        IS-IS Route Preference for Extended IP and IPv6 Reachability

Abstract

   In existing specifications, the route preferences for IPv4/IPv6
   Extended Reachability TLVs are not explicitly stated. There are also
   inconsistencies in the definition of how the up/down bit applies to
   route preference when the prefix advertisement appears in Level 2
   Link State Protocol Data Units (LSPs). This document addresses these
   issues.

   This document updates RFC 5308.

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1. Introduction

   [RFC5302] defines the route preference rules as they apply to TLVs
   128 and 130. [RFC5305] introduced the IP Extended Reachability TLV
   135 but did not explicitly adapt the route preference rules defined
   in [RFC5302] for the new TLV. [RFC5308] defines the IPv6
   Reachability TLV 236 and does include an explicit statement regarding
   route preference -- but the statement introduces use of the up/down
   bit in advertisements that appear in Level 2 LSPs, which is
   inconsistent with statements made in [RFC5302] and [RFC5305]. This
   document defines explicit route preference rules for TLV 135, revises
   the route preference rules for TLV 236, and clarifies the usage of
   the up/down bit when it appears in TLVs in Level 2 LSPs. This
   document is a clarification (NOT a correction) of [RFC5302] and
   [RFC5305]; it is a correction of the route preference rules defined
   in [RFC5308] to be consistent with the rules for IPv4. It also makes
   explicit that the same rules apply to the Multi-Topology (MT)
   equivalent TLVs 235 and 237.

1.1. Requirements Language

   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 RFC 2119 [RFC2119].

2. Use of the Up/Down Bit in Level 2 LSPs

   The up/down bit was introduced in support of leaking prefixes
   downwards in the IS-IS level hierarchy. Routes that are leaked
   downwards have the bit set to 1. Such prefixes MUST NOT be leaked
   upwards in the hierarchy. So long as we confine ourselves to a
   single IS-IS instance and the current number of supported levels
   (two), it is impossible to have a prefix advertised in a Level 2 LSP
   and have the up/down bit set to 1. However, because [RFC5302]
   anticipated a future extension to IS-IS that might support additional
   levels, it allowed for the possibility that the up/down bit might be
   set in a Level 2 LSP and supported easy migration in the event such
   an extension was introduced. Section 3.3 of [RFC5302] states:

      ...it is RECOMMENDED that implementations ignore the up/down bit
      in L2 LSPs, and accept the prefixes in L2 LSPs regardless of
      whether the up/down bit is set.

   [RFC5305] addressed an additional case wherein an implementation
   included support for multiple virtual routers running IS-IS in
   different areas. In such a case, it is possible to redistribute
   prefixes between two IS-IS instances in the same manner that prefixes
   are redistributed from other protocols into IS-IS. This introduced

the possibility that a prefix could be redistributed from Level 1 to
Level 1 (as well as between Level 2 and Level 2), and in the event
the redistributed route was leaked from Level 1 to Level 2, two
different routers in different areas would be advertising the same
prefix into the Level 2 sub-domain. To prevent this, Section 4.1 of
[RFC5305] specifies:

   If a prefix is advertised from one area to another at the same
   level, then the up/down bit SHALL be set to 1.

However, the statement in [RFC5302] that the up/down bit is ignored
in Level 2 LSPs is not altered by [RFC5305].

The conclusion then is that there is no "L2 inter-area route";
indeed, no such route type is defined by [RFC5302]. However,
[RFC5308] ignored this fact and introduced such a route type in
Section 5 when it specified a preference for "Level 2 down prefix".
This is an error that this document corrects. As changing the use of
the up/down bit in TLVs 236 and 237 may introduce interoperability
issues, implementors may wish to support transition mechanisms from
the behavior described in [RFC5308] to the behavior described in this
document.

3. Types of Routes in IS-IS Supported by Extended Reachability TLVs

   [RFC5302] is the authoritative reference for the types of routes
   supported by TLVs 128 and 130. However, a number of attributes
   supported by those TLVs are NOT supported by TLVs 135, 235, 236, and
   237. Distinction between internal/external metrics is not supported.
   In the case of IPv4 TLVs (135 and 235), the distinction between
   internal and external route types is not supported. However, the
   Prefix Attribute Flags sub-TLV defined in [PFXATTR] reintroduces the
   distinction between internal and external route types. The
   definitions below include references to the relevant attribute bits
   from [PFXATTR].

3.1. Types of Routes Supported by TLVs 135 and 235

   This section defines the types of route supported for IPv4 when using
   TLV 135 [RFC5305] and/or TLV 235 [RFC5120]. The text follows as
   closely as possible the original text from [RFC5302].

   L1 intra-area routes: These are advertised in L1 LSPs, in TLV 135 or
      TLV 235. The up/down bit is set to 0. These IP prefixes are
      directly connected to the advertising router. If the Prefix
      Attribute Flags sub-TLV is included, both the X-Flag and the
      R-Flag are set to 0.

   L1 external routes: These are advertised in L1 LSPs, in TLV 135 or
      TLV 235. The up/down bit is set to 0. These IP prefixes are
      learned from other protocols and are usually not directly
      connected to the advertising router. If the Prefix Attribute
      Flags sub-TLV is included, the X-Flag is set to 1, and the R-Flag
      is set to 0.

   L2 intra-area routes: These are advertised in L2 LSPs, in TLV 135 or
      TLV 235. The up/down bit is set to 0. These IP prefixes are
      directly connected to the advertising router. If the Prefix
      Attribute Flags sub-TLV is included, both the X-Flag and the
      R-Flag are set to 0.

   L1->L2 inter-area routes: These are advertised in L2 LSPs, in TLV
      135 or TLV 235. The up/down bit is set to 0. These IP prefixes
      are learned via L1 routing and were derived during the L1 Shortest
      Path First (SPF) computation from prefixes advertised in L1 LSPs
      in TLV 135 or TLV 235. If the Prefix Attribute Flags sub-TLV is
      included, the R-Flag is set to 1.

   L2->L2 inter-area routes: These are advertised in L2 LSPs, in TLV
      135 or TLV 235. The up/down bit is set to 1 but is ignored and
      treated as if it were set to 0. These IP prefixes are learned
      from another IS-IS instance usually operating in another area. If
      the Prefix Attribute Flags sub-TLV is included, the X-Flag is set
      to 1, and the R-Flag is set to 0.

   L2 external routes: These are advertised in L2 LSPs, in TLV 135 or
      TLV 235. The up/down bit is set to 0. These IP prefixes are
      learned from other protocols and are usually not directly
      connected to the advertising router. If the Prefix Attribute
      Flags sub-TLV is included, the X-Flag is set to 1, and the R-Flag
      is set to 0.

   L2->L1 inter-area routes: These are advertised in L1 LSPs, in TLV
      135 or TLV 235. The up/down bit is set to 1. These IP prefixes
      are learned via L2 routing and were derived during the L2 SPF
      computation from prefixes advertised in TLV 135 or TLV 235. If
      the Prefix Attribute Flags sub-TLV is included, the R-Flag is set
      to 1.

   L1->L1 inter-area routes: These are advertised in L1 LSPs, in TLV
      135 or TLV 235. The up/down bit is set to 1. These IP prefixes
      are learned from another IS-IS instance usually operating in
      another area. If the Prefix Attribute Flags sub-TLV is included,
      the X-Flag is set to 1, and the R-Flag is set to 0.

3.2. Types of Routes Supported by TLVs 236 and 237

   This section defines the types of route supported for IPv6 when using
   TLV 236 [RFC5308] and/or TLV 237 [RFC5120].

   L1 intra-area routes: These are advertised in L1 LSPs, in TLV 236 or
      TLV 237. The up/down bit is set to 0. The external bit is set to
      0. These IPv6 prefixes are directly connected to the advertising
      router. If the Prefix Attribute Flags sub-TLV is included, the
      R-Flag is set to 0.

   L1 external routes: These are advertised in L1 LSPs, in TLV 236 or
      TLV 237. The up/down bit is set to 0. The external bit is set to
      1. These IPv6 prefixes are learned from other protocols and are
      usually not directly connected to the advertising router. If the
      Prefix Attribute Flags sub-TLV is included, the R-Flag is set to
      0.

   L2 intra-area routes: These are advertised in L2 LSPs, in TLV 236 or
      TLV 237. The up/down bit is set to 0. The external bit is set to
      0. These IPv6 prefixes are directly connected to the advertising
      router. If the Prefix Attribute Flags sub-TLV is included, the
      R-Flag is set to 0.

   L1->L2 inter-area routes: These are advertised in L2 LSPs, in TLV
      236 or TLV 237. The up/down bit is set to 0. The external bit is
      set to 0. These IPv6 prefixes are learned via L1 routing and were
      derived during the L1 Shortest Path First (SPF) computation from
      prefixes advertised in L1 LSPs in TLV 236 or TLV 237. If the
      Prefix Attribute Flags sub-TLV is included, the R-Flag is set to
      1.

   L2 external routes: These are advertised in L2 LSPs, in TLV 236 or
      TLV 237. The up/down bit is set to 0. The external bit is set to
      1. These IPv6 prefixes are learned from other protocols and are
      usually not directly connected to the advertising router. If the
      Prefix Attribute Flags sub-TLV is included, the R-Flag is set to
      0.

   L1->L2 external routes: These are advertised in L2 LSPs, in TLV 236
      or TLV 237. The up/down bit is set to 0. The external bit is set
      to 1. These IPv6 prefixes are learned via L1 routing and were
      derived during the L1 Shortest Path First (SPF) computation from
      L1 external routes advertised in L1 LSPs in TLV 236 or TLV 237.
      If the Prefix Attribute Flags sub-TLV is included, the R-Flag is
      set to 1.

   L2->L2 inter-area routes: These are advertised in L2 LSPs, in TLV
      236 or TLV 237. The up/down bit is set to 1 but is ignored and
      treated as if it were set to 0. The external bit is set to 1.
      These IP prefixes are learned from another IS-IS instance usually
      operating in another area. If the Prefix Attribute Flags sub-TLV
      is included, the R-Flag is set to 0.

   L2->L1 inter-area routes: These are advertised in L1 LSPs, in TLV
      236 or TLV 237. The up/down bit is set to 1. The external bit is
      set to 0. These IPv6 prefixes are learned via L2 routing and were
      derived during the L2 SPF computation from prefixes advertised in
      TLV 236 or TLV 237. If the Prefix Attribute Flags sub-TLV is
      included, the R-Flag is set to 1.

   L2->L1 external routes: These are advertised in L1 LSPs, in TLV 236
      or TLV 237. The up/down bit is set to 1. The external bit is set
      to 1. These IPv6 prefixes are learned via L2 routing and were
      derived during the L2 SPF computation from prefixes advertised in
      TLV 236 or TLV 237. If the Prefix Attribute Flags sub-TLV is
      included, the R-Flag is set to 1.

   L1->L1 inter-area routes: These are advertised in L1 LSPs, in TLV
      236 or TLV 237. The up/down bit is set to 1. The external bit is
      set to 1. These IP prefixes are learned from another IS-IS
      instance usually operating in another area. If the Prefix
      Attribute Flags sub-TLV is included, the R-Flag is set to 0.

3.3. Order of Preference for All Types of Routes Supported by TLVs 135
      and 235

   This document defines the following route preferences for IPv4 routes
   advertised in TLVs 135 or 235. Note that all types of routes listed
   for a given preference are treated equally.

   1. L1 intra-area routes; L1 external routes

   2. L2 intra-area routes; L2 external routes; L1->L2 inter-area
       routes; L2-L2 inter-area routes

   3. L2->L1 inter-area routes; L1->L1 inter-area routes

3.4. Order of Preference for All Types of Routes Supported by TLVs 236
      and 237

   This document defines the following route preferences for IPv6 routes
   advertised in TLVs 236 or 237. Note that all types of routes listed
   for a given preference are treated equally.

   1. L1 intra-area routes; L1 external routes

   2. L2 intra-area routes; L2 external routes; L1->L2 inter-area
       routes; L1-L2 external routes; L2-L2 inter-area routes

   3. L2->L1 inter-area routes; L2->L1 external routes; L1->L1 inter-
       area routes

4. Security Considerations

   This document raises no new security considerations. Security
   considerations for the IS-IS protocol are covered in [ISO10589],
   [RFC5304], and [RFC5310].

5. References

5.1. Normative References

   [ISO10589] International Organization for Standardization,
              "Intermediate System to Intermediate System intra-domain
              routeing information exchange protocol for use in
              conjunction with the protocol for providing the
              connectionless-mode network service (ISO 8473)",
              ISO Standard 10589, 2002.

   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
              Requirement Levels", BCP 14, RFC 2119,
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   [RFC5120] Przygienda, T., Shen, N., and N. Sheth, "M-ISIS: Multi
              Topology (MT) Routing in Intermediate System to
              Intermediate Systems (IS-ISs)", RFC 5120,
              DOI 10.17487/RFC5120, February 2008,
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   [RFC5302] Li, T., Smit, H., and T. Przygienda, "Domain-Wide Prefix
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   [RFC5304] Li, T. and R. Atkinson, "IS-IS Cryptographic
              Authentication", RFC 5304, DOI 10.17487/RFC5304, October
              2008, <http://www.rfc-editor.org/info/rfc5304>.

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              Engineering", RFC 5305, DOI 10.17487/RFC5305, October
              2008, <http://www.rfc-editor.org/info/rfc5305>.

   [RFC5308] Hopps, C., "Routing IPv6 with IS-IS", RFC 5308,
              DOI 10.17487/RFC5308, October 2008,
              <http://www.rfc-editor.org/info/rfc5308>.

   [RFC5310] Bhatia, M., Manral, V., Li, T., Atkinson, R., White, R.,
              and M. Fanto, "IS-IS Generic Cryptographic
              Authentication", RFC 5310, DOI 10.17487/RFC5310, February
              2009, <http://www.rfc-editor.org/info/rfc5310>.

5.2. Informative References

   [PFXATTR] Ginsberg, L., Ed., Decraene, B., Previdi, S., Xu, X., and
              U. Chunduri, "IS-IS Prefix Attributes for Extended IP and
              IPv6 Reachability", Work in Progress, draft-ietf-isis-
              prefix-attributes-04, January 2016.

Appendix A. Example Interoperability Issue

   This example documents a real-world interoperability issue that
   occurs because implementations from different vendors have
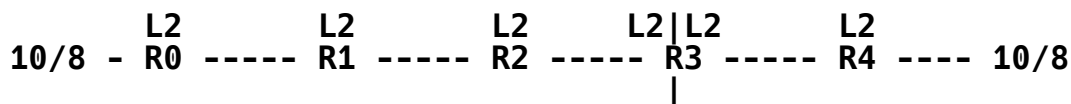   interpreted the use of the up/down bit in Level 2 LSPs
   inconsistently.

```
            L2         L2         L2      L2|L2        L2
   10/8 - R0 ----- R1 ----- R2 ----- R3 ----- R4 ---- 10/8
                                         |
                   Figure 1
```

   In Figure 1, both R0 and R4 are advertising the prefix 10/8. Two IS-
   IS Level 2 instances are running on R3 to separate the network into
   two areas. R3 is performing route leaking and advertises prefixes
   from R4 to the other Level 2 process. The network is using extended
   metrics (TLV 135 defined in [RFC5305]). R0 advertises 10/8 with
   metric 2000, and R3 advertises 10/8 with metric 100. All links have
   a metric of 1. When advertising 10/8 in its Level 2 LSP, R3 sets the
   down bit as specified in [RFC5305].

   R1, R2, and R3 are from three different vendors (R1->Vendor1,
   R2->Vendor2, R3->Vendor3). During interoperability testing, routing
   loops are observed in this scenario.

   o R2 has two possible paths to reach 10/8: Level 2 route with metric
      2002 and up/down bit set to 0 (from R0) and Level 2 route with
      metric 101 and up/down bit set to 1 (from R3). R2 selects R1 as
      the next hop to 10/8 because it prefers the route that does NOT
      have the up/down bit set.

   o R3 has two possible paths to reach 10/8: Level 2 route with metric
      2003 and up/down bit set to 0 (from R0) and Level 2 route with
      metric 101 and up/down bit set to 0 (from R4). R3 selects R4 as
      the next hop due to lowest metric.

   o R1 has two possible paths to reach 10/8: Level 2 route with metric
      2001 and up/down bit set to 0 (from R0) and Level 2 route with
      metric 102 and up/down bit set to 1 (from R3). R1 selects R2 as
      the next hop due to lowest metric.

   When R1 or R2 try to send traffic to 10/8, packets loop due to
   inconsistent routing decisions between R1 and R2.

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