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**Information technology —
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and metropolitan area networks —
Specific requirements —**

**Part 1AB:
Station and media access control
connectivity discovery**

*Technologies de l'information — Télécommunications et échange
d'information entre systèmes — Réseaux locaux et métropolitains —
Exigences spécifiques —*

*Partie 1AB: Découverte de connectivité des stations et du contrôle
d'accès aux supports*



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CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Institute of Electrical and Electronics Engineers, Inc
3 Park Avenue, New York
NY 10016-5997, USA

stds.ipr@ieee.org
www.ieee.org

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IEEE Std 802.1AB™-2016

(Revision of
IEEE Std 802.1AB-2009)

**IEEE Standard for
Local and metropolitan area networks—
Station and Media Access Control
Connectivity Discovery**

Sponsor

**LAN/MAN Standards Committee
of the
IEEE Computer Society**

Approved 29 January 2016

IEEE-SA Standards Board

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Abstract: A protocol and a set of managed objects that can be used for discovering the physical topology from adjacent stations in IEEE 802[®] LANs are defined in this document.

Keywords: IEEE 802.1AB[™], link layer discovery protocol, management information base, topology discovery, topology information

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 Weiying Cheng
 Rodney Cummings
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 Werner Hoelzl
 Noriyuki Ikeuchi
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Raj Jain
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Paul Congdon
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Stephen Haddock	Maximilian Riegel	

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This introduction is not part of IEEE Std 802.1AB™-2016, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

This revision of IEEE Std 802.1AB does not include any new functionality. It simply incorporates the following into the base text of the 2009 revision:

- IEEE Std 802.1AB-2009/Cor 1-2013
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Three annexes from the 2009 revision have been deleted:

- Annex D (Using LLDP to detect potential communication problems) was deleted because it was considered to be no longer useful.
- Annex E and Annex F were deleted because the material in them can be found in Annex D of IEEE Std 802.1Q-2014 and Clause 79 of IEEE Std 802.3-2012, respectively.

The bibliography (found in Annex G of the 2009 revision) is Annex D in this revision.

Contents

1.	Overview	1
1.1	Scope	2
1.2	Purpose	2
2.	Normative references	3
3.	Definitions and numerical representation	5
3.1	Definitions	5
3.2	Numerical representation	6
4.	Acronyms and abbreviations	7
5.	Conformance	9
5.1	Terminology	9
5.2	Protocol Implementation Conformance Statement (PICS)	9
5.3	Required capabilities	9
5.4	Optional capabilities	10
6.	Principles of operation	11
6.1	Transmission and reception	12
6.2	LLDP operational modes	12
6.3	LLDP information categories	13
6.4	TLV selection	13
6.5	Transmission principles	13
6.6	Reception principles	14
6.7	Systems with multiple LLDP Agents	14
6.8	LLDP and Link Aggregation	18
7.	LLDPDU transmission, reception, and addressing	19
7.1	Destination address	19
7.2	Source address	21
7.3	EtherType use and encoding	21
7.4	LLDPDU reception	22
8.	LLDPDU and TLV formats	23
8.1	LLDPDU bit and octet ordering conventions	23
8.2	LLDPDU format	23
8.3	TLV categories	24
8.4	Basic TLV format	24
8.5	Basic management TLV set formats and definitions	26
8.6	Organizationally Specific TLVs	34
9.	LLDP agent operation	37
9.1	Overview	37
9.2	State machines	40
10.	LLDP management	57
10.1	Data storage and retrieval	57

10.2	The LLDP management entity's responsibilities.....	57
10.3	Managed objects	59
10.4	Data types.....	59
10.5	LLDP variables	59
11.	LLDP MIB definitions.....	62
11.1	Internet Standard Management Framework.....	62
11.2	Structure of the LLDP MIB	62
11.3	Relationship to other MIBs.....	67
11.4	Security considerations for LLDP base MIB module.....	68
11.5	LLDP MIB modules	70
Annex A	(normative) PICS proforma.....	121
Annex B	(normative) PTOPO MIB update	127
Annex C	(informative) Example LLDP transmission frame formats.....	128
Annex D	(informative) Bibliography.....	129

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List of figures

Figure 6-1, LLDP agent and its relationship to its LLC entity	11
Figure 6-2, Relationship between LLDP agents, LLC Entities, MSAPs, and the LLDP management entity	15
Figure 6-3, LLDP in a MAC Bridge	16
Figure 6-4, LLDP in an end system with port-based network access control	16
Figure 6-5, LLDP in a MAC Bridge that uses port-based network access control on both ports	17
Figure 6-6, Scope of group MAC addresses	17
Figure 6-7, Multiplexing and demultiplexing using shims	18
Figure 7-1, MSDU format	19
Figure 8-1, LLDPDU format	23
Figure 8-2, Basic TLV format	24
Figure 8-3, End Of LLDPDU TLV format	26
Figure 8-4, Chassis ID TLV format	26
Figure 8-5, Port ID TLV format	28
Figure 8-6, Time To Live TLV format	29
Figure 8-7, Port Description TLV format	29
Figure 8-8, System Name TLV format	30
Figure 8-9, System Description TLV format	31
Figure 8-10, System Capabilities TLV format	31
Figure 8-11, Management Address TLV format	33
Figure 8-12, Basic format for Organizationally Specific TLVs	35
Figure 9-1, Transmit state machine	54
Figure 9-2, Receive state machine	55
Figure 9-3, Transmit timer state machine	56
Figure 11-1, LLDP MIB block diagram	62
Figure C.1, IEEE 802.3 LLDP frame format	128
Figure C.2, IEEE 802.11 LLDP frame format	128

List of tables

Table 7-1, Group MAC addresses used by LLDP	20
Table 7-2, Support for MAC addresses in different systems	21
Table 7-3, LLDP EtherType	22
Table 8-1, TLV type values	25
Table 8-2, chassis ID subtype enumeration	27
Table 8-3, port ID subtype enumeration	28
Table 8-4, System capabilities	32
Table 9-1, Subclause/operating mode applicability	37
Table 9-2, State machine symbols	41
Table 11-1, MIB object groups and operating mode applicability	63
Table 11-2, LLDP MIB structure and object cross reference	63

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IEEE Standard for Local and metropolitan area networks— Station and Media Access Control Connectivity Discovery

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1. Overview

The Link Layer Discovery Protocol (LLDP) specified in this standard allows stations attached to an IEEE 802[®] LAN to advertise, to other stations attached to the same IEEE 802 LAN, the major capabilities provided by the system incorporating that station, the management address or addresses of the entity or entities that provide management of those capabilities, and the identification of the station's point of attachment to the IEEE 802 LAN required by those management entity or entities.

The information distributed via this protocol is stored by its recipients in a standard Management Information Base (MIB), making it possible for the information to be accessed by a Network Management System (NMS) using a management protocol such as the Simple Network Management Protocol (SNMP).

1.1 Scope

The scope of this standard is to define a protocol and management elements, suitable for advertising information to stations attached to the same IEEE 802 LAN, for the purpose of populating physical topology and device discovery management information databases. The protocol facilitates the identification of stations connected by IEEE 802 LANs/MANs, their points of interconnection, and access points for management protocols.

This standard defines a protocol that

- a) Advertises connectivity and management information about the local station to adjacent stations on the same IEEE 802 LAN.
- b) Receives network management information from adjacent stations on the same IEEE 802 LAN.
- c) Operates with all IEEE 802 access protocols and network media.
- d) Establishes a network management information schema and object definitions that are suitable for storing connection information about adjacent stations.
- e) Provides compatibility with the IETF PTOPO MIB (IETF RFC 2922 [B9]).¹

1.2 Purpose

An IETF MIB (IETF RFC 2922 [B9]) and a number of vendor specific MIBs have been created to describe a network's physical topology and associated systems within that topology.

This standard specifies the necessary protocol and management elements to

- a) Facilitate multi-vendor inter-operability and the use of standard management tools to discover and make available physical topology information for network management.
- b) Make it possible for network management to discover certain configuration inconsistencies or malfunctions that can result in impaired communication at higher layers.
- c) Provide information to assist network management in making resource changes and/or re-configurations that correct configuration inconsistencies or malfunctions identified in b) above.

¹The numbers in brackets correspond to those in the bibliography in Annex D.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in the text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 802[®], IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.^{2, 3}

IEEE Std 802.1AC[™], IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

IEEE Std 802.1AE[™], IEEE Standard for Local and Metropolitan Area Networks—Media Access Control (MAC) Security.

IEEE Std 802.1AX[™], IEEE Standard for Local and Metropolitan Area Networks—Link Aggregation.

IEEE Std 802.1Q[™], IEEE Standards for Local and Metropolitan Area Networks: Bridges and Bridged Networks.

IEEE Std 802.1X[™], IEEE Standard for Local and Metropolitan Area Networks—Port-Based Network Access Control.

IEEE Std 802.3[™], IEEE Standard for Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.

IETF RFC 2863, The Interfaces Group MIB, June 2000.⁴

IETF RFC 3046, DHCP Relay Agent Information Option, January 2001.

IETF RFC 3232, Assigned Numbers: RFC 1700 is Replaced by an On-line Database, January 2002.⁵

IETF RFC 3410, Introduction and Applicability Statements for Internet Standard Management Framework, December 2002.

IETF RFC 3417, Transport Mappings for the Simple Network Management Protocol (SNMP), December 2002.

IETF RFC 3418, Management Information Base (MIB) for the Simple Network Management Protocol (SNMP), December 2002.

IETF RFC 3629, UTF-8, a transformation format of ISO 10646, November 2003.

IETF RFC 4502, Remote Network Monitoring Management Information Base Version 2, May 2006.

²IEEE and 802 are registered trademarks in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

³IEEE publications are available from The Institute of Electrical and Electronics Engineers (<http://standards.ieee.org>).

⁴IETF documents (i.e., RFCs) are available for download at <http://www.rfc-archive.org/>.

⁵The IETF RFC 3232 ianaAddressFamilyNumbers on-line database module is accessible at <http://www.iana.org>.

IETF RFC 4639, Cable Device Management Information Base for Data-Over-Cable Service Interface Specification (DOCSIS) Compliant Cable Modems and Cable Modem Termination Systems, December 2006.

IETF RFC 4789, Simple Network Management Protocol (SNMP) over IEEE 802 Networks, November 2006.

IETF RFC 6933, Entity MIB (Version 4), May 2013.

ISO/IEC 8824-1 [ITU-T Rec. X.680 (2002)], Abstract Syntax Notation One (ASN.1): Specification of Basic Notation.⁶

STANDARDSISO.COM : Click to view the full PDF of ISO/IEC/IEEE 8802-1AB:2017

⁶ASN.1 standards are available at <http://asn1.elibel.tm.fr/en/standards/index.htm#asn1>.

3. Definitions and numerical representation

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁷

alpha-numeric information: Information that is encoded using the 8-bit Universal Character Set (UCS)/Unicode Transformation Format (UTF-8) octet sequence [IETF RFC 3629].

chassis: A physical component incorporating one or more IEEE 802[®] LAN stations and their associated application functionality.

chassis identifier: An administratively assigned name that identifies the particular chassis within the context of an administrative domain that comprises one or more networks.

IEEE 802[®] LAN: Local area network (LAN) technologies that provide a media access control (MAC) Service equivalent to the MAC Service defined in IEEE Std 802.1AC.

IEEE 802[®] LAN station: An IEEE 802-compatible entity that incorporates all the necessary mechanisms to participate in media access control of an IEEE 802 LAN, and that is at least capable of providing the MAC service plus the mandatory capabilities of the LLC.

NOTE 1—For example, routers and host computers are stations in a bridged network. Bridges, in addition to their relay function, also include station capabilities.⁸

Link Layer Discovery Protocol (LLDP): A media-independent protocol capable of running on all IEEE 802[®] LAN stations and to allow an LLDP agent to learn the connectivity and management information from adjacent stations.

LLDP agent: The protocol entity that implements LLDP for a particular MSAP associated with a Port.

MAC service access point (MSAP): The access point for MAC services provided to the LLC sublayer.

MSAP identifier: The identifier of a MAC service access point.

NOTE 2—In this standard, the concatenation of the chassis identifier and the port identifier is used by LLDP as an MSAP identifier, to identify the port associated with an IEEE 802[®] LAN station.

management entity: The protocol entity that implements a particular network management protocol and that provides access support to a MIB associated with the protocol and implemented on a host chassis.

Management Information Base (MIB): The instantiation of all MIB modules in a managed entity (e.g., system or device).

Management Information Base module (MIB module): The specification or schema for a data base that can be populated with the information required to support a network management information system.

network: An interconnected group of systems, each comprising one or more IEEE 802[®] LAN stations.

⁷IEEE Standards Dictionary Online subscription is available at:
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

⁸Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

Network Management System (NMS): A management system that is capable of utilizing the information in a MIB.

object identifier (OID): An identifier used to name an object. Structurally, an OID consists of a node in a hierarchically-assigned namespace, formally defined in ISO/IEC 8824-1, Abstract Syntax Notation 1 (ASN.1). OIDs are used in this standard to identify MIB modules and the objects they contain.

physical network topology: The identification of systems, of IEEE 802[®] LAN stations that compose each system, and of the IEEE 802 LAN stations that attach to the same IEEE 802 LAN.

port: The entity in a chassis/system to support an MSAP. A port incorporates one and only one MSAP and identifies the collection of manageable entities that provide the MAC Service at the MSAP.

port identifier: An administratively assigned name that identifies the particular port within the context of a system, where the identification is convenient, local to the system, and persistent for the system's use and management (whereas the MAC address that globally identifies the MSAP can not be).

system: A managed collection of hardware and software components incorporating one or more chassis, stations and ports.

station only: A non-forwarding IEEE 802[®] LAN station such as a user workstation, network file server, or print server.

type, length, value (TLV): A short, variable length encoding of an information element consisting of sequential type, length, and value fields where the type field identifies the type of information, the length field indicates the length of the information field in octets, and the value field contains the information, itself.

3.2 Numerical representation

Decimal, hexadecimal, and binary numbers are used within this document. For clarity, decimal numbers are generally used to represent counts, hexadecimal numbers are used to represent addresses, and binary numbers are used to describe bit patterns within binary fields.

Decimal numbers are represented in their usual 0, 1, 2, ... format. Hexadecimal numbers are represented by a string of one or more hexadecimal (0–9, A–F) digits followed by the subscript 16, except in C-code contexts, where they are written as 0x123EF2, etc. Binary numbers are represented by a string of one or more binary (0,1) digits, followed by the subscript 2. Thus the decimal number “26” may also be represented as “1A₁₆” or “11010₂”.

MAC addresses, EtherType values, and OUI/EUI values are represented as strings of 8-bit hexadecimal numbers separated by hyphens and without a subscript, as, for example, “01-80-C2-00-00-15” or “AA-55-11”, using the hexadecimal representation defined in IEEE Std 802.

4. Acronyms and abbreviations

AP	Access Point
BSSID	basic service set identification
DA	Destination Address
DS	Distribution System
EPD	Ethertype Protocol Discrimination
EUI	Extended Unique Identifier
FCS	Frame Check Sequence
IANA	Internet Assigned Numbers Authority
ID	Identifier
IETF	Internet Engineering Task Force
KaY	Media access control Security Key Agreement Entity
LLC	logical link control (sublayer)
LLDP	Link Layer Discovery Protocol
LLDPDU	Link Layer Discovery Protocol data unit
LSAP	link service access point
MAC	media access control (sublayer)
MAU	medium attachment unit
MDI	media dependent interface
MIB	Management Information Base (module)
MSAP	Media access control service access point
MSDU	Media access control service data unit
NMS	Network Management System
OID	object identifier
OUI	organizationally unique identifier
PD	Powered Device
PHY	physical (sublayer)

PMD	physical media dependent (sublayer)
PSE	Power Sourcing Equipment
PVID	port virtual local area network identifier
PPVID	port and protocol virtual local area network identifier
PTOPO	the name of the Internet Engineering Task Force physical topology Management Information Base
RFC	Request for comments
SA	Source Address
SecY	Media access control Security Entity
SNAP	Subnetwork Access Protocol
SNMP	Simple Network Management Protocol
STP	Spanning Tree Protocol
TPMR	Two-port Media access control relay
TLV	type, length, value
TTL	time to live (value)
UCS	Universal Character Set
UTF-8	8-bit Universal Character Set/Unicode Transformation Format
VID	virtual local area network identifier

5. Conformance

This clause specifies the mandatory and optional capabilities provided by conformant implementations of this standard.

5.1 Terminology

For consistency with IEEE and existing IEEE 802.1™ standards terminology, requirements placed upon conformant implementations of this standard are expressed using the following terminology:

- a) *Shall* is used for mandatory requirements.
- b) *May* is used to describe implementation or administrative choices (“may” means “is permitted to,” and hence, “may” and “may not” mean precisely the same thing).
- c) *Should* is used for recommended choices (the behaviors described by “should” and “should not” are both permissible but not equally desirable choices).

The PICS proforma (see Annex A) reflects the occurrences of the words *shall*, *may*, and *should* within the standard.

The standard avoids needless repetition and apparent duplication of its formal requirements by using *is*, *is not*, *are*, and *are not* for definitions and the logical consequences of conformant behavior. Behavior that is permitted but is neither always required nor directly controlled by an implementor or administrator, or whose conformance requirement is detailed elsewhere, is described by *can*. Behavior that never occurs in a conformant implementation or system of conformant implementations is described by *can not*. The word *allow* is used as a replacement for the phrase “support the ability for,” and the word *capability* means “is able to, or can be configured to.”

5.2 Protocol Implementation Conformance Statement (PICS)

The supplier of an implementation that is claimed to conform to this standard shall complete a copy of the PICS proforma provided in Annex A and shall provide the information necessary to identify both the supplier and the implementation.

5.3 Required capabilities

A system for which conformance to this standard is claimed shall, for all ports for which support is claimed, include the following capabilities:

- a) If port access is controlled by IEEE Std 802.1X,⁹ LLDP exchanges shall be supported through the controlled port, as specified in Clause 6.
- b) The destination and source addressing shall conform to 7.1 and 7.2.
- c) EtherType encapsulation shall conform to 7.3.
- d) LLDPDU recognition and reception shall conform to the operation of the receive state machine as defined in 9.2.9.
- e) LLDPDU encapsulation shall conform to the specifications in 8.2.
- f) The basic TLV format capability shall be implemented as defined in 8.4.
- g) The basic management set of TLVs shall be implemented as defined in 8.5.
- h) The Organizationally Specific TLV format capability shall be implemented as defined in 8.6.

⁹Information on references can be found in Clause 2.

- i) The protocol shall conform to the specifications for all Clause 9 subclauses indicated in Table 9-1 for the particular operating mode (transmit only, receive only, or transmit and receive) being implemented.
- j) If receipt of LLDPDUs is supported, for every set of TLVs (the basic management set and any organizationally specific sets) supported, support shall be implemented for receipt of every TLV defined in the set.
- k) If transmission of LLDPDUs is supported, for every set of TLVs (the basic management set and any organizationally specific sets) supported, support shall be implemented for transmission of every TLV defined in the set.
- l) If transmission of LLDPDUs is supported, for every set of TLVs (the basic management set and any organizationally specific sets) supported, a capability shall be implemented for users to determine which optional TLVs are transmitted in any particular LLDPDU.
- m) If SNMP is supported, then
 - 1) The system shall conform to the LLDP management specifications in Clause 11 and shall implement the sections of version 2 of the basic LLDP MIB indicated in Table 11-1 for the operating mode being implemented.
 - 2) The system shall support at least one of the transport mappings defined by IETF RFC 3417 or IETF RFC 4789.
- n) If SNMP is not supported, the system shall provide storage and retrieval capability equivalent to the functionality specified in 10.1 for the operating mode being implemented.

5.4 Optional capabilities

A system for which conformance to this standard is claimed may, for each port for which support is claimed, support the following capabilities:

- a) If port access is controlled by IEEE Std 802.1X, LLDP exchanges may be supported through the uncontrolled port, as specified in Clause 6.

6. Principles of operation

LLDP is a link layer protocol that allows an IEEE 802 LAN station to advertise the capabilities and current status of the system associated with an MSAP. The MSAP provides the MAC service to an LLC Entity, and that LLC Entity provides an LSAP to an LLDP agent that transmits and receives information to and from the LLDP agents of other stations attached to the same LAN. The information distributed and received in each LLDPDU is stored in one or more Management Information Bases (MIBs). Figure 6-1 illustrates the LLDP agent and its relationship to its LLC Entity and MSAP, and to additional MIBs designed by the IETF, IEEE 802, and others.

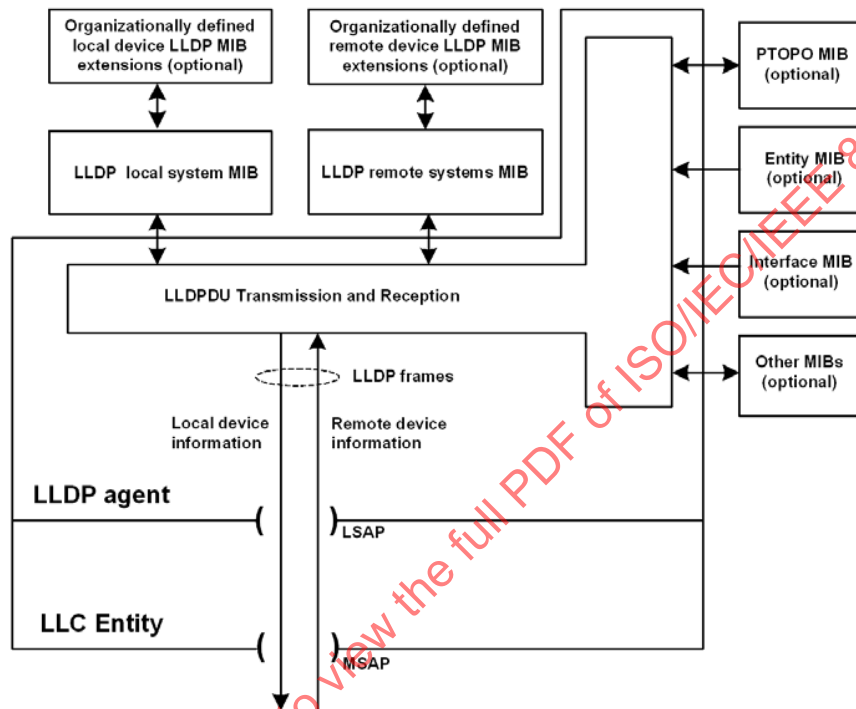


Figure 6-1—LLDP agent and its relationship to its LLC entity

This clause describes general principles of LLDP operation. The following clauses specify transmission, reception, and addressing of LLDPUs (Clause 7); LLDPDU formats (Clause 8); operation of each LLDP agent in detail including state machines (Clause 9); management of LLDP (Clause 10); and the MIB module used for LLDP management (Clause 11).

NOTE 1—For the purposes of this standard, the terms “LLC” and “LLC entity” include the service provided by the operation of entities that support protocol discrimination using an EtherType; i.e., protocol discrimination based on the Type interpretation of the Length/Type field as specified in IEEE Std 802.3, or the use of the SNAP encapsulation of EtherTypes as described in IEEE Std 802. Hence, “LSAP” in the above description can refer to the use of IEEE Std 802.2 LLC addresses, or an EtherType, as a means of higher layer protocol identification.

NOTE 2—The LLC Entity also provides distinct LSAPs to other higher layer protocol entities (such as those responsible for the Spanning Tree Protocol and IP). In a bridge, the LLC Entity associated with each Bridge Port is modeled as being directly connected to the attached LAN, as discussed in 8.13.9 of IEEE Std 802.1Q-2014, so the operation of LLDP is unaffected by the spanning tree Port State.

6.1 Transmission and reception

The information fields in each LLDP frame are contained in a Link Layer Discovery Protocol Data Unit (LLDPDU) as a sequence of variable length information elements, that each include type, length, and value fields (known as TLVs), where

- a) Type identifies what kind of information is being sent.
- b) Length indicates the length of the information string in octets.
- c) Value is the actual information that needs to be sent (for example, a binary bit map or an alpha-numeric string that can contain one or more fields).

Each LLDPDU contains the following three mandatory TLVs (see Table 8-1), and can contain optional TLVs as selected by network management:

- d) A Chassis ID TLV.
- e) A Port ID TLV.
- f) A Time To Live TLV.
- g) Zero or more optional TLVs, as allowed by the maximum size of the LLDPDU.
- h) An optional End Of LLDPDU TLV.

The chassis ID and the port ID values are concatenated to form a logical MSAP identifier that is used by the recipient to identify the sending LLDP agent/port. Both the chassis ID and port ID values can be defined in a number of convenient forms. Once selected, however, the chassis ID/port ID value combination remains the same as long as the particular port remains operable.

NOTE 1—The statement above is true for any LLDP agent; however, there can be multiple LLDP agents sending and receiving LLDPDUs using different MAC addresses.

A non-zero value in the time to live (TTL) field of the Time To Live TLV tells the receiving LLDP agent how long all information pertaining to this LLDPDU's MSAP identifier is valid so that all the associated information can later be automatically discarded by the receiving LLDP agent if the sender fails to update it in a timely manner. A zero value indicates that any information pertaining to this LLDPDU's MSAP identifier is to be discarded immediately.

NOTE 2—A TTL value of zero can be used, for example, to signal that the sending port has initiated a port shutdown procedure.

The End Of LLDPDU TLV marks the end of the LLDPDU.

The format for the LLDPDU is defined in 8.2. The TLV categories and the basic TLV format are defined in 8.3 and 8.4. The specific format and field contents for the Chassis ID TLV are defined in 8.5.2; for the Port ID TLV in 8.5.3; for the Time To Live TLV in 8.5.4; and for the End Of LLDPDU TLV, in 8.5.1.

6.2 LLDP operational modes

LLDP is a one way protocol. An LLDP agent can transmit information about the capabilities and current status of the system associated with its MSAP identifier. The LLDP agent can also receive information about the capabilities and current status of the system associated with a remote MSAP identifier. LLDP does not itself contain a mechanism for soliciting specific information from other LLDP agents, nor does it provide a specific means of confirming the receipt of information.

NOTE—The LLDP protocol is designed to advertise information useful for discovering pertinent information about a remote port and to populate topology MIBs. It is not intended to act as a configuration protocol for remote systems, nor as a mechanism to signal control information between ports. During the operation of LLDP, it may be possible to

discover configuration inconsistencies between systems on the same IEEE 802 LAN. LLDP does not provide a mechanism to resolve those inconsistencies. Rather, it provides a means to report discovered information to higher layer management entities.

LLDP allows the transmitter and the receiver to be separately enabled, making it possible to configure an implementation so the local LLDP agent can either transmit only or receive only, or so the local LLDP agent can transmit and receive LLDP information.

6.3 LLDP information categories

The following basic management TLV set (this set is required in all LLDP implementations) is defined by this standard and can be used to describe the system and/or to assist in the detection of configuration inconsistencies associated with the MSAP identifier:

- a) Port Description TLV.
- b) System Name TLV.
- c) System Description TLV.
- d) System Capabilities TLV (indicates both the system's capabilities and its current primary network function, such as end station, bridge, router).
- e) Management Address TLV.

Table 8-1 includes a list of the optional TLVs in the basic management set and provides subclause references for their specific definitions.

Organizationally Specific TLVs can be defined by either the professional organizations or the individual vendors that are involved with the particular functionality being implemented within a system. The basic format and procedures for defining Organizationally Specific TLVs are provided in 8.6.

6.4 TLV selection

Information for constructing the various TLVs to be sent is stored in the LLDP local system MIB. The selection of which particular TLVs to send is under control of network management. Information received from remote LLDP agents is stored in the LLDP remote systems MIB.

6.5 Transmission principles

Transmission can be initiated either by the expiration of a transmit countdown timing counter or by a change in the value of one or more of the information elements (managed objects) associated with the local system. When a transmit cycle is initiated, the LLDP management entity extracts the managed objects from the LLDP local system MIB and formats this information into TLVs. The TLVs are inserted into an LLDPDU that is passed to the LLDP transmit module. The LLDP transmit module prepends addressing parameters to the LLDPDU as defined in 8.2, 8.3, and 8.4. The LLDPDU and TLV formats are defined in Clause 8. The LLDP transmit state machine is described in 9.2.1 and 9.2.8.

NOTE 1—Because a transmission cycle can be initiated whenever a change occurs within the LLDP local system MIB, it is possible that a series of successive changes over a short period of time could trigger a number of LLDP frames to be sent, each reporting only a single change. LLDP utilizes a transmission delay timer that can be set by network management to ensure that there is a defined maximum number of LLDPDU transmissions in a given time period.

NOTE 2—Under normal circumstances, the information in the receiving LLDP agent's remote systems MIB is refreshed periodically to avoid being discarded due to ageing. To prevent the receiving LLDP agent's remote systems MIB information being aged out because a refresh frame has been lost in transmission, the sending LLDP agent typically sets the TTL value so that several refresh cycles can occur before the received MIB information ages out.

LLDP can disclose information about a device and network that could be considered sensitive in certain environments. Implementers are encouraged to provide controls that take into account the link protection characteristics when including information in an LLDP message. Different information can be included if an LLDP message is being sent on the uncontrolled port, the controlled port, or a MACsec protected connectivity association.

6.6 Reception principles

The LLDP receive module uses the services of the LLC entity to recognize that the incoming MA_UNITDATA.indication contains the correct combination of destination address and MSDU header values to identify it as resulting from a received LLDPDU. The LLDPDU recognition procedures are defined in 7.4 and 9.2.7.7.

6.6.1 LLDPDU and TLV error handling

The LLDPDU is checked to ensure that it contains the correct sequence of three mandatory TLVs at the beginning of the frame (Chassis ID TLV, Port ID TLV, and Time To Live TLV) and then each optional TLV is validated in succession. LLDPDUs that contain detectable errors in the first three mandatory TLVs are discarded. Optional TLVs that contain detectable errors are discarded [see 9.2.7.7.2 c)]. TLVs that are not recognized, but that also contain no basic format errors, are assumed to be valid and are stored for possible later retrieval by network management (see 9.2.7.7.1 and 9.2.7.4). If the End Of LLDPDU TLV is present, any octets that follow it are discarded.

TLVs in which the information string length field contains a value that is greater than the sum of the lengths of the fields within the information string are not discarded.

NOTE—This approach allows later versions of a TLV to define additional fields at the end of the information string; implementations based on an earlier version of the TLV can therefore continue to process the fields that were defined in that version and ignore any new fields added at the end of the information string in later versions. Any information contained in such new fields is not made available to network management protocols via the standard MIB.

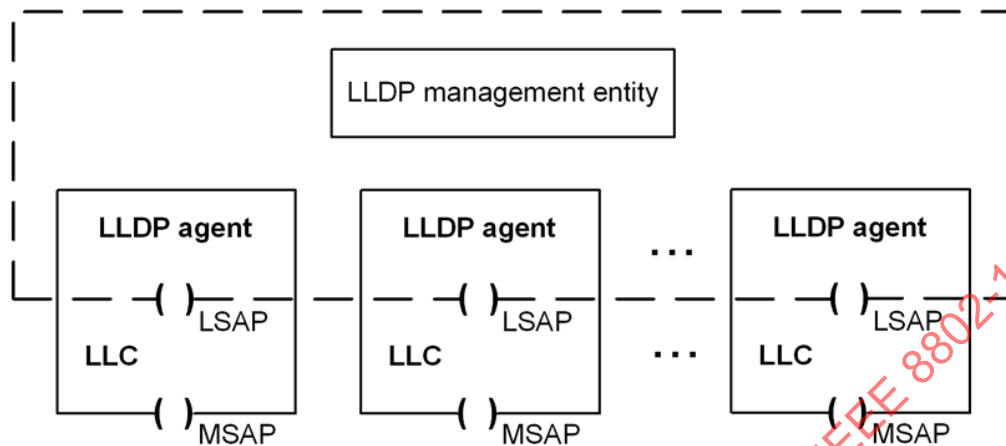
6.6.2 LLDP remote systems MIB update

The LLDP remote systems MIB is updated after all TLVs have been validated. LLDP remote system MIB update procedures are defined in 9.2.7.7.4, 9.2.7.7.5, and 9.2.7.4. The LLDP receive state machine is described in 9.2.1 and 9.2.9.

6.7 Systems with multiple LLDP Agents

Each LLDP agent advertises a single set of information in the various TLVs it encodes in each transmitted LLDPDU, and is associated with the MSAP that supports the LLC entity that the agent uses to transmit and receive. Each LLDP agent uses its LSAP directly, without the use of any additional multiplexing or addressing above the LSAP to support the use of that LSAP by multiple agents; and each LLC entity provides service to one and only one protocol entity at each of its LSAPs that it supports, using the service provided by a single MSAP. It follows that each LLDP agent makes use of a unique MSAP, and that the agent can be uniquely identified by the receiving agent using the MSAP's identifier as specified in 6.2. A single LLDP management entity can support the operation of multiple LLDP agents within the same system.

Figure 6-2 illustrates the relationship between the LLDP agents, LLC Entities, MSAPs, and the LLDP management entity.



LLDP - Link Layer Discovery Protocol
LSAP - Link service access point
MSAP - MAC service access point

Figure 6-2—Relationship between LLDP agents, LLC Entities, MSAPs, and the LLDP management entity

A given system can require the use of multiple LLDP agents because it naturally comprises multiple MSAPs, or because it needs to be able to transmit different information (different sets of TLVs) to different sets of peers. These sets of peers can be determined by the way that the MAC service is supported within the system (see IEEE Std 802.1AC-2015 for a description of the connectionless connectivity that characterizes an IEEE 802 LAN). A MAC Bridge (see IEEE Std 802.1Q), for example, attaches to multiple LANs, each providing the MAC service at a distinct MSAP. A different example is a station that uses port-based network access control (IEEE Std 802.1X) to provide both a Controlled Port and an Uncontrolled Port, i.e., two distinct MSAPs with potentially different connectivity, for transmission and reception to and from a single LAN. Similarly, different destination addresses can be associated with different sets of potential recipients. Table 7-1 identifies group MAC addresses that can be used for LLDPDU transmission, and 7.1 describes the different transmission scopes associated with each address. LLDP can also be used in conjunction with individual MAC addresses, and with other group MAC addresses. Distinct LLDP agents, and hence separate and distinct protocol state machines, local and remote MIB tables, and MSAPs are maintained for each LLDPDU destination address, even if the use of two or more MSAPs can result in transmission and reception on the same LAN.

NOTE—For a given MAC address that is used as a destination address in received LLDPDUs, there is the possibility for a station to receive LLDPDUs from multiple senders. All LLDPDUs that carry that destination MAC address are received by a single LLDP agent, via a single MSAP; however, as the LLDPDU carries information that identifies the source of the LLDPDU, information carried in LLDPDUs from different senders is able to be recorded independently in the remote systems MIB.

Figure 6-3 illustrates the use of LLDP in a MAC Bridge, with an LLDP agent for each of the two ports shown. Figure 6-4 shows the use of LLDP in an end system with port-based network access control (IEEE Std 802.1X) supported by MACsec (IEEE Std 802.1AE); an LLDP agent is supported by the Controlled Port and an additional LLDP agent may be supported by the Uncontrolled Port. Figure 6-5 shows LLDP in a MAC Bridge that uses port-based network access control on both ports.

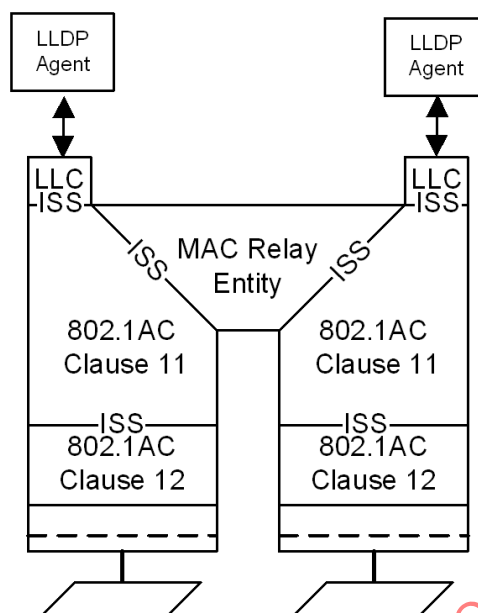


Figure 6-3—LLDP in a MAC Bridge

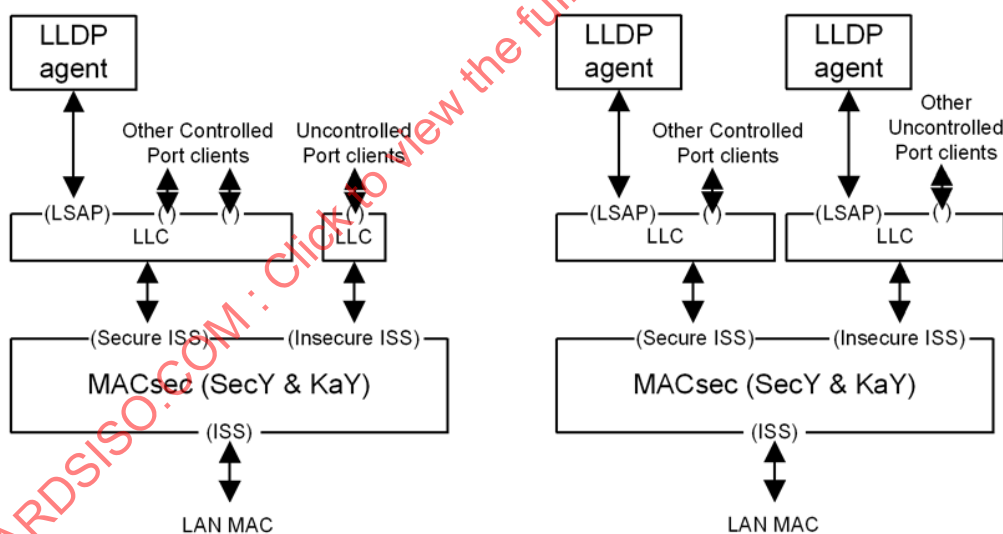


Figure 6-4—LLDP in an end system with port-based network access control

LLDP frames sent on an unprotected link may be modified by an attacker. If an implementation is going to take action based upon a received LLDP attribute, it is advisable to take into account whether the message was received on a protected link, and allow for the system to be configured such that only information received in protected messages is acted upon.



The diagram shows a network topology with several bridges connected in a line. From left to right, the components are:

- Customer Bridge**: The leftmost bridge.
- Nearest non-TPMR Bridge**: A bridge connected to the Customer Bridge.
- S-VLAN Bridge**: A bridge connected to the Nearest non-TPMR Bridge.
- Nearest non-TPMR Bridge**: A bridge connected to the S-VLAN Bridge.
- S-VLAN Bridge**: A bridge connected to the Nearest non-TPMR Bridge.
- Nearest Bridge**: A bridge connected to the S-VLAN Bridge.
- TPMR**: A bridge connected to the Nearest Bridge.
- Nearest Bridge**: A bridge connected to the TPMR.
- Customer Bridge**: The rightmost bridge.

Arrows indicate the selection process:

- A dashed arrow labeled **Nearest Bridge** points from the Customer Bridge to the Nearest non-TPMR Bridge.
- A dashed arrow labeled **Nearest non-TPMR Bridge** points from the Nearest non-TPMR Bridge to the S-VLAN Bridge.
- A dashed arrow labeled **Nearest Bridge** points from the S-VLAN Bridge to the Nearest non-TPMR Bridge.
- A dashed arrow labeled **Nearest Bridge** points from the Nearest non-TPMR Bridge to the S-VLAN Bridge.
- A dashed arrow labeled **Nearest Bridge** points from the S-VLAN Bridge to the Nearest Bridge.
- A dashed arrow labeled **Nearest Bridge** points from the TPMR to the Nearest Bridge.
- A dashed arrow labeled **Nearest Bridge** points from the Nearest Bridge to the Customer Bridge.

More than one LLDP agent, each using a different address scope, can be instantiated for a given system port by adding a simple shim that provides the necessary distinct MSAPs by multiplexing and demultiplexing between those MSAPs and a common MSAP for the port, as illustrated in Figure 6-7.

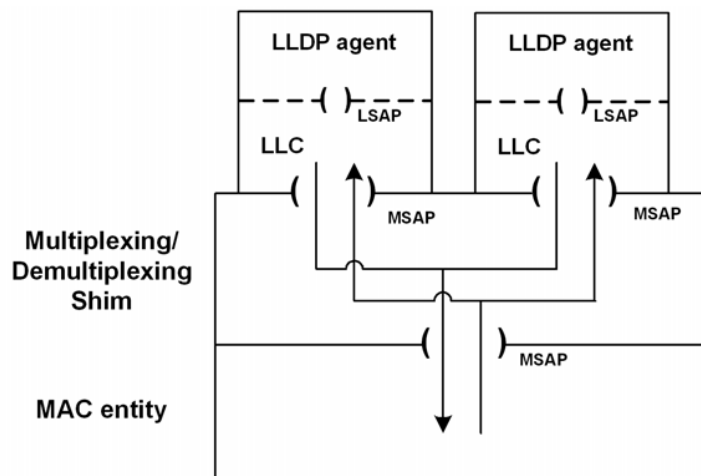


Figure 6-7—Multiplexing and demultiplexing using shims

6.8 LLDP and Link Aggregation

An LLDP agent can be configured on an IEEE 802.1AX™ Aggregated Port and/or on any number of the physical ports belonging to the Aggregation. Some TLVs (e.g., the Power Via MDA TLV defined in 79.3.2 of IEEE Std 802.3-2012) only make sense when transmitted from an LLDP agent configured on a physical port, and can cause incorrect operation if configured on an Aggregation. Other TLVs (e.g., the DCBX TLVs defined in 38.4 of IEEE Std 802.1Q-2014) make sense only when transmitted from an Aggregated Port, because they carry information applicable to the simulated single interface represented by the Aggregation. Not all standards that define LLDP TLVs are careful to state whether each TLV is applicable to an Aggregation, to a physical port, or to both. Only LLDP TLVs that are appropriate for transmission on a given Port should be transmitted on that Port.

An LLDP agent configured on an Aggregated Port, or on one of the physical ports of an Aggregation, transmits the Link Aggregation TLV, and processes received LLDPDUs, as specified in F.1 of IEEE Std 802.1AX-2014. An LLDP agent configured on a physical port of an Aggregation uses the LLDP Parser/Multiplexer as specified in 6.1.3 of IEEE Std 802.1AX-2014 for the transmission and reception of LLDPDUs containing TLVs that are specific to that physical port. Since a port not running Link Aggregation is equivalent to an Aggregation with a single physical port, any LLDP agent can transmit the Link Aggregation TLV and process received LLDPDUs as specified in 802.1AX.

NOTE—The consideration of aggregated vs. Physical ports is similar to the distinction among destination MAC addresses discussed in 7.1. In both cases, LLDP TLVs that carry information specific to a physical link should be used only in the LLDP agent with the shortest reach.

7. LLDPDU transmission, reception, and addressing

This standard is intended to be compatible with all IEEE 802 MACs.

LLDP uses the service provided by the LLDP/LSAP and LLC to transmit and receive LLDPDUs. Each LLDPDU is transmitted as a single MAC service request by an LLC entity that uses a single instance of the MAC Service provided at an MSAP. Each incoming LLDP frame is received at the MSAP by the LLC entity as a MAC service indication.

NOTE—For the purposes of this standard, the terms “LLC” and “LLC entity” include the service provided by the operation of entities that support protocol discrimination using an EtherType, i.e., EtherType Protocol Discrimination (EPD) as specified in IEEE Std 802.

The parameters of each service request and service indication comprise

- a) Destination address
- b) Source address
- c) EtherType
- d) LLDPDU

The LLDP EtherType, used to identify the LLDP protocol, is prepended to the LLDPDU as shown in Figure 7-1 to form the MSDU of the corresponding MAC service request.



Figure 7-1—MSDU format

The values of the parameters used by LLDP, and their encoding by the LLC entity that supports the LLDP LSAP, are specified in the following subclauses.

7.1 Destination address

A set of standard group MAC addresses that can be used by LLDP is specified in Table 7-1. These addresses are in the range of IEEE Std 802.1Q C-VLAN and MAC Bridge component Reserved addresses (see Table 8-1 in IEEE Std 802.1Q-2014), the S-VLAN component Reserved addresses (see Table 8-2 in IEEE Std 802.1Q-2014), and the TPMR component Reserved addresses (see Table 8-3 in IEEE Std 802.1Q-2014). The choice of address used determines the scope of propagation of LLDPDUs within a bridged LAN, as follows:

- a) The **nearest bridge** group MAC address is an address that no conformant Two-Port MAC Relay (TPMR) component, S-VLAN component, C-VLAN component, or MAC Bridge component can forward. LLDPDUs transmitted using this destination address can therefore travel no further than those stations that can be reached via a single individual LAN from the originating station. LLDPDUs received on this address therefore represent information about stations that are attached to the same individual LAN segment as the recipient station.

NOTE 1—This address was selected in order to make it possible to transmit an LLDP frame containing information specific to a single individual LAN, and for that information not to be propagated further than the extent of that individual LAN, to avoid the meaning of that information being misinterpreted. For example, a TLV containing the auto-negotiation status of an IEEE 802.3™ LAN would be open to misinterpretation if it were to be propagated via a Bridge

onto a second IEEE 802.3 LAN, and would be meaningless if propagated onto a LAN based on a different MAC technology. This is the “LLDP_Multicast address” that was used in IEEE Std 802.1AB-2005. This address was erroneously omitted from the table of S-VLAN component Reserved addresses added to IEEE Std 802.1Q by IEEE Std 802.1ad-2005, but has been added to that table by IEEE Std 802.1aj™-2009 [B1] and is included in subsequent revisions of IEEE Std 802.1Q.

- b) The **nearest non-TPMR bridge** group MAC address is an address that no conformant C-VLAN component, S-VLAN component, or MAC Bridge can forward. However, this address is relayed by TPMR components. Therefore, LLDPDUs received on this address represent information about stations that are not separated from the recipient station by any intervening C-VLAN component, S-VLAN component, or MAC Bridge. There may, however, be one or more TPMR components in the path between the originating and receiving stations.

NOTE 2—This address was selected in order to make it possible to communicate information between adjacent bridges and for that communication to be transparent to the presence or absence of TPMRs in the transmission path. This address is primarily intended for use within provider bridged networks.

- c) The **nearest Customer Bridge** group MAC address is an address that no conformant C-VLAN component or MAC Bridge forwards. However, this address is relayed by TPMR components and S-VLAN components. Therefore, LLDPDUs received on this address represent information about stations that are not separated from the recipient station by any intervening C-VLAN components (e.g., a C-VLAN Bridge or Provider Edge Bridge). There may, however, be TPMR components and/or S-VLAN components in the path between the originating and receiving stations.

NOTE 3—This address was selected in order to make it possible to communicate information between adjacent Customer Bridges and for that communication to be transparent to the presence or absence of TPMRs or S-VLAN components in the communication path. The scope of this address is the same as that of a customer-to-customer MACSec connection.

Table 7-1—Group MAC addresses used by LLDP

Name	Value	Purpose
Nearest bridge	01-80-C2-00-00-0E	Propagation constrained to a single physical link; stopped by all types of bridge
Nearest non-TPMR bridge	01-80-C2-00-00-03	Propagation constrained by all bridges other than TPMRs; intended for use within provider bridged networks
Nearest Customer Bridge	01-80-C2-00-00-00	Propagation constrained by customer bridges; this gives the same coverage as a customer-customer MACSec connection

NOTE 4—The LSAP or EtherType field is necessary to distinguish between different protocols conveyed in frames with the same group or individual destination address. Prior to revision of this standard to allow multiple address scopes, the destination address 01-80-C2-00-00-00 was only explicitly specified for Spanning Tree Protocol BPDUs. It is therefore possible that some implementations recognize only a frame's destination address before applying priority handling resources intended to guard against BPDUs loss. Since LLDP rate limits LLDPDU transmission, the additional consumption of these resources by LLDPDUs is unlikely to pose a problem for robust implementations.

It is assumed in the foregoing definitions of the scope of these group MAC addresses that an end station attached to an individual LAN is a potential recipient of any of these addresses, and therefore such end stations fall within the scope of these addresses as well as the identified bridge components.

In addition to determining the scope of transmission, the support of more than one destination MAC address allows different sets of TLVs to be supported over the different transmission scopes.

In addition to the prescribed support for standard group MAC addresses shown in Table 7-1, implementations of LLDP may support the following destination addresses for LLDPDUs:

- d) Any group MAC address.
- e) Any individual MAC address.

Support for the use of each of these destination addresses, for both transmission and reception of LLDPDUs, is either mandatory, recommended, permitted, or not permitted, according to the type of system in which LLDP is implemented, as shown in Table 7-2.

Table 7-2—Support for MAC addresses in different systems

Address	C-VLAN Bridge	S-VLAN Bridge	TPMR Bridge	End station
<i>Nearest bridge</i>	Mandatory	Mandatory	Mandatory	Mandatory
<i>Nearest non-TPMR bridge</i>	Mandatory	Mandatory	Not permitted	Recommended
<i>Nearest Customer Bridge</i>	Mandatory	Not permitted	Not permitted	Recommended
<i>Any other group MAC address</i>	Permitted	Permitted	Permitted	Permitted
<i>Any individual MAC address</i>	Permitted	Permitted	Permitted	Permitted

NOTE 5 —Where the implementation supports the use of individual MAC addresses, there is a need for some means whereby the sender can ascertain what address to use, and what scope is associated with that address; how this is achieved is outside the scope of this standard.

NOTE 6—The option of using an individual MAC addresses supports the use of LLDP in IEEE Std 802.11™ [B2] and other wireless LANs, where it is desirable to target specific TLV content at specific logical Ports. In particular, the use of an individual MAC address allows an access point to direct LLDP frames at an individual station with which it is associated.

NOTE 7—If an individual MAC address is used as the destination address by a given LLDP Agent, then that agent would not also receive LLDPDUs on that address; it makes no sense for an LLDP Agent to send LLDP frames to an individual MAC address that it also receives LLDP frames on. Similarly, if an Agent is able to receive LLDPDUs sent to a given individual MAC address, it would not also transmit LLDPDUs to that address. Therefore, Agents associated with individual MAC addresses are either transmitters or receivers of LLDPDUs for a given address, but not both.

NOTE 8—The destination MAC address used by a given LLDP agent defines only the scope of transmission and the intended recipient(s) of the LLDPDUs; it plays no part in protocol identification. In particular, the group MAC addresses identified in Table 7-1 are not used exclusively by LLDP; other protocols that require to use a similar transmission scope are free to use the same addresses.

7.2 Source address

The source address shall be the individual MAC address of the sending station or port.

7.3 EtherType use and encoding

The EtherType used to identify the LLDP protocol shall be the LLDP EtherType specified in Table 7-3.

Table 7-3—LLDP EtherType

Name	Value
LLDP EtherType	88-CC

Where the LLC entity uses an MSAP that is supported by a specific media access control method (for example, IEEE Std 802.3) or a media access control independent entity (for example, IEEE Std 802.1AE) that directly supports encoding of EtherTypes, the LLC entity shall encode the LLDP EtherType as the two octet LLDPDU header in the MSDU of the corresponding MAC service request.

Where the LLC entity uses an MSAP that is supported by a specific media access control method that does not directly support EtherType encoding (for example, IEEE Std 802.11 [B2]), the encoding shall be as specified in IEEE Std 802.1AC.

NOTE—Annex C provides example LLDP transmission frame formats for both direct-encoded and SNAP-encoded LLDP EtherType encoding methods.

7.4 LLDPDU reception

The LLDPDU shall be delivered to the LLDP receive module if, and only if

- a) The destination MAC address is equal to the MAC address associated with the corresponding LLDP Agent; and

NOTE—The destination MAC address can be one of the addresses in Table 7-1, or any other valid MAC address—see 7.1.

- b) The EtherType is equal to the value shown in Table 7-3.

8. LLDPDU and TLV formats

8.1 LLDPDU bit and octet ordering conventions

All LLDPDUs shall contain an integral number of octets. The octets in an LLDPDU are numbered starting from 1 and increasing in the order they are put into the LLDPDU. The bits in an octet are numbered from 1 to 8, where bit 1 is the low-order bit.

When consecutive bits within an octet are used to represent a binary number, the highest bit number has the most significant value. When consecutive octets are used to represent a binary number, the lower octet number has the most significant value. All TLVs respect these bit and octet ordering conventions.

When the encoding of a field or a number of fields is represented using a diagram

- a) Octets are shown with the lowest numbered octet nearest the left of the page, the octet numbering increasing from left to right.
- b) Within an octet, bits are shown with bit 8 to the left and bit 1 to the right.

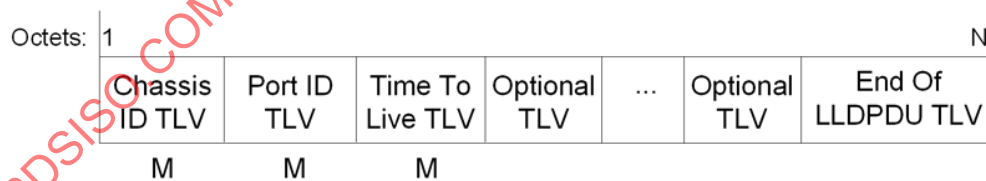
8.2 LLDPDU format

The LLDPDU shall contain the following ordered sequence of three mandatory TLVs followed by zero or more optional TLVs as shown in Figure 8-1. An End of LLDPDU TLV may be present as the last TLV in the LLDPDU.

- a) Three mandatory TLVs shall be included at the beginning of each LLDPDU and shall be in the order shown.
 - 1) Chassis ID TLV
 - 2) Port ID TLV
 - 3) Time To Live TLV
- b) Optional TLVs as selected by network management (may be inserted in any order).

NOTE 1—"Optional" in the sense that they are not required for LLDP operation; however, their presence could be required by other system elements that use LLDP.

- c) If the End Of LLDPDU TLV is present, it shall be the last TLV in the LLDPDU.



M - mandatory TLV - required for all LLDPDUs

Figure 8-1—LLDPDU format

The maximum length of the LLDPDU shall be the maximum information field length allowed by the particular transmission rate and protocol. In IEEE 802.3 MACs, for example, the maximum LLDPDU length is the maximum data field length for the basic, untagged MAC frame (1500 octets).

NOTE 2—There is no defined minimum length of an LLDPDU, other than that implied by the requirement that conformant implementations support the mandatory TLVs specified in Table 8-1.

8.3 TLV categories

The TLVs are grouped into two general categories as follows:

- a) A set of TLVs that are considered to be basic to the management of network stations and that are a required capability of all LLDP implementations. Each TLV in this category is identified by a unique TLV type value that indicates the particular kind of information contained in the TLV.
- b) Organizationally specific extension sets of TLVs that are defined by standards groups such as IEEE 802.1 and IEEE 802.3 and others to enhance management of network stations that are operating with particular media and/or protocols.
 - 1) TLVs in this category are identified by a common TLV type value that indicates the TLV as belonging to the set of Organizationally Specific TLVs.
 - 2) Each organization is identified by its organizationally unique identifier (OUI).
 - 3) Organizationally Specific TLV subtype values indicate the kind of information contained in the TLV.

The basic TLV format and general field definition rules are defined in 8.4. Specific definitions and usage requirements for all basic management set TLVs are defined in 8.5. Usage rules/requirements that pertain to each individual basic TLV are contained in the definition for that particular TLV.

The basic format and the field definition/general usage rules/restrictions for Organizationally Specific TLVs are defined in 8.6. Usage rules/requirements that pertain to each individual basic TLV are contained in the definition for that particular TLV.

8.4 Basic TLV format

Figure 8-2 shows the basic TLV format.

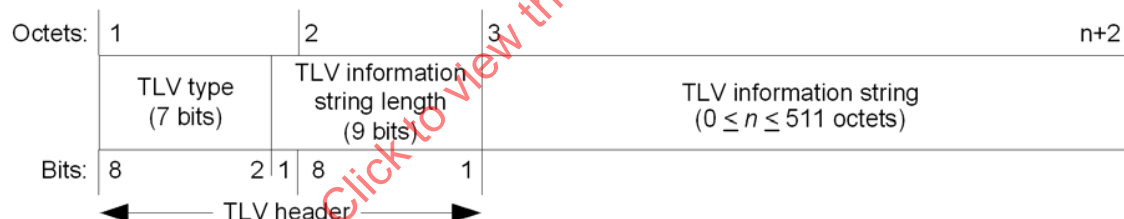


Figure 8-2—Basic TLV format

The TLV type field occupies the seven most significant bits of the first octet of the TLV format. The least significant bit in the first octet of the TLV format is the most significant bit of the TLV information string length field.

8.4.1 TLV type

The TLV type field is seven bits long and identifies the specific TLV. Two classes of TLVs are defined:

- a) Mandatory TLVs that shall be included in all LLDPDUs.
- b) Optional TLVs that may be included in LLDPDUs.

Table 8-1 lists the currently defined TLVs, their identifying TLV type values, and whether they are mandatory or optional for inclusion in any particular LLDPDU.

Table 8-1—TLV type values

TLV type ^a	TLV name	Usage in LLDPDU	Reference
0	End Of LLDPDU	Optional	8.5.1
1	Chassis ID	Mandatory	8.5.2
2	Port ID	Mandatory	8.5.3
3	Time To Live	Mandatory	8.5.4
4	Port Description	Optional	8.5.5
5	System Name	Optional	8.5.6
6	System Description	Optional	8.5.7
7	System Capabilities	Optional	8.5.8
8	Management Address	Optional	8.5.9
9–126	Reserved for future standardization	—	—
127	Organizationally Specific TLVs	Optional	—

^aTLVs with type values 0–8 are members of the basic management set.

8.4.2 TLV information string length

The TLV information string length field shall contain the length of the information string, in octets.

8.4.3 TLV information string

The information string

- a) May be fixed or variable length.
- b) May include one or more information fields with associated subtype identifiers and field length designators as in, for example, the Management Address TLV (see 8.5.9).
- c) May contain either binary or alpha-numeric information that is instance specific for the particular TLV type and/or subtype.
 - 1) Bit 1 in binary bit maps shall be the least significant bit in the field.
 - 2) The first octet of an alpha-numeric field shall be the most significant octet.
 - 3) Alpha-numeric information shall be encoded in UTF-8 [IETF RFC 3629].

8.5 Basic management TLV set formats and definitions

8.5.1 End Of LLDPDU TLV

The End Of LLDPDU TLV is a 2-octet, all-zero TLV that is used to mark the end of the TLV sequence in LLDPDUs. The format for this TLV is shown in Figure 8-3.

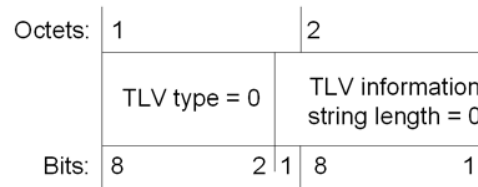


Figure 8-3—End Of LLDPDU TLV format

NOTE—Some IEEE 802 MACs require the data field in a frame to contain a minimum number of octets. For example, the IEEE 802.3 MAC adds pad octets to complete a minimum length data field if the user's data is less than the minimum required length. Since pad octets are unspecified, an End Of LLDPDU TLV can be used to prevent non-zero pad octets from being interpreted by the receiving LLDP agent as another TLV.

8.5.2 Chassis ID TLV

The Chassis ID TLV is a mandatory TLV that identifies the chassis containing the IEEE 802 LAN station associated with the transmitting LLDP agent. There are several ways in which a chassis may be identified and a chassis ID subtype is used to indicate the type of component being referenced by the chassis ID field. Each LLDPDU shall contain one, and only one, Chassis ID TLV and the chassis ID field value shall remain constant for all LLDPDUs while the MAC status parameter for the Port remains operational.

The Chassis ID TLV shall be the first TLV in the LLDPDU. Its format is shown in Figure 8-4.

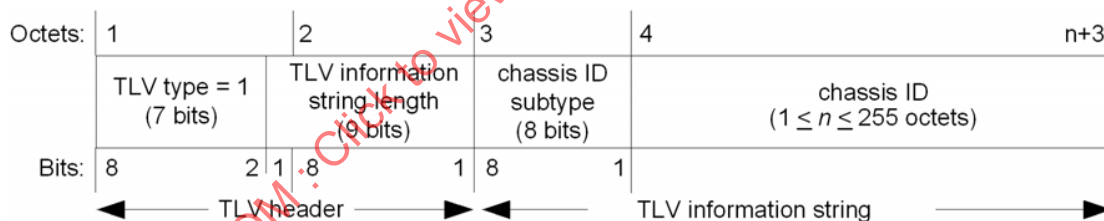


Figure 8-4—Chassis ID TLV format

8.5.2.1 TLV information string length

The TLV information string length field shall indicate the exact length, in octets, of the (chassis ID subtype + chassis ID) fields.

8.5.2.2 chassis ID subtype

The chassis ID subtype field shall contain an integer value indicating the basis for the chassis ID entity that is listed in the chassis ID field. The defined chassis ID subtypes and their preferred use order are listed in Table 8-2.

Table 8-2—chassis ID subtype enumeration

ID subtype	ID basis	Reference
0	Reserved	—
1	Chassis component	EntPhysicalAlias when entPhysClass has a value of 'chassis(3)' (IETF RFC 6933)
2	Interface alias	IfAlias (IETF RFC 2863)
3	Port component	EntPhysicalAlias when entPhysicalClass has a value of 'port(10)' or 'backplane(4)' (IETF RFC 6933)
4	MAC address	MAC address (IEEE Std 802)
5	Network address	networkAddress ^a
6	Interface name	ifName (IETF RFC 2863)
7	Locally assigned	local ^b
8–255	Reserved	—

^anetworkAddress is an octet string that identifies a particular network address family and an associated network address that are encoded in network octet order. An IP address, for example, would be encoded with the first octet containing the IANA Address Family Numbers enumeration value for the specific address type and octets 2 through *n* containing the address value (for example, the encoding for C0-00-02-0A would indicate the IPv4 address 192.0.2.10).

^blocal is an alpha-numeric string and is locally assigned.

8.5.2.3 chassis ID

The chassis ID field shall contain an octet string indicating the specific identifier for the particular chassis in this system. Because chassis ID and port ID values are concatenated to form the local MSAP identifier, the value chosen from Table 8-2 for the chassis ID shall be non-null.

8.5.2.4 Chassis ID TLV usage rules

An LLDPDU shall contain exactly one Chassis ID TLV.

8.5.3 Port ID TLV

The Port ID TLV is a mandatory TLV that identifies the port component of the MSAP identifier associated with the transmitting LLDP agent. As with the chassis, there are several ways in which a port may be identified. A port ID subtype is used to indicate how the port is being referenced in the port ID field. Each LLDPDU shall contain one, and only one, Port ID TLV. The port ID value shall remain constant for all LLDPDUs while the transmitting port remains operational.

The chosen port shall be identified in an unambiguous manner (for example, backplane number, management entity, MAC address).

The Port ID TLV shall be the second TLV in the LLDPDU. Its format is shown in Figure 8-5.

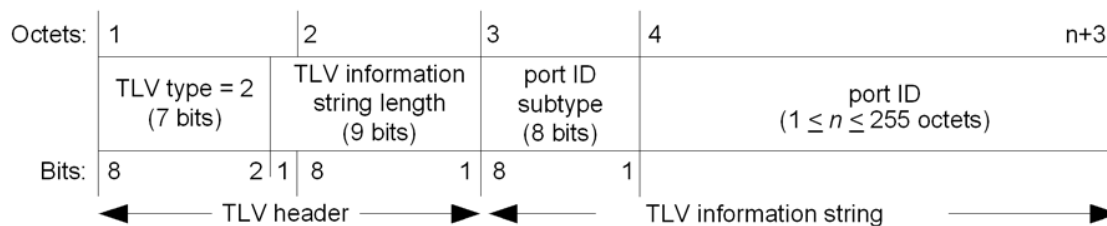


Figure 8-5—Port ID TLV format

8.5.3.1 TLV information string length

The TLV information string length field shall indicate the length, in octets, of the (port ID subtype + port ID) fields.

8.5.3.2 port ID subtype

The port ID subtype field shall contain an integer value indicating the basis for the identifier that is listed in the port ID field. The defined port ID subtypes and their preferred use order are listed in Table 8-3.

Table 8-3—port ID subtype enumeration

ID subtype	ID basis	References
0	Reserved	—
1	Interface alias	ifAlias (IETF RFC 2863)
2	Port component	entPhysicalAlias when entPhysicalClass has a value 'port(10)' or 'backplane(4)' (IETF RFC 6933)
3	MAC address	MAC address (IEEE Std 802)
4	Network address	networkAddress ^a
5	Interface name	ifName (IETF RFC 2863)
6	Agent circuit ID	agent circuit ID (IETF RFC 3046)
7	Locally assigned	local ^b
8–255	Reserved	—

^anetworkAddress is an octet string that identifies a particular network address family and an associated network address that are encoded in network octet order. An IP address, for example, would be encoded with the first octet containing the IANA Address Family Numbers enumeration value for the specific address type and octets 2 through n containing the address value (for example, the encoding for C0-00-02-0A would indicate the IP version 4 address 192.0.2.10).

^blocal is an alpha-numeric string and is locally assigned.

8.5.3.3 port ID

The port ID field is an alpha-numeric string that contains the specific identifier for the port from which this LLDPDU was transmitted. Because chassis ID and port ID values are concatenated to form the local MSAP identifier, the value chosen from Table 8-3 for the port ID shall be non-null.

NOTE—The port ID can contain alphanumeric data or binary data, depending upon the value of the port ID subtype.

8.5.3.4 Port ID TLV usage rules

An LLDPDU shall contain exactly one Port ID TLV.

8.5.4 Time To Live TLV

The Time To Live TLV indicates the number of seconds that the recipient LLDP agent is to regard the information associated with this MSAP identifier to be valid.

- a) When the TTL field is non-zero the receiving LLDP agent is notified to completely replace all information associated with this MSAP identifier with the information in the received LLDPDU.
- b) When the TTL field is set to zero, the receiving LLDP agent is notified to delete all system information associated with the LLDP agent/port. This TLV may be used, for example, to signal that the sending port has initiated a port shutdown procedure.

The Time To Live TLV is mandatory and shall be the third TLV in the LLDPDU. Its format is shown in Figure 8-6.

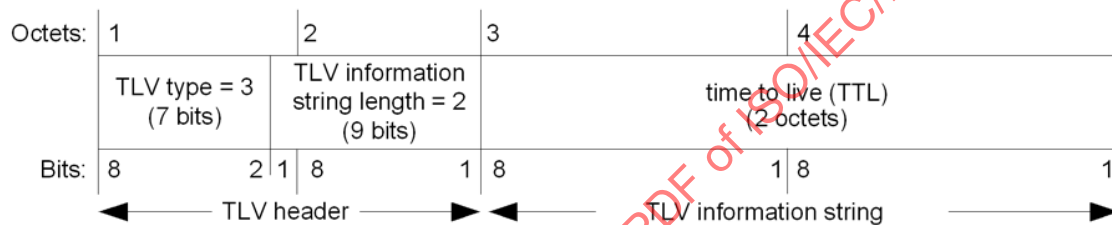


Figure 8-6—Time To Live TLV format

8.5.4.1 time to live (TTL)

The TTL field shall contain an integer value in the range $0 \leq t \leq 65535$ seconds and is set to the computed value of txTTL at the time the LLDPDU is constructed (see 9.2.5.22).

8.5.4.2 Time To Live TLV usage rules

An LLDPDU shall contain exactly one Time To Live TLV.

8.5.5 Port Description TLV

The Port Description TLV allows network management to advertise the IEEE 802 LAN station's port description. The format for this TLV is shown in Figure 8-7.



Figure 8-7—Port Description TLV format

8.5.5.1 TLV information string length

The TLV information string length field shall contain the exact length, in octets, of the port description field.

8.5.5.2 port description

The port description field shall contain an alpha-numeric string that indicates the port's description. If IETF RFC 2863 is implemented, the ifDescr object should be used for this field.

8.5.5.3 Port Description TLV usage rules

An LLDPDU should not contain more than one Port Description TLV.

8.5.6 System Name TLV

The System Name TLV allows network management to advertise the system's assigned name. The format for this TLV is shown in Figure 8-8.

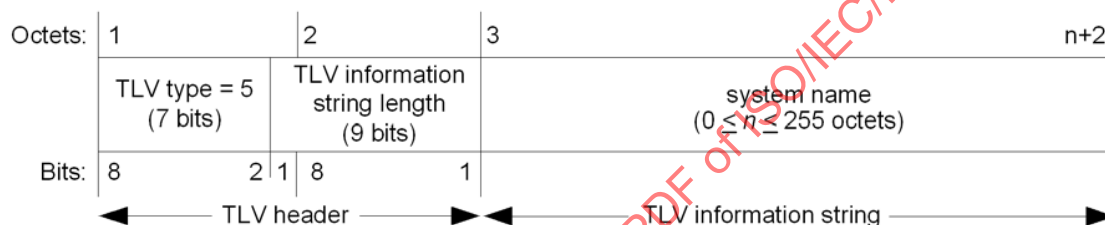


Figure 8-8—System Name TLV format

8.5.6.1 TLV information string length

The TLV information string length field shall contain the exact length, in octets, of the system name.

8.5.6.2 system name

The system name field shall contain an alpha-numeric string that indicates the system's administratively assigned name. The system name should be the system's fully qualified domain name. If implementations support IETF RFC 3418, the sysName object should be used for this field.

8.5.6.3 System Name TLV usage rules

An LLDPDU shall not contain more than one System Name TLV.

8.5.7 System Description TLV

The System Description TLV allows network management to advertise the system's description. The format for this TLV is shown in Figure 8-9.

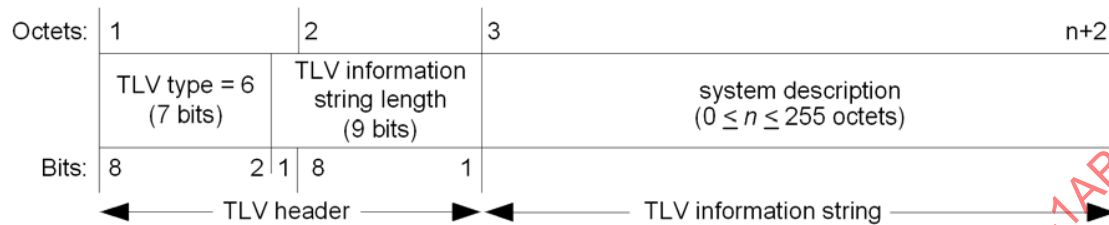


Figure 8-9—System Description TLV format

8.5.7.1 TLV information string length

The TLV information string length field shall indicate the exact length, in octets, of the system description.

8.5.7.2 system description

The system description field shall contain an alpha-numeric string that is the textual description of the network entity. The system description should include the full name and version identification of the system's hardware type, software operating system, and networking software. If implementations support IETF RFC 3418, the sysDescr object should be used for this field.

8.5.7.3 System Description TLV usage rules

An LLDPDU shall not contain more than one System Description TLV.

8.5.8 System Capabilities TLV

The System Capabilities TLV is an optional TLV that identifies the primary function(s) of the system and whether or not these primary functions are enabled. Figure 8-10 shows the format of this TLV.

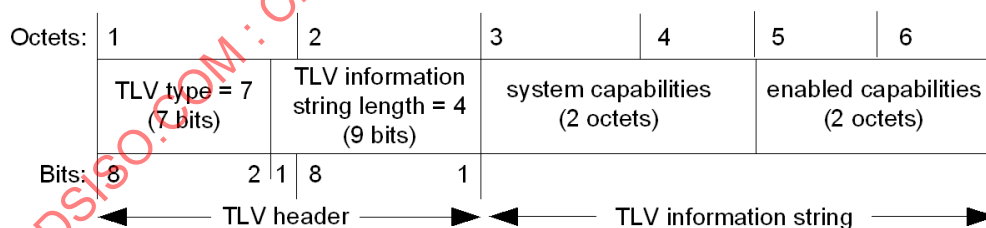


Figure 8-10—System Capabilities TLV format

8.5.8.1 system capabilities

The system capabilities field shall contain a bit-map of the capabilities that define the primary function(s) of the system. The bit positions for each function and the associated MIB or standard that are likely, but not guaranteed, to be supported are listed in Table 8-4. A binary one in the associated bit indicates the existence of that capability. Individual systems may indicate more than one implemented functional capability (for example, both a bridge and router capability).

Table 8-4—System capabilities

Bit	Capability	Reference
1	Other	—
2	Repeater	IETF RFC 2108 [B7]
3	MAC Bridge component	IEEE Std 802.1Q
4	802.11 Access Point (AP)	IEEE Std 802.11 MIB
5	Router	IETF RFC 1812 [B6]
6	Telephone	IETF RFC 4293 [B10]
7	DOCSIS cable device	IETF RFC 4639 and IETF RFC 4546 [B12]
8	Station Only ^a	IETF RFC 4293 [B10]
9	C-VLAN component	IEEE Std 802.1Q
10	S-VLAN component	IEEE Std 802.1Q
11	Two-port MAC Relay component	IEEE Std 802.1Q
12–16	reserved	*

^aThe Station Only capability is intended for devices that implement only an end station capability, and for which none of the other capabilities in the table apply. Bit 8 should therefore not be set in conjunction with any other bits.

8.5.8.2 enabled capabilities

The enabled capabilities field shall contain a bit map of the primary functions listed in Table 8-4. A binary one in a bit position indicates that the function associated with that bit is currently enabled.

8.5.8.3 System Capabilities TLV usage rules

An LLDPDU shall not contain more than one System Capabilities TLV.

If the system capabilities field does not indicate the existence of a capability that the enabled capabilities field indicates is enabled, the TLV is interpreted as containing an error and shall be discarded.

8.5.9 Management Address TLV

The Management Address TLV identifies an address associated with the local LLDP agent that may be used to reach higher layer entities to assist discovery by network management. The TLV also provides room for the inclusion of both the system interface number and an object identifier (OID) that are associated with this management address, if either or both are known. Figure 8-11 shows the Management Address TLV format.

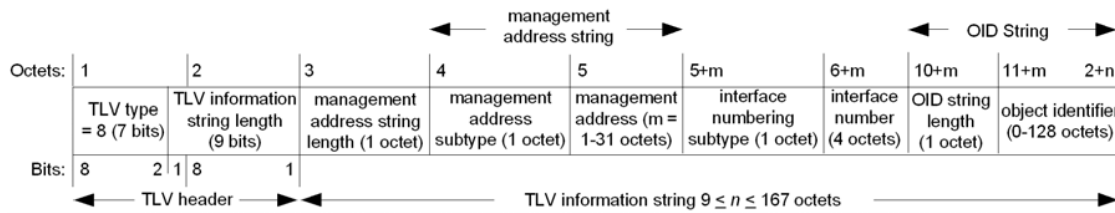


Figure 8-11—Management Address TLV format

8.5.9.1 TLV information string length

The TLV information string length field shall contain the length, in octets, of all the fields in the TLV information string.

8.5.9.2 management address string length

The management address string length field shall contain the length, in octets, of the (management address subtype + management address) fields.

8.5.9.3 management address subtype

The management address subtype field shall contain an integer value indicating the type of address that is listed in the management address field. Enumeration for this field is contained in the ianaAddressFamilyNumbers module of the IETF RFC 3232 on-line database that is accessible through a web page (<http://www.iana.org>). The management address subtype is contained in the first octet of the management address string.

NOTE—As a consequence of the limitation on the size of the management address field (a maximum of 31 octets), some options for the management address subtype (such as long DNS names) may be impractical.

8.5.9.4 management address

The management address field shall contain an octet string indicating the particular management address associated with this TLV.

- The returned address should be the most appropriate for management use, typically a layer 3 address such as the IPv4 address, 192.0.2.10 (see also Table 8-2, footnote a).
- If no management address is available, the return address should be the MAC address for the station or port. The ianaAddressFamilyNumber for a MAC address is all802 (value 6).

8.5.9.5 interface numbering subtype

The interface numbering subtype field shall contain an integer value indicating the numbering method used for defining the interface number. The following three values are currently defined:

- Unknown
- ifIndex
- system port number

8.5.9.6 interface number

The interface number field shall contain the assigned number within the system that identifies the specific interface associated with this management address. If the value of the interface subtype is unknown, this field shall be set to zero.

8.5.9.7 object identifier (OID) string length

The object identifier string length field shall contain the length, in octets, of the OID. A value of zero in this field indicates that the OID field is not provided.

8.5.9.8 object identifier

The object identifier field contains an OID that identifies the type of hardware component or protocol entity associated with the indicated management address. The OID shall be the value portion of the ASN.1 encoding of the object identifier, encoded according to ASN.1 basic encoding rules [ISO/IEC 8824-1]. If no OID is available, this field shall not be provided.

NOTE—The interface number and OID are included in this TLV to assist NMS discovery by indicating Enterprise Specific or other starting points for the search, such as the Interface or Entity MIB (IETF RFC 6933).

8.5.9.9 Management Address TLV usage rules

Management Address TLVs are subject to the following:

- a) At least one Management Address TLV should be included in every LLDPDU.
- b) Since there are typically a number of different addresses associated with a MSAP identifier, an individual LLDPDU may contain more than one Management Address TLV.
- c) When Management Address TLV(s) are included in an LLDPDU, the included address(es) should be the address(es) offering the best management capability.
- d) If more than one Management Address TLV is included in an LLDPDU, each management address shall be different from the management address in any other management address TLV in the LLDPDU.
- e) If an OID is included in the TLV, it shall be reachable by the management address.
- f) In a properly formed Management Address TLV, the TLV information string length is equal to:
(management address string length) + (OID string length) + 7.

If the TLV information string length in a received Management Address TLV is incorrect, then it is ignored and processing of that LLDPDU is terminated.

8.6 Organizationally Specific TLVs

This TLV category is provided to allow different organizations, such as IEEE 802.1, IEEE 802.3, IETF, as well as individual software and equipment vendors, to define TLVs that advertise information to remote entities attached to the same media, subject to the following restrictions:

- a) Information transmitted in an Organizationally Specific TLV is intended to be a one way advertisement.
- b) Information transmitted in an Organizationally Specific TLV shall be independent from information in a TLV received from a remote port.
- c) Information transmitted in one Organizationally Specific TLV shall not be concatenated with information transmitted in another TLV on the same media in order to provide a means for sending messages that are larger than would fit within a single TLV.

- d) Information received in an Organizationally Specific TLV shall not be explicitly forwarded to other ports in the system.
- e) Organizationally Specific TLVs shall conform to 8.4 and 8.6.1.

Each set of Organizationally Specific TLVs shall include associated LLDP MIB extensions and the associated TLV selection management variables and MIB/TLV cross reference tables. Systems that implement LLDP and that also support standard protocols for which Organizationally Specific TLV extension sets have been defined shall support all TLVs and the LLDP MIB extensions defined for that particular TLV set.

Annex D of IEEE Std 802.1Q-2014 and Clause 79 of IEEE Std 802.3-2012 contain Organizationally Specific TLVs for IEEE Std 802.1 and IEEE Std 802.3, respectively, along with their associated LLDP MIB extensions and LLDP MIB/TLV cross reference tables. Organizations wishing to define TLVs for their use should use these annexes as examples.

8.6.1 Basic Organizationally Specific TLV format

The basic format for Organizationally Specific TLVs is shown in Figure 8-12.

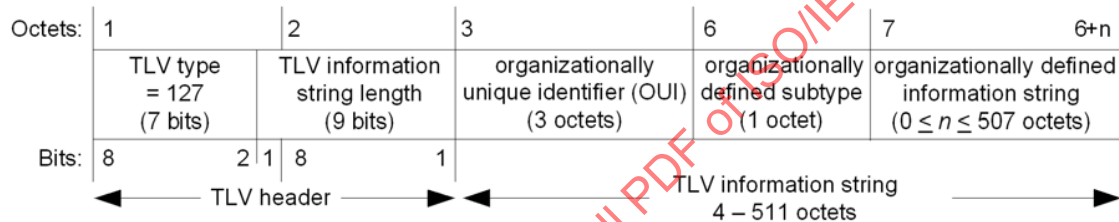


Figure 8-12—Basic format for Organizationally Specific TLVs

The following subclauses indicate how the individual fields shall be defined.

8.6.1.1 TLV type

The same Organizationally Specific TLV type value, 127, shall be used for all organizationally defined TLVs.

8.6.1.2 TLV information string length

The TLV information string length field shall contain the length of the information string, in octets.

8.6.1.3 organizationally unique identifier (OUI)

The organizationally unique identifier field shall contain the organization's OUI (see Clause 8 of IEEE Std 802-2014).

8.6.1.4 organizationally defined subtype

The organizationally defined subtype field shall contain a unique subtype value assigned by the defining organization.

NOTE—Defining organizations are responsible for maintaining listings of organizationally defined subtypes in order to assure uniqueness.

8.6.1.5 organizationally defined information string

The actual format of the organizationally defined information string field is organizationally specific and can

- a) Contain either binary or alpha-numeric information that is instance specific for the particular TLV type and/or subtype. Alpha-numeric information should be encoded in UTF-8 (IETF RFC 3629).
- b) Include one or more information fields with their associated field-type identifiers and field length designators similar to those in the Management Address TLV (see 8.5.9).

8.6.2 Organizationally Specific TLV usage rules

Organizations defining their own Organizationally Specific TLVs should include a subclause that defines any specific usage rules and/or specific conditions that affects how the receiving LLDP agent shall treat the TLV.

The Organizationally Specific TLV usage rules should include the following:

- a) The number of Organizationally Specific TLVs that may be contained in an LLDPDU and any additional information field subtypes that would identify differences between two TLVs with the same OUI and organizationally defined subtype.
- b) Any error conditions that are specific to the particular Organizationally Specific TLV and the action that is taken for each defined error condition.

9. LLDP agent operation

This clause describes the operation of the protocol from the point of view of a single LLDP agent (see Clause 6); i.e., it describes the operation of the protocol for the transmission and reception of LLDPDUs on a single Port, using a MAC address (see Clause 7) as the destination address. Where the use of more than one MAC address is supported on a given Port, a separate instance of the LLDP agent is responsible for the operation of the protocol for each MAC address that is supported.

9.1 Overview

Each LLDP agent is responsible for causing the following tasks to be performed:

- Maintaining current information in the LLDP local system MIB.
- Extracting and formatting LLDP local system MIB information for transmission to the remote port LLDP agent(s) at regular intervals or whenever there is a change in the system condition or status.
- Recognizing and processing received LLDP frames.
- Maintaining current values in the LLDP remote system MIB.
- Using the procedure `somethingChangedLocal()` and the procedure `somethingChangedRemote()` to notify the PTOPO MIB manager and MIB managers of other optional MIBs whenever a value or status change has occurred in one or more objects in the LLDP local system LLDP remote systems MIB.

NOTE—A consequence of the support of multiple MAC addresses on a Port is that there are multiple copies of the LLDP local system MIB and remote system MIB, one copy for each address supported.

LLDP allows implementations that support three different operating modes: transmit only, receive only, or both transmit and receive. An LLDP agent shall conform to the specifications of each of the state machines indicated in Table 9-1 for the operating mode that it supports.

Table 9-1—Subclause/operating mode applicability

Subclause number	Subclause title	Transmit only	Receive only	Transmit and receive
9.2.9	Receive state machine	—	Mandatory	Mandatory
9.2.8	Transmit state machine	Mandatory	—	Mandatory
9.2.10	Transmit timer state machine	Mandatory	—	Mandatory

9.1.1 Frame transmission

LLDPDU transmission is performed by the transmit state machine, and the timing of transmissions is controlled by the transmit timer state machine. Transmissions occur as a result of a number of different local events, as follows:

- A regular background transmission occurs as a result of a transmission timer expiring. This ensures that the receiving system does not time out the information received, as a result of the “time to live” associated with the last received LLDPDU expiring.
- If a *new neighbor* is recognized (i.e., an LLDPDU is received by the receive state machine from a hitherto unknown remote agent), then four LLDPDU transmissions are performed at shorter time intervals to ensure that the new neighbor is quickly updated with current information about its own neighbors. This rapid transmission behavior is suppressed if the remote systems MIB is not able to

- accommodate the new neighbor information without removing current information relating to an older neighbor, in order to prevent excessive PDU transmissions resulting from “churn” effects.
- c) If a condition (status or value) change occurs in one or more objects in the LLDP local system MIB, then an LLDPDU is transmitted immediately, in order to communicate the local changes as quickly as possible to any neighboring systems. The transmit timer state machine operates a simple credit-based transmission strategy that allows a number of LLDPDUs to be transmitted in quick succession (the maximum number being determined by the maximum credit value), thus allowing rapid updating of information in situations where the local state is changing quickly. However, once the LLDP Agent’s transmission credit is exhausted, the rate of transmission is cut to a maximum of one transmission per second.
 - d) The overall timing of regular transmissions is governed by a system “tick” that operates on a nominal timebase of 1 s. However, in shared media LANs, in order to avoid bunching of transmissions, the intervals between ticks include a random jitter component so that, while the average time interval between ticks is 1 s, the interval between adjacent pairs of ticks can vary (see 9.2.2).

In order to minimize synchronization effects, it is recommended that transmission intervals for different LLDP agents on the same multi-port implementation are staggered.

9.1.2 LLDPDU types

The following two types of LLDPDUs are defined:

- a) Normal LLDPDUs that provide management information about the local station to that station’s neighbors.
- b) A special shutdown advisory LLDPDU indicating that any information about the local station that is maintained in a remote LLDP agent’s remote systems MIB is now invalid and is to be discarded.

9.1.2.1 Normal LLDPDUs

The LLDP local system MIB contains the information needed for constructing individual TLVs and includes a capability that allows network managers to select the optional TLVs to be included in the LLDPDU (see 10.2.2).

When the transmit state machine (9.2.8) determines that a normal LLDPDU is to be transmitted, the LLDP MIB manager extracts the selected information from the LLDP local system MIB and constructs an LLDPDU as defined in 9.1 containing the following:

- a) The mandatory TLVs as specified in 8.2:
 - 1) Chassis ID TLV (see 8.5.2).
 - 2) Port ID TLV (see 8.5.3).
 - 3) Time To Live TLV, with the TTL value set equal to txTTL (see 8.5.4).
- b) Additional optional TLVs, from the basic management set or from one or more organizationally specific sets, as allowed by LLDPDU length restrictions and as selected in the LLDP local system MIB by network management (see Table 8-1).
- c) Optionally, an End Of LLDPDU TLV.

Optional TLVs from the basic management set, such as the Management Address TLV, with different TLV type and subtype combinations as well as optional TLVs with different OUI and organizationally defined subtype combinations from one or more organizationally specific sets can be included within the same LLDPDU.

9.1.2.2 Shutdown LLDPDUs

A special procedure exists for the case in which a LLDP agent knows an associated port is about to become non-operational (for example, the adminStatus for the port is transitioning to 'disabled'). In the event a port, currently configured with LLDP frame transmission enabled, either becomes disabled for LLDP activity, or the interface is administratively disabled, the transmit state machine attempts to send a final LLDP shutdown LLDPDU with:

- a) The Chassis ID TLV.
- b) The Port ID TLV.
- c) The Time To Live TLV with the TTL field set to zero.
- d) Optionally, an End Of LLDPDU TLV.

The shutdown LLDPDU does not include any other optional TLVs and, if possible, should be transmitted before the interface is disabled.

NOTE—There is an inherent race condition between an interface knowing it is going down and its ability to send "one more frame." If possible, the actual transition of the port to disabled is delayed until after this frame is transmitted. In the event where adminStatus is transitioning to the disabled state and the LLDP agent is shutting down, this shutdown procedure should be executed for all local ports.

9.1.3 Frame reception

LLDP frame reception consists of three phases: frame recognition, frame validation, and LLDP remote systems MIB updating. All error checking is done during frame validation.

Frame recognition is performed at the LLDP/LSAP (see Figure 6-2), where the destination address and EtherType values determine whether the frame is an LLDP frame destined for this LLDP agent or not. Frames that are recognized as LLDP frames are then validated to determine whether they are properly constructed and contain the correct set of mandatory TLVs; frames that pass the validation criteria are used to update the contents of entries in the LLDP remote systems MIB for the originating LSAP identifier and destination MAC address. If the frame is a normal LLDPDU and an entry does not exist in the LLDP remote systems MIB for the originating LSAP identifier and destination MAC address, then a new entry in the MIB is created, assuming that sufficient space exists to do so. If the frame is a normal LLDPDU and an entry already exists in the remote systems MIB for the originating LSAP identifier and destination MAC address, then the new information contained in the LLDPDU is used to replace the whole of the existing entry in the MIB; i.e., if there are information elements in the existing entry for which there are corresponding elements in the received LLDPDU, then those elements are updated using the information received; any other information elements in the existing entry in the MIB are deleted.

One of the parameters received in an incoming LLDPDU is the TTL value; this determines how long the information associated with that LSAP identifier and destination MAC address is to be stored in the LLDP remote systems MIB before being aged out and deleted. The ageing out of old data ensures that the MIB is purged of data that was originated by systems that are no longer neighbors as a result of topology changes, system failure, or system inactivation.

If the received frame is a shutdown LLDPDU and an entry exists in the LLDP remote systems MIB for the originating LSAP identifier and destination MAC address, then that entry is deleted from the MIB.

9.1.4 Too many neighbors

The amount of space needed in the LLDP remote systems MIB to accommodate the creation of several new MIB structures is beyond the scope of this standard. It may not always be possible to accommodate another

new neighbor in implementations with limited memory. There are several possibilities for handling this case, including but not limited to the following examples:

- a) Ignore and not process the new neighbor's information.
- b) Delete the information from the oldest neighbor(s) until there is sufficient memory available to store the new neighbor's information.
- c) Randomly delete neighbors until there is sufficient memory available to store the new neighbor's information.

The method of handling the case where a new entry in the remote systems MIB can not be created is beyond the scope of this standard, however it is necessary for the implementation to keep track of this case by properly updating the variable `tooManyNeighbors` and the `tooManyNeighborsTimer` (9.2.5.15, 9.2.2). The variable `tooManyNeighbors` identifies when there is insufficient space in the LLDP remote systems MIB to store information from all active neighbors. The `tooManyNeighborsTimer` indicates the minimum time that this condition exists.

Further detail on the handling of the too many neighbors condition can be found in 9.2.7.7.5.

9.1.5 LLDP remote systems rxInfoTTL timer expiration

If the rxInfoTTL timer (9.2.2.1) associated with an MSAP identifier expires, all information associated with that MSAP identifier is deleted and the procedure `somethingChangedRemote()` notifies the managers of the PTOPO MIB and other optional MIB modules (see Figure 11-1) that something has changed in the LLDP remote systems MIB associated with that MSAP identifier.

9.1.6 LLDP local port/connection failure

If the local port or the connection to the remote system fails unexpectedly before a shutdown frame is received, the LLDP management entity does not delete objects in the LLDP remote systems MIB pertaining to information received from any MSAP identifier through that local port until the port is re-initialized or the associated rxInfoTTL timer (9.2.2.1) expires.

9.2 State machines

The operation of the protocol is represented by the following three state machines and associated timers to indicate when local system managed object values are to be transmitted to refresh the values in remote LLDP agent's LLDP remote systems MIB and when values in the local LLDP agent's remote systems MIB have become invalid:

- a) Transmit state machine (9.2.8).
- b) Receive state machine (9.2.9).
- c) Transmit timer state machine (9.2.10).

9.2.1 Notational conventions used in state diagrams

State diagrams are used to represent the operation of a function as a group of connected, mutually exclusive states. Only one state of a function can be active at any given time.

Each state is represented in the state diagram as a rectangular box, divided into two parts by a horizontal line. The upper part contains the state identifier, written in uppercase letters. The lower part contains any procedures that are executed on entry to the state.

All permissible transitions between states are represented by arrows, the arrowhead denoting the direction of the possible transition. Labels attached to arrows denote the condition(s) that shall be met in order for the transition to take place. A transition that is global in nature (i.e., a transition that occurs from any of the possible states if the condition attached to the arrow is met) is denoted by an open arrow; i.e., no specific state is identified as the origin of the transition.

On entry to a state, the procedures defined for the state (if any) are executed exactly once, in the order that they appear on the page. Each action is deemed to be atomic; i.e., execution of a procedure completes before the next sequential procedure starts to execute. No procedures execute outside of a state block. On completion of all of the procedures within a state, all exit conditions for the state (including all conditions associated with global transitions) are evaluated continuously until such a time as one of the conditions is met. All exit conditions are regarded as Boolean expressions that evaluate to TRUE or FALSE; if a condition evaluates to TRUE, then the condition is met. When the condition associated with a global transition is met, it supersedes all other exit conditions, including UCT. The label UCT denotes an unconditional transition (i.e., UCT always evaluates to TRUE). The label ELSE denotes a transition that occurs if none of the other conditions for transitions from the state are met (i.e., ELSE evaluates to TRUE if all other possible exit conditions from the state evaluate to FALSE).

A variable that is set to a particular value in a state block retains this value until a subsequent state block executes a procedure that modifies the value, or until the value is modified by an external event or timer tick.

Where it is necessary to segment a state machine description across more than one diagram, a transition between two states that appear on different diagrams is represented by an exit arrow drawn with dashed lines, plus a reference to the diagram that contains the destination state. Similarly, dashed arrows and a dashed state box are used on the destination diagram to show the transition to the destination state. In a state machine that has been segmented in this way, any global transitions that can cause entry to states defined in one of the diagrams are deemed to be potential exit conditions for all of the states of the state machine, regardless of which diagram the state boxes appear in.

Should a conflict exist between the interpretation of a state diagram and either the corresponding global transition tables or the textual description associated with the state machine, the state diagram takes precedence.

The interpretation of the special symbols and operators used in the state diagrams is defined in Table 9-2; these symbols and operators are derived from the notation of the “C” programming language.

Table 9-2—State machine symbols

Symbol	Interpretation
()	Used to force the precedence of operators in Boolean expressions and to delimit the argument(s) of actions within state boxes.
;	Used as a terminating delimiter for actions within state boxes. Where a state box contains multiple actions, the order of execution follows the normal English language conventions for reading text.
=	Assignment action. The value of the expression to the right of the operator is assigned to the variable to the left of the operator. Where this operator is used to define multiple assignments, e.g., a = b = X the action causes the value of the expression following the right-most assignment operator to be assigned to all of the variables that appear to the left of the right-most assignment operator.
!	Logical NOT operator.

Table 9-2—State machine symbols (continued)

Symbol	Interpretation
&&	Logical AND operator.
	Logical OR operator.
if...then...	Conditional action. If the Boolean expression following the if evaluates to TRUE, then the action following the then is executed.
{statement 1, ... statement N}	Compound statement. Braces are used to group statements that are executed together as if they were a single statement.
!=	Inequality. Evaluates to TRUE if the expression to the left of the operator is not equal in value to the expression to the right.
==	Equality. Evaluates to TRUE if the expression to the left of the operator is equal in value to the expression to the right.
<	Less than. Evaluates to TRUE if the value of the expression to the left of the operator is less than the value of the expression to the right.
>	Greater than. Evaluates to TRUE if the value of the expression to the left of the operator is greater than the value of the expression to the right.
>=	Greater than or equal to. Evaluates to TRUE if the value of the expression to the left of the operator is either greater than or equal to the value of the expression to the right.
+	Arithmetic addition operator.
–	Arithmetic subtraction operator.

9.2.2 Timers

A set of timers is used by the LLDP state machines; these operate as countdown timers (i.e., they expire when their value reaches zero). These timers

- Have a resolution of one second.
- Have an integer value n , where $0 < n < 65535$ seconds.
- Are started by loading an initial integer value.
- Are decremented once per timer tick as long as $n > 0$.
- Represent the remaining time in the period.

For Ports connected to point-to-point LANs, the interval between timer ticks is 1 s. For Ports connected to shared media LANs, the interval between any pair of timer ticks is 0.8 s, plus a “jitter” component that is a random value between 0.0 s and 0.4 s. Hence, the average interval between timer ticks is 1 s; however, the interval between any pair of ticks varies randomly. When a timer tick occurs, all instances of the variable txTick (9.2.5.21) for the Port are set TRUE.

NOTE—The random component of the tick time used in shared media LANs is intended to minimize the possibility of systems connected to the same LAN becoming synchronized in their transmission timings.

9.2.2.1 rxInfoTTL

An instance of this timer exists for each entry in the LLDP remote systems MIB that has been created by this instance of the receive state machine for a given MSAP identifier. The timer value indicates the number of seconds remaining until the information in all the objects in the LLDP remote systems MIB associated with the MSAP identifier is no longer valid and needs to be deleted.

9.2.2.2 tooManyNeighborsTimer

This timer indicates the number of seconds remaining during which it is known that an LLDP neighbor exists that may not be stored in the remote systems MIB.

9.2.2.3 txTTR

An instance of this timer exists for each Agent. The txTTR timer is used to determine the next LLDPDU transmission is due; it is initialized by the transmit timer state machine, with the value msgTxInterval (9.2.5.7) if txFast (9.2.5.18) is equal to zero, or with the value msgFastTx (9.2.5.5) if txFast is greater than zero.

9.2.2.4 txShutdownWhile

An instance of this timer exists for each Agent. The txShutdownWhile timer indicates the number of seconds remaining until LLDP re-initialization can occur.

9.2.3 Per-System variables

An instance of each of these variables exists per system; they are available for use by all of the state machines of all of the LLDP agents in the system.

9.2.3.1 BEGIN

This Boolean variable is controlled by the system initialization process. A value of TRUE causes all state machines to continuously execute their initial state. A value of FALSE allows all state machines to perform transitions out of their initial state, in accordance with the relevant state machine definitions.

9.2.4 Per-Port variables

An instance of each of these variables exists per Port; they are available to all of the state machines associated with a Port.

9.2.4.1 portEnabled

This variable is externally controlled. Its value reflects the operational state of the MAC service supporting the port. Its value is TRUE if the MAC service supporting the Port is in an operable condition; otherwise, it is FALSE.

9.2.5 Per-Agent variables

An instance of each of these variables exists per LLDP agent; they are available to all of the state machines associated with an LLDP agent.

9.2.5.1 adminStatus

This variable indicates whether or not the LLDP agent is enabled. The defined values for this variable are as follows:

- a) enabledRxTx: The LLDP agent is enabled for reception and transmission of LLDPDUs. This is the recommended default value.
- b) enabledTxOnly: The LLDP agent is enabled for transmission of LLDPDUs only.
- c) enabledRxOnly: The LLDP agent is enabled for reception of LLDPDUs only.
- d) disabled: The LLDP agent is disabled for both reception and transmission.

9.2.5.2 badFrame

This variable indicates that an incoming LLDPDU was unable to be validated because the LLDPDU failed validation and was discarded.

9.2.5.3 localChange

This variable is set TRUE by the somethingChangedLocal() procedure (see 9.2.7.8) when there is a change in the value of the LLDP local system MIB associated with this LLDP agent. The variable is set FALSE by the operation of the transmit timer state machine (see 9.2.10).

9.2.5.4 MAC address

The MAC address associated with this instance of the Agent, i.e., the destination MAC address that is used when the Agent transmits LLDPDUs, and the destination MAC address that, when present in a received LLDPDU, causes the PDU to be passed to this agent instance for processing.

9.2.5.5 msgFastTx

This variable defines the time interval in timer ticks between transmissions during fast transmission periods (i.e., txFast is non-zero). The recommended default value of msgFastTx is 1; this value can be changed by management to any value in the range 1 through 3600.

9.2.5.6 msgTxHold

This variable is used, as a multiplier of msgTxInterval, to determine the value of txTTL that is carried in LLDP frames transmitted by the LLDP agent. The recommended default value of msgTxHold is 4; this value can be changed by management to any value in the range 1 through 100.

9.2.5.7 msgTxInterval

This variable defines the time interval in timer ticks between transmissions during normal transmission periods (i.e., txFast is zero). The recommended default value for msgTxInterval is 30 s; this value can be changed by management to any value in the range 1 through 3600.

9.2.5.8 newNeighbor

This variable is set TRUE by the rxProcessFrame() procedure (see 9.2.7.7) when information is received from a new neighbor. It is set FALSE by the Transmit timer state machine (9.2.10).

NOTE—The newNeighbor variable is used to force a more rapid regular transmission rate when a new neighbor appears, to ensure that the new neighbor also receives new information from the receiving system.

9.2.5.9 rcvFrame

This variable indicates that an LLDP frame has been recognized by the LLDP LSAP function and is ready to be processed by the LLDP receive state machine. If both of the following conditions are TRUE, the variable rcvFrame is set to TRUE and the frame is made available to the receive state machine for validation and processing:

- a) The destination address value is the MAC address associated with this specific LLDP Agent.
- b) The EtherType value carried by the frame is the LLDP EtherType defined in Table 7-3.

NOTE—The model that is assumed for reception is that incoming LLDPDUs are presented to all LLDP agents associated with the reception Port, and if the destination MAC address is not one that is associated with a given Agent, that LLDPDU is ignored by that agent. In practice, at most one agent processes any received LLDPDU, as there is only one agent associated with any given destination MAC address on a given reception Port.

9.2.5.10 reinitDelay

This parameter indicates the amount of delay from when adminStatus becomes ‘disabled’ until re-initialization is attempted. The recommended default value for reinitDelay is 2 s.

9.2.5.11 remoteChanges

A Boolean indication of whether the status/value of one or more selected objects in the LLDP remote systems MIB has changed or that all objects associated with a particular MSAP identifier have been deleted. This variable takes the value *(rxInfoAge OR (rxChanges && (rxTTL !=0)))*

9.2.5.12 rxChanges

This variable indicates that the incoming LLDPDU has been received with different TLV values from those currently in the LLDP remote systems MIB associated with the LLDPDU’s MSAP identifier.

9.2.5.13 rxInfoAge

This variable is set TRUE when a timer expiry event occurs for the rxInfoTTL timing counter associated with a particular MSAP identifier in the LLDP remote systems MIB (i.e., the counter transitions from non-zero to zero). It is set FALSE by the operation of the Receive state machine.

9.2.5.14 rxTTL

This variable indicates the time to live value associated with all TLVs received in the current frame.

9.2.5.15 tooManyNeighbors

This Boolean variable indicates that there is insufficient space in the LLDP remote systems MIB to store information from all connected active remote ports (see 9.2.7.7.5).

9.2.5.16 txCredit

The number of consecutive LLDPDUs that can be transmitted at any time. This variable is incremented by the txAddCredit() procedure, up to the maximum value specified by the txCreditMax variable (see 9.2.5.17), and is decremented whenever an LLDPDU is transmitted by the transmit state machine.

9.2.5.17 txCreditMax

The maximum value of txCredit. The recommended default value is 5; this value can be changed by management to any value in the range 1 through 10.

9.2.5.18 txFast

This variable is used as a down counter to count the number of transmissions to be made during a fast transmission period. Fast transmission periods are initiated when a new neighbor is detected, and cause LLDPDU transmissions to take place at shorter time intervals than during normal (steady state) operation of the protocol. The fast transmission period ensures that more than one LLDPDU is transmitted when a new neighbor is detected. The first transmission is immediate; the subsequent transmissions occur at intervals

determined by msgFastTx. The number of transmissions is determined by the value of txFastInit (see 9.2.5.19).

9.2.5.19 txFastInit

This variable is used as the initial value for the txFast variable (see 9.2.5.18). This value determines the number of LLDPDUs that are transmitted during a fast transmission period. The recommended default value of txFastInit is 4; this value can be changed by management to any value in the range 1 through 8.

9.2.5.20 txNow

This variable is used to signal to the transmit state machine that a transmission is required. It is set TRUE by the transmit timer state machine, and set FALSE by the transmit state machine when the transmission has been initiated.

9.2.5.21 txTick

This variable is set TRUE by the system timer tick at one second intervals (see 9.2.2). It is set FALSE by the operation of the transmit timer state machine.

9.2.5.22 txTTL

This variable indicates the time remaining before information in the outgoing LLDPDU is no longer valid. The TTL field in the Time To Live TLV is set to txTTL during LLDPDU construction (see 9.1.2). The value of txTTL depends on the following:

- a) During normal operation, txTTL is set to whichever is the smaller of the values represented by Equation (1) and Equation (2):

$$(\text{msgTxInterval} \times \text{msgTxHold}) + 1 \quad (1)$$

$$65535 \quad (2)$$

where msgTxInterval is defined in 9.2.5.7 and msgTxHold is defined in 9.2.5.6.

- b) If adminStatus is transitioning to 'disabled' or portEnabled is transitioning to FALSE, txTTL shall be set to zero.

9.2.6 Per-Agent statistical counters

An instance of each of these statistical counters exists per LLDP agent; they are used to count significant events in the transmit and receive state machines and are made available to the management functions described in Clause 10 and Clause 11. All counters are maintained as unsigned integer values, four octets in length, and are initialized to zero only on system initialization (i.e., when the BEGIN system variable is set TRUE).

9.2.6.1 statsAgeoutsTotal

This counter provides a count of the times that a neighbor's information has been deleted from the LLDP remote systems MIB because the rxInfoTTL timer associated with the neighbor's MSAP has expired.

9.2.6.2 statsFramesDiscardedTotal

This counter provides a count of all LLDPDUs received and then discarded for any of the following reasons:

- a) One or more of the three mandatory TLVs at the beginning of the LLDPDU is missing, out of order, or contains an out of range information string length.
- b) There is insufficient space in the remote systems MIB to store the LLDPDU.

9.2.6.3 statsFramesInErrorsTotal

This counter provides a count of all LLDPDUs received with one or more detectable errors.

9.2.6.4 statsFramesInTotal

This counter provides a count of all LLDP frames received.

9.2.6.5 statsFramesOutTotal

This counter provides a count of all LLDP frames transmitted by this instance of the transmit state machine. The counter shall be maintained as an unsigned integer value, four octets in length.

9.2.6.6 statsTLVsDiscardedTotal

This counter provides a count of all TLVs received and then discarded for any reason.

9.2.6.7 statsTLVsUnrecognizedTotal

This counter provides a count of all TLVs received on the port that are not recognized by the LLDP local agent.

9.2.6.8 lldpduLengthErrors

A count of the number of LLDPDU length restriction errors detected by the `mibConstrInfoLLDPDU()` procedure (9.2.7.2).

9.2.7 State machine procedures**9.2.7.1 dec (variable-name)**

If the state machine variable *variable-name* has a non-zero value, this procedure decrements the value of the variable by 1.

9.2.7.2 mibConstrInfoLLDPDU()

The `mibConstrInfoLLDPDU()` procedure constructs an information LLDPDU, structured according to the specification in 8.2, the associated basic TLV formats defined in 8.4, plus any optional Organizationally Specific TLVs as specified and their associated individual organizationally defined formats (see 8.6). The information LLDPDU contains the following:

- a) The set of mandatory TLVs as specified in 8.2, with the value of `txTTL` set in accordance with the definition in 9.2.5.22.
- b) Additional optional TLVs, from the basic management set or from one or more organizationally specific sets, as allowed by LLDPDU length restrictions and as selected in the LLDP local system MIB by network management (see Table 8-1).

- c) Optionally, an End Of LLDPDU TLV.

If the set of TLVs that is selected in the LLDP local system MIB by network management would result in an LLDPDU that violates LLDPDU length restrictions, then the variable `lldpduLengthErrors` (9.2.7.2) is incremented by 1, and an LLDPDU is sent containing the mandatory TLVs plus as many of the optional TLVs in the set as will fit in the remaining LLDPDU length.

9.2.7.3 `mibConstrShutdownLLDPDU()`

The `mibConstrShutdownLLDPDU()` procedure constructs a shutdown LLDPDU according to the LLDPDU and the associated TLV formats specified in 8.2 and 8.5. The shutdown LLDPDU contains only the following items:

- a) The Chassis ID and Port ID TLVs.
- b) The Time To Live TLV with the TTL field set to zero.
- c) Optionally, an End Of LLDPDU TLV.

9.2.7.4 `mibDeleteObjects()`

The `mibDeleteObjects()` procedure deletes all information in the LLDP remote systems MIB associated with a given MSAP identifier if an LLDPDU is received with an `rxTTL` value of zero (see 9.2.7.7.1) or the timing counter `rxInfoTTL` expires (see 9.2.2.1).

9.2.7.5 `mibUpdateObjects()`

The `mibUpdateObjects()` procedure updates the MIB objects corresponding to the TLVs contained in the received LLDPDU for the LLDP remote system if MIB space is available, as follows:

- a) Compare the MSAP identifier in the current LLDPDU with the MSAP identifiers in the LLDP remote systems MIB:
 - 1) If a match is found, replace all current information associated with the MSAP identifier in the LLDP remote systems MIB with the information in the current LLDPDU.
 - 2) If no match is found, create a new MIB structure to receive information associated with the new MSAP identifier, and set these MIB objects to the values indicated in their respective TLVs.
- b) Set the timing counter `rxInfoTTL` associated with the MSAP identifier to `rxTTL`.

If an incoming TLV is not recognized by the receiving LLDP agent, the TLV is stored in the LLDP remote systems MIB as follows:

- c) If the TLV type value is in the range of the reserved TLV types in Table 8-1, the TLV can be from a later version of the basic management set and is stored according to the basic TLV format shown in Figure 8-2. These TLVs are indexed by their TLV type.
- d) If the TLV type value is 127, the TLV is an Organizationally Specific TLV and is stored according to the basic format for Organizationally Specific TLVs shown in Figure 8-12. These TLVs are indexed by their OUI and organizationally defined TLV subtype.

9.2.7.6 `rxInitializeLLDP()`

The `rxInitializeLLDP()` procedure initializes the LLDP receive module. After the variable `portEnabled` is equal to `TRUE`, the LLDP receive module is initialized or re-initialized for frame reception. During this process, the local LLDP agent performs the following tasks:

- a) The variable `tooManyNeighbors` is set to `FALSE`.
- b) All information in the remote systems MIB associated with this LLDP agent is deleted.

9.2.7.7 rxProcessFrame()

The rxProcessFrame() procedure:

- a) Validates the TLVs contained in the LLDPDU as defined in 9.2.7.7.1 through 9.2.7.7.3.
- b) Determines whether or not a MIB update may be required as defined in 9.2.7.7.4.
- c) If sufficient space is not available, determines whether to discard the incoming LLDPDU from a new neighbor or to delete information from an existing neighbor that is already in the LLDP remote systems MIB, as defined in 9.2.7.7.5. The tooManyNeighborsTimer and the tooManyNeighbors flag variable are both set during this process.

NOTE—The flag variable tooManyNeighbors is automatically reset when the tooManyNeighborsTimer expires.

9.2.7.7.1 LLDPDU validation

The receive module processes each incoming LLDPDU as it is received. The statsFramesInTotal counter for the port is incremented and the LLDPDU is checked to verify the presence of the three mandatory TLVs at the beginning of the LLDPDU as defined in 8.2.

- a) The first TLV is extracted:
 - 1) If the extracted TLV type value does not equal 1, the TLV is not a Chassis ID TLV:
 - i) The LLDPDU is discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - iii) The variable badFrame is set to TRUE.
 - iv) The procedure rxProcessFrame() is terminated.
 - 2) If the extracted TLV type value equals 1, and the chassis ID TLV information string length is not within the range $2 \leq n \leq 256$:
 - i) The LLDPDU is discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - iii) The variable badFrame is set to TRUE.
 - iv) The procedure rxProcessFrame() is terminated.
 - 3) If the extracted TLV type value equals 1, and the chassis ID TLV information string length is within the range $2 \leq n \leq 256$, the chassis ID value is extracted to become the first part of the MSAP identifier.
- b) The second TLV is extracted:
 - 1) If the extracted TLV type value does not equal 2, the TLV is not a Port ID TLV:
 - i) The LLDPDU is discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - iii) The variable badFrame is set to TRUE.
 - iv) The procedure rxProcessFrame() is terminated.
 - 2) If the extracted TLV type value equals 2, and the port ID TLV information string length is not within the range $2 \leq n \leq 256$:
 - i) The LLDPDU is discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - iii) The variable badFrame is set to TRUE.

- iv) The procedure rxProcessFrame() is terminated.
- 3) If the extracted TLV type value equals 2, and the port ID TLV information string length is within the range $2 \leq n \leq 256$, the port ID value is extracted and appended to the chassis ID value to complete construction of the MSAP identifier.
- c) The third TLV is extracted:
 - 1) If the extracted TLV type value does not equal 3, the TLV is not a Time To Live TLV.
 - i) The LLDPDU is discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - iii) The variable badFrame is set to TRUE.
 - iv) The procedure rxProcessFrame() is terminated.
 - 2) If the extracted TLV type value equals 3, and the Time To Live TLV information string length is less than 2:
 - i) The LLDPDU is discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - iii) The variable badFrame is set to TRUE.
 - iv) The procedure rxProcessFrame() is terminated.
 - 3) If the extracted TLV type value equals 3, and the Time To Live TLV information string length is greater than or equal to 2, the first two octets of the TLV information string is extracted and rxTTL is set to this value:
 - i) If rxTTL equals zero, a shutdown frame has been received. The MSAP identifier and rxTTL are passed up to the LLDP MIB manager, and further LLDPDU validation is terminated.
 - ii) If rxTTL is non-zero, LLDPDU validation continues and the remaining TLVs are validated.

Each of the remaining TLV information elements are decoded in succession as required by their particular TLV format definitions:

- d) If the TLV type value equals 0, the TLV is the End Of LLDPDU TLV. The MSAP identifier, rxTTL, and all validated TLVs are passed to the LLDP management entity for LLDP remote systems MIB updating.
- e) If $(0 < \text{TLV_type_value} \leq 8)$ the TLV is a member of the basic management set and is validated according to the general rules for all TLVs defined in 9.2.7.7.2 as well as any specific rules defined for the particular TLVs defined in 8.5.
- f) If TLV_type_value is in the range of reserved TLV types in Table 8-1, the TLV is unrecognized and may be a basic TLV from a later LLDP version. The statsTLVsUnrecognizedTotal counter is incremented, and the TLV is assumed to be validated.
- g) If the TLV type value is 127, the TLV is an Organizationally Specific TLV:
 - 1) If the TLV's OUI and organizationally defined subtype are recognized, the TLV is validated according to the general rules for all TLVs defined in 9.2.7.7.2 as well as the general rules for Organizationally Specific TLVs defined in 9.2.7.7.3 plus any specific rules defined for the particular TLV.
 - 2) If the TLV's OUI and/or organizationally defined subtype are not recognized, the statsTLVsUnrecognizedTotal counter is incremented, and the TLV is assumed to be validated.
- h) If the end of the LLDPDU has been reached, the MSAP identifier, rxTTL, and all validated TLVs are passed to the LLDP management entity for LLDP remote systems MIB updating.

9.2.7.7.2 General validation rules for all TLVs

The value in the TLV information string length field is the value used to validate the TLV and to indicate the location of the next TLV in the LLDPDU.

All TLVs are subject to the general validation rules listed in this subclause as well as any specific usage rules defined for the particular TLV (for example, see systems capabilities TLV usage rules in 8.5.8.3):

- a) If the LLDPDU contains more than one Chassis ID TLV, Port ID TLV, or Time To Live TLV:
 - 1) The LLDPDU is discarded.
 - 2) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - 3) The variable badFrame is set to TRUE.
 - 4) The procedure rxProcessFrame() is terminated.
- b) If the TLV information string length value is not greater than or equal to the sum of the lengths of all fields contained in the TLV information string:
 - 1) The LLDPDU is discarded.
 - 2) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - 3) The variable badFrame is set to TRUE.
 - 4) The procedure rxProcessFrame() is terminated.
- c) If any TLV contains an error condition specified for that particular TLV:
 - 1) The TLV is discarded.
 - 2) The statsTLVsDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - 3) The location of the next TLV is based on the TLV information string length value of the current TLV.
- d) With the exception of the TTL TLV for which specific rules apply (see 9.2.7.7.1), if the length of any field of a TLV is outside the length range specified for that particular TLV (for example, the TLV information string length is greater than the maximum permitted length for the TLV information string as specified for that TLV):
 - 1) The TLV is discarded.
 - 2) The statsTLVsDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
 - 3) The location of the next TLV is based on the TLV information string length value of the current TLV.
- e) If any TLV extends past the physical end of the frame:
 - 1) The TLV is discarded.
 - 2) The statsTLVsDiscardedTotal and statsFramesInErrorsTotal counters are both incremented.
- f) Any information following an End Of LLDPDU TLV is ignored.

NOTE—Usage rules for individual TLVs allow some TLVs to appear more than once in an LLDPDU. Duplicate TLVs result in any one of the values being placed in the MIB, can cause the discard stats to increment, and can cause the change marker for the MIB entry to change if any of the TLV copies change the value even if the value finally recorded is unchanged. The only thing guaranteed is that the MIB value is set to one (unspecified) of the TLV values, and if that value is different to what was previously in the MIB then the change marker is set.

9.2.7.7.3 General validation rules for all Organizationally Specific TLVs

If an Organizationally Specific TLV is not recognized by the receiving LLDP agent, the content of the TLV can be ignored but the TLV is stored in the LLDP remote systems MIB for possible retrieval by network management using the basic Organizationally Specific TLV format (see 8.6) and the StatsTLVsUnrecognizedTotal counter is incremented. If more than one unrecognized Organizationally Specific TLV is received with the same OUI and organizationally defined subtype, but with identifiable differences in the organizationally defined information strings, all copies are assigned a temporary identification index and stored.

9.2.7.7.4 TLV/MIB object value comparison

The LLDP MIB manager is responsible for updating and maintaining the LLDP remote systems MIB with information received by LLDP agents. It uses the rxChanges variable to signal when any change has occurred in the LLDP remote systems MIB due to new or different information in the TLVs from an incoming LLDPDU.

The TLV/MIB object value comparison function is associated with the following actions:

Compare the MSAP identifier in the current LLDPDU with the MSAP identifiers in the LLDP remote systems MIB:

- a) If a match is found, but no difference exists between the information in the TLVs just received and the information in the LLDP remote systems MIB, set the control variable rxChanges to FALSE, set the timing counter rxInfoTTL associated with the MSAP identifier to rxTTL, and wait for the next LLDPDU.
- b) If a match is not found, or if a match is found and any differences exist between the information in the TLVs just received and the information in the LLDP remote systems MIB, check to determine if sufficient space exists in the LLDP remote systems MIB to accommodate the current LLDPDU:
 - 1) If sufficient space exists, set the control variable rxChanges to TRUE and set the flag variable tooManyNeighbors to FALSE.
 - 2) If sufficient space does not exist, perform the “Too many neighbors” process defined in 9.2.7.7.5.

9.2.7.7.5 Too many neighbors

When there is insufficient space in the LLDP remote systems MIB to store information from a new neighbor something needs to be discarded. Either the received LLDPDU is discarded or existing information within the current remote systems MIB is discarded in order to make space for the new information received in the LLDPDU:

- a) Set the flag variable tooManyNeighbors to TRUE.
- b) If the information selected to be discarded is the information in the current LLDPDU:
 - 1) Set the tooManyNeighborsTimer as specified in Equation (3).

$$\text{tooManyNeighborsTimer} = \max(\text{tooManyNeighborsTimer}, \text{rxTTL}) \quad (3)$$

where rxTTL is the TTL value in the current LLDPDU

- 2) Discard the current LLDPDU and increment the statsFramesDiscardedTotal counter.
- 3) Wait for the next LLDPDU.
- c) If the information selected to be discarded is currently in the LLDP remote systems MIB:
 - 1) Delete all information associated with the selected neighbor’s MSAP identifier from the LLDP remote systems MIB.
 - 2) Set the tooManyNeighborsTimer as specified in Equation (4).

$$\text{tooManyNeighborsTimer} = \max(\text{tooManyNeighborsTimer}, \text{rxInfoTTL}) \quad (4)$$

where rxInfoTTL = the selected neighbor’s TTL value

- 3) If sufficient space exists to store the information received in the current LLDPDU in the LLDP remote systems MIB, set control variable rxChanges to TRUE.
- 4) If sufficient space still does not exist to store the information received in the current LLDPDU in the LLDP remote systems MIB, perform steps 1–3 again.

The variable `tooManyNeighbors` is automatically set to `FALSE` whenever the `tooManyNeighborsTimer` expires.

NOTE—The `tooManyNeighborsTimer` is not precise, as it is only cleared (and the `tooManyNeighbors` variable set `FALSE`) by timer expiration, and not by the removal of the too many neighbors condition.

9.2.7.8 `somethingChangedLocal()`

This procedure is called to indicate that the status/value of one or more of the selected objects in the LLDP local system MIB has changed, and that there is therefore a need to transmit new information. It is used to notify the managers of the PTOPO and other optional MIBs that something has changed in the LLDP local systems MIB.

This procedure also sets the value of the variable `localChange` (see 9.2.5.3) to signal the need for the LLDP agent(s) to transmit the new information, and copies the value of the variable `txFastInit` (see 9.2.5.19) to the variable `txFast` (see 9.2.5.18) to ensure that the new values will be seen by the neighbors on the port.

It is assumed that the system provides the ability for any processes that need to receive such indications to register with this procedure so that appropriate signals can be received by those processes when the procedure is called.

9.2.7.9 `somethingChangedRemote()`

This procedure is called after all the information associated with the particular MSAP identifier has been updated in the LLDP remote systems MIB. The procedure call serves as an indication to the managers of the PTOPO and other optional MIBs that one or more of the following conditions is true:

- a) That the status/value of one or more objects in the LLDP remote systems MIB associated with the particular MSAP identifier has changed.
- b) That an incoming LLDPDU contained an MSAP identifier requiring creation of a new MIB structure in the LLDP remote systems MIB to receive the information in that LLDPDU.
- c) That information in the LLDP remote systems MIB associated with the MSAP identifier has been deleted.

It is assumed that the system provides the ability for any processes that need to receive such indications to register with this procedure so that appropriate signals can be received by those processes when the procedure is called.

9.2.7.10 `txAddCredit()`

This procedure increments the value of the `txCredit` variable (9.2.5.16) by one if the current value of the `txCredit` variable is less than the value of `txCreditMax` (9.2.5.17).

9.2.7.11 `txFrame()`

The `txFrame()` procedure makes use of the services of LLC to transmit the LLDPDU constructed by either the `mibConstrInfoLLDPDU()` or `mibConstrShutdownLLDPDU()` procedures (9.2.7.2, 9.2.7.3). The destination MAC address used is the MAC address associated with the instance of the LLDP Agent (see 7.1 and 9.2.5.4). The source MAC address used is the individual MAC address of the transmitting port. The EtherType used is the LLDP EtherType identified in Table 7-3.

After the frame has been transmitted, the `statsFramesOutTotal` counter (9.2.6.5) is incremented.

9.2.7.12 txInitializeLLDP()

The txInitializeLLDP() procedure initializes the LLDP transmit module. It performs the following tasks:

- a) If applicable, either the non-volatile configuration for the LLDP local system MIB are retrieved or the appropriate default values are assigned to all LLDP configuration variables.
- b) The internal (implementation specific) data structures are initialized with appropriate local physical topology information.
- c) System default values are set for the following timing parameters:
 - 1) reinitDelay (9.2.5.10)
 - 2) msgTxHold (9.2.5.6)
 - 3) msgTxInterval (9.2.5.7)
 - 4) msgFastTx (9.2.5.5)

NOTE—It is recommended to introduce a degree of stagger into starting the LLDP local agent initialization in multi-port implementations so that the timing of LLDP frame transmission cycles can be distributed among system ports, and distributed among supported MAC addresses on each port. The method of accomplishing the stagger is an implementation issue and is beyond the scope of this standard.

9.2.8 Transmit state machine

The transmit state machine for an individual port and destination MAC address (see 7.1) shall implement the function specified by the state diagram contained in Figure 9-1 and the attendant definitions contained in 9.2.3 through 9.2.6.8.

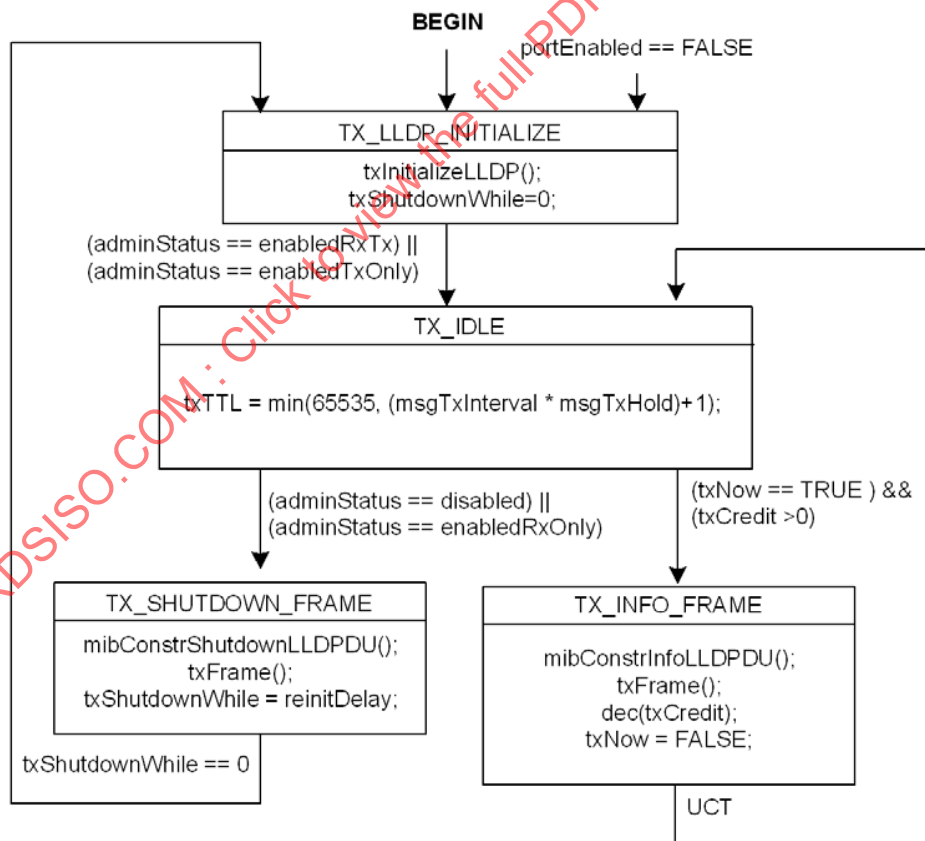


Figure 9-1—Transmit state machine

9.2.9 Receive state machine

The receive state machine for an individual port and destination MAC address (see 7.1) shall implement the function specified by the state diagram contained in Figure 9-2 and the attendant definitions contained in 9.2.2 through 9.2.6.8.

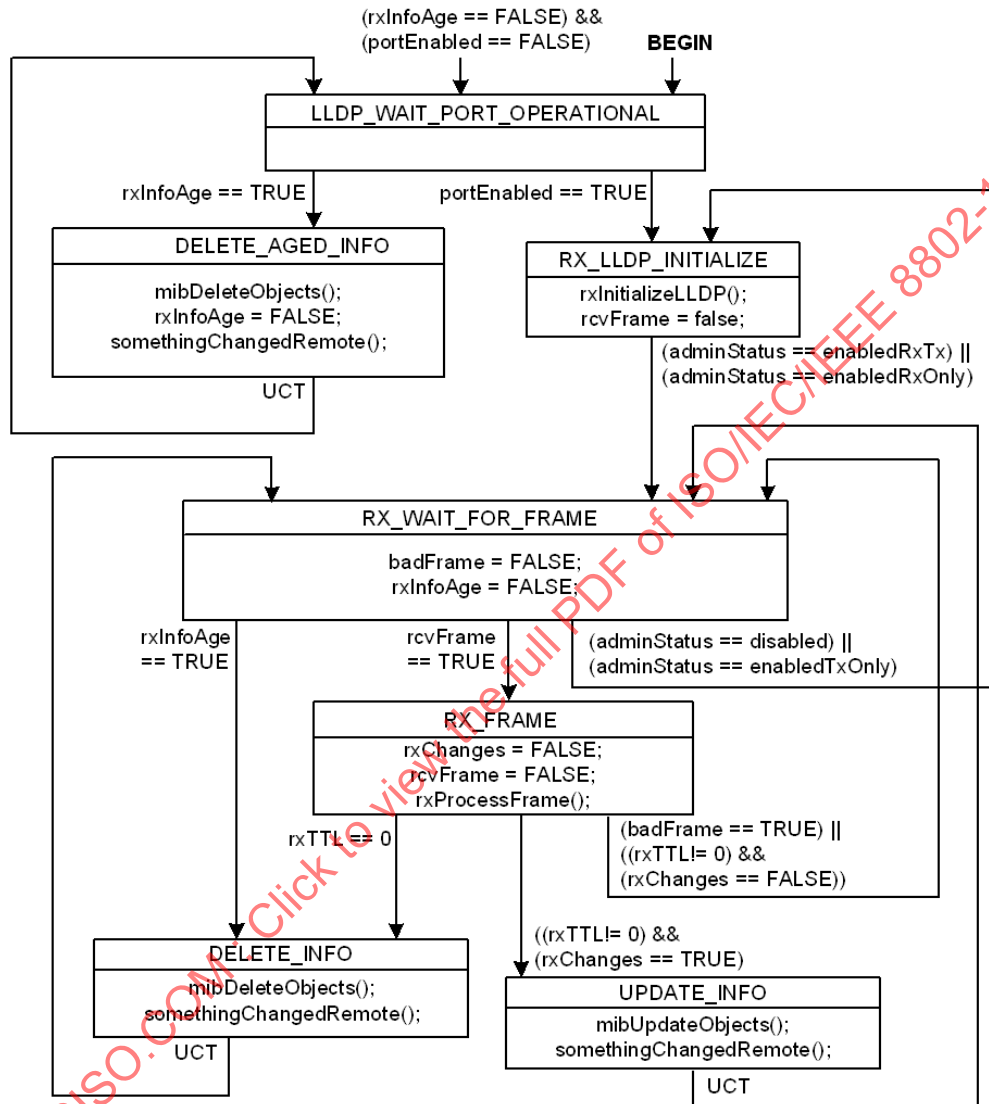


Figure 9-2—Receive state machine

9.2.10 Transmit timer state machine

The transmit timer state machine for an individual port and destination MAC address (see 7.1) shall implement the function specified by the state diagram contained in Figure 9-3 and the attendant definitions contained in 9.2.3 through 9.2.6.8.

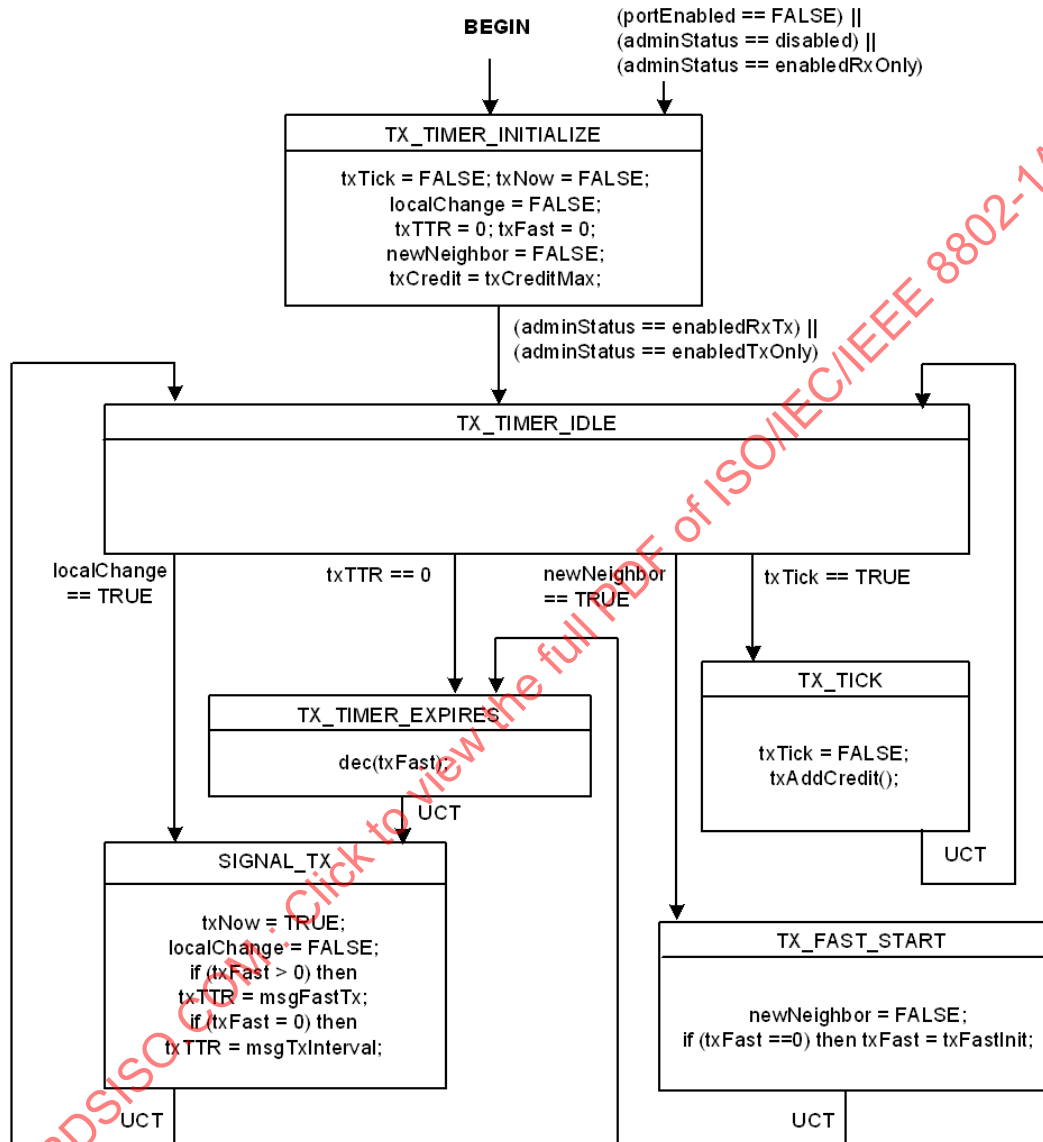


Figure 9-3—Transmit timer state machine

10. LLDP management

This clause defines the set of managed objects and their functionality that allow administrative configuration and monitoring of LLDP operation.

10.1 Data storage and retrieval

LLDP agents need to have a place to store both information about the local system and information they have received about remote systems. Data storage and retrieval capability to support the functionality defined in Clause 7, Clause 8, Clause 9, and Clause 10 shall be provided. No particular implementation is implied.

10.2 The LLDP management entity's responsibilities

The LLDP management entity has the following responsibilities:

- a) Starting the transmit and receive state machines.
- b) Providing a means for the network manager to select TLVs to be included in outgoing LLDPDUs.
- c) Extracting the necessary information from the LLDP local system MIB and constructing the individual TLVs selected for insertion into the LLDPDU.
- d) Prepending appropriate addressing and LLDP EtherType to the LLDPDU before submitting the MA_UNITDATA.request for frame transmission.
- e) Updating the LLDP remote systems MIB and monitoring for MIB object adds, deletions and value changes.
- f) Maintaining operational statistics.

10.2.1 Protocol initialization management

Protocol initialization consists of the following:

- a) Retrieving non-volatile configuration values for the LLDP local system MIB.
- b) Assigning default or management assigned values to LLDP configuration variables.
- c) Loading physical topology information into their associated LLDP local system MIB objects.

10.2.2 TLV selection management

TLV selection management consists of providing the network manager with the means to select which specific TLVs are enabled for inclusion in an LLDPDU. The following LLDP variables cross reference to LLDP local systems configuration MIB tables indicating which specific TLVs are enabled for the particular port(s) on the system. The specific port(s) through which each TLV is enabled for transmission may be set (or reset) by the network manager.

- a) **mibBasicTLVsTxEnable:** This variable lists the single-instance-use basic management TLVs, each with a bit map indicating the system ports through which the referenced TLV is enabled for transmission.
- b) **mibMgmtAddrInstanceTxEnable:** This variable lists the different management addresses (by subtype) that are defined for the system, each with a bit map indicating the system ports through which the particular management address/subtype TLV is enabled for transmission.

NOTE—Implementers of new TLVs should be aware that provision needs to be made to allow similar network management selection of new TLVs and that doing so requires linkage to the LLDP MIB, regardless of whether or not the TLV is part of the basic management set or part of an Organizationally Specific TLV set.

10.2.3 Transmission management

Transmission management consists of the following:

- a) Determining when a new transmission cycle is required, as signaled by the somethingChangedLocal() procedure (see 9.2.7.8).
- b) Extracting the appropriate LLDP local system MIB information for the three mandatory TLVs and inserting them at the beginning of the LLDPDU in proper format order.
- c) Extracting the appropriate LLDP local system MIB information for the selected optional TLVs and inserting them into the LLDPDU.
- d) Optionally, appending an End Of LLDPDU TLV after the last optional TLV in the LLDPDU.
- e) Maintaining length control during LLDPDU construction to ensure that the TLVs do not exceed the maximum length allowed for the LLDPDU.
- f) Submitting the frame for transmission.

10.2.4 Reception management

Reception management consists of the following:

- a) Receiving and parsing the incoming LLDPDUs.
- b) Validating, and checking the types of the first three TLVs to ensure that they are the required type and in LLDPDU format order.
- c) Validating optional TLVs and extracting information values.
- d) Checking whether or not the current LLDPDU represents a new MSAP identifier.
- e) Monitoring whether or not there is sufficient space available in the LLDP remote systems MIB for all active neighbors.
- f) Arbitrating which information is to be discarded in cases where insufficient space is available in the LLDP remote systems MIB for all active neighbors.
- g) Checking whether or not the received information represents a status or value change to the existing MIB object.
- h) Updating remote systems MIB objects as necessary.

10.2.5 Performance management

Performance management consists of the following:

- a) Monitoring the LLDP local system MIB update activities for status or value changes to selected MIB objects and:
 - 1) Calling the somethingChangedLocal() procedure (see 9.2.7.8) whenever a status/value change occurs.
 - 2) Initiating a new transmit cycle if txCredit > 0.
- b) Monitoring the txTTR timer for countdown expiration and initiating a new transmit cycle if txCredit > 0.
- c) Monitoring the rxInfoTTL timer for countdown expiration and:
 - 1) Deleting the associated objects from the LLDP remote systems MIB whenever the timing counter expires.
 - 2) Performing the procedure somethingChangedRemote() associated with the MSAP identifier.
- d) Monitoring rxTTL in the incoming LLDPDUs for shutdown indication and:
 - 1) Deleting the associated objects from the LLDP remote systems MIB whenever rxTTL = 0.
 - 2) Performing the procedure somethingChangedRemote() associated with the MSAP identifier.

- e) Monitoring the “tooManyNeighbors” variable to determine whether an existing neighbor’s information needs to be deleted and:
 - 1) Deleting the objects associated with a selected MSAP identifier from the LLDP remote systems MIB whenever existing information is selected to be deleted.
 - 2) Performing the procedure somethingChangedRemote() associated with the MSAP identifier.
- f) Monitoring the tooManyNeighborsTimer to determine when there is not sufficient space available to accommodate information from all active neighbors and setting the variable tooManyNeighbors associated with the port to FALSE when the tooManyNeighborsTimer expires.
- g) Notifying the managers of the PTOPO MIB and other optional MIB modules (see Figure 11-1) whenever the procedures somethingChangedLocal() or somethingChangedRemote() are performed.
- h) Maintaining operational statistics regarding the LLDP frames sent and received.

10.3 Managed objects

Managed objects model the semantics of management operations. Operations upon a managed object supply information concerning, or facilitate control over, the process or entity associated with that managed object.

Management of LLDP is described in terms of the managed resources that are associated with individual TLVs and that support frame transmission and reception.

10.4 Data types

This subclause specifies the semantics of operations independent of their encoding in management protocol. The data types of the parameters of operations are defined for that specification.

The following data types are used:

- a) Boolean.
- b) Enumerated, for a collection of named values.
- c) Unsigned, for all parameters specified as “number of” some quantity.
- d) MAC address.
- e) Time interval, an Unsigned value representing a positive integral number of seconds for all time out parameters.
- f) Counter, for all parameters specified as a “count” of some quantity (all counters increment and wrap with a modulus of 2 to the power 32).

10.5 LLDP variables

LLDP managed objects fall into the following categories:

- a) Status/control variables necessary for operation of the protocol.
- b) Variables that accumulate operational statistics.
- c) Variables that are required by the particular TLVs.

10.5.1 LLDP operational status and control

- a) Global parameters and variables:
 - 1) **adminStatus:** The authority that controls whether or not a local LLDP agent is enabled for transmit and receive, transmit only, or receive only; or is disabled (9.2.5.1).

- b) Transmit state machine parameters and variables:
 - 1) **msgTxHold:** A multiplier on msgTxInterval used to compute the TTL value of txTTL (9.2.5.6, 9.2.5.22).
 - 2) **msgTxInterval:** The interval between successive transmit cycles in normal transmission mode (9.2.5.7).
 - 3) **reinitDelay:** The delay after adminStatus becomes ‘disabled’ before re-initialization is attempted (9.2.5.10).
 - 4) **txCreditMax:** The maximum value of transmission credit (9.2.5.17).
 - 5) **txFastInit:** The interval between successive LLDPDU transmissions in fast transmission mode (9.2.5.19).
- c) Receive state machine parameters and variables:
 - 1) **remoteChanges:** An indication that the status/value of one or more selected objects in the LLDP remote systems MIB has changed or that all objects associated with a particular MSAP identifier have been deleted (9.2.5.11).
 - 2) **tooManyNeighbors:** An indication that there is insufficient space in the LLDP remote systems MIB to store information from all active neighbors (9.2.5.15).

10.5.2 LLDP operational statistics counters

The following counters provide operational statistics on a per port basis:

- a) Transmission counters:
 - 1) **statsFramesOutTotal:** A count of all LLDP frames transmitted through the port (9.2.6.5).
 - 2) **statsLengthErrorsTotal:** A count of all LLDP length errors detected when constructing LLDPDU frames for transmission through the port (9.2.7.2).
- b) Reception counters:
 - 1) **statsAgeoutsTotal:** A count of the times that a neighbor’s information is deleted from the LLDP remote systems MIB because of rxInfoTTL timer expiration (9.2.6.1).
 - 2) **statsFramesDiscardedTotal:** A count of all LLDPDUs received and then discarded (9.2.6.2).
 - 3) **statsFramesInErrorsTotal:** A count of all LLDPDUs received at the port with one or more detectable errors 9.2.6.3).
 - 4) **statsFramesInTotal:** A count of all LLDP frames received at the port (9.2.6.4).
 - 5) **statsTlvsDiscardedTotal:** A count of all TLVs received at the port and discarded for any reason. (9.2.6.6)
 - 6) **statsTLVsUnrecognizedTotal:** This counter provides a count of all TLVs not recognized by the receiving LLDP local agent (9.2.6.7).

10.5.3 TLV required variables

Variables in this category are defined by the requirements of the particular TLVs. They are maintained with reference to the local system in the LLDP local system MIB; and with reference to the remote system, in the LLDP remote systems MIB. TLV variables are outputs from the local LLDP agent and inputs to the remote LLDP agent.

Variables that pertain to basic set TLVs are listed in the following subclauses.

10.5.3.1 Chassis ID TLV objects

- a) **chassis ID subtype:** The type of identifier used for the chassis (see 8.5.2.2).
- b) **chassis ID:** The identification assigned to the chassis containing the port (see 8.5.2.3).

10.5.3.2 Port ID TLV objects

- a) **port ID subtype:** The type of identifier used for the port (see 8.5.3.2).
- b) **port ID:** The identification assigned to the port (see 8.5.3.3).

10.5.3.3 Port description TLV object

- a) **port description:** The port's description (see 8.5.5.2).

10.5.3.4 System name TLV object

- a) **system name:** The system's assigned name (see 8.5.6.2).

10.5.3.5 System description TLV object

- a) **system description:** The system's description (see 8.5.7.2).

10.5.3.6 System capabilities TLV objects

- a) **system capabilities:** The primary capabilities of the system (see 8.5.8.1).
- b) **enabled capabilities:** The system's enabled capabilities (see 8.5.8.2).

10.5.3.7 Management address TLV objects

- a) **management address length:** The length of the management address (see 8.5.9.2).
- b) **management address subtype:** The management address type (see 8.5.9.3).
- c) **management address:** The management address (see 8.5.9.4).
- d) **interface numbering subtype:** The interface type (see 8.5.9.5).
- e) **interface number:** The interface number (see 8.5.9.6).
- f) **OID length:** The object identifier length (see 8.5.9.7).
- g) **OID:** The object identifier (see 8.5.9.8).

11. LLDP MIB definitions

This clause defines the LLDP basic MIB for use with SNMP in TCP/IP based internets. In particular, it defines objects for managing the operation of LLDP based on the specifications of Clause 7, Clause 8, Clause 9, and Clause 10.

11.1 Internet Standard Management Framework

LLDP MIBs are designed to operate in a manner consistent with the principles of the Internet Standard Management Framework, which describes the separation of a data modeling language (for example, SMIV2) from content-specific data models (for example, the LLDP remote systems MIB), and from messages and protocol operations used to manipulate the data (for example, SNMPv3).

For a detailed overview of the documents that describe the current Internet Standard Management Framework, please refer to section 7 of IETF RFC 3410.

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This clause specifies a MIB module that is compliant to the SMIV2, which is described in IETF RFC 2578 (STD 58) [B3], IETF RFC 2579 (STD 58) [B4], and IETF RFC 2580 (STD 58) [B5].

11.2 Structure of the LLDP MIB

The LLDP MIB consists of two types of MIB modules, the mandatory basic MIB defined in this clause and from zero to n optional organizationally specific MIB extensions such as the IEEE 802.1 MIB in Annex D of IEEE Std 802.1Q-2014 and the IEEE 802.3 MIB in Clause 79 of IEEE Std 802.3-2012.

Each MIB module is divided into two major sections as shown in Figure 11-1 to allow selective MIB support for the particular operating mode (transmit only, receive only, or both transmit and receive) being implemented.

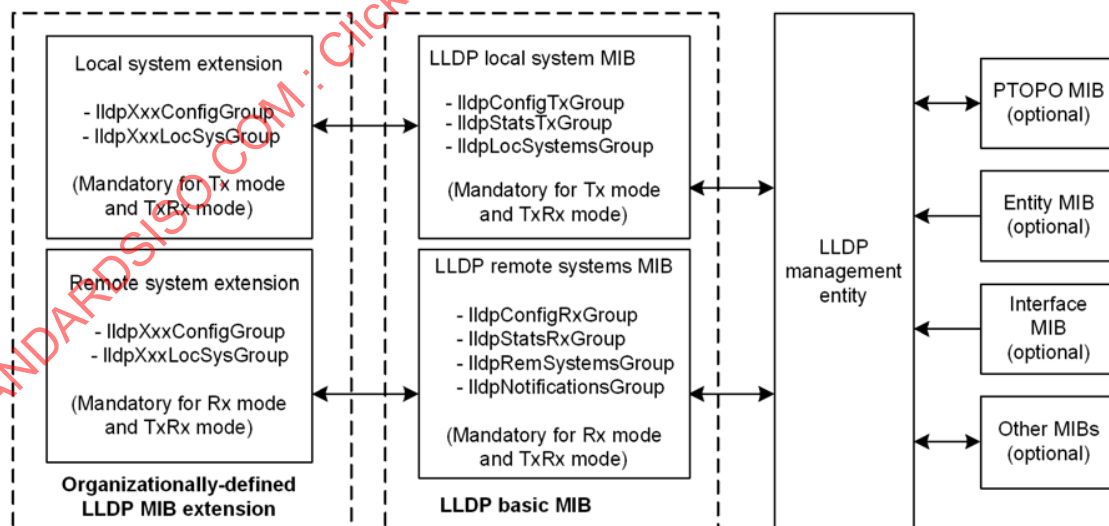


Figure 11-1—LLDP MIB block diagram

Table 11-1 summarizes the particular object groups that are required for each operating mode. The basic MIB shall comply with the MIB conformance section for the particular operating mode (Rx, Tx, or TxRx mode) being supported.

Table 11-1—MIB object groups and operating mode applicability

MIB group	Rx mode	Tx mode	TxRx mode
lldpV2ConfigGroup			
lldpV2ConfigRxGroup	M ^a	—	M
lldpV2ConfigTxGroup	—	M	M
lldpV2StatsRxGroup	M	—	M
lldpV2StatsTxGroup	—	M	M
lldpV2LocSysGroup	—	M	M
lldpV2RemSysGroup	M	—	M
lldpV2NotificationsGroup	M	—	M
ifGeneralInformationGroup	M	M	M

^aM=Mandatory

Table 11-2 shows the structure of the MIB and the relationship of the MIB objects to the LLDP operational status/control variables, LLDP statistics variables, and TLV variables.

Table 11-2—LLDP MIB structure and object cross reference

MIB table	MIB object	LLDP reference
<i>LLDP Configuration group</i>		
	lldpV2MessageTxInterval	msgTxInterval, 9.2.5.7
	lldpV2MessageTxHoldMultiplier	msgTxHold, 9.2.5.6
	lldpV2ReinitDelay	reinitDelay, 9.2.5.10
	lldpV2NotificationInterval	msgTxInterval, 9.2.5.7
	lldpV2TxCreditMax	txCreditMax, 9.2.5.17
	lldpV2MessageFastTx	msgFastTx, 9.2.5.5
	lldpV2TxFastInit	txFastInit, 9.2.5.19

Table 11-2—LLDP MIB structure and object cross reference (continued)

MIB table	MIB object	LLDP reference
lldpV2PortConfigTableV2		
	lldpV2PortConfigIfIndexV2	(Table index)
	lldpV2PortConfigDestAddressIndexV2	(Table index)
	lldpV2PortConfigAdminStatusV2	adminStatus, 9.2.5.1
	lldpV2PortMessageTxInterval	msgTxInterval, 9.2.5.7
	lldpV2PortMessageTxHoldMultiplier	msgTxHold, 9.2.5.6
	lldpV2PortReinitDelay	reinitDelay, 9.2.5.10
	lldpV2PortNotificationInterval	msgTxInterval, 9.2.5.7
	lldpV2PortTxCreditMax	txCreditMax, 9.2.5.17
	lldpV2PortMessageFastTx	msgFastTx, 9.2.5.5
	lldpV2PortTxFastInit	txFastInit, 9.2.5.19
	lldpV2PortConfigNotificationEnableV2	—
	lldpV2PortConfigTLVsTxEnableV2	9.1.2.1
lldpV2DestAddressTable		
	lldpV2AddressTableIndex	(Table index)
	lldpV2DestMacAddress	(Table index)
lldpV2ManAddrConfigTxPortsTable		
	lldpV2ManAddrConfigIfIndex	(Table index)
	lldpV2ManAddrConfigDestAddressIndex	(Table index)
	lldpV2ManAddrConfigLocManAddrSubtype	8.5.9.3 (Table index)
	lldpV2ManAddrConfigLocManAddr	8.5.9.4 (Table index)
	lldpV2ManAddrConfigTxEnable	9.1.2.1
	lldpV2ManAddrConfigRowStatus	—
LLDP Statistics group		
	lldpV2StatsRemTablesLastChangeTime	—
	lldpV2StatsRemTablesInserts	—
	lldpV2StatsRemTablesDeletes	—
	lldpV2StatsRemTablesDrops	—
	lldpV2StatsRemTablesAgeouts	—

Table 11-2—LLDP MIB structure and object cross reference (continued)

MIB table	MIB object	LLDP reference
lldpV2StatsTxPortTable		
	lldpV2StatsTxIfIndex	(Table index)
	lldpV2StatsTxDestMACAddress	(Table index)
	lldpV2StatsTxPortFramesTotal	statsFramesOutTotal, 9.2.6.5
	lldpV2StatsTxLLDPDULengthErrors	lldpduLengthErrors, 9.2.6.8
lldpV2StatsRxPortTable		
	lldpV2StatsRxDestIfIndex	(Table index)
	lldpV2StatsRxDestMACAddress	(Table index)
	lldpV2StatsRxPortFramesDiscardedTotal	statsFramesDiscardedTotal, 9.2.6.2
	lldpV2StatsRxPortFramesErrors	statsFramesInErrorsTotal, 9.2.6.3
	lldpV2StatsRxPortFramesTotal	statsFramesInTotal, 9.2.6.4
	lldpV2StatsRxPortTLVsDiscardedTotal	statsTLVsDiscardedTotal, 9.2.6.6
	lldpV2StatsRxPortTLVsUnrecognizedTotal	statsTLVsUnrecognizedTotal, 9.2.6.7
	lldpV2StatsRxPortAgeoutsTotal	statsAgeoutsTotal, 9.2.6.1
<i>Local System Data group</i>		
	lldpV2LocChassisIdSubtype	chassis ID subtype, 8.5.2.2
	lldpV2LocChassisId	chassis ID, 8.5.2.3
	lldpV2LocSysName	system name, 8.5.6.2
	lldpV2LocSysDesc	system description, 8.5.7.2
	lldpV2LocSysCapSupported	system capabilities, 8.5.8.1
	lldpV2LocSysCapEnabled	enabled capabilities, 8.5.8.2
lldpV2LocPortTable		
	lldpV2LocPortIfIndex	(Table index)
	lldpV2LocPortIdSubtype	port ID subtype, 8.5.3.2
	lldpV2LocPortId	port ID, 8.5.3.3
	lldpV2LocPortDesc	port description, 8.5.5.2
lldpV2LocManAddrTable		
	lldpV2LocManAddrSubtype	management address subtype, 8.5.9.3 (Table index)
	lldpV2LocManAddr	management address, 8.5.9.4 (Table index)
	lldpV2LocManAddrLen	management address string length, 8.5.9.2
	lldpV2LocManAddrIfSubtype	interface numbering subtype, 8.5.9.5

Table 11-2—LLDP MIB structure and object cross reference (continued)

MIB table	MIB object	LLDP reference
	lldpV2LocManAddrIfId	interface number, 8.5.9.6
	lldpV2LocManAddrOID	object identifier, 8.5.9.8
<i>Remote Systems Data group</i>		
lldpV2RemTable		
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2RemChassisIdSubtype	chassis ID subtype, 8.5.2.2
	lldpV2RemChassisId	chassis ID, 8.5.2.3
	lldpV2RemPortIdSubtype	port ID subtype, 8.5.3.2
	lldpV2RemPortId	port ID, 8.5.3.3
	lldpV2RemPortDesc	port description, 8.5.5.2
	lldpV2RemSysName	system name, 8.5.6.2
	lldpV2RemSysDesc	system description, 8.5.7.2
	lldpV2RemSysCapSupported	system capabilities, 8.5.8.1
	lldpV2RemSysCapEnabled	enabled capabilities, 8.5.8.2
	lldpV2RemRemoteChanges	remoteChanges, 9.2.5.11
	lldpV2RemTooManyNeighbors	tooManyNeighbors, 9.2.5.15
lldpV2RemManAddrTable		(Table index)
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2RemManAddrSubtype	management address subtype, 8.5.9.3 (Table index)
	lldpV2RemManAddr	management address, 8.5.9.4 (Table index)
	lldpV2RemManAddrIfSubtype	interface numbering subtype, 8.5.9.5
	lldpV2RemManAddrIfId	interface number, 8.5.9.6
	lldpV2RemManAddrOID	object identifier, 8.5.9.8

Table 11-2—LLDP MIB structure and object cross reference (continued)

MIB table	MIB object	LLDP reference
lldpV2RemUnknownTLVTable		
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2RemUnknownTLVType	LLDPDU validation, 9.2.7.7.1 (Table index)
	lldpV2RemUnknownTLVInfo	LLDPDU validation, 9.2.7.7.1
lldpV2RemOrgDefInfoTable		
	lldpV2RemTimeMark	(Table index)
	lldpV2RemLocalIfIndex	(Table index)
	lldpV2RemLocalDestMACAddress	(Table index)
	lldpV2RemIndex	(Table index)
	lldpV2RemOrgDefInfoOUI	organizationally unique identifier, 8.6.1.3 (Table index)
	lldpV2RemOrgDefInfoSubtype	organizationally defined subtype, 8.6.1.4 (Table index)
	lldpV2RemOrgDefInfoIndex	(Table index)
	lldpV2RemOrgDefInfo	organizationally defined information, 8.6.1.5
LLDP MIB Notifications		
	lldpV2RemTablesChange	

11.3 Relationship to other MIBs

This clause includes specifications for an LLDP Textual Conventions MIB module, an LLDP MIB module, and for IEEE 802.1 and IEEE 802.3 extension MIB modules that are compliant with the SMIPv2 as defined in IETF RFC 2578 (STD 58) [B3], IETF RFC 2579 (STD 58) [B4], and IETF RFC 2580 (STD 58) [B5].

LLDP is designed to operate in conjunction with MIB modules defined by the IETF, IEEE 802, and others. The following subclauses discuss the relationship between LLDP and IETF MIB modules. LLDP agents automatically notify the managers of these MIB modules whenever there is a value or status change in an LLDP MIB object.

LLDP managed objects for the local system are stored in the LLDP local system MIB. Information received from a remote LLDP agent is stored in the local LLDP agent's LLDP remote system MIB.

NOTE—In this standard, managed objects for an LLDP MIB module are defined as they would be for an SNMP MIB. However, it is not required for LLDP implementations to support SNMP to store and retrieve system data. LLDP agents need to have a place to store both information about the local system and information they have received about remote systems. No particular implementation is implied.

11.3.1 Relationship to LLDP Version 1 MIB

The version 1 MIB module that was published in the initial 2005 publication of this standard has been superseded by the version 2 MIB module specified in 11.5.1, and support of the version 2 module is a requirement for conformance to the required or optional capabilities (Clause 5) in this revision of the standard. The version 2 MIB module reflects changes in indexation of the MIB objects that support the use of LLDP with multiple destination MAC addresses, as discussed in Clause 6.

In addition to the changes in indexation, the version 2 MIB module also supports changes to the management of the LLDP protocol that have resulted from changes to the LLDP protocol state machines. As these protocol changes affect only the timing and frequency of transmission of LLDPDUs, and not the content of the LLDPDUs, version 1 and version 2 implementations can successfully co-exist and interoperate.

From the perspective of a version 2 implementation, a version 1 neighbor behaves as a version 2 neighbor that is only using a single destination MAC address (the 01-80-C2-00-00-0E address specified for use in the IEEE 802.1AB-2005 version of the standard). From the perspective of a version 1 implementation, a version 2 neighbor that uses the 01-80-C2-00-00-0E destination MAC address behaves as a version 1 neighbor.

11.3.2 IETF Physical Topology MIB

The IETF Physical Topology (PTOPO) MIB (IETF RFC 2922 [B9]) allows a LLDP agent to expose learned physical topology information, using an IETF MIB. LLDP is intended to support the PTOPO MIB.

NOTE—The LLDP MIB module is a logical superset of the IETF PTOPO MIB; therefore, from a functional point of view, if the LLDP MIB module is implemented, it is likely not to be necessary to implement the PTOPO MIB defined in IETF RFC 2922 [B9]. However, for backward compatibility, this standard also supports the use of the PTOPO MIB.

11.3.3 IETF Entity MIB

The Entity MIB (IETF RFC 6933) allows the physical component inventory and hierarchy to be identified. Chassis IDs passed in the LLDPDU can identify entPhysicalTable entries. SNMP agents that implement the LLDP MIB should implement the entPhysicalAlias object from the Entity MIB version 2 or higher.

11.3.4 IETF Interfaces MIB

The Interfaces MIB (IETF RFC 2863) provides a standard mechanism for managing network ports. Port IDs passed in the LLDPDU can identify ifTable (or entPhysicalTable) entries. SNMP agents that implement the LLDP MIB shall also implement the ifTable and ifXTable for the ports that are represented in the Interfaces MIB.

11.4 Security considerations for LLDP base MIB module

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-write.¹⁰ Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations.

¹⁰In IETF MIB definitions, the MAX-ACCESS clause defines the type of access that is allowed for particular data elements in the MIB. An explanation of the MAX-ACCESS mappings is given in section 7.3 of IETF RFC 2578 [B3].

- a) Setting the following objects to incorrect values can result in an excessive number of LLDP packets being sent by the LLDP agent:
 - 1) lldpV2MessageTxInterval, lldpV2PortMessageTxInterval
 - 2) lldpV2TxCreditMax, lldpV2PortTxCreditMax
 - 3) lldpV2MessageFastTx, lldpV2PortMessageFastTx
 - 4) lldpV2TxFastInit, lldpV2PortTxFastInit
- b) Setting the object, lldpV2MessageTxHoldMultiplier or lldpV2PortMessageTxHoldMultiplier, to incorrect values can cause the LLDP agent to transmit LLDPDUs with too-high TTL values, which affect the expiration time of objects grouped under lldpV2RemoteSystemsData identifier.
- c) Setting the object, lldpV2ReinitDelay or lldpV2PortReinitDelay, to too low a value can cause the transmit state machine to attempt excessive re-initializations.
- d) Setting incorrect bits in the object, lldpV2PortConfigTLVsTxEnableV2, can cause the LLDP agent to transmit LLDPDUs with an undesired optional TLV sequence.
- e) Setting incorrect bits in the object, lldpV2ConfigManAddrPortsTxEnable, can cause the LLDP agent to advertise management addresses that were not meant to be disclosed and/or to omit addresses that were desired.
- f) Setting the following objects to incorrect values can result in improper operation of the MIB notification process:
 - 1) lldpV2NotificationInterval
 - 2) lldpV2PortNotificationInterval
 - 3) lldpV2PortConfigNotificationEnableV2
- g) Setting the object, lldpV2PortConfigAdminStatusV2, to the incorrect value can result in enabling a non-desired operational mode.

The following readable objects in this MIB module may be considered to be sensitive or vulnerable in some network environments:

- h) Objects that are associated with the transmit mode
 - 1) lldpV2LocChassisIdSubtype
 - 2) lldpV2LocChassisId
 - 3) lldpV2LocPortIdSubtype
 - 4) lldpV2LocPortId
 - 5) lldpV2LocPortDesc
 - 6) lldpV2LocSysName
 - 7) lldpV2LocSysDesc
 - 8) lldpV2LocSysCapSupported
 - 9) lldpV2LocSysCapEnabled
 - 10) lldpV2LocManAddrLen
 - 11) lldpV2LocManAddrIfSubtype
 - 12) lldpV2LocManAddrIfId
 - 13) lldpV2LocManAddrOID
- i) Objects that are associated with the receive mode
 - 1) lldpV2NotificationInterval
 - 2) lldpV2PortConfigNotificationEnable
 - 3) lldpV2RemChassisIdSubtype
 - 4) lldpV2RemChassisId
 - 5) lldpV2RemPortIdSubtype
 - 6) lldpV2RemPortId
 - 7) lldpV2RemPortDesc
 - 8) lldpV2RemSysName
 - 9) lldpV2RemSysDesc
 - 10) lldpV2RemSysCapSupported
 - 11) lldpV2RemSysCapEnabled
 - 12) lldpV2RemManAddrIfSubtype

- 13) lldpV2RemManAddrIfId
- 14) lldpV2RemManAddrOID
- 15) lldpV2RemUnknownTLVInfo
- 16) lldpV2RemOrgDefInfo

This concern applies both to objects that describe the configuration of the local host, as well as for objects that describe information from the remote hosts, acquired via LLDP and displayed by the objects in this MIB module. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP.

SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example, by using IPsec), even then, there is no control as to who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB module.

Implementers should consider the security features as provided by the SNMPv3 framework (see IETF RFC 3410, section 8), including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy).

Further, implementers should not deploy SNMP versions prior to SNMPv3. Instead, implementers should deploy SNMPv3 to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of this MIB module is properly configured to give access to the objects only to those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

11.5 LLDP MIB modules ^{11,12}

Two MIB modules are defined—a textual conventions MIB module (11.5.1) that contains the textual conventions used by the LLDP version 2 MIB module and by the version 2 extension MIB module in Annex D of IEEE Std 802.1Q-2014, and the LLDP version 2 MIB module itself (11.5.2). The textual conventions defined in the Textual-Conventions MIB module are also available by extension MIB modules defined in other standards, such as the extension MIB modules defined in IEEE Std 802.1Q.

¹¹Copyright release for MIBs: Users of this standard may freely reproduce the MIB contained in this subclause so that it can be used for its intended purpose.

¹²An ASCII version of this MIB module can be obtained by Web browser from the IEEE 802.1 Website at <http://www.ieee802.org/1/pages/MIBS.html>.

IEEE Std 802.1AB-2016
IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery

11.5.1 Definitions for the LLDP-V2-TC MIB module

In the following MIB module, should any discrepancy between the DESCRIPTION text and the corresponding definition in Clause 9 and Clause 10 occur, the definition in Clause 9 and Clause 10 shall take precedence.

LLDP-V2-TC-MIB DEFINITIONS ::= BEGIN

IMPORTS

MODULE-IDENTITY,
Unsigned32,
org
FROM SNMPv2-SMI
TEXTUAL-CONVENTION
FROM SNMPv2-TC;

lldpV2TcMIB MODULE-IDENTITY

LAST-UPDATED "201603110000Z" -- March 11, 2016

ORGANIZATION "IEEE 802.1 Working Group"

CONTACT-INFO

" WG-URL: <http://www.ieee802.org/1/>

WG-E-Mail: stds-802-1-L@ieee.org

Contact: IEEE 802.1 Working Group Chair

Postal: C/O IEEE 802.1 Working Group

IEEE Standards Association

445 Hoes Lane

Piscataway

NJ 08854

USA

E-mail: stds-802-1-L@ieee.org"

DESCRIPTION

"Textual conventions used throughout the IEEE Std 802.1AB version 2 and later MIB modules.

Unless otherwise indicated, the references in this MIB module are to IEEE 802.1AB-2016.

The TCs in this MIB are taken from the original LLDP-MIB, LLDP-EXT-DOT1-MIB, and LLDP-EXT-DOT3-MIB published in IEEE Std 802-1D-2004, with the addition of TCs to support the management address table. They have been made available as a separate TC MIB module to facilitate referencing from other MIB modules.

Copyright (C) IEEE (2016). This version of this MIB module is published as 11.5.1 of IEEE Std 802.1AB-2016; see the standard itself for full legal notices."

REVISION "201603110000Z" -- March 11, 2016

DESCRIPTION

"Published as part of IEEE Std 802.1AB-2016.
This revision updated referencees."

REVISION "200906080000Z" -- June 08, 2009

DESCRIPTION

"Published as part of IEEE Std 802.1AB-2009 revision."

```
::= { org ieee(111) standards-association-numbers-series-standards(2)
      lan-man-stds(802) ieee802dot1(1) 1 12 }
```

```
--
-- Definition of the root OID arc for IEEE 802.1 MIBs
--
```

ieee802dot1mibs OBJECT IDENTIFIER

```
::= { org ieee(111) standards-association-numbers-series-standards(2)
      lan-man-stds(802) ieee802dot1(1) 1 }
```

```
--
-- *****
```

```
-- Textual Conventions
--
```

```
-- *****
```

LldpV2ChassisIdSubtype ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"This TC describes the source of a chassis identifier.

The enumeration 'chassisComponent(1)' represents a chassis identifier based on the value of entPhysicalAlias object (defined in IETF RFC 6933) for a chassis component (i.e., an entPhysicalClass value of 'chassis(3)').

The enumeration 'interfaceAlias(2)' represents a chassis identifier based on the value of ifAlias object (defined in IETF RFC 2863) for an interface on the containing chassis.

The enumeration 'portComponent(3)' represents a chassis identifier based on the value of entPhysicalAlias object (defined in IETF RFC 6933) for a port or backplane component (i.e., entPhysicalClass value of 'port(10)' or 'backplane(4)'), within the containing chassis.

The enumeration 'macAddress(4)' represents a chassis identifier based on the value of a unicast source address (encoded in network byte order and IEEE 802.3 canonical bit order), of a port on the containing chassis as defined in IEEE Std 802.

The enumeration 'networkAddress(5)' represents a chassis identifier based on a network address, associated with a particular chassis. The encoded address is actually composed of two fields. The first field is a single octet, representing the IANA AddressFamilyNumbers value for the specific address type, and the second field is the network address value.

The enumeration 'interfaceName(6)' represents a chassis identifier based on the value of ifName object (defined in IETF RFC 2863) for an interface on the containing chassis.

The enumeration 'local(7)' represents a chassis identifier

```

        based on a locally defined value."
SYNTAX  INTEGER {
        chassisComponent(1),
        interfaceAlias(2),
        portComponent(3),
        macAddress(4),
        networkAddress(5),
        interfaceName(6),
        local(7)
    }

```

LldpV2ChassisId ::= TEXTUAL-CONVENTION

DISPLAY-HINT "1x:"

STATUS current

DESCRIPTION

"This TC describes the format of a chassis identifier string. Objects of this type are always used with an associated LldpChassisIdSubtype object, which identifies the format of the particular LldpChassisId object instance.

If the associated LldpChassisIdSubtype object has a value of 'chassisComponent(1)', then the octet string identifies a particular instance of the entPhysicalAlias object (defined in IETF RFC 6933) for a chassis component (i.e., an entPhysicalClass value of 'chassis(3)').

If the associated LldpChassisIdSubtype object has a value of 'interfaceAlias(2)', then the octet string identifies a particular instance of the ifAlias object (defined in IETF RFC 2863) for an interface on the containing chassis. If the particular ifAlias object does not contain any values, another chassis identifier type should be used.

If the associated LldpChassisIdSubtype object has a value of 'portComponent(3)', then the octet string identifies a particular instance of the entPhysicalAlias object (defined in IETF RFC 6933) for a port or backplane component within the containing chassis.

If the associated LldpChassisIdSubtype object has a value of 'macAddress(4)', then this string identifies a particular unicast source address (encoded in network byte order and IEEE 802.3 canonical bit order), of a port on the containing chassis as defined in IEEE Std 802.

If the associated LldpChassisIdSubtype object has a value of 'networkAddress(5)', then this string identifies a particular network address, encoded in network byte order, associated with one or more ports on the containing chassis. The first octet contains the IANA Address Family Numbers enumeration value for the specific address type, and octets 2 through N contain the network address value in network byte order.

If the associated LldpChassisIdSubtype object has a value of 'interfaceName(6)', then the octet string identifies a particular instance of the ifName object (defined in IETF RFC 2863) for an interface on the containing chassis. If the particular ifName object does not contain any values, another chassis identifier type should be used.

If the associated LldpChassisIdSubtype object has a value of 'local(7)', then this string identifies a locally assigned Chassis ID."

SYNTAX OCTET STRING (SIZE (1..255))

LldpV2PortIdSubtype ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"This TC describes the source of a particular type of port identifier used in the LLDP MIB.

The enumeration 'interfaceAlias(1)' represents a port identifier based on the ifAlias MIB object, defined in IETF RFC 2863.

The enumeration 'portComponent(2)' represents a port identifier based on the value of entPhysicalAlias (defined in IETF RFC 6933) for a port component (i.e., entPhysicalClass value of 'port(10)'), within the containing chassis.

The enumeration 'macAddress(3)' represents a port identifier based on a unicast source address (encoded in network byte order and IEEE 802.3 canonical bit order), which has been detected by the agent and associated with a particular port (IEEE Std 802).

The enumeration 'networkAddress(4)' represents a port identifier based on a network address, detected by the agent and associated with a particular port.

The enumeration 'interfaceName(5)' represents a port identifier based on the ifName MIB object, defined in IETF RFC 2863.

The enumeration 'agentCircuitId(6)' represents a port identifier based on the agent-local identifier of the circuit (defined in IETF RFC 3046), detected by the agent and associated with a particular port.

The enumeration 'local(7)' represents a port identifier based on a value locally assigned."

SYNTAX INTEGER {
 interfaceAlias(1),
 portComponent(2),
 macAddress(3),
 networkAddress(4),
 interfaceName(5),
 agentCircuitId(6),
 local(7)
 }

LldpV2PortId ::= TEXTUAL-CONVENTION

DISPLAY-HINT "1x:"

STATUS current

DESCRIPTION

"This TC describes the format of a port identifier string. Objects of this type are always used with an associated

LldpPortIdSubtype object, which identifies the format of the particular LldpPortId object instance.

If the associated LldpPortIdSubtype object has a value of 'interfaceAlias(1)', then the octet string identifies a particular instance of the ifAlias object (defined in IETF RFC 2863). If the particular ifAlias object does not contain any values, another port identifier type should be used.

If the associated LldpPortIdSubtype object has a value of 'portComponent(2)', then the octet string identifies a particular instance of the entPhysicalAlias object (defined in IETF RFC 6933) for a port or backplane component.

If the associated LldpPortIdSubtype object has a value of 'macAddress(3)', then this string identifies a particular unicast source address (encoded in network byte order and IEEE 802.3 canonical bit order) associated with the port (IEEE Std 802).

If the associated LldpPortIdSubtype object has a value of 'networkAddress(4)', then this string identifies a network address associated with the port. The first octet contains the IANA AddressFamilyNumbers enumeration value for the specific address type, and octets 2 through N contain the networkAddress address value in network byte order.

If the associated LldpPortIdSubtype object has a value of 'interfaceName(5)', then the octet string identifies a particular instance of the ifName object (defined in IETF RFC 2863). If the particular ifName object does not contain any values, another port identifier type should be used.

If the associated LldpPortIdSubtype object has a value of 'agentCircuitId(6)', then this string identifies a agent-local identifier of the circuit (defined in IETF RFC 3046).

If the associated LldpPortIdSubtype object has a value of 'local(7)', then this string identifies a locally assigned port ID."

SYNTAX OCTET STRING (SIZE (1..255))

LldpV2ManAddrIfSubtype ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"This TC defines an enumeration value that identifies the interface numbering method used for defining the interface number associated with a management address. An object with this syntax defines the format of an interface number object.

The enumeration 'unknown(1)' represents the case where the interface is not known. In this case, the corresponding interface number is of zero length.

The enumeration 'ifIndex(2)' represents interface identifier based on the ifIndex MIB object.

The enumeration 'systemPortNumber(3)' represents interface

identifier based on the system port numbering convention."

REFERENCE

"8.5.9.5"

SYNTAX INTEGER {
 unknown(1),
 ifIndex(2),
 systemPortNumber(3)
}

LldpV2ManAddress ::= TEXTUAL-CONVENTION

DISPLAY-HINT "1x:"

STATUS current

DESCRIPTION

"The value of a management address associated with the LLDP agent that may be used to reach higher layer entities to assist discovery by network management.

It should be noted that appropriate security credentials, such as SNMP engineId, may be required to access the LLDP agent using a management address. These necessary credentials should be known by the network management and the objects associated with the credentials are not included in the LLDP agent."

SYNTAX OCTET STRING (SIZE (1..31))

LldpV2SystemCapabilitiesMap ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"This TC describes the system capabilities.

The bit 'other(0)' indicates that the system has capabilities other than those listed below.

The bit 'repeater(1)' indicates that the system has repeater capability.

The bit 'bridge(2)' indicates that the system has bridge capability.

The bit 'wlanAccessPoint(3)' indicates that the system has WLAN access point capability.

The bit 'router(4)' indicates that the system has router capability.

The bit 'telephone(5)' indicates that the system has telephone capability.

The bit 'docsisCableDevice(6)' indicates that the system has DOCSIS Cable Device capability (IETF RFC 4639 & 2670).

The bit 'stationOnly(7)' indicates that the system has only station capability and nothing else.

The bit 'cVLANComponent(8)' indicates that the system has C-VLAN component functionality.

The bit 'sVLANComponent(8)' indicates that the system has

S-VLAN component functionality.

The bit 'twoPortMACRelay(10)' indicates that the system has Two-port MAC Relay (TPMR) functionality."

```
SYNTAX BITS {
    other(0),
    repeater(1),
    bridge(2),
    wlanAccessPoint(3),
    router(4),
    telephone(5),
    docsisCableDevice(6),
    stationOnly(7),
    cVLANComponent(8),
    sVLANComponent(9),
    twoPortMACRelay(10)
}
```

LldpV2DestAddressTableIndex ::= TEXTUAL-CONVENTION

DISPLAY-HINT "d"

STATUS current

DESCRIPTION

"An index value, used as the index to the table of destination MAC addresses used both as the destination addresses on transmitted LLDPDUs and on received LLDPDUs. This index value is also used as a secondary index value in tables indexed by fields of type ifIndex, in order to associate a destination address with each row of the table."

SYNTAX Unsigned32(1..4096)

LldpV2PowerPortClass ::= TEXTUAL-CONVENTION

STATUS current

DESCRIPTION

"This TC describes the Power over Ethernet (PoE) port class."

```
SYNTAX INTEGER {
    pClassPSE(1),
    pClassPD(2)
}
```

END

11.5.2 LLDP MIB module - version 2

In the following MIB module, should any discrepancy between the DESCRIPTION text and the corresponding definition in Clause 9 and Clause 10 occur, the definition in Clause 9 and Clause 10 shall take precedence.

```
LLDP-V2-MIB DEFINITIONS ::= BEGIN
```

```
IMPORTS
```

```
    MODULE-IDENTITY,
    OBJECT-TYPE,
    Unsigned32,
    Counter32,
    NOTIFICATION-TYPE
        FROM SNMPv2-SMI
    TimeStamp,
    TruthValue,
    MacAddress,
    RowStatus
        FROM SNMPv2-TC
    SnmpAdminString
        FROM SNMP-FRAMEWORK-MIB
    MODULE-COMPLIANCE,
    OBJECT-GROUP,
    NOTIFICATION-GROUP
        FROM SNMPv2-CONF
    TimeFilter,
    ZeroBasedCounter32
        FROM RMON2-MIB
    AddressFamilyNumbers
        FROM IANA-ADDRESS-FAMILY-NUMBERS-MIB
    ifGeneralInformationGroup,
    InterfaceIndex
        FROM IF-MIB
    LldpV2ChassisIdSubtype,
    LldpV2ChassisId,
    LldpV2PortIdSubtype,
    LldpV2PortId,
    LldpV2ManAddrIfSubtype,
    LldpV2ManAddress,
    LldpV2SystemCapabilitiesMap,
    LldpV2DestAddressTableIndex,
    ieee802dot1mibs
        FROM LLDP-V2-TC-MIB;
```

```
lldpV2MIB MODULE-IDENTITY
```

```
    LAST-UPDATED "201603110000Z" -- March 11, 2016
```

```
    ORGANIZATION "IEEE 802.1 Working Group"
```

```
    CONTACT-INFO
```

```
        "WG-URL: http://www.ieee802.org/1/"
```

```
        WG-EMail: stds-802-1-L@ieee.org
```

```
        Contact: IEEE 802.1 Working Group Chair
```

```
        Postal: IEEE Standards Board
```

```
                445 Hoes Lane
```

```
                Piscataway, NJ 08854
```

```
                USA
```

```
        E-mail: stds-802-1-L@ieee.org"
```

```
DESCRIPTION
```

IEEE Std 802.1AB-2016
IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery

"Management Information Base module for LLDP configuration, statistics, local system data and remote systems data components.

This MIB module supports the architecture described in Clause 6, where multiple LLDP agents can be associated with a single Port, each supporting transmission by means of a different MAC address.

Unless otherwise indicated, the references in this MIB module are to IEEE Std 802.1AB-2016.

Copyright (C) IEEE (2016). This version of this MIB module is published as 11.5.2 of IEEE Std 802.1AB-2016; see the standard itself for full legal notices."

REVISION "201603110000Z" -- March 11, 2016

DESCRIPTION

"Published as part of the 2016 revision of IEEE Std 802.1AB.
This revision incorporated changes to the MIB to address issues identified in maintenance item 0121 - see <http://www.ieee802.org/1/maint.html>.
The changes involved correcting the way that lldpV2MessageTxHoldMultiplier is calculated, in accordance with 9.2.5.22."

REVISION "201502160000Z" -- February 16, 2015

DESCRIPTION

"Published as part of IEEE Std 802.1AB-2009 Cor-2.
This corrigendum incorporated changes to the MIB to address issues identified in maintenance item 0121 - see <http://www.ieee802.org/1/maint.html>."

REVISION "200906080000Z" -- June 08, 2009

DESCRIPTION

"Published as part of IEEE Std 802.1AB-2009 revision.
This revision incorporated changes to the MIB to support the use of LLDP with multiple destination MAC addresses."

::= { ieee802dot1mibs 13 }

lldpV2Notifications	OBJECT IDENTIFIER ::= { lldpV2MIB 0 }
lldpV2Objects	OBJECT IDENTIFIER ::= { lldpV2MIB 1 }
lldpV2Conformance	OBJECT IDENTIFIER ::= { lldpV2MIB 2 }
--	
-- LLDP MIB Objects	
--	
lldpV2Configuration	OBJECT IDENTIFIER ::= { lldpV2Objects 1 }
lldpV2Statistics	OBJECT IDENTIFIER ::= { lldpV2Objects 2 }
lldpV2LocalSystemData	OBJECT IDENTIFIER ::= { lldpV2Objects 3 }
lldpV2RemoteSystemsData	OBJECT IDENTIFIER ::= { lldpV2Objects 4 }

lldpV2Extensions OBJECT IDENTIFIER ::= { lldpV2Objects 5 }

```
--
-- *****
--
--           L L D P       C O N F I G
--
-- *****
--
```

lldpV2MessageTxInterval OBJECT-TYPE

SYNTAX Unsigned32(5..32768)

UNITS "seconds"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The interval at which LLDP frames are transmitted on behalf of this LLDP agent.

The default value for lldpV2MessageTxInterval object is 30 seconds.

The value of this object is used as the initial value of the lldpV2PortMessageTxInterval object on row creation in the lldpV2PortConfigTableV2.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE

"9.2.5.7"

DEFVAL { 30 }

::= { lldpV2Configuration 1 }

lldpV2MessageTxHoldMultiplier OBJECT-TYPE

SYNTAX Unsigned32(2..10)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The time to live value expressed as a multiple of the lldpV2MessageTxInterval object. The actual time to live value used in LLDP frames, transmitted on behalf of this LLDP agent, can be expressed by the following formula:

$TTL = \min(65535,$

$(lldpV2MessageTxInterval * lldpV2MessageTxHoldMultiplier) + 1)$

For example, if the value of lldpV2MessageTxInterval is

'30', and the value of lldpV2MessageTxHoldMultiplier

is '4', then the value '121' is encoded in the

TTL field in the LLDP header.

The default value for lldpV2MessageTxHoldMultiplier object is 4.

The value of this object is used as the initial value of the lldpV2PortMessageTxHoldMultiplier object on row creation in the lldpV2PortConfigTableV2.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE

"9.2.5.6"
 DEFVAL { 4 }
 ::= { lldpV2Configuration 2 }

lldpV2ReinitDelay OBJECT-TYPE

SYNTAX Unsigned32(1..10)
 UNITS "seconds"
 MAX-ACCESS read-write
 STATUS current
 DESCRIPTION

"The lldpV2ReinitDelay indicates the delay (in units of seconds) from when lldpPortConfigAdminStatus object of a particular port becomes 'disabled' until re-initialization is attempted.

The default value for lldpV2ReinitDelay is 2 s.

The value of this object is used as the initial value of the lldpV2PortReinitDelay object on row creation in the lldpV2PortConfigTableV2.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE

"9.2.5.10"

DEFVAL { 2 }
 ::= { lldpV2Configuration 3 }

lldpV2NotificationInterval OBJECT-TYPE

SYNTAX Unsigned32(5..3600)
 UNITS "seconds"
 MAX-ACCESS read-write
 STATUS current
 DESCRIPTION

"This object controls the interval between transmission of LLDP notifications during normal transmission periods.

The value of this object is used as the initial value of the lldpV2PortNotificationInterval object on row creation in the lldpV2PortConfigTableV2.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

DEFVAL { 30 }
 ::= { lldpV2Configuration 4 }

lldpV2TxCreditMax OBJECT-TYPE

SYNTAX Unsigned32(1..100)
 UNITS "PDUs"
 MAX-ACCESS read-write
 STATUS current
 DESCRIPTION

"The maximum number of consecutive LLDPDUs that can be transmitted at any time.

The default value for lldpV2TxCreditMax object is 5 PDUs.

The value of this object is used as the initial value of the lldpV2PortTxCreditMax object on row creation in

the lldpV2PortConfigTableV2.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE

"9.2.5.17"

DEFVAL { 5 }

::= { lldpV2Configuration 5 }

lldpV2MessageFastTx OBJECT-TYPE

SYNTAX Unsigned32(1..3600)

UNITS "seconds"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The interval at which LLDP frames are transmitted on behalf of this LLDP agent during fast transmission period (e.g., when a new neighbor is detected).

The default value for lldpV2MessageFastTx object is 1 second.

The value of this object is used as the initial value of the lldpV2PortMessageFastTx object on row creation in the lldpV2PortConfigTableV2.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE

"9.2.5.5"

DEFVAL { 1 }

::= { lldpV2Configuration 6 }

lldpV2TxFastInit OBJECT-TYPE

SYNTAX Unsigned32(1..8)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The initial value used to initialize the txFast variable which determines the number of transmissions that are made in fast transmission mode.

The default value for lldpV2TxFastInit object is 4.

The value of this object is used as the initial value of the lldpV2PortTxFastInit object on row creation in the lldpV2PortConfigTableV2.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE

"9.2.5.19"

DEFVAL { 4 }

::= { lldpV2Configuration 7 }

--

-- lldpV2PortConfigTable: LLDP configuration indexed on a per port,
-- per destination address basis. The ifIndex, coupled with an
-- index into the lldpDestAddressTable, is used to index per port
-- per destination MAC address.

-- ***This table and its associated objects are now deprecated
 -- and replaced by lldpV2PortConfigTableV2.***
 --

lldpV2PortConfigTable OBJECT-TYPE

SYNTAX SEQUENCE OF LldpV2PortConfigEntry

MAX-ACCESS not-accessible

STATUS deprecated

DESCRIPTION

"The table that controls LLDP frame transmission on individual ports that uses particular destination MAC addresses."

::= { lldpV2Configuration 8 }

lldpV2PortConfigEntry OBJECT-TYPE

SYNTAX LldpV2PortConfigEntry

MAX-ACCESS not-accessible

STATUS deprecated

DESCRIPTION

"LLDP configuration information for a particular port and destination MAC address."

This configuration parameter controls the transmission and the reception of LLDP frames on those interface/address combinations whose rows are created in this table.

Rows in this table can only be created for MAC addresses that can validly be used in association with the type of interface concerned, as defined by Table 7-2.

The contents of this table is persistent across re-initializations or re-boots."

INDEX { lldpV2PortConfigIfIndex,
 lldpV2PortConfigDestAddressIndex }

::= { lldpV2PortConfigTable 1 }

LldpV2PortConfigEntry ::= SEQUENCE {

lldpV2PortConfigIfIndex

InterfaceIndex,

lldpV2PortConfigDestAddressIndex

LldpV2DestAddressTableIndex,

lldpV2PortConfigAdminStatus

INTEGER,

lldpV2PortConfigNotificationEnable

TruthValue,

lldpV2PortConfigTLVsTxEnable

BITS }

lldpV2PortConfigIfIndex OBJECT-TYPE

SYNTAX InterfaceIndex

MAX-ACCESS not-accessible

STATUS deprecated

DESCRIPTION

"The interface index value used to identify the port associated with this entry. Its value is an index into the interfaces MIB."

The value of this object is used as an index to the lldpV2PortConfigTable."

::= { lldpV2PortConfigEntry 1 }

lldpV2PortConfigDestAddressIndex OBJECT-TYPE

SYNTAX LldpV2DestAddressTableIndex

MAX-ACCESS not-accessible

STATUS deprecated

DESCRIPTION

"The index value used to identify the destination MAC address associated with this entry. Its value identifies the row in the lldpV2DestAddressTable where the MAC address can be found.

The value of this object is used as an index to the lldpV2PortConfigTable."

::= { lldpV2PortConfigEntry 2 }

lldpV2PortConfigAdminStatus OBJECT-TYPE

SYNTAX INTEGER {
txOnly(1),
rxOnly(2),
txAndRx(3),
disabled(4)
}

MAX-ACCESS read-write

STATUS deprecated

DESCRIPTION

"The administratively desired status of the local LLDP agent.

If the associated lldpV2PortConfigAdminStatus object is set to a value of 'txOnly(1)', then LLDP agent transmits LLDP frames on this port and it does not store any information about the remote systems connected.

If the associated lldpV2PortConfigAdminStatus object is set to a value of 'rxOnly(2)', then the LLDP agent receives, but it does not transmit LLDP frames on this port.

If the associated lldpV2PortConfigAdminStatus object is set to a value of 'txAndRx(3)', then the LLDP agent transmits and receives LLDP frames on this port.

If the associated lldpV2PortConfigAdminStatus object is set to a value of 'disabled(4)', then LLDP agent does not transmit or receive LLDP frames on this port. If there is remote systems information that is received on this port and stored in other tables, before the port's lldpV2PortConfigAdminStatus becomes disabled, then that information is deleted."

REFERENCE

"9.2.5.1"

DEFVAL { txAndRx }

::= { lldpV2PortConfigEntry 3 }

lldpV2PortConfigNotificationEnable OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-write

STATUS deprecated

DESCRIPTION

"The lldpV2PortConfigNotificationEnable controls, on a per agent basis, whether or not notifications from the agent are enabled. The value true(1) means that notifications are enabled; the value false(2) means that they are not."

DEFVAL { false }

::= { lldpV2PortConfigEntry 4 }

lldpV2PortConfigTLVsTxEnable OBJECT-TYPE

```

SYNTAX      BITS {
    portDesc(0),
    sysName(1),
    sysDesc(2),
    sysCap(3)
}
MAX-ACCESS  read-write
STATUS      deprecated
DESCRIPTION

```

"The lldpV2PortConfigTLVsTxEnable, defined as a bitmap, includes the basic set of LLDP TLVs whose transmission is allowed on the local LLDP agent by the network management. Each bit in the bitmap corresponds to a TLV type associated with a specific optional TLV.

It should be noted that the organizationally-specific TLVs are excluded from the lldpV2PortConfigTLVsTxEnable bitmap.

LLDP Organization Specific Information Extension MIBs should have similar configuration objects to control transmission of their organizationally defined TLVs.

The bit 'portDesc(0)' indicates that LLDP agent should transmit 'Port Description TLV'.

The bit 'sysName(1)' indicates that LLDP agent should transmit 'System Name TLV'.

The bit 'sysDesc(2)' indicates that LLDP agent should transmit 'System Description TLV'.

The bit 'sysCap(3)' indicates that LLDP agent should transmit 'System Capabilities TLV'.

There is no bit reserved for the management address TLV type since transmission of management address TLVs are controlled by another object, lldpV2ConfigManAddrTable.

The default value for lldpV2PortConfigTLVsTxEnable object is empty set, which means no enumerated values are set.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE

"9.1.2.1"

DEFVAL { { } }

-- { lldpV2PortConfigEntry 5 }

```

-- lldpV2PortConfigTableV2: LLDP configuration indexed on a per port,
-- per destination address basis. The ifIndex, coupled with an
-- index into the lldpDestAddressTable, is used to index per port
-- per destination MAC address.
--

```

```

-- V2 extends the original table definition to include per-port
-- per-MAC address parameters msgTxInterval, msgTxHold, reinitDelay,
-- notificationInterval, txCreditMax, msgFastTx, and txFastInit.
--

```

lldpV2PortConfigTableV2 OBJECT-TYPE

SYNTAX SEQUENCE OF LldpV2PortConfigEntryV2

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The table that controls LLDP frame transmission on individual ports and using particular destination MAC addresses."

```
::= { lldpV2Configuration 11 }
```

lldpV2PortConfigEntryV2 OBJECT-TYPE

SYNTAX LldpV2PortConfigEntryV2

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"LLDP configuration information for a particular port and destination MAC address."

This configuration parameter controls the transmission and the reception of LLDP frames on those interface/address combinations whose rows are created in this table.

Rows in this table can only be created for MAC addresses that can validly be used in association with the type of interface concerned, as defined by Table 7-2.

The contents of this table is persistent across re-initializations or re-boots."

```
INDEX { lldpV2PortConfigIfIndexV2,
        lldpV2PortConfigDestAddressIndexV2 }
```

```
::= { lldpV2PortConfigTableV2 1 }
```

LldpV2PortConfigEntryV2 ::= SEQUENCE {

lldpV2PortConfigIfIndexV2	InterfaceIndex,
lldpV2PortConfigDestAddressIndexV2	LldpV2DestAddressTableIndex,
lldpV2PortConfigAdminStatusV2	INTEGER,
lldpV2PortMessageTxInterval	Unsigned32,
lldpV2PortMessageTxHoldMultiplier	Unsigned32,
lldpV2PortReinitDelay	Unsigned32,
lldpV2PortNotificationInterval	Unsigned32,
lldpV2PortTxCreditMax	Unsigned32,
lldpV2PortMessageFastTx	Unsigned32,
lldpV2PortTxFastInit	Unsigned32,
lldpV2PortConfigNotificationEnableV2	TruthValue,
lldpV2PortConfigTLVsTxEnableV2	BITS }

lldpV2PortConfigIfIndexV2 OBJECT-TYPE

SYNTAX InterfaceIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The interface index value used to identify the port associated with this entry. Its value is an index into the interfaces MIB."

The value of this object is used as an index to the lldpV2PortConfigTable."

```
::= { lldpV2PortConfigEntryV2 1 }
```

lldpV2PortConfigDestAddressIndexV2 OBJECT-TYPE

SYNTAX LldpV2DestAddressTableIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The index value used to identify the destination MAC address associated with this entry. Its value identifies the row in the lldpV2DestAddressTable where the MAC address can be found.

The value of this object is used as an index to the lldpV2PortConfigTable."

```
::= { lldpV2PortConfigEntryV2 2 }
```

lldpV2PortConfigAdminStatusV2 OBJECT-TYPE

SYNTAX INTEGER {

txOnly(1),

rxOnly(2),

txAndRx(3),

disabled(4)

}

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The administratively desired status of the local LLDP agent.

If the associated lldpV2PortConfigAdminStatus object is set to a value of 'txOnly(1)', then LLDP agent transmits LLDP frames on this port and it does not store any information about the remote systems connected.

If the associated lldpV2PortConfigAdminStatus object is set to a value of 'rxOnly(2)', then the LLDP agent receives, but it does not transmit, LLDP frames on this port.

If the associated lldpV2PortConfigAdminStatus object is set to a value of 'txAndRx(3)', then the LLDP agent transmits and receives LLDP frames on this port.

If the associated lldpV2PortConfigAdminStatus object is set to a value of 'disabled(4)', then LLDP agent does not transmit or receive LLDP frames on this port. If there is remote systems information that is received on this port and stored in other tables, before the port's lldpV2PortConfigAdminStatus becomes disabled, then that information is deleted."

REFERENCE

"9.2.5.1"

DEFVAL { txAndRx }

```
::= { lldpV2PortConfigEntryV2 3 }
```

lldpV2PortMessageTxInterval OBJECT-TYPE

SYNTAX Unsigned32(5..32768)

UNITS "seconds"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The interval at which LLDP frames are transmitted on behalf of this LLDP agent.

This object takes its initial value from the
lldpV2MessageTxInterval object on table row creation.

The value of this object is restored from non-volatile
storage after a re-initialization of the management system."

REFERENCE

"9.2.5.7"

DEFVAL { 30 }

::= { lldpV2PortConfigEntryV2 4 }

lldpV2PortMessageTxHoldMultiplier OBJECT-TYPE

SYNTAX Unsigned32(2..10)

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The time to live value expressed as a multiple of the
lldpV2MessageTxInterval object. The actual time to live
value used in LLDP frames, transmitted on behalf of this
LLDP agent, can be expressed by the following formula:
 $TTL = \min(65535, (lldpV2MessageTxInterval * lldpV2MessageTxHoldMultiplier) + 1)$
For example, if the value of lldpV2MessageTxInterval is
'30', and the value of lldpV2MessageTxHoldMultiplier
is '4', then the value '121' is encoded in the
TTL field in the LLDP header.

This object takes its initial value from the
lldpV2PortMessageTxHoldMultiplier object on table row creation.

The value of this object is restored from non-volatile
storage after a re-initialization of the management system."

REFERENCE

"9.2.5.6"

DEFVAL { 4 }

::= { lldpV2PortConfigEntryV2 5 }

lldpV2PortReinitDelay OBJECT-TYPE

SYNTAX Unsigned32(1..10)

UNITS "seconds"

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The lldpV2ReinitDelay indicates the delay (in units of
seconds) from when lldpPortConfigAdminStatus object of a
particular port becomes 'disabled' until re-initialization
is attempted.

This object takes its initial value from the
lldpV2PortReinitDelay object on table row creation.

The value of this object is restored from non-volatile
storage after a re-initialization of the management system."

REFERENCE

"9.2.5.10"

DEFVAL { 2 }

::= { lldpV2PortConfigEntryV2 6 }

lldpV2PortNotificationInterval OBJECT-TYPE

SYNTAX Unsigned32(5..3600)
 UNITS "seconds"
 MAX-ACCESS read-write
 STATUS current
 DESCRIPTION

"This object controls the interval between transmission of LLDP notifications during normal transmission periods.

This object takes its initial value from the lldpV2PortNotificationInterval object on table row creation.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

DEFVAL { 30 }
 ::= { lldpV2PortConfigEntryV2 7 }

lldpV2PortTxCreditMax OBJECT-TYPE

SYNTAX Unsigned32(1..100)
 UNITS "PDUs"
 MAX-ACCESS read-write
 STATUS current
 DESCRIPTION

"The maximum number of consecutive LLDPDUs that can be transmitted at any time.

This object takes its initial value from the lldpV2PortTxCreditMax object on table row creation.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE
 "9.2.5.17"
 DEFVAL { 5 }
 ::= { lldpV2PortConfigEntryV2 8 }

lldpV2PortMessageFastTx OBJECT-TYPE

SYNTAX Unsigned32(1..3600)
 UNITS "seconds"
 MAX-ACCESS read-write
 STATUS current
 DESCRIPTION

"The interval at which LLDP frames are transmitted on behalf of this LLDP agent during fast transmission period (e.g., when a new neighbor is detected).

This object takes its initial value from the lldpV2PortMessageFastTx object on table row creation.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE
 "9.2.5.5"
 DEFVAL { 1 }
 ::= { lldpV2PortConfigEntryV2 9 }

lldpV2PortTxFastInit OBJECT-TYPE

SYNTAX Unsigned32(1..8)
 MAX-ACCESS read-write
 STATUS current

DESCRIPTION

"The initial value used to initialize the txFast variable which determines the number of transmissions that are made in fast transmission mode.

This object takes its initial value from the lldpV2PortTxFastInit object on table row creation.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE

"9.2.5.19"

DEFVAL { 4 }

::= { lldpV2PortConfigEntryV2 10 }

lldpV2PortConfigNotificationEnableV2 OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The lldpV2PortConfigNotificationEnableV2 controls, on a per agent basis, whether or not notifications from the agent are enabled. The value true(1) means that notifications are enabled; the value false(2) means that they are not."

DEFVAL { false }

::= { lldpV2PortConfigEntryV2 11 }

lldpV2PortConfigTLVsTxEnableV2 OBJECT-TYPE

SYNTAX BITS {
portDesc(0),
sysName(1),
sysDesc(2),
sysCap(3)

}

MAX-ACCESS read-write

STATUS current

DESCRIPTION

"The lldpV2PortConfigTLVsTxEnableV2, defined as a bitmap, includes the basic set of LLDP TLVs whose transmission is allowed on the local LLDP agent by the network management. Each bit in the bitmap corresponds to a TLV type associated with a specific optional TLV.

It should be noted that the organizationally-specific TLVs are excluded from the lldpV2PortConfigTLVsTxEnable bitmap.

LLDP Organization Specific Information Extension MIBs should have similar configuration objects to control transmission of their organizationally defined TLVs.

The bit 'portDesc(0)' indicates that LLDP agent should transmit 'Port Description TLV'.

The bit 'sysName(1)' indicates that LLDP agent should transmit 'System Name TLV'.

The bit 'sysDesc(2)' indicates that LLDP agent should transmit 'System Description TLV'.

The bit 'sysCap(3)' indicates that LLDP agent should transmit 'System Capabilities TLV'.

There is no bit reserved for the management address TLV type since transmission of management address TLVs are controlled by another object, `lldpV2ConfigManAddrTable`.

The default value for `lldpV2PortConfigTLVsTxEnable` object is empty set, which means no enumerated values are set.

The value of this object is restored from non-volatile storage after a re-initialization of the management system."

REFERENCE

"9.1.2.1"

DEFVAL { { } }

::= { lldpV2PortConfigEntryV2 12 }

--

-- lldpV2DestAddressTable: Destination MAC addresses used by LLDP

--

lldpV2DestAddressTable OBJECT-TYPE

SYNTAX SEQUENCE OF LldpV2DestAddressTableEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The table that contains the set of MAC addresses used by LLDP for transmission and reception of LLDPDUs."

::= { lldpV2Configuration 9 }

lldpV2DestAddressTableEntry OBJECT-TYPE

SYNTAX LldpV2DestAddressTableEntry

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"Destination MAC address information for LLDP.

This configuration parameter identifies a MAC address corresponding to a `LldpV2DestAddressTableIndex` value.

Rows in this table are created as necessary, to support MAC addresses needed by other tables in the MIB that are indexed by MAC address.

A given row in this table cannot be deleted if the MAC address table index value is in use in any other table in the MIB.

The contents of this table are persistent across re-initializations or re-boots."

INDEX { lldpV2AddressTableIndex }

::= { lldpV2DestAddressTable 1 }

LldpV2DestAddressTableEntry ::= SEQUENCE {

lldpV2AddressTableIndex

LldpV2DestAddressTableIndex,

lldpV2DestMacAddress

MacAddress }

lldpV2AddressTableIndex OBJECT-TYPE

SYNTAX LldpV2DestAddressTableIndex
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION

"The index value used to identify the destination MAC address associated with this entry.

The value of this object is used as an index to the lldpV2DestAddressTable."

::= { lldpV2DestAddressTableEntry 1 }

lldpV2DestMacAddress OBJECT-TYPE

SYNTAX MacAddress
MAX-ACCESS read-only
STATUS current
DESCRIPTION

"The MAC address associated with this entry.

The octet string identifies an individual or a group MAC address that is in use by LLDP as a destination MAC address.

The MAC address is encoded in the octet string in canonical format (see IEEE Std 802)."

::= { lldpV2DestAddressTableEntry 2 }

--

-- lldpV2ManAddrConfigTxPortsTable : selection of management addresses
-- to be transmitted on a specified set of port/destination
-- address pairs.

--

lldpV2ManAddrConfigTxPortsTable OBJECT-TYPE

SYNTAX SEQUENCE OF LldpV2ManAddrConfigTxPortsEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION

"The table that controls selection of LLDP management address TLV instances to be transmitted on individual port/destination address pairs."

::= { lldpV2Configuration 10 }

lldpV2ManAddrConfigTxPortsEntry OBJECT-TYPE

SYNTAX LldpV2ManAddrConfigTxPortsEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION

"LLDP configuration information that specifies the set of port/destination address pairs on which the local system management address instance is transmitted.

Each active lldpManAddrConfigTxPortsTableV2Entry is restored from non-volatile storage and re-created after a re-initialization of the management system."

INDEX {

lldpV2ManAddrConfigIfIndex,
lldpV2ManAddrConfigDestAddressIndex,
lldpV2ManAddrConfigLocManAddrSubtype,

IEEE Std 802.1AB-2016
IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery

```

        lldpV2ManAddrConfigLocManAddr }
 ::= { lldpV2ManAddrConfigTxPortsTable 1 }

lldpV2ManAddrConfigTxPortsEntry ::= SEQUENCE {
    lldpV2ManAddrConfigIfIndex          InterfaceIndex,
    lldpV2ManAddrConfigDestAddressIndex LldpV2DestAddressTableIndex,
    lldpV2ManAddrConfigLocManAddrSubtype AddressFamilyNumbers,
    lldpV2ManAddrConfigLocManAddr       LldpV2ManAddress,
    lldpV2ManAddrConfigTxEnable          TruthValue,
    lldpV2ManAddrConfigRowStatus         RowStatus
}

```

lldpV2ManAddrConfigIfIndex OBJECT-TYPE

SYNTAX InterfaceIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The interface index value used to identify the port associated with this entry. Its value is an index into the interfaces MIB.

The value of this object is used as an index to the lldpV2PortConfigTable.

The value in this column of the table MUST match the IfIndex value specified in the BridgePort table."

::= { lldpV2ManAddrConfigTxPortsEntry 1 }

lldpV2ManAddrConfigDestAddressIndex OBJECT-TYPE

SYNTAX LldpV2DestAddressTableIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The index value used to identify the destination MAC address associated with this entry. Its value identifies the row in the lldpV2DestAddressTable where the MAC address can be found.

The value of this object is used as an index to the lldpV2PortConfigTable."

::= { lldpV2ManAddrConfigTxPortsEntry 2 }

lldpV2ManAddrConfigLocManAddrSubtype OBJECT-TYPE

SYNTAX AddressFamilyNumbers

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The type of management address identifier encoding used in the associated 'lldpLocManagmentAddr' object.

It should be noted that only a subset of the possible address encodings enumerated in AddressFamilyNumbers are appropriate for use as a LLDP management address, either because some are just not applicable or because the maximum size of a LldpV2ManAddress octet string would prevent the use of some address identifier encodings."

REFERENCE

"8.5.9.3"

```

 ::= { lldpV2ManAddrConfigTxPortsEntry 3 }

lldpV2ManAddrConfigLocManAddr OBJECT-TYPE
    SYNTAX      LldpV2ManAddress
    MAX-ACCESS  not-accessible
    STATUS      current
    DESCRIPTION
        "The string value used to identify the management address
        component associated with the local system. The purpose of
        this address is to contact the management entity."
    REFERENCE
        "8.5.9.4"
    ::= { lldpV2ManAddrConfigTxPortsEntry 4 }

lldpV2ManAddrConfigTxEnable OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "A Boolean controlling the transmission of system
        management address instance for the specified port,
        destination, subtype, and MAN address used to index
        this table. If set to the default value of false,
        no transmission occurs. If set to true, the
        appropriate information is transmitted out of the
        port specified in the row's index."
    REFERENCE
        "9.1.2.1"
    DEFVAL { false } -- not transmitted
    ::= { lldpV2ManAddrConfigTxPortsEntry 5 }

lldpV2ManAddrConfigRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS  read-create
    STATUS      current
    DESCRIPTION
        "Indicates the status of an entry in this table, and is used
        to create/delete entries.
        The corresponding instances of the following objects
        must be set before this object can be made active(1):
            lldpV2ManAddrConfigDestAddressIndex
            lldpV2ManAddrConfigLocManAddrSubtype
            lldpV2ManAddrConfigLocManAddr
            lldpV2ManAddrConfigTxEnable

        The corresponding instances of the following objects
        may not be changed while this object is active(1):
            lldpV2ManAddrConfigDestAddressIndex
            lldpV2ManAddrConfigLocManAddrSubtype
            lldpV2ManAddrConfigLocManAddr "
    ::= { lldpV2ManAddrConfigTxPortsEntry 6 }

```

```

--
-- *****
--
--           L L D P       S T A T S
--

```

```
-- *****
--
-- LLDP Stats Group
```

lldpV2StatsRemTablesLastChangeTime OBJECT-TYPE

```
SYNTAX      TimeStamp
MAX-ACCESS  read-only
STATUS      current
```

DESCRIPTION

"The value of sysUpTime object (defined in IETF RFC 3418) at the time an entry is created, modified, or deleted in the tables associated with the lldpV2RemoteSystemsData objects and all LLDP extension objects associated with remote systems.

An NMS can use this object to reduce polling of the lldpV2RemoteSystemsData objects."

```
::= { lldpV2Statistics 1 }
```

lldpV2StatsRemTablesInserts OBJECT-TYPE

```
SYNTAX      ZeroBasedCounter32
UNITS       "table entries"
MAX-ACCESS  read-only
STATUS      current
```

DESCRIPTION

"The number of times the complete set of information advertised by a particular MSAP has been inserted into tables contained in lldpV2RemoteSystemsData and lldpV2Extensions objects.

The complete set of information received from a particular MSAP should be inserted into related tables. If partial information cannot be inserted for a reason such as lack of resources, all of the complete set of information should be removed.

This counter should be incremented only once after the complete set of information is successfully recorded in all related tables. Any failures during inserting information set that result in deletion of previously inserted information should not trigger any changes in lldpV2StatsRemTablesInserts since the insert is not completed yet or in lldpStatsRemTablesDeletes since the deletion would only be a partial deletion. If the failure was the result of lack of resources, the lldpStatsRemTablesDrops counter should be incremented once."

```
::= { lldpV2Statistics 2 }
```

lldpV2StatsRemTablesDeletes OBJECT-TYPE

```
SYNTAX      ZeroBasedCounter32
UNITS       "table entries"
MAX-ACCESS  read-only
STATUS      current
```

DESCRIPTION

"The number of times the complete set of information advertised by a particular MSAP has been deleted from tables contained in lldpV2RemoteSystemsData and lldpV2Extensions objects.

This counter should be incremented only once when the

complete set of information is completely deleted from all related tables. Partial deletions, such as deletion of rows associated with a particular MSAP from some tables, but not from all tables are not allowed, thus should not change the value of this counter."

```
::= { lldpV2Statistics 3 }
```

```
lldpV2StatsRemTablesDrops OBJECT-TYPE
```

```
SYNTAX      ZeroBasedCounter32
```

```
UNITS       "table entries"
```

```
MAX-ACCESS  read-only
```

```
STATUS      current
```

```
DESCRIPTION
```

"The number of times the complete set of information advertised by a particular MSAP could not be entered into tables contained in lldpV2RemoteSystemsData and lldpV2Extensions objects because of insufficient resources."

```
::= { lldpV2Statistics 4 }
```

```
lldpV2StatsRemTablesAgeouts OBJECT-TYPE
```

```
SYNTAX      ZeroBasedCounter32
```

```
UNITS       "table entries"
```

```
MAX-ACCESS  read-only
```

```
STATUS      current
```

```
DESCRIPTION
```

"The number of times the complete set of information advertised by a particular MSAP has been deleted from tables contained in lldpV2RemoteSystemsData and lldpV2Extensions objects because the information timeliness interval has expired."

This counter should be incremented only once when the complete set of information is completely invalidated (aged out) from all related tables. Partial ageing, similar to deletion case, is not allowed, and thus, should not change the value of this counter."

```
::= { lldpV2Statistics 5 }
```

```
--
```

```
-- TX statistics
```

```
-- Indexed by port (via ifIndex) and
```

```
-- destination MAC address.
```

```
--
```

```
lldpV2StatsTxPortTable OBJECT-TYPE
```

```
SYNTAX      SEQUENCE OF LldpV2StatsTxPortEntry
```

```
MAX-ACCESS  not-accessible
```

```
STATUS      current
```

```
DESCRIPTION
```

"A table containing LLDP transmission statistics for individual port/destination address combinations.

Entries are not required to exist in this table while the lldpPortConfigEntry object is equal to 'disabled(4)'."

```
::= { lldpV2Statistics 6 }
```

```
lldpV2StatsTxPortEntry OBJECT-TYPE
```

```
SYNTAX      LldpV2StatsTxPortEntry
```

```
MAX-ACCESS  not-accessible
```

STATUS current

DESCRIPTION

"LLDP frame transmission statistics for a particular port and destination MAC address.

The port is contained in the same chassis as the LLDP agent.

All counter values in a particular entry shall be maintained on a continuing basis and shall not be deleted upon expiration of rxInfoTTL timing counters in the LLDP remote systems MIB of the receipt of a shutdown frame from a remote LLDP agent.

All statistical counters associated with a particular port on the local LLDP agent become frozen whenever the adminStatus is disabled for the same port.

Rows in this table can only be created for MAC addresses that can validly be used in association with the type of interface concerned, as defined by Table 7-2."

INDEX { lldpV2StatsTxIfIndex,
 lldpV2StatsTxDestMACAddress }
 ::= { lldpV2StatsTxPortTable 1 }

LldpV2StatsTxPortEntry ::= SEQUENCE {
 lldpV2StatsTxIfIndex InterfaceIndex,
 lldpV2StatsTxDestMACAddress LldpV2DestAddressTableIndex,
 lldpV2StatsTxPortFramesTotal Counter32,
 lldpV2StatsTxLLDPDULengthErrors Counter32 }

lldpV2StatsTxIfIndex OBJECT-TYPE

SYNTAX InterfaceIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The interface index value used to identify the port associated with this entry. Its value is an index into the interfaces MIB.

The value of this object is used as an index to the lldpV2StatsTxPortTable."

::= { lldpV2StatsTxPortEntry 1 }

lldpV2StatsTxDestMACAddress OBJECT-TYPE

SYNTAX LldpV2DestAddressTableIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The index value used to identify the destination MAC address associated with this entry. Its value identifies the row in the lldpV2DestAddressTable where the MAC address can be found.

The value of this object is used as an index to the lldpV2StatsTxPortTable."

::= { lldpV2StatsTxPortEntry 2 }

lldpV2StatsTxPortFramesTotal OBJECT-TYPE

SYNTAX Counter32

UNITS "LLDP frames"
 MAX-ACCESS read-only
 STATUS current

DESCRIPTION

"The number of LLDP frames transmitted by this LLDP agent on the indicated port to the destination MAC address associated with this row of the table."

REFERENCE

"9.2.6.5"

::= { lldpV2StatsTxPortEntry 3 }

lldpV2StatsTxLLDPDULengthErrors OBJECT-TYPE

SYNTAX Counter32
 UNITS "LLDP frames"
 MAX-ACCESS read-only
 STATUS current

DESCRIPTION

"The number of LLDPDU Length Errors recorded for the Port."

REFERENCE

"9.2.6.8"

::= { lldpV2StatsTxPortEntry 4 }

--

-- lldpV2StatsRxPortTable - RX statistics

-- This table is indexed by ifIndex and destination MAC address.

--

lldpV2StatsRxPortTable OBJECT-TYPE

SYNTAX SEQUENCE OF LldpV2StatsRxPortEntry
 MAX-ACCESS not-accessible
 STATUS current

DESCRIPTION

"A table containing LLDP reception statistics for individual ports and destination MAC addresses.

Entries are not required to exist in this table while the lldpPortConfigEntry object is equal to 'disabled(4)'."

::= { lldpV2Statistics 7 }

lldpV2StatsRxPortEntry OBJECT-TYPE

SYNTAX LldpV2StatsRxPortEntry
 MAX-ACCESS not-accessible
 STATUS current

DESCRIPTION

"LLDP frame reception statistics for a particular port. The port is contained in the same chassis as the LLDP agent.

All counter values in a particular entry shall be maintained on a continuing basis and shall not be deleted upon expiration of rxInfoTTL timing counters in the LLDP remote systems MIB of the receipt of a shutdown frame from a remote LLDP agent.

All statistical counters associated with a particular port on the local LLDP agent become frozen whenever the adminStatus is disabled for the same port.

Rows in this table can only be created for MAC addresses that can validly be used in association with the type of

interface concerned, as defined by Table 7-2.

The contents of this table is persistent across re-initializations or re-boots."

```
INDEX { lldpV2StatsRxDestIfIndex,
        lldpV2StatsRxDestMACAddress }
 ::= { lldpV2StatsRxPortTable 1 }
```

```
LldpV2StatsRxPortEntry ::= SEQUENCE {
    lldpV2StatsRxDestIfIndex          InterfaceIndex,
    lldpV2StatsRxDestMACAddress       LldpV2DestAddressTableIndex,
    lldpV2StatsRxPortFramesDiscardedTotal Counter32,
    lldpV2StatsRxPortFramesErrors     Counter32,
    lldpV2StatsRxPortFramesTotal      Counter32,
    lldpV2StatsRxPortTLVsDiscardedTotal Counter32,
    lldpV2StatsRxPortTLVsUnrecognizedTotal Counter32,
    lldpV2StatsRxPortAgeoutsTotal     ZeroBasedCounter32
}
```

lldpV2StatsRxDestIfIndex OBJECT-TYPE

SYNTAX InterfaceIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The interface index value used to identify the port associated with this entry. Its value is an index into the interfaces MIB.

The value of this object is used as an index to the lldpStatsRxPortV2Table."

```
::= { lldpV2StatsRxPortEntry 1 }
```

lldpV2StatsRxDestMACAddress OBJECT-TYPE

SYNTAX LldpV2DestAddressTableIndex

MAX-ACCESS not-accessible

STATUS current

DESCRIPTION

"The index value used to identify the destination MAC address associated with this entry. Its value identifies the row in the lldpV2DestAddressTable where the MAC address can be found.

The value of this object is used as an index to the lldpStatsRxPortV2Table."

```
::= { lldpV2StatsRxPortEntry 2 }
```

lldpV2StatsRxPortFramesDiscardedTotal OBJECT-TYPE

SYNTAX Counter32

UNITS "LLDP frames"

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"The number of LLDP frames received by this LLDP agent on the indicated port, and then discarded for any reason. This counter can provide an indication that LLDP header formatting problems may exist with the local LLDP agent in the sending system or that LLDPDU validation problems may exist with the local LLDP agent in the receiving system."

REFERENCE

"9.2.6.2"

::= { lldpV2StatsRxPortEntry 3 }

lldpV2StatsRxPortFramesErrors OBJECT-TYPE

SYNTAX Counter32
UNITS "LLDP frames"
MAX-ACCESS read-only
STATUS current
DESCRIPTION

"The number of invalid LLDP frames received by this LLDP agent on the indicated port, while this LLDP agent is enabled."

REFERENCE

"9.2.6.3"

::= { lldpV2StatsRxPortEntry 4 }

lldpV2StatsRxPortFramesTotal OBJECT-TYPE

SYNTAX Counter32
UNITS "LLDP frames"
MAX-ACCESS read-only
STATUS current
DESCRIPTION

"The number of valid LLDP frames received by this LLDP agent on the indicated port, while this LLDP agent is enabled."

REFERENCE

"9.2.6.4"

::= { lldpV2StatsRxPortEntry 5 }

lldpV2StatsRxPortTLVsDiscardedTotal OBJECT-TYPE

SYNTAX Counter32
UNITS "TLVs"
MAX-ACCESS read-only
STATUS current
DESCRIPTION

"The number of LLDP TLVs discarded for any reason by this LLDP agent on the indicated port."

REFERENCE

"9.2.6.6"

::= { lldpV2StatsRxPortEntry 6 }

lldpV2StatsRxPortTLVsUnrecognizedTotal OBJECT-TYPE

SYNTAX Counter32
UNITS "TLVs"
MAX-ACCESS read-only
STATUS current
DESCRIPTION

"The number of LLDP TLVs received on the given port that are not recognized by this LLDP agent on the indicated port."

An unrecognized TLV is referred to as the TLV whose type value is in the range of reserved TLV types (000 1001 - 111 1110) in Table 8-1 of IEEE Std 802.1AB-2015. An unrecognized TLV may be a basic management TLV from a later LLDP version."

REFERENCE

"9.2.6.7"

::= { lldpV2StatsRxPortEntry 7 }

lldpV2StatsRxPortAgeoutsTotal OBJECT-TYPE

SYNTAX ZeroBasedCounter32