IS-IS Extended Hierarchy
draft-ietf-lsr-isis-extended-hierarchy-00

Abstract

   The IS-IS routing protocol was originally defined with a two level
   hierarchical structure. This was adequate for the networks at the
   time. As we continue to expand the scale of our networks, it is
   apparent that additional hierarchy would be a welcome degree of
   flexibility in network design.

   This document defines IS-IS Levels 3 through 8.

Status of This Memo

Copyright Notice

Table of Contents

1. Introduction

   The IS-IS routing protocol IS-IS [ISO10589] currently supports a two
   level hierarchy of abstraction. The fundamental unit of abstraction
   is the 'area', which is a (hopefully) connected set of systems
   running IS-IS at the same level. Level 1, the lowest level, is
   abstracted by routers that participate in both Level 1 and Level 2.

   Practical considerations, such as the size of an area's link state
   database, cause network designers to restrict the number of routers
   in any given area. Concurrently, the dominance of scale-out

architectures based around small routers has created a situation where the scalability limits of the protocol are going to become critical in the foreseeable future.

The goal of this document is to enable additional hierarchy within IS-IS. Each additional level of hierarchy has a multiplicative effect on scale, so the addition of six levels should be a significant improvement. While all six levels may not be needed in the short term, it is apparent that the original designers of IS-IS reserved enough space for these levels, and defining six additional levels is only slightly harder than adding a single level, so it makes sense to expand the design for the future.

The modifications described herein are designed to be fully backward compatible and have no effect on existing networks. The modifications are also designed to have no effect whatsoever on networks that only use Level 1 and/or Level 2.

Section references in this document are references to sections of IS-IS [ISO10589].

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. PDU changes

In this section, we enumerate all of the redefinitions of protocol header fields necessary to add additional levels.

2.1. Circuit Type

In the fixed header of some IS-IS PDUs, a field is named 'Reserved/ Circuit Type' (Section 9.5). The high order six bits are reserved, with the low order two bits indicating Level 1 (bit 1) and Level 2 (bit 2).

This field is renamed to be 'Circuit Type'. The bits are redefined as follows:

1. Level 1

2. Level 2

3. Level 3

   4.   Level 4

   5.   Level 5

   6.   Level 6

   7.   Level 7

   8.   Level 8

   The value of zero (no bits set) is reserved. PDUs with a Circuit
   Type of zero SHALL be ignored.

   The set bits of the Circuit Type MUST be contiguous. If bit n and
   bit m are set in the Circuit Type, then all bits in the interval
   [n:m] must be set.

2.2. PDU Type

   The fixed header of IS-IS PDUs contains an octet with three reserved
   bits and the 'PDU Type' field. The three reserved bits are
   transmitted as zero and ignored on receipt. (Section 9.5)

   To allow for additional PDU space, this entire octet is renamed the
   'PDU Type' field.

3. Additional PDUs

3.1. Level n LAN IS to IS hello PDU (Ln-LAN-HELLO-PDU)

   The 'Level n LAN IS to IS hello PDU' (Ln-LAN-HELLO-PDU) is identical
   in format to the 'Level 2 LAN IS to IS hello PDU' (Section 9.6),
   except that the PDU Types are defined as follows:

      Level 3 (L3-LAN-HELLO-PDU): 33 (Suggested - to be assigned by
      IANA)

      Level 4 (L4-LAN-HELLO-PDU): 34 (Suggested - to be assigned by
      IANA)

      Level 5 (L5-LAN-HELLO-PDU): 35 (Suggested - to be assigned by
      IANA)

      Level 6 (L6-LAN-HELLO-PDU): 36 (Suggested - to be assigned by
      IANA)

      Level 7 (L7-LAN-HELLO-PDU): 37 (Suggested - to be assigned by
      IANA)

      Level 8 (L8-LAN-HELLO-PDU): 38 (Suggested - to be assigned by
      IANA)

   The Circuit Type field MUST be set to indicate all levels supported
   on that circuit.

3.2. Level n Point-to-point IS to IS hello PDU (Ln-P2P-HELLO-PDU)

   The 'Point-to-point IS to IS hello PDU' (Section 9.7) is used on
   Level 1 and Level 2 circuits. Legacy systems will not expect the
   circuit type field to indicate other levels, so a new PDU is used if
   the circuit supports other levels. The additional PDU is the 'Level
   n Point-to-point IS to IS hello PDU' (Ln-P2P-HELLO-PDU) and has PDU
   Type 39 (Suggested - to be assigned by IANA). The format of this PDU
   is identical to the existing Point-to-Point IS to IS hello PDU. Both
   PDUs may be used on the same circuit.

4. Level Specific Area Identifiers

   [ISO10589] defines an Area Address to uniquely identify a Level-1
   area. A given area may have multiple synonymous area addresses -
   which is useful in support of hitless merging or splitting of areas.
   Area address matching is part of the adjacency formation rules
   defined in Section 8 which determine whether a given adjacency
   supports Level-1, Level-2, or both. Area addresses are advertised in
   IIHs and LSPs using the Area Address TLV.

   With the extensions defined in this document, there is a need to
   define an equivalent identifier for Levels 2-8. This identifier is a
   32 bit value and is advertised using the new Area Identifier TLV
   defined in the following section. There is no relationship between
   the Level-1 Area Addresses and the new Level Specific Area
   Identifier.

   Just as with Area Addresses, multiple synonomous Area Identifiers may
   be assigned to a given level. This supports hitless merging or
   splitting of the level specific area. Although it is legal to do so,
   it is generally not useful to define more than two Area Identifiers
   for a given level.

4.1. IS-IS Area Identifier TLV

   The Area Identifier TLV is added to IS-IS to allow nodes to indicate
   which areas they participate in for Levels 2-8. Area Identifiers are
   locally administered 32 bit numbers. Each level may have multiple
   Area Identifiers. The format of the TLV is:

```
   0                   1                   2                   3
   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
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |   TLV Type    |  TLV Length   |     Level     |    Count      |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |                       Area Identifier                         |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV Type: ZZZ

TLV Length: (2 * number of Levels) + (4 * each Count field)

Level: The level number of the area. (1 octet) Legal values are
2-8

Count: The number of Area Identifier fields (1 octet)

Area Identifier: One or more identifiers associated with the area.
(4 * count octets)

The Level/Count/Area Identifier tuple MAY be repeated as necessary.

The Area Identifier TLV MAY appear in all types of IIHs except for
Level 1 LAN IS to IS hellos.

The Area Identifier TLV MAY appear in LSP #0 of non-pseudo-node Level
3-8 Flooding Scoped LSPs defined in Section 5. It MUST NOT be
present in any LSP with non-zero LSP number. If present in an LSP
with non-zero LSP number it MUST be ignored on receipt.

A system may participate in more than one level. At a given level,
an area may have a number of synonymous identifiers. A system MUST
advertise all of the levels it supports and the associated Area
Identifiers.

4.2. Adjacency Formation Rules

Adjacency formation rules for Levels 1 and 2 are defined in
[ISO10589] and are not altered by these extensions except where noted
below.

Adjacency Formation rules for Levels 3 and above are defined to
insure that adjacency support for a given level is only enabled when
there is a matching Area Identifier. Adjacency formation rules also
are defined so as to prevent interconnection of neighbors which will
connect to different areas at levels above any supported level.

4.2.1. Level 3-8 Adjacency Formation Rules

   When the Area Identifier TLV appears in a Level N Point-to-point IS
   to IS hello PDU or a Level N LAN IS to IS Hello PDU, the Circuit Type
   field is inspected. For all levels with their corresponding bit set
   in the Circuit Type in the range 3-8 the following checks are
   performed:

   o Check for a matching Area Identifier at the same level

   o Check for a matching Area Identifier at all supported levels
      greater than the level being checked

   If both checks pass, then an adjacency can be formed supporting the
   level. If any of the checks fail, then that level MUST NOT be
   supported by an adjacency formed on that circuit.

   On a Point-to-Point circuit, a single adjacency is formed which
   supports all of the levels which pass the above checks.

   On a LAN circuit, an adjacency is formed only for the level specified
   by the PDU type. Nevertheless, the checks for all levels with the
   corresponding bit set in the Circuit Type MUST be performed.

   Note that (as previously specified) the set of levels supported MUST
   be contiguous.

4.2.2. Special Level-2 Adjacency Formation Rules

   The Area Identifier TLV MAY appear in a Point-to-point IS to IS hello
   PDU or Level 2 LAN IS to IS Hello PDU (both specified in [ISO10589]).
   In such a case, the neighbor may or may not support the Area
   Identifier TLV. If the Area Identifier TLV is present and Level 2 is
   indicated as being supported in the Circuit Type field, then in
   addition to the checks specified in [ISO10589] the checks specified
   in the previous section SHOULD be performed for Level 2.

5. New Flooding Scopes

   For levels 3-8, all link state information, PSNPs, and CSNPs are
   relayed in conformance with RFC 7356 [RFC7356]. Additional flooding
   scopes are defined for each new level, for both circuit flooding
   scope and level flooding scope. Level flooding scopes are defined
   for both Standard and Extended TLV formats. The list of additional
   flooding scopes is:

```
                                         FS LSP ID Format/
     Value Description                    TLV Format
     ----- ------------------------------ ----------------
      6     Level 3 Circuit Flooding Scope Extended/Standard
      7     Level 4 Circuit Flooding Scope Extended/Standard
      8     Level 5 Circuit Flooding Scope Extended/Standard
      9     Level 6 Circuit Flooding Scope Extended/Standard
      10    Level 7 Circuit Flooding Scope Extended/Standard
      11    Level 8 Circuit Flooding Scope Extended/Standard
      12    Level 3 Flooding Scope        Extended/Standard
      13    Level 4 Flooding Scope        Extended/Standard
      14    Level 5 Flooding Scope        Extended/Standard
      15    Level 6 Flooding Scope        Extended/Standard
      16    Level 7 Flooding Scope        Extended/Standard
      17    Level 8 Flooding Scope        Extended/Standard
      18    Level 3 Flooding Scope        Standard/Standard
      19    Level 4 Flooding Scope        Standard/Standard
      20    Level 5 Flooding Scope        Standard/Standard
      21    Level 6 Flooding Scope        Standard/Standard
      22    Level 7 Flooding Scope        Standard/Standard
      23    Level 8 Flooding Scope        Standard/Standard
      70    Level 3 Circuit Flooding Scope Extended/Extended
      71    Level 4 Circuit Flooding Scope Extended/Extended
      72    Level 5 Circuit Flooding Scope Extended/Extended
      73    Level 6 Circuit Flooding Scope Extended/Extended
      74    Level 7 Circuit Flooding Scope Extended/Extended
      75    Level 8 Circuit Flooding Scope Extended/Extended
      76    Level 3 Flooding Scope        Extended/Extended
      77    Level 4 Flooding Scope        Extended/Extended
      78    Level 5 Flooding Scope        Extended/Extended
      79    Level 6 Flooding Scope        Extended/Extended
      80    Level 7 Flooding Scope        Extended/Extended
      81    Level 8 Flooding Scope        Extended/Extended
```

6. MAC Addresses

On a broadcast network, PDUs are currently sent to the AllL1Iss or
AllL2Iss MAC addresses. We will need additional MAC addresses for
Levels 3-8.

    AllL3ISs: MAC3

    AllL4ISs: MAC4

    AllL5ISs: MAC5

    AllL6ISs: MAC6

      AllL7ISs: MAC7

      AllL8ISs: MAC8

   When operating in Point-to-Point mode on a broadcast network
   [RFC5309], a Level N Point-to-Point Hello PDU will be sent. Any of
   the above MAC addresses could be used in this case, but it is
   recommended to use the AllL3ISs MAC address.

7. Inheritance of TLVs

   All existing Level 2 TLVs may be used in the corresponding Level 3
   through Level 8 PDUs. When used in a Level 3 through Level 8 PDU,
   the semantics of these TLVs will be applied to the Level of the
   containing PDU. If the original semantics of the PDU was carrying a
   reference to Level 1 in a Level 2 TLV, then the semantics of the TLV
   at level N will be a reference to level N-1. The intent is to retain
   the original semantics of the TLV at the higher level.

8. Behavior of Level n

   The behavior of Level n is analogous to the behavior of Level 2.

9. Relationship between levels

   The relationship between Level n and Level n-1 is analogous to the
   relationship between Level 2 and Level 1.

   An area at Level n has at most one parent at Level n+1.

10. Acknowledgements

   The authors would like to thank Dinesh Dutt for inspiring this
   document and Huaimo Chen for his comments.

11. IANA Considerations

   This document makes many requests to IANA, as follows:

11.1. PDU Type

   The existing IS-IS PDU registry currently supports values 0-31. This
   should be expanded to support the values 0-255. The existing value
   assignments should be retained. Value 255 should be reserved.

11.2. New PDUs

   IANA is requested to allocate values from the IS-IS PDU registry for
   the following:

      L3-LAN-HELLO-PDU: 33 (Suggested - to be assigned by IANA)

      L4-LAN-HELLO-PDU: 34 (Suggested - to be assigned by IANA)

      L5-LAN-HELLO-PDU: 35 (Suggested - to be assigned by IANA)

      L6-LAN-HELLO-PDU: 36 (Suggested - to be assigned by IANA)

      L7-LAN-HELLO-PDU: 37 (Suggested - to be assigned by IANA)

      L8-LAN-HELLO-PDU: 38 (Suggested - to be assigned by IANA)

      Ln-P2P-HELLO-PDU: 39 (Suggested - to be assigned by IANA)

11.3. New TLVs

   IANA is requested to allocate values from the IS-IS TLV registry for
   the following:

      Area Identifier: ZZZ

11.4. New Flooding Scopes

   IANA is requested to allocate the following values from the IS-IS
   Flooding Scope Identifier Registry.

```
                             FS LSP ID Format/ IIH Announce
     Value Description           TLV Format        Lx-P2P Lx-LAN
     ----- ------------------------------ ----------------- ------ ------
      6     Level 3 Circuit Flooding Scope Extended/Standard  Y       Y
      7     Level 4 Circuit Flooding Scope Extended/Standard  Y       Y
      8     Level 5 Circuit Flooding Scope Extended/Standard  Y       Y
      9     Level 6 Circuit Flooding Scope Extended/Standard  Y       Y
     10     Level 7 Circuit Flooding Scope Extended/Standard  Y       Y
     11     Level 8 Circuit Flooding Scope Extended/Standard  Y       Y
     12     Level 3 Flooding Scope         Extended/Standard  Y       Y
     13     Level 4 Flooding Scope         Extended/Standard  Y       Y
     14     Level 5 Flooding Scope         Extended/Standard  Y       Y
     15     Level 6 Flooding Scope         Extended/Standard  Y       Y
     16     Level 7 Flooding Scope         Extended/Standard  Y       Y
     17     Level 8 Flooding Scope         Extended/Standard  Y       Y
     18     Level 3 Flooding Scope         Standard/Standard  Y       Y
     19     Level 4 Flooding Scope         Standard/Standard  Y       Y
     20     Level 5 Flooding Scope         Standard/Standard  Y       Y
     21     Level 6 Flooding Scope         Standard/Standard  Y       Y
     22     Level 7 Flooding Scope         Standard/Standard  Y       Y
     23     Level 8 Flooding Scope         Standard/Standard  Y       Y
     70     Level 3 Circuit Flooding Scope Extended/Extended  Y       Y
     71     Level 4 Circuit Flooding Scope Extended/Extended  Y       Y
     72     Level 5 Circuit Flooding Scope Extended/Extended  Y       Y
     73     Level 6 Circuit Flooding Scope Extended/Extended  Y       Y
     74     Level 7 Circuit Flooding Scope Extended/Extended  Y       Y
     75     Level 8 Circuit Flooding Scope Extended/Extended  Y       Y
     76     Level 3 Flooding Scope         Extended/Extended  Y       Y
     77     Level 4 Flooding Scope         Extended/Extended  Y       Y
     78     Level 5 Flooding Scope         Extended/Extended  Y       Y
     79     Level 6 Flooding Scope         Extended/Extended  Y       Y
     80     Level 7 Flooding Scope         Extended/Extended  Y       Y
     81     Level 8 Flooding Scope         Extended/Extended  Y       Y
```

11.5. New MAC Addresses

   IANA is requested to allocate values from the IANA Multicast 48-bit
   MAC Addresses block for the following:

      AllL3Iss: MAC3

      AllL4Iss: MAC4

      AllL5Iss: MAC5

      AllL6Iss: MAC6

      AllL7Iss: MAC7

     AllL8Iss: MAC8

12. Security Considerations

   This document introduces no new security issues. Security of routing
   within a domain is already addressed as part of the routing protocols
   themselves. This document proposes no changes to those security
   architectures.

13. Normative References

   [ISO10589]
              International Organization for Standardization,
              "Intermediate System to Intermediate System Intra-Domain
              Routing Exchange Protocol for use in Conjunction with the
              Protocol for Providing the Connectionless-mode Network
              Service (ISO 8473)", ISO/IEC 10589:2002, Nov. 2002.

   [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate
              Requirement Levels", BCP 14, RFC 2119,
              DOI 10.17487/RFC2119, March 1997,
              <https://www.rfc-editor.org/info/rfc2119>.

   [RFC5309] Shen, N., Ed. and A. Zinin, Ed., "Point-to-Point Operation
              over LAN in Link State Routing Protocols", RFC 5309,
              DOI 10.17487/RFC5309, October 2008,
              <https://www.rfc-editor.org/info/rfc5309>.

   [RFC7356] Ginsberg, L., Previdi, S., and Y. Yang, "IS-IS Flooding
              Scope Link State PDUs (LSPs)", RFC 7356,
              DOI 10.17487/RFC7356, September 2014,
              <https://www.rfc-editor.org/info/rfc7356>.

Authors' Addresses

   Tony Li
   Arista Networks
   5453 Great America Parkway
   Santa Clara, California 95054
   United States of America

   Email: tony.li@tony.li

Les Ginsberg
Cisco Systems
United States of America

Email: ginsberg@cisco.com

Paul Wells
Cisco Systems
United States of America

Email: pauwells@cisco.com