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IEEE Std 802.1AB LLDP for IETF LSVR Neighbor Discovery and Configuration

Abstract

IEEE Std 802.1AB, known as the Link Layer Discovery Protocol (LLDP), can be applied to LSVR neighbor discovery and configuration. This can be achieved by using a “nearest router group address” as the LLDP Scope MAC Address to target the LSVR interface and to advertise a set of LSVR-specific LLDP TLVs. These LSVR-specific TLVs are defined using LLDP Organizationally Specific TLVs, as specified by LLDP for use by individual organizations to allow them to define their own Type-Length-Value (TLV) objects for exchange over the LLDP protocol. The IETF Organizationally Specific TLVs for LSVR can be encoded using the IETF IANA OUI (RFC 7042). This document provides an overview of applying LLDP to LSVR neighbor discovery and configuration and specifies the IETF Organizationally Specific TLVs that support link discovery for the LSVR routing protocol. In addition, a brief discussion of the use of IEEE Connectivity Fault Management (CFM) as specified in IEEE Std 802.1Q-2022 cl 18-22 for link liveliness is included.

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1. Introduction

The IEEE Std 802.1AB [802.1AB][802.1ABcu][802.1ABdh], commonly known as the Link Layer Discovery Protocol (LLDP), is an extremely simple protocol used to advertise the identity and capabilities of router, switch, and end-station ports to network neighbors. It is widely

deployed in data centers and campus networks where it provides information used to identify neighbors, capabilities, and current state. The LLDP information is used in turn by management systems to map the network topology and capabilities and by LLDP applications to perform protocol configuration.

The LLDP protocol operates over both point-to-point and multipoint networks. It can be used to advertise neighbors and capabilities both at the physical port level and at virtual interfaces within systems. LLDP provides three standardized advertisement scopes which identify the type of port being advertised. These standard types are identified by a group Scope MAC Addresses which is used as an LLDP destination address. The standard port types are nearest bridge, nearest non-TPMR bridge, and nearest customer bridge. In addition, the standard allows the use of an alternate group MAC address or individual MAC address for the Scope MAC Address. For LSVR an alternate Scope MAC Address can be used to identify router ports which are internal to a switch or to identify router ports that are behind a bridged network.

LLDP provides a means for individual organizations to define their own Type-Length-Value (TLV) objects for exchange over the protocol. TLVs that belong to an organization are identified by the inclusion of the organization's OUI and an organizationally defined subtype in the initial octets of the information field.

The IETF is a standards development organization with an IANA OUI. The usage and considerations for this OUI are discussed in [RFC7042]. The IANA OUI can be used to identify IETF specific LLDP Organizationally Specific TLVs.

The LSVR working group is specifying protocols that need to discover IP Layer 3 attributes of links, encapsulations, and neighbors. This document specifies a set of IETF LLDP Organizationally Specific TLVs that carry the necessary discovery attributes for LSVR working group protocols.

2. Terminology

Extended Link Layer Discovery Protocol: An LLDP extension used to retrieve the frames beyond the Normal LLDPDU of a multi-frame LLDP database.

Extension LLDPDU: An LLDPDU containing an Extension Identifier TLV and not containing a Time to Live TLV or Extension Request TLV.

Extension Request LLDPDU: An LLDPDU containing an Extension Request TLV and not containing a Time to Live TLV or Extension Identifier TLV.

Link or Logical Link: A logical connection between two logical ports on two devices. E.g. two VLANs between the same two ports are two links.

Logical Link Endpoint: One end of a logical link.

Logical Link Endpoint Identifier: The unique identifier for a Logical Link Endpoint.

LLDP Protocol Data Unit: A single L2 frame carrying LLDP TLVs.

Manifest LLDPDU: A Normal LLDPDU containing a Manifest TLV.

Normal LLDPDU: A LLDPDU containing a Time To Live TLV and not containing an Extension Request TLV or an Extension Identifier TLV.

Scope MAC Address: The MAC address used as the destination address in Normal LLDPDUs, which determines the limits of propagation in the network.

3. Abbreviations

LLDP - Link Layer Discovery Protocol

LLDPDU: LLDP Protocol Data Unit

LLEI: Logical Link Identifier

TLV - Type-Length-Value

XLLDP - Extended Link Layer Discovery Protocol

XPDU - Extension LLDPDU

XREQ - Extension Request LLDPDU

In the event the TLVs that encode the local database do not fit in a single LLDPDU, the LLDP Agent will encode additional TLVs in extension LLDPDUs (XPDUs) and will add a Manifest TLV to the Normal LLDPDU. The Manifest TLV contains a digest of each XPDU. The receiver of a Normal TLV containing a Manifest TLV will decide if any of the XPDUs contains new information by comparing the digest for its existing XPDUs with the digest contained in the Manifest. If new XPDUs are found the receiver will make explicit requests for the new XPDUs using the Extension Request LLDPDU (XREQ). The transmitting LLDP Agent responds to XREQs by sending the requested XPDUs. The LLDP extended request response performed using the XREQ and XPDU exchange is performed using unicast addressing. Since the receiver makes explicit requests for XPDUs it can determine the pacing rate based on its processing overhead and resources. The receiver is responsible for timing out and retrying failed XREQs.

4.1. Nearest Router Scope MAC Address for LLDP

There are two choices for how to address LLDPDUs for application to LSVR. These are to use the Nearest Bridge Address (01-80-C2-00-00-0E) [802.1AB] for the LLDP Scope MAC Address or to select an application specific Nearest Router Multicast Address for use as the LLDP Scope MAC Address.

If the IEEE standard nearest bridge address is used, the LLDP Agent will be at the physical switch port. In this case, routers attached to subinterfaces or Switched Virtual Interfaces (SVIs) will need to support information for multiple Logical Link Endpoints within the local LLDP databases on each physical port. The LLDP local databases will require the Logical Link Endpoint Identifier (LLEI), VLAN IDs, and MAC addresses associated with each Logical Link Endpoint. In addition, if the nearest bridge address is used, router interfaces with bridges between them will not be discoverable because the LLDPDUs will not travel through the bridges.

If a LSVR specific Nearest Router Multicast Address which is not a member of the reserved bridge addresses is selected for the LLDP Scope MAC Address, then the LLDP Agents can be associated directly with the router interfaces regardless of whether they are physical, subinterfaces, or switched virtual interfaces (SVIs). In addition, such an address will allow LLDP to operate when a bridge intervenes between the router interfaces.

Within this document a Nearest Router Multicast will be assumed as the only LLDP Scope MAC Address used for the LSVR discovery application. We believe this approach is consistent with the current intent of draft-ietf-lsvr-l3dl. The Nearest Router Multicast Address for the LLDP Scope MAC Address should be reserved for router

interface discovery applications by IANA. IEEE may also reserve the nearest router multicast selected by IANA, however since the nearest router multicast would not have any special meaning to the IEEE 802 protocols reservation by IEEE is not required.

4.2. Logical Link Endpoint Identification

Every LLDPDU begins with a ChassisID TLV and a PortID TLV [802.1AB]. These two TLVs identify the sending LLDP location which is the equivalent of the draft-ietf-lsvr-l2dl Logical Link Endpoint Identifier. The ChassisID provides a unique identifier for the system, in this case an LSVR router (i.e. a MAC address, any IANA address family identifier). The PortID provides a unique identifier for the interface within the system (i.e. port number, IfIndex).

Within this draft we assume the use of a Nearest Router Multicast Scope MAC Address for LLDP which always places LLDP Agents at the Logical Link Endpoint. Provided the LLDP Agent is advertising information from each router interface (physical or virtual) the ChassisID and PortID can be used as the Logical Link Endpoint Identifier. This draft assumes the LLDP ChassisID and PortID are used to identify Logical Link Endpoints.

4.3. Layer-2 Link Liveliness

Two mechanisms are available to determine layer-2 link liveliness. These are the periodic LLDPDU transmissions along with the LLDP time-to-live protocol and the IEEE Connectivity Fault Management (CFM) protocol as specified in IEEE Std 802.1Q cl 18-22 [802.1Q].

The LLDP mechanism is part of the basic LLDP protocol. Every Normal LLDPDU contains a Time-To-Live TLV which specifies how long the information advertised for each Logical Link Endpoint is valid. LLDP retransmits the Normal LLDPDU periodically to maintain the liveliness of the information in the remote LLDP databases. The default retransmit time for LLDP is once every 30 seconds and is settable in 1 second steps. The Time-To-Live is calculated based on the Normal LLDPDU retransmit window to allow multiple LLDPDU retransmits before expiring. The default is 4 transmission times. A time-to-live timeout is indicated to the coupled application layer, in this case the router, which can take action to disable the associated Logical Link(s).

The l3dl protocol specifies a hello timer of 10 seconds with a timeout of 3 transmission intervals for liveliness. The LLDP transmissions and timeout can be set to match these values if desired.

The Connectivity Fault Management (CFM) mechanism provides a multi-level Operations, Administration and Maintenance facility that can be used to provide liveliness as well as L2 network diagnostics. For application to LSVR link liveless CFM Continuity Check Messages (CCMs) can be generated from each Logical Link Endpoint by implementing a CFM Management End Point (MEP) at each Logical Link Endpoint. These CCM messages travel over a Maintenance Domain (MD) within a Maintenance Association (MA).

The Maintenance Domain (MD) specifies the boundaries of the L2 communication such as Customer/Service Provider/Operator. The MD levels nest, however never intersect allowing support for network layering. The MD level are 0-7 where 7 is the broadest reach. Each MD level also is named. For the application of LLDP to LSVR LLE discovery there could lower level MDs. For instance if the LSVR router interface was attached to a MEF E-LINE service, then there could be both service provider and operator MDs as part of the router link. In this case the LSVR interface MD should be in the upper level. Another possibility is that the LSVR router provides an L2 service interface to the data center (perhaps to an overlay). In this case there could be MDs of greater extent than the one used for LSVR Link discovery. To allow for these two cases the MD selected for LSVR Link discovery could be MD level 5 which is the lowest customer level allowing 0-4 for provider networking and 6-7 for data center L2 services.

A Maintenance Association (MA) within a MD is defined by a set of Maintenance End Points (MEPs) at the edge of the MD to monitor connectivity of a particular service. In this case every LSVR LLE can be part of an MA.

The Connectivity Check Messages (CCMs) running over LSVR Management Associations can provide link continuity checking down to the 10 msec range.

Further support for rapid L2 link liveliness may use the IEEE 802.3ah OAM procedures. Refer to IEEE 802.3 cl 57.

4.4. LLDP Organizationally Specific TLVs

IEEE Std 802.1AB defines the format of the Organizationally Specific TLVs. The format is redrawn here for convenience.

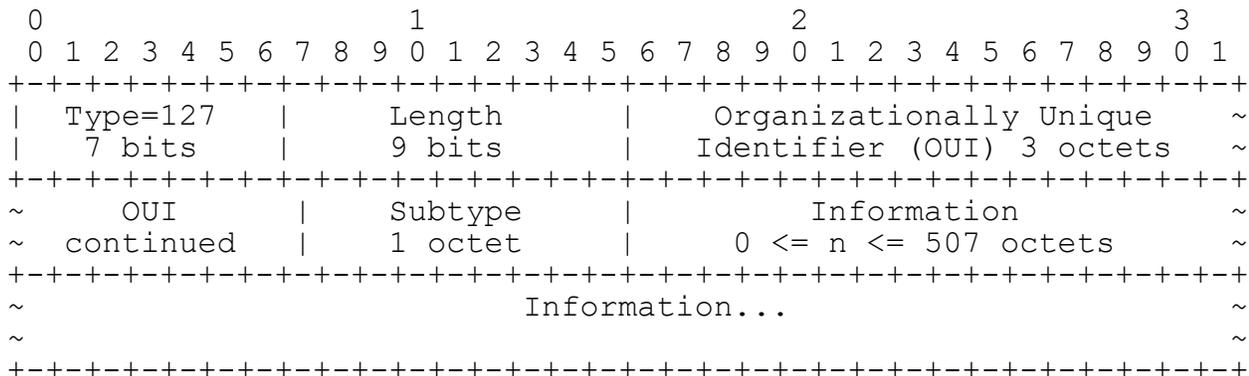


Figure 2 LLDP Organizationally Specific TLV Format

4.4.1. Type

The Type field is 7 bits in length and is set to the value of 127 indicating the TLV type is an Organizationally Specific TLV.

4.4.2. Length

The Length field contains the length of the TLV specific information, the OUI and subtype. The Length is from 4 to 511 octets.

4.4.3. Organizationally Unique Identifier

The Organizationally Unique Identifier indicates the organization specifying the TLV. For IETF use, this field is the IANA OUI as discussed in RFC 7042 and has the hex value of 00-00-5E.

4.4.4. Subtype

The Subtype field indicates the specific IETF Organizationally Specific TLV. The format of the information string is dependent upon the Subtype field.

4.4.5. Information

The Information field contains the octets that are specific to the Organizationally Specific TLV. The field length is between 0 and 507 octets.

4.5. IETF LLDP Organizationally Specific TLVs for LSVR

The IETF draft [I-D.acee-adr-lldp-peer-discovery] describes the use of LLDP by BGP for peer discovery. The IETF LLDP TLV format specified for BGP is used here as the basis for LSVR router discovery TLVs.

The format taken from draft-acee-idr-lldp-peer-discovery specifies using the LLDP Organizationally Specific TLV subtype (4.4.4.) to identify the IETF working group followed by a working group specific subtype.

The content of the specified here for the LSVR TLVs is modeled after the TLVs specified for the L3DL protocol in draft [I-D.ietf-lsvr-l3dl].

Each LLDP Organizationally Specific TLV starts with the same first four fields as shown in (4.4.). For LSVR the Type field SHALL be 127; the Length field SHALL be the length in octets of the LLDP TLV information string which starts immediately after the Length field; the OUI field SHALL be the IETF OUI 00-00-0E; the Subtype field SHALL be xx to designate the LSVR group.

Following the LLDP Organizationally Specific TLV subtype a LSVR specific one octet subtype SHALL be used to identify the TLV content. The values of the LSVR TLV subtype are shown in the following table:

Subtype	Name
-----	-----
0	Reserved
1	IPv4 Announcement
2	IPv6 Announcement
3	MPLS IPv4 Announcement
4	MPLS IPv6 Announcement
5	Upper-Layer Protocol Configuration
6-255	Reserved

The specific TLV format for each subtype and remaining fields of each Organizationally Specific TLV for LSVR are specified in the following sections.

Since LLDP TLVs are limited in size the LLDP database may contain multiple copies of a single LSVR TLV type.

4.6. LSVR LLDP L3 data link application

LSVR LLDP Agents are associated with each router Logical Link Endpoint. Each agent advertises the local database associated with the Logical Link Endpoint and updates its remote database to include the information advertised by other router Logical Link Endpoints.

An L3 data link application accesses the LLDP databases to determine the network configuration and operation. The application using the LLDP databases signals to the LLDP Agent whenever it changes something in the local database by using the LLDP SomethingChangedLocal() routine. The LLDP Agent signals the application whenever a change is detected in the remote database using the LLDP SomethingChangedRemote() routine.

The L3 data link application uses the information in the LLDP databases to determine active logical links and operating configurations. The application informs the LSVR router of operational links and parameters. The interface between the L3 data link application and BGP-SPF can use the restricted profile of BGP-LS [RFC9552] API as specified in l3dl if desired.

5. Encapsulation TLVs for LSVR

LLDP advertises the encapsulations available in the local database associated with its interface. The interface is uniquely identified by the ChassisID and PortID TLVs encoded as the first two TLVs within each LLDPDU. The ChassisID and PortID TLVs together encode the Logical Link Endpoint Identifier for the router interface within the sending system associated with the LLDP Agent.

The encapsulation types the peers can exchange are IPv4, IPv6, MPLS IPv4, MPLS IPv6, and/or possibly others not defined here.

The sender of an encapsulation type MUST NOT assume the peer is capable of the same encapsulation type. Only if an interface has the encapsulation type in both the local and remote LLDP databases is it safe for layer-3 protocols to assume they are compatible for that type.

The LLDP L3 data link application might recognize an addressing conflict, such as both ends of the link trying to use the same address. As there can be other usable addresses or encapsulations, this error might be logged, letting an upper layer topology builder deal with what works.

Further, to consider a L3 data link of an encapsulation type to formally be established, so it can be pushed up to upper layer

protocols, the addressing for the type must be compatible, e.g. on the same IP subnet.

5.1. Encaps Flags

Each Encapsulation TLV specifies a set of flags for each address listed for the encapsulation. These flags are specified here and used in all the encapsulations.

The Encaps Flags specify attributes about the address being announced and are compatible with the Encapsulation Flags defined [I-D.ietf-lsvr-l3dl]. The Encaps Flags have the following format:

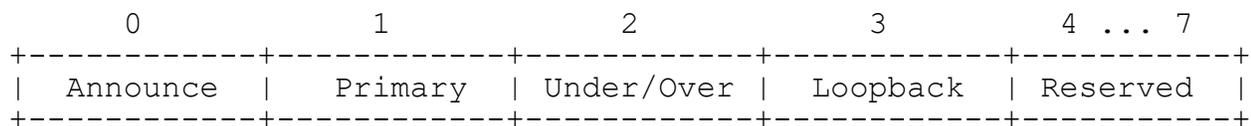


Figure 3 Encapsulation Flags

5.1.1. Announce

The Announce flag bit SHALL always be set to 1. [I-D.ietf-lsvr-l3dl] defines this bit as an Announce/Withdraw bit to allow encapsulations to be both announced and withdrawn by the L3DL protocol. Old encapsulations are withdrawn in LLDP by simply excluding them in the next transmission of an LLDPDU.

5.1.2. Primary

The Primary flag bit indicates that the encapsulation interface is a primary interface. The value of 1 indicates the interface is primary and the value of 0 indicates it is not. If the LLEI has multiple addresses for an encapsulation type, one and only one address SHOULD be marked as primary.

5.1.3. Under/Over

The Under/Over flag bit indicates if the interface address is for an underlay interface or an overlay interface. The value of 1 indicates the interface is an underlay and the value of 0 indicates it is an overlay.

5.1.4. Loopback

The Loopback flag bit indicates if the interface address is a loopback address. Loopback addresses are generally not seen directly on an external interface. One or more loopback addresses

MAY be announced. The value of 1 indicates that the interface address is a loopback address and the value of 0 indicates it is not.

5.1.5. Reserved

MUST be transmitted as 0 and ignored on receive.

5.2. IPv4 Announcement TLV

The IPv4 Announcement TLV describes a device's ability to exchange IPv4 packets on one or more subnets. It does so by announcing the interface's addresses and the corresponding prefix lengths. Multiple tuples of IPv4 address information can be announced in a single TLV, each tuple with its own set of encapsulation flags, address and prefix length. The format of the IPv4 Announcement TLV is as follows:

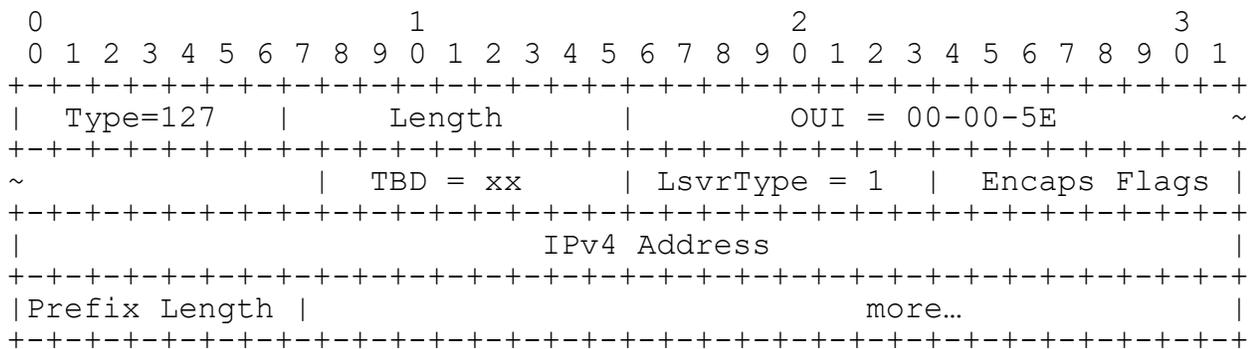


Figure 4 IPv4 Announcement TLV

5.2.1. Encaps Flags

The Encaps Flags are the same flags specified in section 5.1.

5.2.2. IPv4 Address

The IPv4 Address field holds the IPv4 address to be announced.

5.2.3. Prefix Length

The Prefix Length field indicates the number of bits in the IPv4 Address that represent the IPv4 prefix for the subnet (network portion of the address).

5.3.3. IPv6 Address

The IPv6 Address field holds the IPv6 address to be announced.

5.3.4. IPv6 Announcement TLV usage rules

An LLDPDU MAY contain multiple IPv6 Announcement TLVs, however, the encapsulation flags, IPv6 address and prefix length tuple for a specific IPv6 address MUST only appear once in the LLDPDU.

5.4. MPLS IPv4 Announcement TLV

The MPLS IPv4 Encapsulation describes a logical link's ability to exchange labeled IPv4 packets on one or more subnets. It does so by stating the interface's addresses the corresponding prefix lengths, and the corresponding labels which will be accepted for each address. The format of the MPLS IPv4 Announcement TLV is as follows:

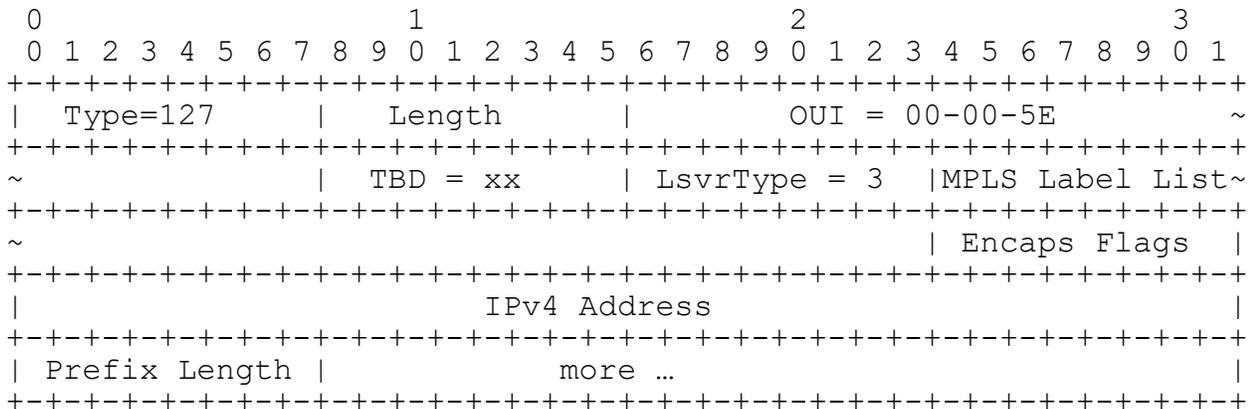


Figure 6 MPLS IPv4 Announcement TLV

5.4.1. MPLS Label List

The MPLS Label List is a variable length field that contains the label stack, see [RFC3032], that the sender will accept for the prefix to which the list is attached. The format of the MPLS Label List is as follows:

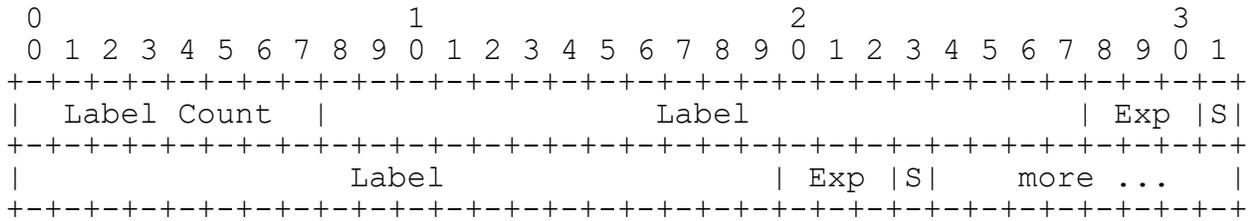


Figure 7 MPLS Label List

5.4.1.1. Label Count

The number of label stack entries that are included in the list. Each label stack entry has a label, experimental use bits and the bottom of stack indicator. The Label Count MUST NOT be 0.

<<Editor's note: We really don't need this count because the S bit indicates when the list ends>>

5.4.1.2. Label

The Label field is the 20-bit value of the label.

5.4.1.3. Exp

The Exp field is a 3-bit value reserved for experimental use.

5.4.1.4. S

The S field is a single bit that indicates the last entry in the label stack. The bit is set to 1 for the last entry and 0 for all other entries in the list.

5.4.2. Encaps Flags

The Encaps Flags are the same flags specified in section 5.1.

5.4.3. Prefix Length

The Prefix Length field indicates the number of bits in the IPv4 Address that represent the IPv4 prefix for the subnet (network portion of the address).

5.4.4. IPv4 Address

The IPv4 Address field holds the IPv4 address to be announced.

5.5.3. IPv6 Address

The IPv6 Address field holds the IPv6 address to be announced.

5.5.4. Prefix Length

The Prefix Length field indicates the number of bits in the IPv6 Address that represent the IPv6 prefix for the subnet (network portion of the address).

5.5.5. MPLS IPv6 Announcement TLV usage rules

An LLDPDU MAY contain multiple MPLS IPv6 Announcement TLVs, however, the encapsulation flags, label list, IPv6 address and prefix length tuple for a specific IPv6 address MUST only appear once in the LLDPDU.

6. Upper-Layer Protocol Configuration TLVs

A router or switch supporting LSVR protocols MAY include the BGP Attribute TLVs. The format of the BGP Protocol Configuration TLVs is shown in Figure 2.

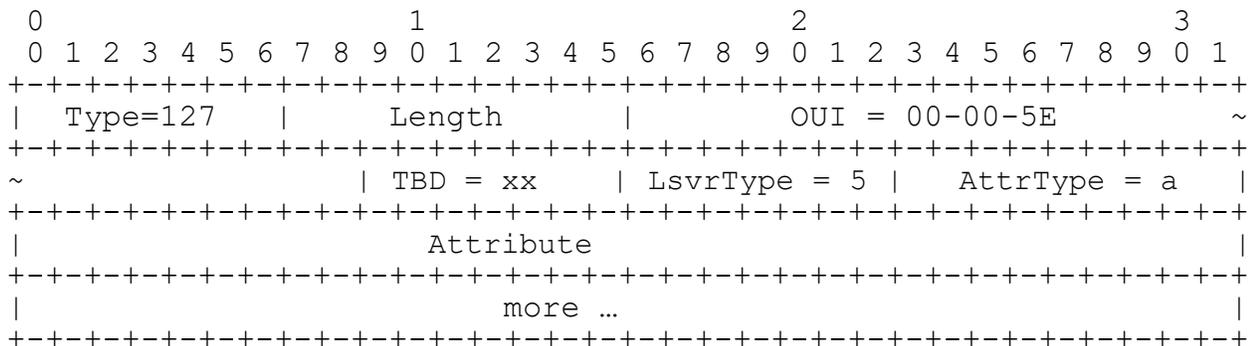


Figure 9 BGP Protocol Configuration TLV Format

6.1.1. AttrTypes

The subtype identifies the BGP attribute type. The types are:

- AttrType = 1: BGP ASN
- AttrType = 2: BGP IPv4 Peering Address
- AttrType = 3: BGP IPv6 Peering Address
- AttrType = 4: BGP Authentication Data
- AttrType = 5: BGP Flags, Bit 0: GTSM, Bit 1: BFD,
Bit 2-15 reserved = 0

6.1.2. BGP ASN

The four octet Autonomous System number MUST be specified. If the AS Number is less than 32 bits, it is padded with high order zeros.

6.1.3. BGP IPv4 Peering Address

The five octet IPv4 Peering Address along with the Prefix Length.

6.1.4. BGP IPv6 Peering Address

The 17 octet IPv6 Peering Address along with the Prefix Length.

6.1.5. BGP Authentication Data

The BGP Authentication TLV provides any authentication data needed to OPEN the BGP session. Depending on operator configuration of the environment, it might be a simple MOS key (see [RFC2385]), the name of a key chain in a KARP database (see [RFC7210]), or one of multiple Authentication TLVs to support[RFC4808].

6.1.6. BGP Flags

The BGP session OPEN has extensive, and a bit complex, capability negotiation facilities. In case one or more extra attributes might be needed, the two octet BGP Flags TLV may be used. No flags are currently defined.

BGP Flags:

- Bit 0: GTSM
- Bit 1: BFD
- Bit 2-15: Must be zero

The GTSM flag, when 1, indicates that the sender wishes to enable the [RFC5082] Generalized TTL Security Mechanism for the session.

The BFD flag, when 1, indicates that the sender wishes to enable the [RFC5880] Bidirectional Forwarding Detection for the session.

7. References

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