            EVPN Multi-Homing Extensions for Split Horizon Filtering
                  draft-ietf-bess-evpn-mh-split-horizon-00

Abstract

   Ethernet Virtual Private Network (EVPN) is commonly used along with
   Network Virtualization Overlay (NVO) tunnels. The EVPN multi-homing
   procedures may be different depending on the NVO tunnel type used in
   the EVPN Broadcast Domain. In particular, there are two multi-homing
   Split Horizon procedures to avoid looped frames on the multi-homed
   CE: ESI Label based and Local Bias. ESI Label based Split Horizon is
   used for MPLSoX tunnels, E.g., MPLSoUDP, whereas Local Bias is used
   for others, E.g., VXLAN tunnels. The current specifications do not
   allow the operator to decide which Split Horizon procedure to use for
   tunnel encapsulations that could support both. Examples of tunnels
   that may support both procedures are MPLSoGRE, MPLSoUDP, GENEVE or
   SRv6. This document extends the EVPN Multi-Homing procedures so that
   an operator can decide the Split Horizon procedure for a given NVO
   tunnel depending on their own requirements.

Status of This Memo

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1. Introduction

   Ethernet Virtual Private Network (EVPN) is commonly used along with
   Network Virtualization Overlay (NVO) tunnels and specified in
   [RFC8365]. The EVPN multi-homing procedures may be different
   depending on the NVO tunnel type used in the EVPN Broadcast Domain.
   In particular, there are two Multi-Homing Split Horizon procedures to
   avoid looped frames on the multi-homed CE: ESI Label based and Local
   Bias. ESI Label based Split Horizon is used for MPLSoX tunnels,
   E.g., MPLSoUDP [RFC7510], and its procedures described in [RFC7432].
   Local Bias is used by non-MPLS NVO tunnels, E.g., VXLAN tunnels, and
   it is described in [RFC8365].

   As a refresher:

o ESI Label based Split-Horizon filtering [RFC7432]

   When EVPN is used for MPLS transport tunnels, an MPLS label
   enables the Split Horizon filtering capability to support All-
   Active multi-homing. The ingress NVE adds a label corresponding
   to the source Ethernet Segment (aka an ESI label) when
   encapsulating the packet. The egress NVE checks the ESI label
   when attempting to forward a multi-destination frame out of a
   local ES interface, and if the label corresponds to the same site
   identifier (ESI) associated with that ES interface, the packet is
   not forwarded. This prevents the occurrence of forwarding loops
   for BUM traffic.

   The ESI Label Split Horizon filtering SHOULD also be used with
   Single-Active multi-homing to avoid transient loops for in-flight
   packets when the egress NVE takes over as DF for an Ethernet
   Segment.

o Local Bias for non-MPLS NVO tunnels [RFC8365]

   Since non-MPLS NVO tunnels (such as VXLAN or NVGRE) do not support
   the ESI label (or any MPLS label at all), a different Split
   Horizon filtering procedure must be used for All-Active multi-
   homing. This mechanism is called Local Bias and relies on the NVO
   tunnel source IP address to decide whether to forward BUM traffic
   to a local ES interface at the egress NVE.

   In a nutshell, every NVE tracks the IP address(es) associated with
   the other NVE(s) with which it has shared multi-homed ESs. When
   the egress NVE receives a BUM frame encapsulated in a non-MPLS NVO
   packet, it examines the source IP address in the tunnel header
   (which identifies the ingress NVE) and filters out the frame on
   all local interfaces connected to ESes that are shared with the
   ingress NVE.

   Due to this behavior at the egress NVE, the ingress NVE's behavior
   is also changed to perform replication locally to all directly
   attached Ethernet Segments (regardless of the DF election state)
   for all BUM ingress from the access ACs. Because of this "local"
   replication at the ingress NVE, this approach is referred to as
   Local Bias.

   Local Bias cannot be used for Single-Active multi-homing, since
   the ingress NVE brings operationally down the ACs for which it is
   non-DF (hence local replication to non-DF ACs cannot be done).
   This means transient in-flight BUM packets may be looped back to
   the originating site by new elected DF egress NVEs.

[RFC8365] states that Local Bias is used only for non-MPLS NVO
tunnels, and ESI Label based Split Horizon for MPLS NVO tunnels.
However, MPLS NVO tunnels, such as MPLSoGRE or MPLSoUDP, can
potentially support both procedures, since they can carry ESI Labels
and they also use a tunnel IP header where the source IP address
identifies the ingress NVE.

Similarly, some non-MPLS NVO tunnels that carry an identifier of the
source ES in the tunnel header, may potentially follow either
procedure too. Some examples are GENEVE or SRv6:

o In a GENEVE tunnel the source IP address identifies the ingress
   NVE therefore local bias is possible. Also,
   [I-D.ietf-bess-evpn-geneve] defines an Ethernet option TLV (Type
   Length Value) to encode an ESI label value.

o In an SRv6 tunnel, the source IP address also identifies the
   ingress NVE, however, by default and as described in
   [I-D.ietf-bess-srv6-services] the ingress PE will add information
   in the SRv6 packet so that the egress PE can identify the source
   ES of the BUM packet. That information is the ESI filtering
   argument of the service SID received on an A-D per ES route from
   the egress PE.

Table 1 shows different tunnel encapsulations and their supported and
default Split Horizon method. In the case of GENEVE, the default
Split Horizon Type (SHT) depends on whether the Ethernet Option with
Source ID TLV is negotiated. In the case of SRv6, the default SHT is
listed as ESI label filtering in the Table, since the behavior is
equivalent to that of ESI Label filtering. In this document, ESI
Label filtering refers to the Split Horizon filtering based on the
existence of a source ES identifier in the tunnel header.

```
+---------------+-----------------------+------------+------------+
| Tunnel        | Default Split Horizon  | Supports   | Supports   |
| Encapsulation | Type (SHT)             | Local Bias | ESI Label  |
+---------------+-----------------------+------------+------------+
| VXLAN         | Local Bias            | Yes        | No         |
+---------------+-----------------------+------------+------------+
| NVGRE         | Local Bias            | Yes        | No         |
+---------------+-----------------------+------------+------------+
| MPLS          | ESI Label filtering   | No         | Yes        |
+---------------+-----------------------+------------+------------+
| MPLSoGRE      | ESI Label filtering   | Yes        | Yes        |
+---------------+-----------------------+------------+------------+
| MPLSoUDP      | ESI Label filtering   | Yes        | Yes        |
+---------------+-----------------------+------------+------------+
| GENEVE        | Local Bias (no ESI Lb) | Yes        | Yes        |
|               | ESI Label (if ESI lb)  |            |            |
+---------------+-----------------------+------------+------------+
| SRv6          | ESI Label filtering   | Yes        | Yes        |
+---------------+-----------------------+------------+------------+
```

         Table 1: Tunnel Encapsulations and Split Horizon Types

   The ESI Label method works for All-Active and Single-Active, while
   Local Bias only works for All-Active. In addition, the ESI Label
   method works across different network domains, whereas Local Bias is
   limited to networks with no next hop change between the NVEs attached
   to the same Ethernet Segment. However, some operators prefer the
   Local Bias method, since it simplifies the encapsulation, consumes
   less resources on the NVEs and the ingress NVE always forwards
   locally to other interfaces, reducing the delay to reach multi-homed
   hosts.

   This document extends the EVPN Multi-Homing procedures so that an
   operator can decide the Split Horizon procedure for a given NVO
   tunnel depending on their own specific requirements. The choice of
   Local Bias or ESI Label Split Horizon is now allowed for NVO tunnels
   that support both methods. Non-MPLS NVO tunnels that do not support
   both methods, E.g., VXLAN or NVGRE, will keeo following [RFC8365]
   procedures.

1.1. Conventions and Terminology

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and
   "OPTIONAL" in this document are to be interpreted as described in BCP
   14 [RFC2119] [RFC8174] when, and only when, they appear in all
   capitals, as shown here.

   o BUM: Broadcast, Unknown unicast and Multicast traffic.

   o ES and ESI: Ethernet Segment and Ethernet Segment Identifier.

   o A-D per ES route: refers to the EVPN Ethernet Auto-Discovery per
      Ethernet Segment route defined in [RFC7432].

   o AC: Attachment Circuit.

   o NVE: Network Virtualization Edge device.

   o EVI and EVI-RT: EVPN Instance and EVI Route Target. A group of
      NVEs attached to the same EVI will share the same EVI-RT.

   o MPLS and non-MPLS NVO tunnels: refer to Multi-Protocol Label
      Switching (or the absence of it) Network Virtualization Overlay
      tunnels. Network Virtualization Overlay tunnels use an IP
      encapsulation for overlay frames, where the source IP address
      identifies the ingress NVE and the destination IP address the
      egress NVE.

   o MPLSoUDP: Multi-Protocol Label Switching over User Datagram
      Protocol, [RFC7510]

   o MPLSoGRE: Multi-Protocol Label Switching over Generic Network
      Encapsulation, [RFC4023].

   o MPLSoX: refers to MPLS over any IP encapsulation. Examples are
      MPLSoUDP or MPLSoGRE.

   o GENEVE: Generic Network Virtualization Encapsulation,
      [I-D.ietf-nvo3-geneve].

   o VXLAN: Virtual eXtensible Local Area Network, [RFC7348].

   o NVGRE: Network Virtualization Using Generic Routing Encapsulation,
      [RFC7637].

   o VNI: Virtual Network Identifier. A 24-bit identifier used by
      Network Virtualization Overlay (NVO) over IP encapsulations.
      Examples are VXLAN (Virtual Extended Local Area Network) or GENEVE
      (Generic Network Virtualization Encapsulation).

   o Broadcast Domain (BD): an emulated ethernet, such that two systems
      on the same BD will receive each other's link-local broadcasts.
      In this document, BD also refers to the instantiation of a
      Broadcast Domain on an EVPN PE. An EVPN PE can be attached to one
      or multiple BDs of the same tenant.

   o Designated Forwarder (DF): as defined in [RFC7432], an ethernet
      segment may be multi-homed (attached to more than one PE). An
      ethernet segment may also contain multiple BDs, of one or more
      EVIs. For each such EVI, one of the PEs attached to the segment
      becomes that EVI's DF for that segment. Since a BD may belong to
      only one EVI, we can speak unambiguously of the BD's DF for a
      given segment.

   o SHT: Split Horizon Type, it refers to the Split Horizon method
      that a PE intends to use and advertises in an A-D per ES route.

   This document also assumes familiarity with the terminology of
   [RFC7432] and [RFC8365].

2. BGP EVPN Extensions

   EVPN extensions are needed so that NVEs can advertise their
   preference for the Split Horizon method to be used in the Ethernet
   Segment. Figure 1 shows the ESI Label extended community that is
   always advertised along with the EVPN A-D per ES route. All the NVEs
   attached to an Ethernet Segment advertise an A-D per ES route for the
   ES, including this extended community that conveys the information
   for the multi-homing mode (All-active or Single-Active), as well as
   the ESI Label to be used (if needed).

```
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Type=0x06     | Sub-Type=0x01 | Flags(1 octet)|  Reserved=0   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Reserved=0   |            ESI Label                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                   Figure 1: ESI Label extended community

   [RFC7432] defines the low-order bit of the Flags octet (bit 0) as the
   "Single-Active" bit:

   o A value of 0 means that the multi-homed Ethernet Segment is
      operating in All-Active mode.

   o A value of 1 means that the multi-homed Ethernet Segment is
      operating in Single-Active mode.

2.1. The Split Horizon Type (SHT)

   [RFC8365] does not add any explicit indication about the Split
   Horizon method in the A-D per ES route. In this document, the
   [RFC8365] Split Horizon procedure is the default behavior and assumes

that Local Bias is used only for non-MPLS NVO tunnels, and ESI Label
based Split Horizon for MPLS NVO tunnels. This document defines the
two high-order bits in the Flags octet (bits 6 and 7) as the "Split
Horizon Type" (SHT) field, where:

```
SHT bit 7 6
-----------
        0 0  --> Default SHT. Backwards compatible with [RFC8365]
        0 1  --> Local Bias
        1 0  --> ESI Label based filtering
        1 1  --> reserved for future use
```

o SHT = 00 is backwards compatible with [RFC8365] and indicates that
   the advertising NVE intends to use the default or native SHT. The
   default SHT is shown in Table 1 for each NVO encapsulation. An
   egress NVE that follows the [RFC8365] behavior and does not
   support this specification will ignore the SHT bits (which is
   equivalent to process them as value of 00).

o SHT = 01 indicates that the advertising NVE intends to use Local
   Bias procedures in the Ethernet Segment for which the AD per-ES
   route is advertised.

o SHT = 10 indicates that the advertising NVE intends to use the ESI
   Label based Split Horizon method procedures in the Ethernet
   Segment for which the AD per-ES route is advertised.

2.2. Use of the Split Horizon Type In A-D Per ES Routes

The following must be observed:

o An SHT value of 01 or 10 MUST NOT be used with encapsulations that
   support only one SHT in Table 1, and MAY be used by encapsulations
   that support the two SHTs in Table 1.

o An SHT value different than 00 expresses the intend to use a
   specific Split Horizon method, but does not reflect the actual
   operational SHT used by the advertising NVE, unless all the NVEs
   attached to the ES advertise the same SHT.

o In case of inconsistency in the SHT value advertised by the NVEs
   attached to the same ES for a given EVI, all the NVEs MUST revert
   to the [RFC8365] behavior, and use the default SHT in Table 1,
   irrespective of the advertised SHT.

o An SHT different from 00 MUST NOT be set if the Single-Active bit
   is set. A received A-D per ES route where Single-Active and SHT
   bits are different from zero MUST be treat-as-withdraw [RFC7606].

o The SHT MUST have the same value in each Ethernet A-D per ES route
   that an NVE advertises for a given ES and a given encapsulation
   (see Section 3 for NVEs supporting multiple encapsulations).

As an example, egress NVEs that support MPLS NVO tunnels, E.g.,
MPLSoGRE or MPLSoUDP, will advertise A-D per ES route(s) for the ES
along with the [RFC5512] BGP Encapsulation extended community
[I-D.ietf-idr-tunnel-encaps]indicating the encapsulation (MPLSoGRE or
MPLSoUDP) and MAY use the SHT = 01 or 10 to indicate the intend to
use Local Bias or ESI Label, respectively.

An egress NVE MUST NOT use an SHT value different from 00 when
advertising an A-D per ES route with encapsulation VXLAN, NVGRE, MPLS
or no [I-D.ietf-idr-tunnel-encaps] BGP tunnel encapsulation extended
community. We assume that, in all these cases, there is no Split
Horizon method choice, and therefore the SHT value MUST be 00. A
received route with one of the above encapsulation options and SHT
value different from 00 SHOULD be treat-as-withdraw.

An egress NVE advertising A-D per ES route(s) for an ES with
encapsulation GENEVE MAY use an SHT value of 01 or 10. A value of 01
indicates the intend to use Local Bias, irrespective of the presence
of an Ethernet option TLV with a non-zero Source-ID
[I-D.ietf-bess-evpn-geneve]. A value of 10 indicates the intend to
use ESI Label based Split Horizon. A value of 00 indicates the
default behavior in Table 1, that is, use Local Bias if no ESI-Label
exists in the Ethernet option TLV or no Ethernet option TLV
whatsoever. Otherwise the ESI Label Split Horizon method is used.

The above procedures assume a single encapsulation supported in the
egress NVE. Section 3 describes additional procedures for NVEs
supporting multiple encapsulations.

2.3. ESI Label Value In A-D Per ES Routes

This document also updates [RFC8365] in the value that is advertised
in the ESI Label field of the ESI Label extended community, as
follows:

o The A-D per ES route(s) for an ES MAY have an ESI Label value of
   zero if the SHT value is 01. Section 2.2 specifies the cases
   where the SHT can be 01. An ESI Label value of zero avoids the
   allocation of Labels in the cases where they are not used (Local
   Bias).

o The A-D per ES route(s) for an ES MAY have an ESI Label value of
   zero for VXLAN or NVGRE encapsulations.

2.4. Backwards Compatibility With [RFC8365] NVEs

As discussed in Section 2.2 this specification is backwards
compatible with the Split Horizon filtering behavior in [RFC8365] and
a non-upgraded NVE can be attached to the same ES as other NVEs
supporting this specification.

An NVE has an administrative SHT value for an ES (the one that is
advertised along with the A-D per ES route) and an operational SHT
value (the one that is actually used irrespective of what the NVE
advertised). The administrative SHT matches the operational SHT if
all the NVEs attached to the ES have the same administrative SHT.

This document assumes that an [RFC7432] or [RFC8365] implementation
that does not support this document, ignores the value of all the
Flags in the ESI Label extended community except for the Single-
Active bit. Based on this assumption, a non-upgraded NVE will ignore
an SHT different from 00. As soon as an upgraded NVE receives at
least one A-D per ES route for the ES with SHT value of 00, it MUST
revert its operational SHT to the default Split Horizon method, as in
Table 1, and irrespective of its administrative SHT.

As an example, consider an NVE attached to Ethernet Segment N that
receives two A-D per ES routes for N from different NVEs, NVE1 and
NVE2. If the route from NVE1 has SHT = 00 and the one from NVE2 an
SHT = 01, the NVE MUST use the default Split Horizon method in
Table 1 as operational SHT, irrespective of its administrative SHT.

All the NVEs attached to an ES with operational SHT value of 10 MUST
advertise a valid non-zero ESI Label. If the operational SHT value
is 01, the ESI Label MAY be zero. If the operational SHT value is
00, the ESI Label MAY be zero only if the default encapsulation
supports Local Bias only and the NVEs do not check the presence of a
valid non-zero ESI Label.

If an NVE changes its operational SHT value from 01 to 00 (as a
result of a new non-upgraded NVE present in the ES) and it previously
advertised a zero ESI Label, it MUST send an update with a non-zero
valid ESI Label, unless all the non-upgraded NVEs in the ES support
Local Bias only.

3. Procedures for NVEs Supporting Multiple Encapsulations

As specified by [RFC8365], an egress NVE that supports multiple data
plane encapsulations (I.e., VXLAN, NVGRE, MPLS, MPLSoUDP, GENEVE)
needs to indicate all the supported encapsulations using BGP
Encapsulation extended communities defined in
[I-D.ietf-idr-tunnel-encaps] with all EVPN routes. This section

clarifies the multi-homing Split Horizon behavior for NVEs advertising and receiving multiple BGP Encapsulation extended communities along with the A-D per ES routes. This section uses a notation of {x,y} to indicate the encapsulations advertised in [I-D.ietf-idr-tunnel-encaps] BGP Encapsulation extended communities, with x and y being different encapsulation values.

It is important to remember that an NVE MAY advertise multiple A-D per ES routes for the same ES (and not only one), each route conveying a number of Route Targets (RT). We refer to the total number of Route Targets in a given ES as RT-set for that ES. Any of the EVIs represented in the RT-set will have its RT included in one (and only one) A-D per ES route for the ES. When multiple A-D per ES routes are advertised for the same ES, each route MUST have a different Route Distinguisher.

As per [RFC8365], an NVE that advertises multiple encapsulations in the A-D per ES route(s) for an ES, MUST advertise encapsulations that use the same Split Horizon filtering method in the same route. For example:

o An A-D per ES route for ES-x may be advertised with {VXLAN, NVGRE} encapsulations.

o An A-D per ES route for ES-y may be advertised with {MPLS, MPLSoUDP, MPLSoGRE} encapsulations (or a subset).

o But an A-D per ES route for ES-z MUST NOT be advertised with {MPLS, VXLAN} encapsulations.

This document extends this behavior as follows:

a. An A-D per ES route for ES-x may be advertised with multiple encapsulations where some support a single Split Horizon method. In this case, the SHT value MUST be 00. As an example, {VXLAN, NVGRE}, {VXLAN, GENEVE} or {MPLS, MPLSoGRE, MPLSoUDP} can be advertised in an A-D per ES route. In all those cases SHT MUST be 00.

b. An A-D per ES route for ES-y may be advertised with multiple encapsulations where all of them support both Split Horizon methods. In this case the SHT value MAY be 01 if the desired method is Local Bias, or 10 if ESI Label based. For example, {MPLSoGRE, MPLSoUDP, GENEVE} (or a subset) may be advertised in an A-D per ES route with SHT value of 01. The ESI Label value in this case MAY be zero.

   c. If ES-z with RT-set composed of (RT1, RT2, RT3.. RTn) supports
       multiple encapsulations that require a different Split Horizon
       method, a different A-D per ES route (or group of routes) per
       Split Horizon method MUST be advertised. For example, consider n
       RTs in ES-z and:

       o the EVIs corresponding to (RT1..RTi) support VXLAN,

       o the ones for (RTi+1..RTm) (with i<m) support MPLSoUDP with
          Local Bias,

       o and the ones for (RTm+1..RTn) (with m<n) support GENEVE with
          ESI Label based Split Horizon.

       In this case, three groups of A-D per ES routes MUST be
       advertised for ES-z:

       o A-D per ES route group 1, including (RT1..RTi), with
          encapsulation {VXLAN}, SHT = 00. The ESI Label MAY be zero.

       o A-D per ES route group 2, including (RTi+1..RTm), with
          encapsulation {MPLSoUDP}, SHT = 01. The ESI Label MAY be
          zero.

       o A-D per ES route group 3, including (RTm+1..RTn), with
          encapsulation {GENEVE}, SHT = 10. The ESI Label MUST have a
          valid value, different from zero, and the Ethernet option
          [I-D.ietf-nvo3-geneve] MUST be advertised.

   As per [RFC8365], it is the responsibility of the operator of a given
   EVI to ensure that all of the NVEs in that EVI support a common
   encapsulation. If this condition is violated, it could result in
   service disruption or failure.

4. Security Considerations

   The same security considerations described in [RFC7432] relevant to
   Multi-Homing apply to this document.

   In addition, this document modifies the [RFC8365] procedures for
   Split Horizon filtering, providing the operator with a choice between
   Local Bias and ESI Label based filtering for the tunnels that support
   both methods. A misconfiguration of the desired SHT to be used may
   result in a forwarding behavior that is different from the intended
   one. Other than that, this document describes procedures so that all
   the PEs or NVEs attached to the same ES agree on a common SHT method,
   therefore an attacker changing the configuration of the SHT should

not cause traffic disruption, only a change in the forwarding
behavior.

5. IANA Considerations

IANA is requested to allocate the SHT bits (6 and 7) in the Flags
Octet of the EVPN ESI Label extended community. This field is called
"Split Horizon Type" bits.

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Appendix A. Acknowledgments

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