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The Line-Identification Option

Abstract

In Ethernet-based aggregation networks, several subscriber premises may be logically connected to the same interface of an Edge Router. This document proposes a method for the Edge Router to identify the subscriber premises using the contents of the received Router Solicitation messages. The applicability is limited to broadband network deployment scenarios in which multiple user ports are mapped to the same virtual interface on the Edge Router.

Status of This Memo

This is an Internet Standards Track document.

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1. Introduction

Digital Subscriber Line (DSL) is a widely deployed access technology for Broadband Access for Next Generation Networks. While traditional DSL access networks were Point-to-Point Protocol (PPP) [RFC1661] based, some networks are migrating from the traditional PPP access model into a pure IP-based Ethernet aggregated access environment. Architectural and topological models of an Ethernet aggregation network in the context of DSL aggregation are described in [TR101].

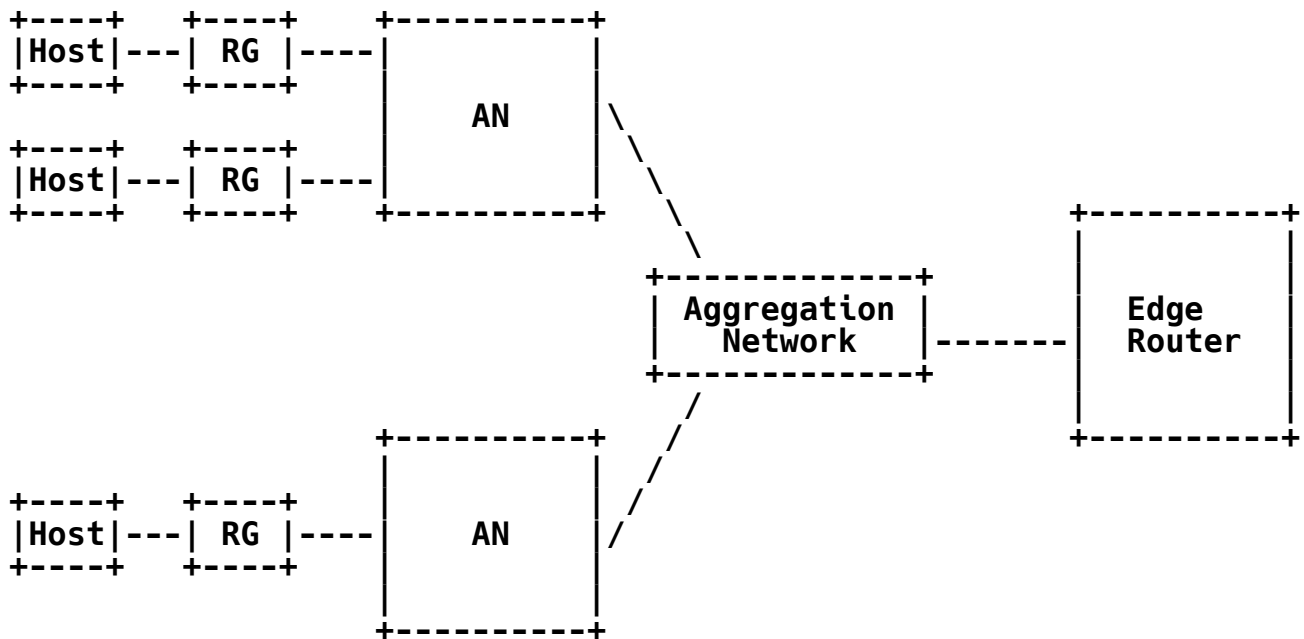


Figure 1: Broadband Forum Network Architecture

One of the Ethernet and Gigabit-capable Passive Optical Network (GPON) aggregation models specified in this document bridges sessions from multiple user ports behind a DSL Access Node (AN), also referred to as a Digital Subscriber Line Access Multiplexer (DSLAM), into a single VLAN in the aggregation network. This is called the N:1 VLAN allocation model.

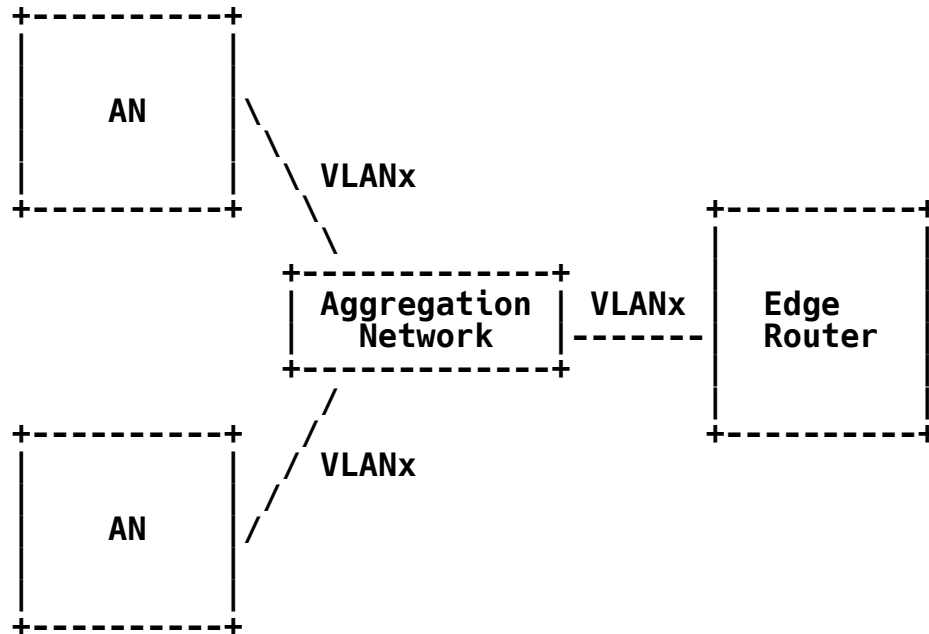


Figure 2: n:1 VLAN model

1.1. Terminology

1:1 VLAN

A broadband network deployment scenario in which each user port is mapped to a different VLAN on the Edge Router. The uniqueness of the mapping is maintained in the Access Node and across the aggregation network.

N:1 VLAN

A broadband network deployment scenario in which multiple user ports are mapped to the same VLAN on the Edge Router. The user ports may be located in the same or different Access Nodes.

GPON

Gigabit-capable Passive Optical Network is an optical access network that has been introduced into the Broadband Forum architecture in [TR156].

AN	A DSL or a GPON Access Node. The Access Node terminates the physical layer (e.g., DSL termination function or GPON termination function), may physically aggregate other nodes implementing such functionality, or may perform both functions at the same time. This node contains at least one standard Ethernet interface that serves as its "northbound" interface into which it aggregates traffic from several user ports or Ethernet-based "southbound" interfaces. It does not implement an IPv6 stack but performs some limited inspection/modification of IPv6 packets. The IPv6 functions required on the Access Node are described in Section 5 of [TR177].
Aggregation Network	The part of the network stretching from the Access Nodes to the Edge Router. In the context of this document, the aggregation network is considered to be Ethernet based, providing standard Ethernet interfaces at the edges, for connecting the Access Nodes and the broadband network. It is comprised of Ethernet switches that provide very limited IP functionality (e.g., IGMP snooping, Multicast Listener Discovery (MLD) snooping, etc.).
RG	A residential gateway device. It can be a Layer-3 (routed) device or a Layer-2 (bridged) device. The residential gateway for Broadband Forum networks is defined in [TR124].
Edge Router	The Edge Router, also known as the Broadband Network Gateway (BNG), is the first IPv6 hop for the user. In cases where the RG is bridged, the BNG acts as the default router for the hosts behind the RG. In cases where the RG is routed, the BNG acts as the default router for the RG itself. This node implements IPv6 router functionality.
Host	A node that implements IPv6 host functionality.

End-Device

A node that sends Router Solicitations and processes received Router Advertisements. When a Layer-3 (L3) RG is used, it is considered an end-device in the context of this document. When a Layer-2 (L2) RG is used, the host behind the RG is considered to be an end-device in the context of this document.

1.2. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. Applicability Statement

The Line-Identification Option (LIO) is intended to be used only for the N:1 VLAN deployment model. For the other VLAN deployment models, line identification can be achieved differently. The mechanism described in this document allows the connection of hosts that only support IPv6 stateless address auto-configuration to attach to networks that use the N:1 VLAN deployment model.

When the Dynamic Host Configuration Protocol (DHCP) [RFC3315] is used for IPv6 address assignment, it has the side-effect of providing end-device-initiated reliability as well as inactivity detection. The reliability is provided by the end-device continuing to retransmit DHCP messages until it receives a response), and inactivity is detected by the end-device not renewing its DHCP lease. The "IPv6 Stateless Address Autoconfiguration" protocol [RFC4862] was not designed to satisfy such requirements [RSDA]. While this option improves the reliability of operation in deployments that use Router Solicitations rather than DHCP, there are some limitations as specified below.

The mechanism described in this document deals with the loss of subscriber-originated Router Solicitations (RSes) by initiating RSes at the AN, which improves robustness over solely relying on the end-device's few initial retransmissions of RSes.

However, the AN retransmissions imply that some information (e.g., the subscriber's MAC address) that was obtained by the Edge Router from subscriber-originated RSes may no longer be available. For example, since there is no L2 frame received from the subscriber in case of an RS sent by an AN, the L2-address information of the end-device cannot be determined. One piece of L2-address information currently used in some broadband networks is the MAC address. For

this reason, the solution described in this document is NOT RECOMMENDED for networks that require the MAC address of the endpoint for identification.

There is no indication when a subscriber is no longer active. Thus, this protocol cannot be used to automatically reclaim resources, such as prefixes, that are associated with an active subscriber. See Section 8. Thus, this protocol is NOT RECOMMENDED for networks that require automatic notification when a subscriber is no longer active.

This mechanism by itself provides no protection against the loss of RS-induced state in access routers that would lead to loss of IPv6 connectivity for end-devices. Given that regular IPv6 hosts do not have RS retransmission behavior that would allow automatic recovery from such a failure, this mechanism SHOULD only be used in deployments employing N:1 VLANs.

3. Issues with Identifying the Subscriber Premises in an N:1 VLAN Model

In a DSL- or GPON-based fixed broadband network, IPv6 end-devices are connected to an AN. Today, these end-devices will typically send a Router Solicitation message to the Edge Router, to which the Edge Router responds with a Router Advertisement message. The Router Advertisement typically contains a prefix that the end-devices will use to automatically configure an IPv6 address. Upon sending the Router Solicitation message, the node connecting the end-device on the access circuit, typically an AN, forwards the RS to the Edge Router upstream over a switched network. In such Ethernet-based aggregation networks, several subscriber premises may be connected to the same interface of an Edge Router (e.g., on the same VLAN). However, the Edge Router requires some information to identify the end-device on the circuit. To accomplish this, the AN needs to add line-identification information to the Router Solicitation message and forward this to the Edge Router. This is analogous to the case where DHCP is being used, and the line-identification information is inserted by a DHCP relay agent [RFC3315]. This document proposes a method for the Edge Router to identify the subscriber premises using the contents of the received Router Solicitation messages. Note that there might be several end-devices located on the same subscriber premises.

4. Basic Operation

This document uses a mechanism that tunnels Neighbor Discovery (ND) packets inside another IPv6 packet that uses a destination option (Line-ID option) to convey line-identification information as depicted in Figure 3. The use of the Line-ID option in any other IPv6 datagrams, including untunneled RS and RA messages, is not

defined by this document. The ND packets are left unmodified inside the encapsulating IPv6 packet. In particular, the Hop Limit field of the ND message is not decremented when the packet is being tunneled. This is because an ND message whose Hop Limit is not 255 will be discarded by the receiver of such messages, as described in Sections 6.1.1 and 6.1.2 of [RFC4861].

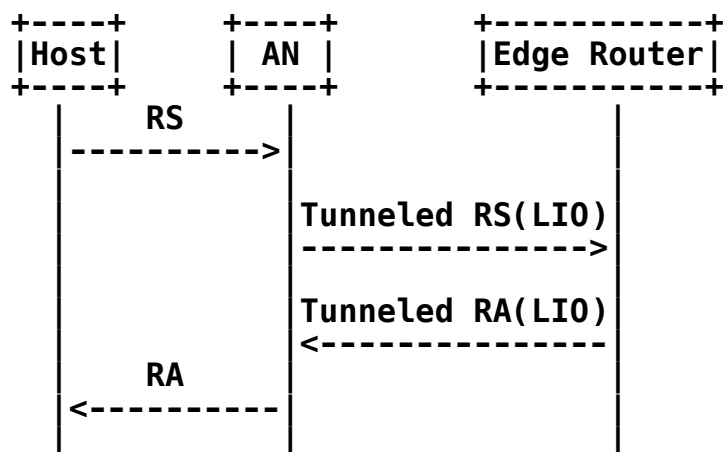


Figure 3: Basic Message Flow

5. AN Behavior

5.1. On Initialization

On initialization, the AN **MUST** join the All-BBF-Access-Nodes multicast group on all its upstream interfaces towards the Edge Router.

5.2. On Receiving a Router Solicitation from the End-Device

When an end-device sends out a Router Solicitation, it is received by the AN. The AN identifies these messages by looking for ICMPv6 messages (IPv6 Next Header value of 58) with ICMPv6 type 133. The AN intercepts and then tunnels the received Router Solicitation in a newly created IPv6 datagram with the Line-Identification Option (LIO). The AN forms a new IPv6 datagram whose payload is the received Router Solicitation message as described in [RFC2473], except that the Hop Limit field of the Router Solicitation message **MUST NOT** be decremented. If the AN has an IPv6 address, it **MUST** use this address in the Source Address field of the outer IPv6 datagram. Otherwise, the AN **MUST** copy the source address from the received Router Solicitation into the Source Address field of the outer IPv6 datagram. The destination address of the outer IPv6 datagram **MUST** be

copied from the destination address of the tunneled RS. The AN **MUST** include a destination options header between the outer IPv6 header and the payload. It **MUST** insert an LIO destination option and set the Line ID field of the option to contain the circuit identifier corresponding to the logical access loop port of the AN from which the RS was initiated.

5.3. On Receiving a Router Advertisement from the Edge Router

When the Edge Router sends out a tunneled Router Advertisement in response to the RS, it is received by the AN. If there is an LIO present, the AN **MUST** use the line-identification data of the LIO to identify the subscriber agent circuit of the AN on which the RA should be sent. The AN **MUST** then remove the outer IPv6 header of this tunneled RA and multicast the inner packet (the original RA) on this specific subscriber circuit.

5.3.1. Identifying Tunneled Router Advertisements

The AN can identify tunneled RAs by installing filters based on the destination address (All-BBF-Access-Nodes, which is a reserved link-local scoped multicast address) of the outer packets and the presence of a destination option header with an LIO destination option.

5.4. On Detecting a Subscriber Circuit Coming Up

RSes initiated by end-devices as described in Section 5.2 may be lost due to lack of connectivity between the AN and the end-device. To ensure that the end-device will receive an RA, the AN needs to trigger the sending of periodic RAs on the Edge Router. For this purpose, the AN needs to inform the Edge Router that a subscriber circuit has come up. Each time the AN detects that a subscriber circuit has come up, it **MUST** create a Router Solicitation message as described in Section 6.3.7 of [RFC4861]. It **MUST** use the unspecified address as the source address of this RS. It **MUST** then tunnel this RS towards the Edge Router as described in Section 5.2.

In case there are connectivity issues between the AN and the Edge Router, the RSeS initiated by the AN can be lost. The AN **SHOULD** continue retransmitting the Router Solicitations following the algorithm described in Section 5.6 for a given LIO until it receives an RA for that specific LIO.

5.5. On Detecting Edge Router Failure

When the Edge Router reboots and loses state or is replaced by a new Edge Router, the AN will detect it using connectivity check mechanisms that are already in place in broadband networks (e.g., Bidirectional Forwarding Detection). When such Edge Router failure is detected, the AN needs to start transmitting RSes for each of its subscriber circuits that have come up, as described in Section 5.4.

5.6. RS Retransmission Algorithm

The AN **SHOULD** use the exponential backoff algorithm for retransmits that is described in Section 14 of [RFC3315] in order to continuously retransmit the Router Solicitations for a given LIO until a response is received for that specific LIO. The AN **SHOULD** use the following variables as input to the retransmission algorithm:

Initial retransmission time (IRT)	1 Second
Maximum retransmission time (MRT)	30 Seconds
Maximum retransmission count (MRC)	0
Maximum retransmission duration (MRD)	0

6. Edge Router Behavior

6.1. On Receiving a Tunneled Router Solicitation from the AN

When the Edge Router receives a tunneled Router Solicitation forwarded by the AN, it needs to check if there is an LIO destination option present in the outer datagram. The Edge Router can use the contents of the Line ID field to lookup the addressing information and policy that need to be applied to the line from which the Router Solicitation was received. The Edge Router **MUST** then process the inner RS message as specified in [RFC4861].

6.2. On Sending a Router Advertisement Towards the End-Device

When the Edge Router sends out a Router Advertisement in response to a tunneled RS that included an LIO, it **MUST** tunnel the Router Advertisement in a newly created IPv6 datagram with the LIO as described below. First, the Edge Router creates the Router Advertisement message as described in Section 6.2.3 of [RFC4861]. The Edge Router **MUST** include a Prefix Information option in this RA that contains the prefix that corresponds to the received LIO. (The LIO from the received tunneled RS is usually passed on from the Edge Router to some form of provisioning system that returns the prefix to be included in the RA. It could e.g., be based on RADIUS.) Then, the Edge Router forms the new IPv6 datagram whose payload is the Router Advertisement message, as described in [RFC2473], except that

the Hop Limit field of the Router Advertisement message **MUST NOT** be decremented. The Edge router **MUST** use a link-local IPv6 address on the outgoing interface in the Source Address field of the outer IPv6 datagram. The Edge Router **MUST** include a destination options header between the outer IPv6 header and the payload. It **MUST** insert an LIO and set the Line ID field of the option to contain the same value as that of the Line-ID option in the received RS. The IPv6 destination address of the inner RA **MUST** be set to the all-nodes multicast address.

If the Source Address field of the received IPv6 datagram was not the unspecified address, the Edge Router **MUST** copy this address into the Destination Address field of the outer IPv6 datagram sent back towards the AN. The link-layer destination address of the outer IPv6 datagram containing the outer IPv6 datagram **MUST** be resolved using regular Neighbor Discovery procedures.

If the Source Address field of the received IPv6 datagram was the unspecified address, the destination address of the outer IPv6 datagram **MUST** be set to the well-known link-local scope All-BBF-Access-Nodes multicast address (ff02::10). The link-layer destination address of the tunneled RA **MUST** be set to the unicast link-layer address of the AN that sent the tunneled Router Solicitation that is being responded to.

The Edge Router **MUST** ensure that it does not transmit tunneled RAs whose size is larger than the MTU of the link between the Edge Router and the AN, which would require that the outer IPv6 datagram undergo fragmentation. This limitation is imposed because the AN may not be capable of handling the reassembly of such fragmented datagrams.

6.3. Sending Periodic Unsolicited Router Advertisements Towards the End-Device

After sending a tunneled Router Advertisement as specified in Section 6.2 in response to a received RS, the Edge Router **MUST** store the mapping between the LIO and the prefixes contained in the Router Advertisement. It should then initiate periodic sending of unsolicited Router Advertisements as described in Section 6.2.3. of [RFC4861]. The Router Advertisements **MUST** be created and tunneled as described in Section 6.2. The Edge Router **MAY** stop sending Router Advertisements if it receives a notification from the AN that the subscriber circuit has gone down. This notification can be received out-of-band using a mechanism such as the Access Node Control Protocol (ANCP). Please consult Section 8 for more details.

7. Line-Identification Option (LIO)

The Line-Identification Option (LIO) is a destination option that can be included in IPv6 datagrams that tunnel Router Solicitation and Router Advertisement messages. The use of the Line-ID option in any other IPv6 datagrams is not defined by this document. Multiple Line-ID destination options **MUST NOT** be present in the same IPv6 datagram. The LIO has no alignment requirement.

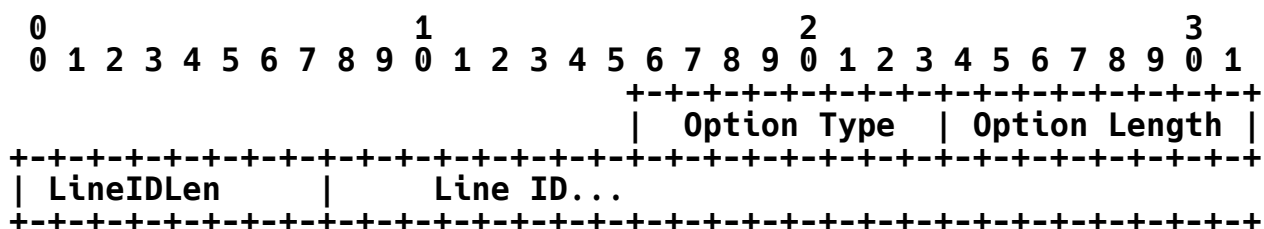


Figure 4: Line-Identification Option Layout

Option Type

8-bit identifier of the type of option. The option identifier for the Line-Identification Option (0x8C) has been allocated by the IANA.

Option Length

8-bit unsigned integer. The length of the option (excluding the Option Type and Option Length fields). The value **MUST** be greater than 0.

LineIDLen

8-bit unsigned integer. The length of the Line ID field in number of octets.

Line ID

Variable-length data inserted by the AN describing the subscriber-agent circuit identifier corresponding to the logical access loop port of the AN from which the RS was initiated. The line identification **MUST** be unique across all the ANs that share a link to the Edge Router, e.g., one such line-identification scheme is described in Section 3.9 of [TR101]. The line identification should be encoded as specified in Section 7.1.

7.1. Encoding of the Line ID Field Content

This IPv6 Destination option is derived from an existing widely deployed DHCPv6 option [RFC4649], which is in turn derived from a widely deployed DHCPv4 option [RFC3046]. These options derive from and cite the basic DHCP options specification [RFC2132]. These widely deployed DHCP options use the Network Virtual Terminal (NVT) character set [RFC2132] [RFC0020]. Since the data carried in the Line-ID option is used in the same manner by the provisioning systems as the DHCP options, it is beneficial for it to maintain the same encoding as the DHCP options.

The IPv6 Line ID option contains a description that identifies the line using only character positions (decimal 32 to decimal 126, inclusive) of the US-ASCII character set [X3.4] [RFC0020]. Consistent with [RFC2132], [RFC3046], and [RFC4649], the Line ID field **SHOULD NOT** contain the US-ASCII NUL character (decimal 0). However, implementations receiving this option **MUST NOT** fail merely because an ASCII NUL character is (erroneously) present in the Line ID field.

Some existing widely deployed implementations of Edge Routers and ANs that support the previously mentioned DHCP option only support US-ASCII and strip the high-order bit from any 8-bit characters entered by the device operator. The previously mentioned DHCP options do not support 8-bit character sets either. Therefore, for compatibility with the installed base and to maximize interoperability, the high-order bit of each octet in this field **MUST** be set to zero by any device inserting this option in an IPv6 packet.

Consistent with [RFC3046] and [RFC4649], this option always uses binary comparison. Therefore, two Line IDs **MUST** be equal when they match when compared byte-by-byte. Line-ID A and Line-ID B match byte-by-byte when (1) A and B have the same number of bytes, and (2) for all byte indexes P in A: the value of A at index P has the same binary value as the value of B at index P.

Two Line IDs **MUST NOT** be equal if they do not match byte-by-byte. For example, an IPv6 Line-ID option containing "f123" is not equal to a Line-ID option "F123".

Intermediate systems **MUST NOT** alter the contents of the Line ID.

8. Garbage Collection of Unused Prefixes

Following the mechanism described in this document, the broadband network associates a prefix to a subscriber line based on the LIO. Even when the subscriber line goes down temporarily, this prefix stays allocated to that specific subscriber line, i.e., the prefix is not returned to the unused pool. When a subscriber line no longer needs a prefix, the prefix can be reclaimed by manual action dissociating the prefix from the LIO in the backend systems.

9. Interactions with Secure Neighbor Discovery

Since the RS/RA packets that are protected by the "SEcure Neighbor Discovery (SEND)" [RFC3971] are not modified in any way by the mechanism described in this document, there are no issues with SEND verification.

10. Acknowledgements

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11. Security Considerations

The line identification information inserted by the AN or the Edge Router is not protected. This means that this option may be modified, inserted, or deleted without being detected. In order to ensure validity of the contents of the Line ID field, the network between the AN and the Edge Router needs to be trusted.

12. IANA Considerations

This document defines a new IPv6 destination option for carrying line identification. IANA has assigned the following new destination option type in the "Destination Options and Hop-by-Hop Options" registry maintained at <http://www.iana.org/assignments/ipv6-parameters>:

0x8C Line-Identification Option [RFC6788]

The act bits for this option are 10 and the chg bit is 0.

Per this document, IANA has also allocated the following well-known link-local scope multicast address from the "IPv6 Multicast Address Space Registry" located at
<<http://www.iana.org/assignments/ipv6-multicast-addresses/>>:

FF02:0:0:0:0:0:0:10 All-BBF-Access-Nodes [RFC6788]

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