

802.1AB™

IEEE Standard for
Local and metropolitan area networks

Station and Media Access Control Connectivity Discovery

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee



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Abstract: This document defines a protocol and a set of managed objects that can be used for discovering the physical topology from adjacent stations in IEEE 802® LANs.

Keywords: link layer discovery protocol, management information base, topology discovery, topology information.

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CONTENTS

1.	Overview.....	1
1.1	Scope.....	1
1.2	Purpose.....	1
2.	References.....	3
3.	Definitions and numerical representation	5
3.1	Definitions	5
3.2	Numerical representation	6
4.	Acronyms and abbreviations	7
5.	Conformance.....	8
5.1	Terminology.....	8
5.2	Required capabilities.....	8
5.3	Optional capabilities	9
6.	Architectural overview	10
7.	Principles of operation	12
7.1	LLDP operational modes	12
7.2	Connectivity and management information.....	12
7.3	Optional information categories	13
7.4	LLDP design principles	13
7.5	TLV selection	14
7.6	Transmission principles	14
7.7	Reception principles	14
7.7.1	LLDPDU and TLV error handling	14
7.7.2	LLDP remote systems MIB update	14
7.8	Relationship between LLDP and IETF MIBs.....	15
7.8.1	IETF Physical Topology MIB	15
7.8.2	IETF Entity MIB.....	15
7.8.3	IETF Interfaces MIB.....	15
8.	LLDPDU transmission, reception, and addressing.....	16
8.1	Destination address	16
8.2	Source address	17
8.3	Ethertype use and encoding	17
8.4	LLDPDU reception.....	17
9.	LLDPDU and TLV formats.....	18
9.1	LLDPDU bit and octet ordering conventions	18
9.2	LLDPDU format	18
9.3	TLV categories	18

9.4	Basic TLV format	19
9.4.1	TLV type	19
9.4.2	TLV information string length.....	20
9.4.3	TLV information string.....	20
9.5	Basic management TLV set formats and definitions	20
9.5.1	End Of LLDPDU TLV	20
9.5.2	Chassis ID TLV	21
9.5.2.1	TLV information string length.....	21
9.5.2.2	chassis ID subtype	21
9.5.2.3	chassis ID	22
9.5.2.4	Chassis ID TLV usage rules	22
9.5.3	Port ID TLV	22
9.5.3.1	TLV information string Length	23
9.5.3.2	port ID subtype	23
9.5.3.3	port ID	24
9.5.3.4	Port ID TLV usage rules	24
9.5.4	Time To Live TLV	24
9.5.4.1	time to live (TTL)	24
9.5.4.2	Time To Live TLV usage rules.....	24
9.5.5	Port Description TLV	24
9.5.5.1	TLV information string length.....	25
9.5.5.2	port description	25
9.5.5.3	Port Description TLV usage rules	25
9.5.6	System Name TLV	25
9.5.6.1	TLV information string length.....	25
9.5.6.2	system name.....	25
9.5.6.3	System Name TLV usage rules	26
9.5.7	System Description TLV	26
9.5.7.1	TLV information string length.....	26
9.5.7.2	system description.....	26
9.5.7.3	System Description TLV usage rules	26
9.5.8	System Capabilities TLV	26
9.5.8.1	system capabilities	27
9.5.8.2	enabled capabilities	27
9.5.8.3	System Capabilities TLV usage rules	27
9.5.9	Management Address TLV.....	27
9.5.9.1	TLV information string length.....	28
9.5.9.2	management address string length.....	28
9.5.9.3	management address subtype.....	28
9.5.9.4	management address	28
9.5.9.5	interface numbering subtype.....	28
9.5.9.6	interface number	29
9.5.9.7	object identifier (OID) string length	29
9.5.9.8	object identifier	29
9.5.9.9	Management Address TLV usage rules.....	29
9.6	Organizationally Specific TLVs	29
9.6.1	Basic Organizationally Specific TLV format	30
9.6.1.1	TLV type.....	30
9.6.1.2	TLV information string length.....	30
9.6.1.3	organizationally unique identifier (OUI)	30
9.6.1.4	organizationally defined subtype	30
9.6.1.5	organizationally defined information string	31
9.6.2	Organizationally Specific TLV usage rules.....	31

10.	The protocol.....	32
10.1	Protocol initialization.....	33
10.1.1	LLDP transmit module initialization	33
10.1.2	LLDP receive module initialization.....	33
10.2	Frame transmission.....	33
10.2.1	LLDPDU construction.....	34
10.2.1.1	Normal LLDPDU construction.....	34
10.2.1.2	Shutdown LLDPDU construction.....	35
10.2.2	LLDP frame formatting/transmission	35
10.3	Frame reception	35
10.3.1	LLDP frame recognition	35
10.3.2	LLDPDU validation.....	35
10.3.2.1	General validation rules for all TLVs	37
10.3.2.2	General validation rules for all Organizationally Specific TLVs	38
10.3.3	TLV/MIB object value comparison	38
10.3.4	Too many neighbors	39
10.3.5	LLDP remote systems MIB update	40
10.3.6	LLDP remote systems rxInfoTTL timer expiration.....	40
10.3.7	LLDP local port/connection failure	40
10.4	Notational conventions used in state diagrams.....	40
10.5	State machines	43
10.5.1	Global variables	43
10.5.2	Statistical counters	43
10.5.2.1	Transmission counters	43
10.5.2.2	Reception counters.....	43
10.5.3	Timers	44
10.5.3.1	Transmit state machine timers	44
10.5.3.2	Receive state machine timers.....	44
10.5.3.3	Transmit state machine timing parameters	44
10.5.3.4	Receive state machine timing parameters.....	45
10.5.4	Transmit state machine	45
10.5.4.1	Transmit state machine variables.....	45
10.5.4.2	Transmit state machine procedures.....	45
10.5.4.3	Transmit state machine diagram	46
10.5.5	Receive state machine.....	46
10.5.5.1	Receive state machine variables	46
10.5.5.2	Receive state machine procedures	47
10.5.5.3	Receive state machine diagram.....	48
11.	LLDP management	49
11.1	Data storage and retrieval	49
11.2	The LLDP manager's responsibilities:	49
11.2.1	Protocol initialization management	49
11.2.2	TLV selection management	49
11.2.3	Transmission management	50
11.2.4	Reception management.....	50
11.2.5	Performance management.....	50
11.3	Managed objects	51
11.4	Data types	51
11.5	LLDP variables	51
11.5.1	LLDP operational status and control	51
11.5.2	LLDP operational statistics counters	52

11.5.3	TLV required variables	52
11.5.3.1	Chassis ID TLV objects	52
11.5.3.2	Port ID TLV objects	53
11.5.3.3	Port description TLV object	53
11.5.3.4	System name TLV object	53
11.5.3.5	System description TLV object	53
11.5.3.6	System capabilities TLV objects	53
11.5.3.7	Management address TLV objects	53
11.5.4	Relationship between LLDP variables and LLDP managed objects	53
12.	LLDP MIB definitions	57
12.1	LLDP MIB design philosophy.....	57
12.2	LLDP MIB module , ...	58
12.3	Security considerations for LLDP base MIB module.....	93
Annex A	(informative) Bibliography	95
Annex B	(normative) PICS Proforma.....	96
B.1	Introduction.....	96
B.2	Abbreviations and special symbols.....	96
B.3	Instructions for completing the PICS proforma.....	97
B.4	Major capabilities and options.....	100
Annex C	(informative) PTOPO MIB update	102
Annex D	(informative) Example LLDP transmission frame formats.....	103
D.1	Direct-encoded LLDP frame format.....	103
D.2	SNAP-encoded LLDP frame format.....	103
Annex E	(informative) Using LLDP to detect potential communication problems	104
E.1	Overview.....	104
E.2	IEEE 802.1 Organizationally Specific TLVs	104
E.3	IEEE 802.3 Organizationally Specific TLVs	105
Annex F	(normative) IEEE 802.1 Organizationally Specific TLVs.....	107
F.1	Requirements of the IEEE 802.1 Organizationally Specific TLV set	107
F.2	Port VLAN ID TLV.....	107
F.3	Port And Protocol VLAN ID TLV	108
F.4	VLAN Name TLV.....	109
F.5	Protocol Identity TLV.....	110
F.6	IEEE 802.1 Organizationally Specific TLV management.....	111
F.7	IEEE 802.1/LLDP extension MIB.....	113
F.8	PICS proforma for IEEE 802.1 Organizationally SpecificTLV extensions	130
Annex G	(normative) IEEE 802.3 Organizationally Specific TLVs	132
G.1	Requirements of the IEEE 802.3 Organizationally Specific TLV set	132
G.2	MAC/PHY Configuration/Status TLV	132
G.3	Power Via MDI TLV	133

G.4 Link Aggregation TLV 135

G.5 Maximum Frame Size TLV 136

G.6 IEEE 802.3 Organizationally Specific TLV selection management 136

G.7 IEEE 802.1/LLDP extension MIB..... 139

G.8 PICS proforma for IEEE 802.3 TLV extensions 157

List of Figures

Figure 6-1—Architectural relationship between LLDP and the LLC	10
Figure 6-2—LLDP agent block diagram	10
Figure 8-1—MSDU format	16
Figure 9-1—LLDPDU Format	18
Figure 9-2—Basic TLV format	19
Figure 9-3—End Of LLDPDU TLV format	21
Figure 9-4—Chassis ID TLV format	21
Figure 9-5—Port ID TLV format	23
Figure 9-6—Time To Live TLV format	24
Figure 9-7—Port Description TLV format	25
Figure 9-8—System Name TLV format	25
Figure 9-9—System Description TLV format	26
Figure 9-10—System Capabilities TLV format	26
Figure 9-11—Management Address TLV format	28
Figure 9-12—Basic format for Organizationally Specific TLVs	30
Figure 10-1—Transmit state machine	46
Figure 10-2—Receive state machine	48
Figure 12-1—LLDP MIB block diagram	57
Figure D-1—IEEE 802.3 LLDP frame format	103
Figure D-2—Token Ring/FDDI LLDP frame format	103
Figure F-1—Port VLAN ID TLV Format	107
Figure F-2—Port And Protocol VLAN ID TLV Format	108
Figure F-3—VLAN Name TLV format	109
Figure F-4—Protocol Identity TLV format	110
Figure G-1—MAC/PHY configuration/status TLV format	132
Figure G-2—Power Via MDI TLV format	134
Figure G-3—Link Aggregation TLV format	135
Figure G-4—Maximum Frame Size TLV format	136

List of Tables

Table 8-1—LLDP_Multicast address	16
Table 8-2—LLDP Ethertype	17
Table 9-1—TLV type values	20
Table 9-2—Chassis ID subtype enumeration	22
Table 9-3—Port ID subtype enumeration.....	23
Table 9-4—System capabilities	27
Table 10-1—Subclause/operating mode applicability	32
Table 10-2—State machine symbols	42
Table 11-1—LLDP variable/LLDP MIB object cross reference.....	54
Table 11-2—Basic TLV variable/local system MIB object cross references.....	55
Table 11-3—Basic TLV variable/remote systems MIB object cross references.....	56
Table 12-1—MIB object group operating mode applicability	58
Table F-1— IEEE 802.1 Organizationally Specific TLVs	107
Table F-2—Port and protocol capability/status	108
Table F-4—IEEE 802.1 Organizationally Specific TLV/local system MIB cross references	112
Table F-3—802.1 Organizationally Specific TLV selection variable/LLDP MIB object cross reference .	112
Table F-6—802.1 extension MIB object group conformance requirements	113
Table F-5—IEEE 802.1 Organizationally Specific TLV/remote system MIB cross references	113
Table G-1—IEEE 802.3 Organizationally Specific TLVs	132
Table G-2—IEEE 802.3 auto-negotiation support/status	133
Table G-3—MDI power capabilities/status.....	134
Table G-4—Link aggregation capability/status.....	135
Table G-5—802.3 Organizationally Specific TLV selection variable/LLDP MIB object cross reference.	137
Table G-6—IEEE 802.3 Organizationally Specific TLV/local system MIB cross references.....	138
Table G-7—IEEE 802.3 Organizationally Specific TLV/remote systems MIB cross references.....	139
Table G-8—802.1 extension MIB object group conformance requirements	140

IEEE Standard for Local and metropolitan area networks

Station and Media Access Control Connectivity Discovery

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 [B15]).¹

1.2 Purpose

An IETF Standard MIB (IETF RFC 2922 [B15]), as well as a number of vendor specific MIBs, have been created to describe a network's physical topology and associated systems within that topology. However, there is no standard protocol for populating these MIBs or communicating this information among stations on the IEEE 802 LAN.

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

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.

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. A port in this context is a single point of attachment to the LAN infrastructure.²

²Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

2. References

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of this publication, editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of ISO and IEC maintain registers of currently valid International standards.

Abstract Syntax Notation One (ASN.1): Specification of Basic Notation, ITU-T Rec. X.680 (2002) ISO/IEC 8824-1:2002.³

IEEE Std 802[®]-2001, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture.^{4, 5}

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IETF RFC 2737, Entity MIB (Version 2), McCloghrie, K., and Bierman, A., December 1999.

IETF RFC 2863, The Interfaces Group MIB, McCloghrie, K. and Kastenholz, F., June 2000.

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

IETF RFC 3232, Assigned Numbers: RFC 1700 is Replaced by an On-line Database, Reynolds, J., January 2002.⁷

IETF RFC 3410, Introduction and Applicability Statements for Internet-Standard Management Framework, Case, J., Mundy, R., Partain, D., and Stewart, B., December 2002.

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

IETF RFC 3621, Power Ethernet MIB, Berger, A. and Romascanu, D., December 2003.

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

IETF RFC 3636, Definitions of Managed Objects for IEEE 802.3 Medium Attachment Units (MAUs), Flick, J., September 2003.

⁷The IETF RFC 3232 ianaAddressFamilyNumbers on-line database module is accessible through a web page (currently, <http://www.iana.org>).

3. Definitions and numerical representation

3.1 Definitions

For purposes of this standard, the following terms and definitions apply. IEEE 100, *The Authoritative Dictionary of IEEE Standard Terms*, Seventh Edition [B2], as well as other referenced IEEE standards and IETF RFCs, should be referenced for terms not defined in this clause.

3.1.1 alpha-numeric information: Information that is encoded using the UTF-8 octet sequence [IETF RFC 3629].

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

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

3.1.4 IEEE 802[®] LAN: Local area network (LAN) technologies that provide a media access control (MAC) Service equivalent to the MAC Service defined in ISO/IEC 15802-1. IEEE 802 LANs include IEEE Std 802.3, (CSMA/CD), IEEE Std 802.5[™] (Token Ring), IEEE Std 802.11[™] (Wireless), and ISO 9314-2 (FDDI) LANs.

3.1.5 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.

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

3.1.7 LLDP agent: The protocol entity that implements LLDP for a particular IEEE 802[®] chassis.

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

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

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

3.1.10 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.

3.1.11 Management Information Base (MIB): The instantiation of MIB module.

3.1.12 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.

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

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

3.1.15 object identifier (OID): An identifier used to identify the type of a MIB object. Each MIB object's object type is named by an object identifier, an administratively assigned name.

3.1.16 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.

3.1.17 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.

3.1.18 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).

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

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

3.1.21 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 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".

4. Acronyms and abbreviations

EUI	Extended Unique Identifier
IETF	Internet Engineering Task Force
LLC	logical link control (sublayer)
LLDP	Link Layer Discovery Protocol
LLDPDU	LLDP data unit
LSAP	link service access point
MAC	media access control (sublayer)
MDI	media dependent interface
MIB	Management Information Base (module)
MSAP	MAC service access point
MSDU	MAC service data unit
NMS	Network Management System
OID	object identifier
OUI	organizationally unique identifier
PHY	physical (sublayer)
PMD	physical media dependent (sublayer)
PVID	port VLAN ID
PPVID	port and protocol VLAN ID
PTOPO	the name of the IETF physical topology MIB
SNAP	Subnetwork Access Protocol
SNMP	Simple Network Management Protocol
STP	Spanning Tree Protocol
TLV	type length value
TTL	time to live (value)
VID	VLAN ID

5. Conformance

5.1 Terminology

For consistency with IEEE and existing IEEE 802.1™ standards, 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 provided in Annex B 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 **cannot**. The word **allow** is used as a replacement for the cliché “Support the ability for”, and the word **capability** means “can be configured to.”

5.2 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-2004⁸, LLDP exchanges shall be through the controlled port as specified in Clause 6.
- b) The destination and source addressing shall conform to 8.1 and 8.2.
- c) Ethertype encapsulation shall conform to 8.3.
- d) LLDPDU recognition and reception shall conform to 8.4 and 10.3.1.
- e) LLDPDU encapsulation shall conform to the specifications in 9.2.
- f) The basic TLV format capability shall be implemented as defined in 9.4.
- g) The basic management set of TLVs shall be implemented as defined in 9.5.
- h) The Organizationally Specific TLV format capability shall be implemented as defined in 9.6.
- i) The protocol shall conform to the specifications for all Clause 10 subclauses indicated in Table 10-1 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.

⁸Information on references can be found in Clause 2.

- 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, the system shall conform to the LLDP management specifications in Clause 11. and shall implement the sections of the basic LLDP MIB indicated in Table 12-1 for the operating mode being implemented.
- n) If SNMP is not supported, the system shall provide storage and retrieval capability equivalent to the functionality specified in 11.1 for the operating mode being implemented.

5.3 Optional capabilities

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

- a) Implement the entire IEEE 802.1 Organizationally Specific TLV extension set and the associated IEEE 802.1 MIB extension capability defined in Annex F.
- b) Implement the entire IEEE 802.3 Organizationally Specific TLV extension set and the associated IEEE 802.3 MIB extension capability defined in Annex G.

6. Architectural overview

LLDP is a link layer protocol that is an optional part of the protocol stack of an IEEE 802 LAN station. Figure 6-1 indicates the hierarchical relationships of the LLDP agents and the LLDP entity to the LLC sublayers.

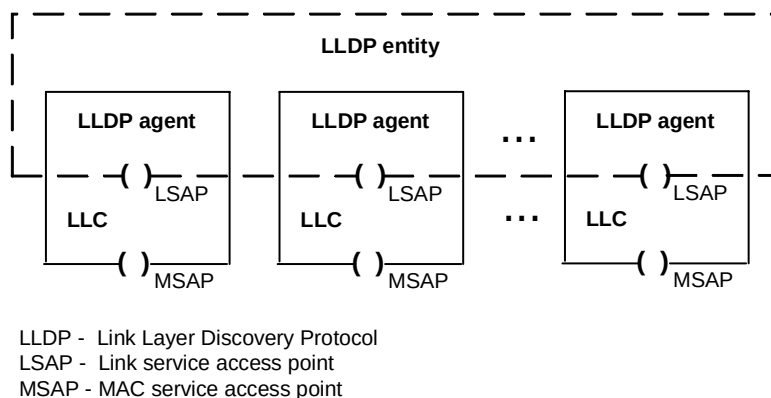


Figure 6-1—Architectural relationship between LLDP and the LLC

The logical link control (LLC) provides an LSAP for access to higher layers plus additional LSAPs for each implemented link layer protocol such as LLDP and STP. Figure 6-2 shows the LLDP block diagram with respect to its associated LSAP.

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 LLDP Ethertype, i.e., protocol discrimination based on the Type interpretation of the Ethertype field as specified in IEEE Std 802a-2003.

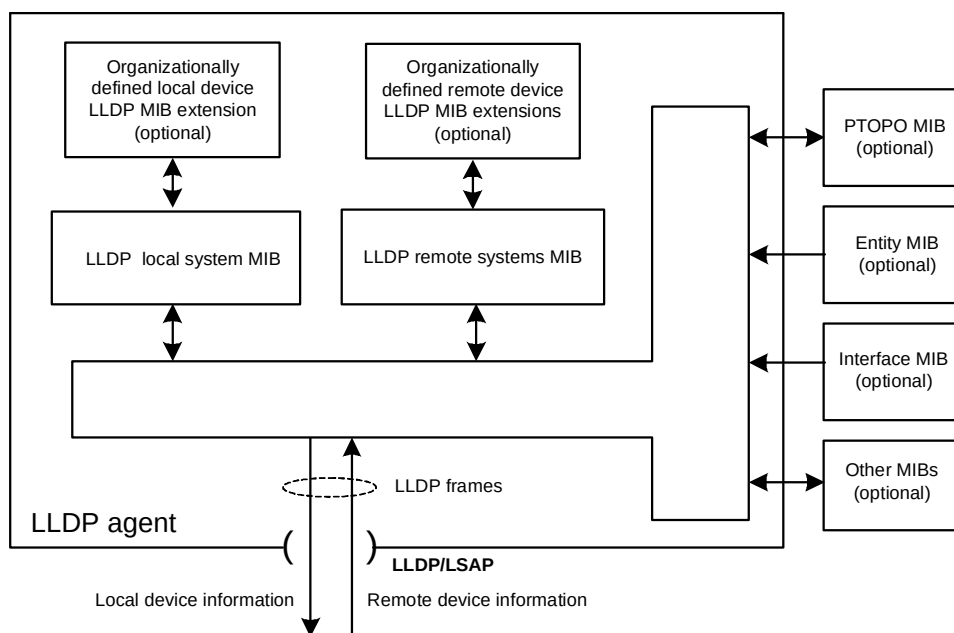


Figure 6-2—LLDP agent block diagram

If port access is controlled by IEEE Std 802.1X-2004, Clause 8, LLDP exchanges shall run on the controlled port. (See also IEEE Std 802.1D-2004, 7.12.7). In a bridge, LLDP operates as an LLC procedure over the bridge port and is therefore not affected by the spanning tree port state.

7. Principles of operation

LLDP uses the services of the LLC and the MAC to transmit and receive information to and from other LLDP agents, as defined in 8.1, 8.2, 8.3, and 8.4.

7.1 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. However, LLDP agents are not provided any means of soliciting information from other LLDP agents via this protocol.

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

7.2 Connectivity and management information

The information fields in each LLDP frame are contained in a Link Layer Discovery Protocol Data Unit (LLDPDU) as a sequence of short, variable length, information elements known as TLVs that each include type, length, and value fields 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 alphanumeric string that can contain one or more fields).

Each LLDPDU includes four mandatory TLVs plus optional TLVs as selected by network management:

- a) A Chassis ID TLV.
- b) A Port ID TLV.
- c) A Time To Live TLV.
- d) From zero to n optional TLVs, as allowed by the space limitation of the LLDPDU.
- e) An 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.

A non-zero value in the TTL field of Time To Live TLV tells the receiving LLDP agent how long all information pertaining to this LLDPDU's MSAP identifier will be 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.

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

The format for the LLDPDU is defined in 9.2. The TLV categories and the basic TLV format are defined in 9.3 and 9.4. The specific format and field contents for the Chassis ID TLV are defined in 9.5.2; for the Port ID TLV, in 9.5.3; for the Time To Live TLV in 9.5.4; and for the End Of LLDPDU TLV, in 9.5.1.

NOTE—A time to live (TTL) value of zero, tells the recipient LLDP agent that all the system information associated with the LLDPDU's MSAP identifier is to be deleted. This can be used, for example, to signal that the sending port has initiated a port shutdown procedure.

7.3 Optional information categories

Three sets of optional use TLVs are currently defined and may be used to describe the system and/or to assist in the detection of configuration inconsistencies associated the MSAP identifier:

- a) Basic management TLV set (this set is required in all LLDP implementations):
 - 1) Port Description TLV.
 - 2) System Name TLV.
 - 3) System Description TLV.
 - 4) System Capabilities TLV (indicates both the system's capabilities and its current primary network function, such as end station, bridge, router).
 - 5) Management Address TLV.
- b) IEEE 802.1 Organizationally Specific TLV set (this set is optional for all LLDP implementations).
 - 1) Port VLAN ID TLV.
 - 2) Port And Protocol VLAN ID TLV.
 - 3) VLAN Name TLV.
 - 4) Protocol Identity TLV.
- c) IEEE 802.3 Organizationally Specific TLV set (this set is optional for all LLDP implementations).
 - 1) MAC/PHY Configuration/Status TLV (indicates the auto-negotiation capability and the duplex/speed status of IEEE 802.3 MAC/PHYs).
 - 2) Power Via MDI TLV (indicates the capabilities and current status of IEEE 802.3 PMDs that either require or are able to provide power over twisted-pair copper links).
 - 3) Link Aggregation TLV (indicates the current link aggregation status of IEEE 802.3 MACs).
 - 4) Maximum Frame Size TLV (indicates the maximum supported IEEE 802.3 frame size).

Table 9-1 includes a list of the currently defined 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 9.6.

Annex F contains definitions of Organizationally Specific TLVs associated with IEEE Std 802.1. Annex G contains definitions of Organizationally Specific TLVs associated with IEEE Std 802.3. Annex E contains an informative discussion of how several Organizationally Specific TLVs could be used to detect potential problems in communications networks.

7.4 LLDP design principles

LLDP is 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). Managed objects are accessed via a virtual information store (the MIB). MIB objects are generally accessed through SNMP. Objects in the MIB are defined using the mechanisms of the Structure of Management Information (SMI). For an overview of this structure, see section 7 of IETF RFC 3410.

Clause 12, Annex G, and Annex F include specifications for an LLDP MIB module and for IEEE 802.1 and IEEE 802.3 extension MIB modules that are compliant with the SMIV2 as defined in IETF STD 58, RFC 2578 [B10]; IETF STD 58, RFC 2579 [B11]; and IETF STD 58, RFC 2580 [B12].

7.5 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 the network manager. Information received from remote LLDP agents is stored in the LLDP remote systems MIB.

7.6 Transmission principles

Transmission can be initiated either by the expiration of a transmit countdown timing counter or by a change in the status or value in one or more of the information elements (managed objects) associated with the local system. When a transmit cycle is initiated, the LLDP manager extracts the managed objects from the LLDP local system MIB and formats this information into TLVs. The TLVs are inserted into the LLDPDU that is passed to the LLDP transmit module. The LLDP transmit module prepends addressing parameters to the LLDPDU as defined in 9.2, 9.3, and 9.4. The LLDPDU and TLV formats are defined in Clause 9. The LLDP transmit state machine is described in 10.4 and 10.5.4.

NOTES

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 minimum time between successive LLDP frame transmissions.

2—Under normal circumstances, the information in the receiving LLDP agent's remote systems MIB is refreshed periodically to avoid being discarded due to aging. 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 will typically set the TTL value so that several refresh cycles will occur before the received MIB information will age out.

7.7 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 being derived from an incoming LLDP frame. The LLDPDU recognition is defined in 8.4 and 10.3.1.

7.7.1 LLDPDU and TLV error handling

The LLDPDU is checked to ensure that it contains the correct sequence of mandatory TLVs and then each optional TLV is validated in succession. LLDPDUs and TLVs that contain detectable errors are discarded. TLVs that are not recognized, but that also contain no basic format errors, are assumed to be validated and are stored for possible later retrieval by network management (see 10.3.2 and 10.3.5).

7.7.2 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 10.3.3, 10.3.4, 10.3.5, 10.3.6, and 10.3.7. The LLDP receive state machine is described in 10.4 and 10.5.5.

7.8 Relationship between LLDP and IETF MIBs

LLDP is designed to operate in conjunction with MIBs defined by IETF, IEEE 802, and others. The following subclauses discuss the relationship between LLDP and IETF MIBs. LLDP agents automatically notify the managers of these MIBs 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.

7.8.1 IETF Physical Topology MIB

The Physical Topology MIB (IETF RFC 2922 [B15]) allows a LLDP agent to expose learned physical topology information, using a standard MIB. LLDP is intended to support the PTOPO MIB.

NOTE—The LLDP MIB module is a logical superset of the IETF Physical Topology MIB, and from a functional point of view if the LLDP MIB module is implemented, there is no need to implement the PTOPO MIB defined in RFC 2922 [B15].

7.8.2 IETF Entity MIB

The Entity MIB (IETF RFC 2737) allows the physical component inventory and hierarchy to be identified. Chassis IDs passed in the LLDPDU may identify entPhysicalTable entries. SNMP agents that implement the LLDP MIB should implement the entPhysicalAlias object from the Entity MIB version 2 or higher.

7.8.3 IETF Interfaces MIB

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

8. 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., protocol discrimination based on the Ethertype field specified in IEEE Std 802a-2003.

The parameters of each service request and service indication comprise:

- a) destination address.
- b) source address.
- c) Ethertype.
- d) LLDPDU.

The LLDP Ethertype is prepended to the LLDPDU as shown in Figure 8-1 to form the MSDU of the corresponding MAC service request.



Figure 8-1—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.

8.1 Destination address

The destination address shall be as specified in Table 8-1. This address is within the range reserved by IEEE Std 802.1D-2004 for protocols constrained to an individual LAN, and ensures that the LLDPDU will not be forward by MAC Bridges that conform to IEEE Std 802.1D-2004.

Table 8-1—LLDP_Multicast address

Name	Value
LLDP_Multicast address	01-80-C2-00-00-0E

NOTE—This address has been selected from amongst those addresses that are not forwarded by MAC Bridges, or by VLAN-aware Bridges (see IEEE Std 802.1Q-1998).

8.2 Source address

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

8.3 Ethertype use and encoding

The Ethertype shall be the LLDP Ethertype specified in Table 8-2.

Table 8-2—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 802.3-2002, IEEE Std 802.11-1999) or a media access control independent entity (for example, IEEE P802.1AE) that directly supports encoding of Ethernets, 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 (for example, IEEE Std 802.5) that does not directly support Ethertype encoding, the LLDP Ethertype shall be encoded in the octets of LLDPDU header according to the procedures specified in IEEE Std 802-2001 for Subnetwork Access Protocols (SNAP).

NOTES

1—The SNAP discriminator comprises the octets AA-AA-03-00-00-00 prepended to the LLDP Ethertype.

2—Annex D provides example LLDP transmission frame formats for both direct-encoded and SNAP-encoded LLDP Ethertype encoding methods.

8.4 LLDPDU reception

The LLDPDU shall be delivered to the LLDP receive module if, and only if, both the destination address and the Ethertype encoding are equal to the values defined in Table 8-1 and Table 8-2 respectively.

9. LLDPDU and TLV formats

9.1 LLDPDU bit and octet ordering conventions

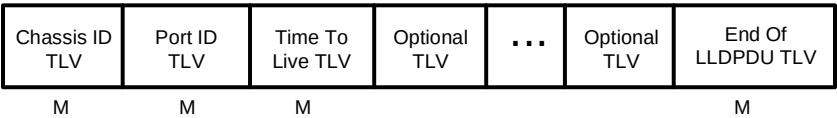
All LLDPDUs shall contain an integral number of octets. The octets in an LLDPDU are numbered starting from 1 and increasing in the order they are put into the LLDP frame. The bits are numbered from 0 to 7, where 0 is the low-order bit.

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, thus allowing communications to take place.

9.2 LLDPDU format

The LLDPDU shall contain an ordered sequence of three mandatory TLVs followed by one or more optional TLVs plus an End Of LLDPDU TLV, as shown in Figure 9-1:

- 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).
- c) The End Of LLDPDU TLV shall be the last TLV in the LLDPDU.



M - mandatory TLV - required for all LLDPDUs

Figure 9-1—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).

9.3 TLV categories

The TLVs are grouped into two general categories:

- 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 an 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 9.4. Specific definitions and usage requirements for all basic management set TLVs are defined in 9.5. 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 9.6. Specific definitions for IEEE 802.1 and IEEE 802.3 extension sets are contained in Annex F and Annex G.

Usage rules/requirements that pertain to each individual basic TLV are contained in the definition for that particular TLV.

9.4 Basic TLV format

Figure 9-2 shows the basic TLV format.

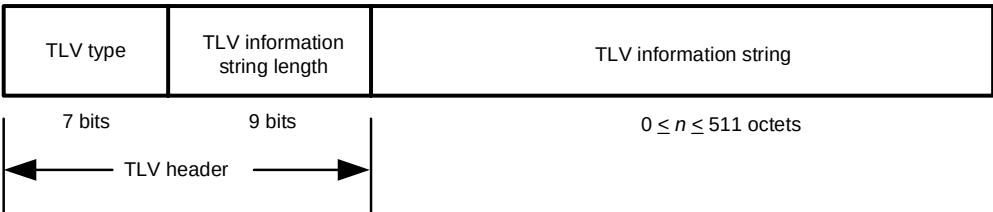


Figure 9-2—Basic TLV format

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.

9.4.1 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 each LLDPDU.
- b) Optional TLVs that may be included some LLDPDUs.

Table 9-1 lists the currently defined TLVs, their identifying TLV type values, and whether they are mandatory or optional for inclusion in any particular LLDPDU.

Table 9-1—TLV type values

TLV type *	TLV name	Usage in LLDPDU	Subclause reference
0	End Of LLDPDU	Mandatory	Clause 9.5.1
1	Chassis ID	Mandatory	Clause 9.5.2
2	Port ID	Mandatory	Clause 9.5.3
3	Time To Live	Mandatory	Clause 9.5.4
4	Port Description	Optional	Clause 9.5.5
5	System Name	Optional	Clause 9.5.6
6	System Description	Optional	Clause 9.5.7
7	System Capabilities	Optional	Clause 9.5.8
8	Management Address	Optional	Clause 9.5.9
9–126	reserved	—	—
127	Organizationally Specific TLVs	Optional	IEEE 802.1 TLV set, Annex F IEEE 802.3 TLV set, Annex G

*TLVs with type values 0–8 are members of the basic management set.

9.4.2 TLV information string length

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

9.4.3 TLV information string

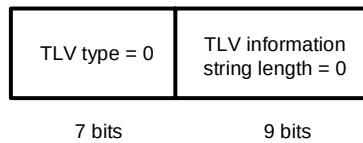
The information string:

- May be fixed or variable length.
- May include one or more information fields with associated subtype identifiers and field length designators as in, for example, the Management Address TLV (see 9.5.9).
- May contain either binary or alpha-numeric information that is instance specific for the particular TLV type and/or subtype:
 - Bit 0 in binary bit maps shall be the least significant bit in the field.
 - The first octet of an alpha-numeric field shall be the most significant octet.
 - Alpha-numeric information shall be encoded in UTF-8 [IETF RFC 3629].

9.5 Basic management TLV set formats and definitions

9.5.1 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 9-3.

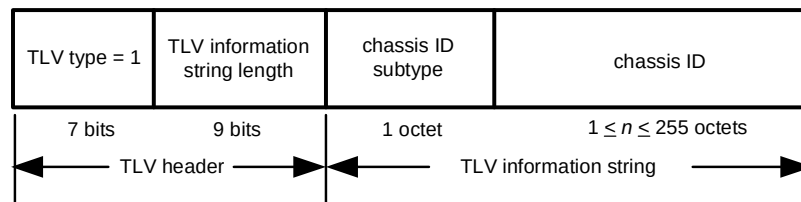
**Figure 9-3—End Of LLDPDU TLV format**

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 is necessary to prevent non-zero pad octets from being interpreted by the receiving LLDP agent as another TLV.

9.5.2 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 connection remains operational.

The Chassis ID TLV shall be the first TLV in the LLDPDU. Its format is shown in Figure 9-4.

**Figure 9-4—Chassis ID TLV format**

9.5.2.1 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.

9.5.2.2 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 9-2.

Table 9-2—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 2737)
2	Interface alias	IfAlias (IETF RFC 2863)
3	Port component	EntPhysicalAlias when entPhysicalClass has a value 'port(10)' or 'backplane(4)' (IETF RFC 2737)
4	MAC address	MAC address (IEEE Std 802-2001)
5	Network address	networkAddress [*]
6	Interface name	ifName (IETF RFC 2863)
7	Locally assigned	local [†]
8–255	Reserved	—

^{*}networkAddress 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-A8-FE-0A would indicate the IP version 4 address 192.168.254.10).

[†]local is an alpha-numeric string and is locally assigned.

9.5.2.3 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 9-2 for the chassis ID shall be non-null.

9.5.2.4 Chassis ID TLV usage rules

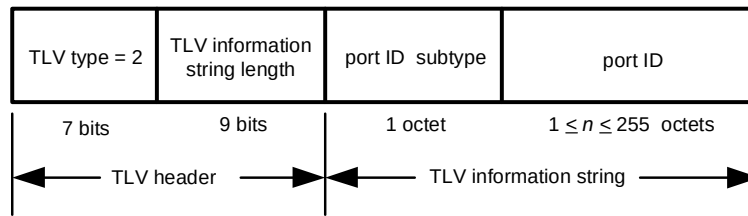
An LLDPDU shall contain exactly one Chassis ID TLV.

9.5.3 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 9-5.

**Figure 9-5—Port ID TLV format****9.5.3.1 TLV information string Length**

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

9.5.3.2 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 9-3.

Table 9-3—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 2737)
3	MAC address	MAC address (IEEE Std 802-2001)
4	Network address	networkAddress *
5	Interface name	ifName (IETF RFC 2863)
6	Agent circuit ID	agent circuit ID (IETF RFC 3046)
7	Locally assigned	local †
8–255	Reserved	—

*networkAddress 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-A8-FE-0A would indicate the IP version 4 address 192.168.254.10).

†local is an alpha-numeric string and is locally assigned.

9.5.3.3 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 9-3 for the port ID shall be non-null.

9.5.3.4 Port ID TLV usage rules

An LLDPDU shall contain exactly one Port ID TLV.

9.5.4 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 all system information associated with the LLDP agent/port is to be deleted. 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 9-6.

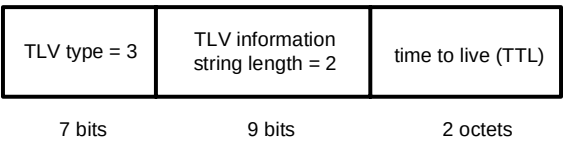


Figure 9-6—Time To Live TLV format

9.5.4.1 time to live (TTL)

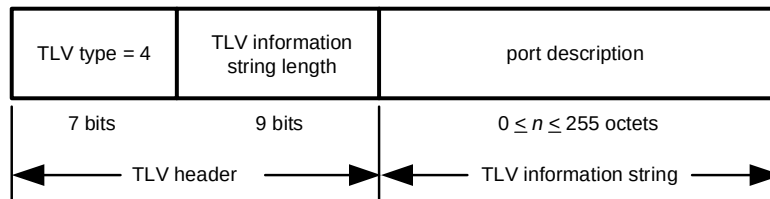
The TTL field shall contain an integer value in the range $0 \leq t \leq 65535$ seconds and shall be set to the computed value of txTTL at the time the LLDPDU is constructed (see 10.5.4.1).

9.5.4.2 Time To Live TLV usage rules

An LLDPDU shall contain exactly one Time To Live TLV.

9.5.5 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 9-7.

**Figure 9-7—Port Description TLV format****9.5.5.1 TLV information string length**

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

9.5.5.2 port description

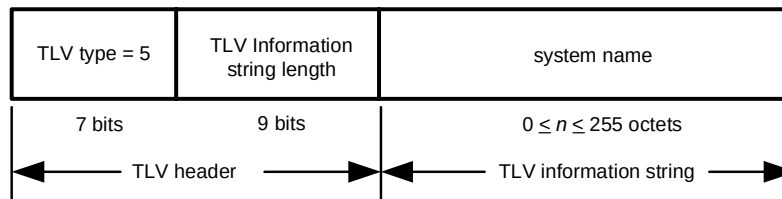
The port description field shall contain an alpha-numeric string that indicates the port's description. If RFC 2863 is implemented, the ifDescr object should be used for this field.

9.5.5.3 Port Description TLV usage rules

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

9.5.6 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 9-8.

**Figure 9-8—System Name TLV format****9.5.6.1 TLV information string length**

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

9.5.6.2 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.

9.5.6.3 System Name TLV usage rules

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

9.5.7 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 9-9.

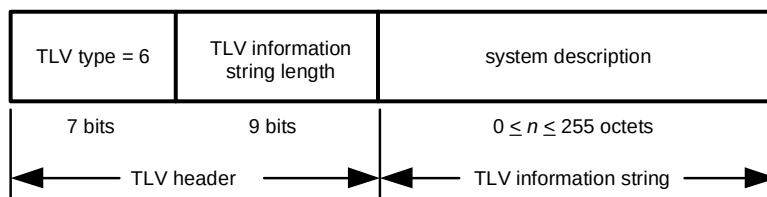


Figure 9-9—System Description TLV format

9.5.7.1 TLV information string length

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

9.5.7.2 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.

9.5.7.3 System Description TLV usage rules

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

9.5.8 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 9-10 shows the format of this TLV.

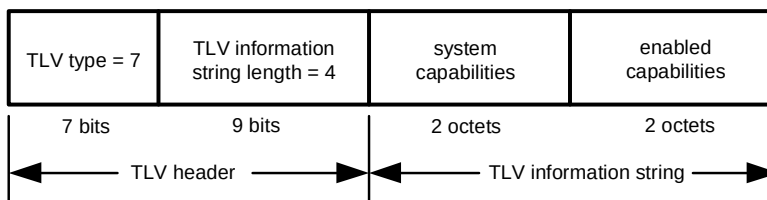


Figure 9-10—System Capabilities TLV format

9.5.8.1 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 9-4. 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 9-4—System capabilities

Bit	Capability	Reference
0	Other	—
1	Repeater	IETF RFC 2108
2	Bridge	IETF RFC 2674
3	WLAN Access Point	IEEE 802.11 MIB
4	Router	IETF RFC 1812
5	Telephone	IETF RFC 2011
6	DOCSIS cable device	IETF RFC 2669 and IETF RFC 2670
7	Station Only *	IETF RFC 2011
8–15	reserved	—

*The station only capability is intended for devices that implement only an end station capability. Bit 7 should not be set in conjunction with any other bits.

9.5.8.2 enabled capabilities

The enabled capabilities field shall contain a bit map of the primary functions listed in Table 9-4. A binary one in a bit position indicates that the function associated with that bit is currently enabled.

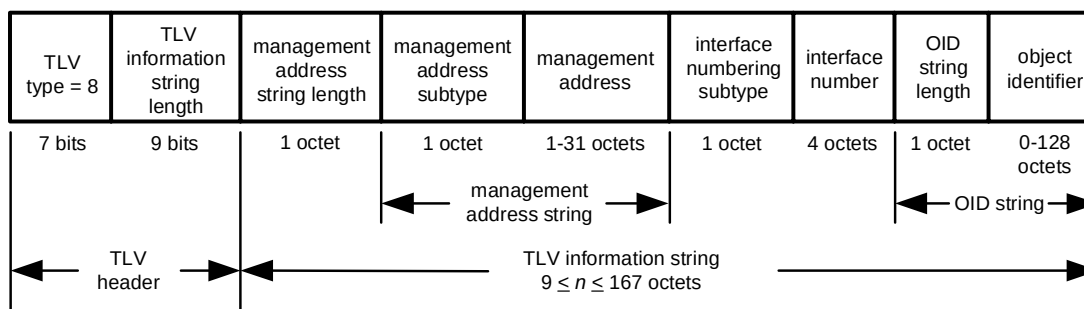
9.5.8.3 System Capabilities TLV usage rules

An LLDPDU should 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 will be interpreted as containing an error and shall be discarded.

9.5.9 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 9-11 shows the Management Address TLV format.

**Figure 9-11—Management Address TLV format**

9.5.9.1 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.

9.5.9.2 management address string length

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

9.5.9.3 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 (currently, <http://www.iana.org>). The management address subtype is contained in the first octet of the management address string.

9.5.9.4 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, 192.168.254.10 (see also Table 9-2, footnote 1).
- If no management address is available, the return address should be the MAC address for the station or port.

9.5.9.5 interface numbering subtype

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

- Unknown.
- ifIndex.
- system port number.

9.5.9.6 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.

9.5.9.7 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.

9.5.9.8 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 [ASN.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.

9.5.9.9 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 no management address is available, the MAC address may be used.
- f) If an OID is included in the TLV, it shall be reachable by the management address.
- g) If the network system is a VLAN bridge that implements the port and protocol based VLAN classification, every Management Address TLV that reports an address that is accessible on a port and protocol VLAN through the particular port should be accompanied by a port and protocol VLAN TLV that indicates the VLAN identifier (VID) associated with the management address reported by this TLV (see F.3.2).

9.6 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. The TLV shall not solicit a response and shall not provide an acknowledgement.
- 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 9.4 and 9.6.1.

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 (for example, see F.6 and G.6). 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 F and Annex G contain currently defined Organizationally Specific TLVs for IEEE 802.1 and IEEE 802.3, 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. Future TLV definitions for IEEE 802 working groups should be included in annexes to this standard.

9.6.1 Basic Organizationally Specific TLV format

The basic format for Organizationally Specific TLVs is shown in Figure 9-12.

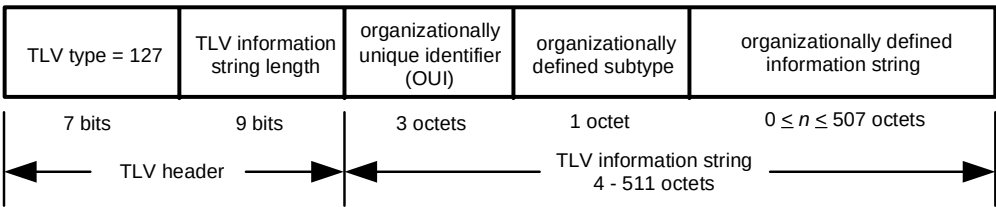


Figure 9-12—Basic format for Organizationally Specific TLVs

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

9.6.1.1 TLV type

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

9.6.1.2 TLV information string length

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

9.6.1.3 organizationally unique identifier (OUI)

The organizationally unique identifier field shall contain the organization's OUI as defined in Clause 9 of IEEE Std 802-2001.

9.6.1.4 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.

9.6.1.5 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 9.5.9).

9.6.2 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 will affect how the receiving LLDP agent shall treat the TLV.

The Organizationally Specific TLV usage rules should include:

- 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 (for example, see F.3.3 a).
- b) Any error conditions that are specific to the particular Organizationally Specific TLV and the action that will be taken for each defined error condition (see F.3.3 b and c).

10. The protocol

This clause describes the protocol for a single port where the local LLDP agent manages LLDP operations for that port.

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

- a) Maintaining current information in the LLDP local system MIB.
- b) 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.
- c) Recognizing and processing received LLDP frames.
- d) Maintaining current values in the LLDP remote system MIB.
- e) Setting the variables somethingChangedLocal and 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.

LLDP allows implementations that support three different operating modes: transmit only mode, receive only, or both transmit and receive. Implementations of this protocol shall conform to the specifications each subclause indicated in Table 10-1 for the operating mode being implemented.

Table 10-1—Subclause/operating mode applicability

Subclause number	Subclause title	Transmit only	Receive only	Transmit and receive
10.1.1	LLDP transmit module initialization	M*	—	M
10.2.1	LLDP receive module initialization	—	M	M
10.2	Frame transmission	M	—	M
10.3	Frame reception	—	M	M
10.4	Notational conventions used in state machines	M	M	M
10.5.1	Global variables	M	M	M
10.5.2	Statistical counters	M	M	M
10.5.2.1	Transmission counters	M	—	M
10.5.2.2	Reception counters	—	M	M
10.5.3	Timers	M	M	M
10.5.3.1	Transmit state machine timers	M	—	M
10.5.3.4	Receive state machine timers	—	M	M
10.5.3.3	Transmit state machine timing parameters	M	—	M
10.5.3.4	Receive state machine timing parameters	—	M	M
10.5.4	Transmit state machine	M	—	M
10.5.5	Receive state machine	—	M	M

*M = mandatory

10.1 Protocol initialization

Because the local LLDP agent may be configured to both transmit and receive LLDP frames, to only transmit LLDP frames, or to only receive LLDP frames, separate protocol initialization processes are needed for frame transmission and reception.

10.1.1 LLDP transmit module initialization

During LLDP initialization or re-initialization of the transmit module, the local LLDP agent shall perform the following tasks:

- a) If applicable, either the non-volatile configuration for the LLDP local system MIB shall be retrieved or the appropriate default values shall be assigned to all LLDP configuration variables.
- b) The internal (implementation specific) data structures shall be initialized with appropriate local physical topology information.
- c) The variable somethingChangedLocal shall be set to FALSE
- d) Appropriate values shall be set for the following timing parameters:
 - 1) reinitDelay.
 - 2) msgTxHold.
 - 3) msgTxInterval.
 - 4) txDelay.
- e) The variable adminStatus shall be interrogated to determine whether initialization should proceed further. If the value of adminStatus is 'disabled', LLDP transmit module initialization shall be halted until the variable portEnabled is equal to TRUE and the value of adminStatus is either of the following:
 - 1) enabledTxRx: the local LLDP agent can both transmit and receive LLDP frames.
 - 2) enabledTxOnly: the local LLDP agent can only transmit LLDP frames.

NOTE—It is both permissible and 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. The method of accomplishing the stagger is an implementation issue and is beyond the scope of this standard.

10.1.2 LLDP receive module initialization

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 shall perform the following tasks:

- a) The variable tooManyNeighbors shall be set to FALSE.
- b) The adminStatus object shall be interrogated to determine whether initialization should proceed further. If the value of adminStatus is 'disabled', LLDP receive initialization shall be halted until the value of adminStatus is one of the following:
 - 1) enabledTxRx: the local LLDP agent can both transmit and receive LLDP frames.
 - 2) enabledRxOnly: the local LLDP agent can only receive LLDP frames.
- c) All information in the remote systems MIB associated with this port shall be deleted.

10.2 Frame transmission

Frame transmission is a combined responsibility of the LLDP MIB manager and the LLDP transmit module. LLDP transmission shall conform to the following:

- a) An active LLDP agent enabled for transmission shall initiate an LLDP frame transmission whenever either of the following events occur:
 - 1) Expiration of the transmission countdown timing counter, txTTR, associated with the LLDP local system MIB.
 - 2) A condition (status or value) change in one or more objects in the LLDP local system MIB.
- b) To prevent a series of successive LLDP frame transmissions during a short period due to rapid changes in LLDP local systems MIB objects and to increase the probability that multiple, rather than single changes are reported in each frame, the local LLDP shall limit the LLDP frame transmission rate through use of a variable transmit delay timer that may be set by network management.
- c) The LLDP agent shall suppress the transmission of multiple frames during a single transmission cycle if frame transmission cannot be restricted to a single port, but rather is transmitted through a group of ports attached to the same LAN segment (for example, in a repeater). In this case, a single port in the port group should be selected (in an implementation specific manner) to represent the port group. An LLDP agent should represent port groups as “backplanes”, in the LLDP local system MIB (and in the entPhysicalTable of the Entity MIB, rather than individual ports in either the Entity MIB or Interfaces MIB).
- d) Actual transmission intervals for different ports on the same multi-port implementation should be staggered to prevent synchronization effects.

10.2.1 LLDPDU construction

Two types of LLDPDUs are defined:

- a) Normal LLDPDUs where the purpose is to provide management information about the local station.
- b) A special shutdown advisory LLDPDU indicating that the information about the local station that is maintained in the remote LLDP agent’s remote systems MIB is about to become invalid.

10.2.1.1 Normal LLDPDU construction

The LLDP local system MIB shall contain the information needed for constructing individual TLVs and shall include a capability that will allow network managers to select which optional TLVs are to be included in the LLDPDU (see 11.2.2).

When a new transmission cycle is indicated for an LLDP enabled port, the LLDP MIB manager shall extract the selected information from the LLDP local system MIB and shall construct an LLDPDU as defined in 9.1, containing:

- a) Three mandatory TLVs as specified in 9.2:
 - 1) Chassis ID TLV (see 9.5.2).
 - 2) Port ID TLV (see 9.5.3).
 - 3) Time To Live TLV, with the TTL value set equal to txTTL (see 9.5.4).
- b) Additional optional TLVs from either 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 9-1, Table F-1, and Table G-1).
- c) 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 may be included within the same LLDPDU.

When the LLDPDU is complete, the MIB manager shall re-initialize the txTTR timing counter in the LLDP local system MIB.

10.2.1.2 Shutdown LLDPDU construction

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, a final LLDP shutdown LLDPDU may be sent with:

- 1) The Chassis ID and Port ID TLVs.
- 2) The Time To Live TLV with the TTL field set to zero.
- 3) An End Of LLDPDU TLV.

The LLDPDU shall not include any optional TLVs and 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 termination of the connection should be delayed until after this frame is transmitted. In the event where adminStatus is transitioning to the disabled state and the LLDP agent will be shutting down, then this shutdown procedure should be executed for all local ports.

10.2.2 LLDP frame formatting/transmission

Upon receipt of an LLDPDU, the LLDP transmission module shall:

- a) Prepend the appropriate source and destination addresses plus the LLDP Ethertype to the LLDPDU as defined in 8.1, 8.2, and 8.3 to complete the construction of the MA_UNITDATA.request.
- b) Utilize the services of the LLC to pass the MA_UNITDATA.request to the MAC for final frame formatting and transmission.
- c) Increment the statsFramesOutTotal counter.

10.3 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.

10.3.1 LLDP frame recognition

The frame recognition is done at the LLDP/LSAP (see Figure 6-2) where the following frame elements shall be checked to determine whether:

- a) The destination address value is the assigned LLDP_Multicast address defined in 8.1.
- b) The Ethertype value is the LLDP Ethertype defined in 8.3 for the particular frame format.

If both of the above conditions are TRUE, the global variable rcvFrame shall be set to TRUE and the frame shall be sent to the LLDP receive module for validation.

10.3.2 LLDPDU validation

The receive module shall process each incoming LLDPDU as it is received. The statsFramesInTotal counter for the port shall be incremented and the LLDPDU shall be checked to verify the presence of the three mandatory TLVs at the beginning of the LLDPDU as defined in 9.2.

- a) The first TLV shall be extracted:
 - 1) If the extracted TLV type value does not equal 1, the TLV is not a Chassis ID TLV:

- i) The LLDPDU shall be discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters shall both be incremented.
 - iii) The variable badFrame shall be set to TRUE.
 - iv) The procedure rxProcessFrame() shall be 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 shall be discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters shall both be incremented.
 - iii) The variable badFrame shall be set to TRUE.
 - iv) The procedure rxProcessFrame() shall be 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 shall be extracted to become the first part of the MSAP identifier.
- b) The second TLV shall be extracted:
 - 1) If the extracted TLV type value does not equal 2, the TLV is not a Port ID TLV:
 - i) The LLDPDU shall be discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters shall both be incremented.
 - iii) The variable badFrame shall be set to TRUE.
 - iv) The procedure rxProcessFrame() shall be 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 shall be discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters shall both be incremented.
 - iii) The variable badFrame shall be set to TRUE.
 - iv) The procedure rxProcessFrame() shall be 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 shall be extracted and appended to the chassis ID value to complete construction of the MSAP identifier.
- c) The third TLV shall be extracted:
 - 1) If the extracted TLV type value does not equal 3, the TLV is not a Time To Live TLV.
 - i) The LLDPDU shall be discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters shall both be incremented.
 - iii) The variable badFrame shall be set to TRUE.
 - iv) The procedure rxProcessFrame() shall be 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 shall be discarded.
 - ii) The statsFramesDiscardedTotal and statsFramesInErrorsTotal counters shall both be incremented.
 - iii) The variable badFrame shall be set to TRUE.
 - iv) The procedure rxProcessFrame() shall be terminated.