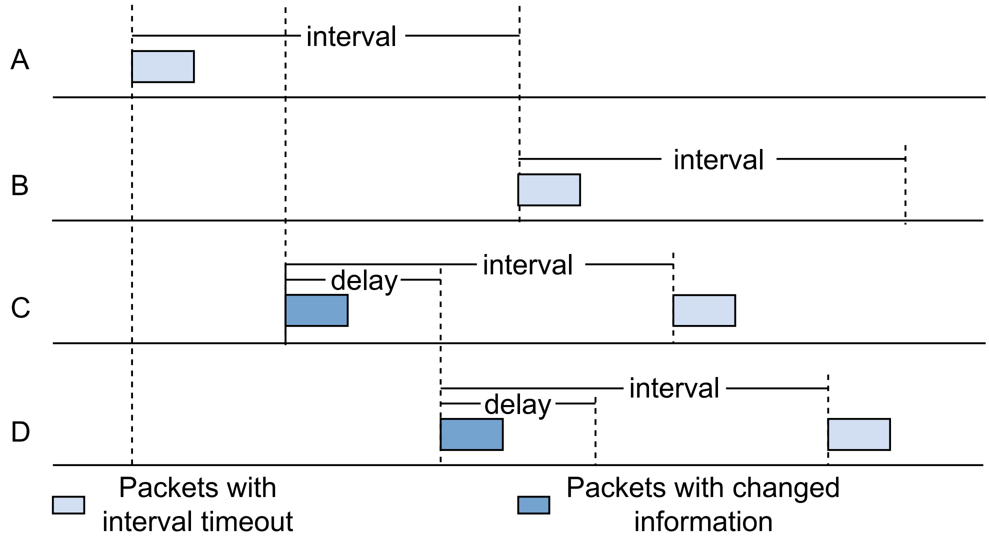


Figure 2-13 Packets sent at different time points



Time Multiplier of Device Information Held on Neighboring Nodes

The time multiplier is used to calculate how long an LLDP packet can be saved on a neighboring node. You can change the time to live (TTL) of device information on a neighboring node by adjusting this parameter. After receiving an LLDP packet, a neighboring node updates the aging time of the device information from the sender based on the TTL.

The TTL is calculated using the following formula: TTL = Min(65535, (Interval x Hold-multiplier)).

- TTL is the device information storage time. It is the smaller value between 65535 and (interval x hold-multiplier).
- The interval is the period at which the local device sends LLDP packets to neighboring nodes.
- Hold-multiplier is the time multiplier of device information held on neighboring nodes.

Delay in Re-Enabling LLDP on an Interface

If the delay in re-enabling LLDP on an interface is configured on an AP, the AP does not immediately notify neighboring nodes when LLDP is manually enabled on an interface. Instead, the AP sends LLDP packets to notify neighboring nodes until the delay timer expires. The delay time prevents network topology flapping caused by frequent LLDP status changes.

Delay in Sending LLDP Traps

The delay in sending LLDP traps is the minimum delay for an AP to send LLDP traps to the NMS when the LLDP trap function is enabled and the LLDP remote system MIB information frequently changes. The delay is valid only for the traps generated when the following items change:

- Number of added neighboring nodes
- Number of deleted neighboring nodes
- Number of aged neighboring nodes
- Number of dropped neighboring nodes

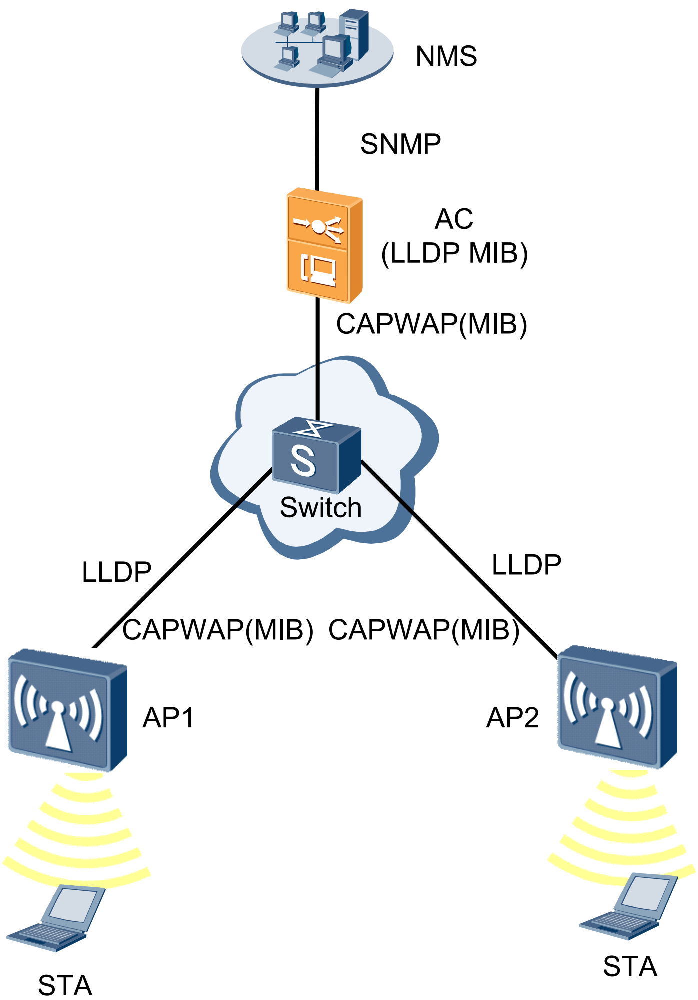
After the delay in sending traps is set on an AP, all the LLDP-enabled interfaces on the AP send traps of neighbor information changes to the neighboring nodes by using this value as the minimum delay. However, the interface may send LLDP packets at different time points. When the neighbor information changes frequently, you can prolong the delay to suppress topology flapping.

3 Applications

Directly Connected Neighbors

Figure 3-1 shows how LLDP discovers the topology between directly connected neighbors.

Figure 3-1 LLDP topology discovery of directly connected neighbors



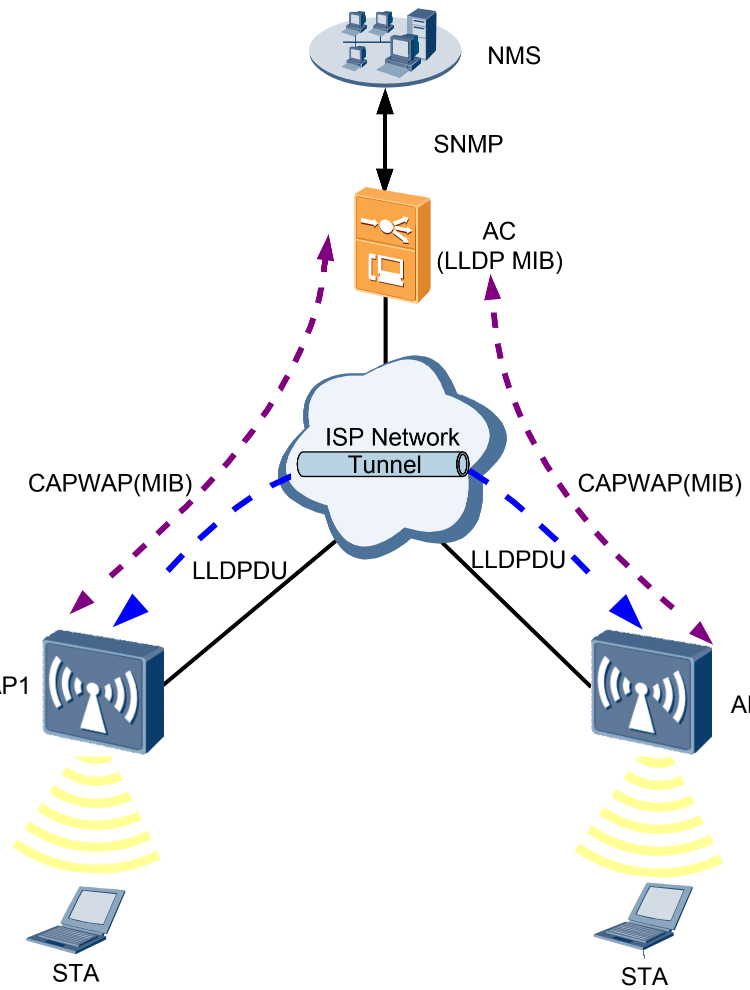
LLDP is enabled on AP1 and the switch. The process of LLDP topology discovery between directly connected neighbors is as follows:

1. AP1 sends LLDP packets to notify the switch of local status.
2. The switch analyzes received LLDP packets and stores the analysis result in its LLDP remote system MIB for the NMS to obtain.
3. The switch sends LLDP packets with its own status to AP1. AP1 analyzes the received LLDP packets and stores the analysis result in its LLDP remote system MIB.
4. AP1 sends LLDP neighbor information to the AC over the CAPWAP tunnel. The NMS obtains AP1's LLDP neighbor information from the AC through the SNMP interface. The NMS then analyzes the topology information and obtains the topology of the entire network.

Transparent Transmission

Figure 3-2 shows how LLDP discovers the topology between remote neighbors.

Figure 3-2 LLDP topology discovery of remote neighbors



The process of LLDP topology discovery between remote neighbors is as follows:

1. AP1 sends an LLDP packet with the type 0x88CC and destination MAC address 01-80-C2-00-00-0E.

2. The LLDP packet is transparently transmitted to AP2 over the tunnel on the Internet service provider (ISP) network.
3. After receiving the LLDP packet, AP2 analyzes the packet type and determines whether it can process the packet. When determining that it can process the packet, AP2 analyzes the LLDP packet and stores the analysis result in its LLDP remote system MIB for the NMS to obtain.
4. AP2 sends an LLDP packet in the same manner as AP1 does. AP1 also analyzes the LLDP packet and stores the analysis result in its LLDP remote system MIB.
5. The NMS finds AP1 and AP2 according to their management addresses and obtains the topology information to analyze the network topology.

Configuring LLDP

Enable LLDP globally.

```
<AC>system-view
[AC]wlan
[AC-wlan-view]wlan ap lldp enablb
```

Enable LLDP on an AP.

```
[AC-wlan-view]ap id 0
[AC-wlan-ap-0]lldp enable
```

NOTE

By default, LLDP is enabled on an AP.

Enable the AP to send or receive LLDP packets.

```
[AC-wlan-ap-0]lldp admin-status tx
```

(Optional) Configure the type of TLVs that an AP advertises in an LLDP packet.

```
[AC-wlan-ap-0]lldp tlv-enable basic-tlv system-name
```

(Optional) Configure LLDP parameters for the AP.

```
[AC-wlan-ap-0]lldp message-transmission interval 60
[AC-wlan-ap-0]lldp message-transmission delay 10
[AC-wlan-ap-0]lldp message-transmission hold-multiplier 5
```

NOTE

By default, LLDP parameter settings on an AP are as follows:

- delay delay-time: 2s
- hold-multiplier multiplier-id: Four times
- interval interval-time: 30s

(Optional) Configure the interval at which the AP reports neighbor information to the AC.

```
[AC-wlan-ap-0]lldp report-interval 20
```

(Optional) Configure the delay in re-enabling the LLDP function on the AP.

```
[AC-wlan-ap-0]lldp restart-delay 1
```

Display LLDP neighbor information of APs.

```
[AC-wlan-view]display lldp ap-neighbor
  ------------------------------------------------------------------------------
  AP 0 Port 0 has 1 neighbor(s):

  Neighbor index: 1
  Chassis ID type: macAddress
  Chassis ID: 5489-9848-ee30
  Port ID type: interfaceName
  Port ID: eth0
  Time To Live: 120s
  Port Description: eth0
  System name: ap-11
```

```
 System description: Linux (none) 2.6.32.45-Wlan.BSP #1 Sun Sep 23 10:35:43 CST
2012 mips64
 System capabilities supported: wlanAccessPoint
 System capabilities enabled: wlanAccessPoint
 Management address type: ipV4
 Management address: 100.1.1.250
 -----------------------------------------------------------------------------
 AP 11 Port 0 has 1 neighbor(s):

 Neighbor index: 1
 Chassis ID type: macAddress
 Chassis ID: 0033-3333-3360
 Port ID type: interfaceName
 Port ID: eth0
 Time To Live: 160s
 Port Description: eth0
 System name: ap-0
 System description: Linux (none) 2.6.32.45-Wlan.BSP #1 Sun Sep 23 10:35:43 CST
2012 mips64
 System capabilities supported: wlanAccessPoint
 System capabilities enabled: wlanAccessPoint
 Management address type: ipV4
 Management address: 100.1.1.244
 -----------------------------------------------------------------------------
```