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IS-IS Extended Hierarchy

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.

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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].

Note that [ISO10589] uses a bit encoding convention where bit
numbers are 1 based and Bit 1 is the Least Significant Bit (LSB) of
the datatype. Traditionally IETF documents have used a bit encoding
convention where bit numbers are 0 based and Bit 0 is the Most
Significant Bit (MSB) of the datatype. This document uses [ISO10589]
conventions throughout.

1.1. Requirements Language

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.

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 - not just the level associated with the containing
PDU type.

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. The Level Specific
Area Identifier (LSAI) is a 16 bit value and is advertised using the
new Area Hierarchy TLV defined in Section 4.1. There is no
relationship between a Level-1 Area Address and an LSAI.

Just as with Area Addresses, multiple synonomous LSAIs 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.

A node MAY support any set of contiguous levels. Support for non-contiguous levels is undefined.

4.1. IS-IS Area Hierarchy TLV

The Area Hierarchy TLV specifies the set of LSAIs which comprise the branch of the network hierarchy to which the advertising node is connected. The TLV MUST include at least one LSAI for Levels 2-N, where N is >= 2 and N represents the highest level supported in the IS-IS domain. It is RECOMMENDED that N == 8 even when not all 8 levels are currently in use, but in cases where a network does not support higher levels a number less than 8 MAY be used.

Note that the levels advertised MAY include levels which are not supported by the advertising node.

The Area Hierarchy TLV has the following format:

```
     8 7 6 5 4 3 2 1
    +-+-+-+-+-+-+-+-+
    |    TLV Type    |
    +-+-+-+-+-+-+-+-+
    | TLV Length    |
    +-+-+-+-+-+-+-+-+
    | Supp-Levels   |
    +-+-+-+-+-+-+-+-+
```

Followed by one or more Level Specific Area ID Sets:

```
     1             0
     6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |     Level     | # of LSAIs    |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |Level Specific Area Id(s)      |
    ...
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

    TLV Type: ZZZ (1 octet)

    TLV Length: Variable (1 octet)

    Supp-Levels: A contiguous bitmask representing the set of levels
      supported by the advertising node (1 octet)
      Bit #8 of this field is set if Level 8 is supported.
      Bit #7 of this field is set if Level 7 is supported.
      Bit #6 of this field is set if Level 6 is supported.
      Bit #5 of this field is set if Level 5 is supported.
      Bit #4 of this field is set if Level 4 is supported.
      Bit #3 of this field is set if Level 3 is supported.
      Bit #2 of this field is set if Level 2 is supported.
      Bit #1 of this field is set if Level 1 is supported

     If the Supp-level bit mask is non-contiguous all advertised LSAIs
     are ignored.

Each Level Specific Area ID Set consists of:

     Level: 2-8 (1 octet)
     # of LSAI: >=1 (1 octet)
     LSAIs: The set of synonomous LSAIs associated with this level
       (2 * # of LSAIs octets)

    The Area Hierarchy TLV MUST appear in all new IIH PDUs defined in
    Section 3. It MAY appear in P2P-HELLO-PDUs, L1-LAN-HELLO-PDUs, or
    L2-LAN-HELLO-PDUs.

The Area Hierarchy TLV MUST appear in LSP #0 of non-pseudo-node
Level 3-8 Flooding Scoped LSPs defined in [Section 5](). It MAY appear
in L1 or L2 LSP #0. 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.

Multiple Area Hierarchy TLVs MUST NOT be sent. In the event multiple
Area Hierarchy TLVs are received, the first such TLV in the PDU is
used. Subsequent TLVs in the same PDU MUST be ignored.

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.

The checks discussed below need to be performed on receipt of an
IIH.

4.2.1. Level 3-8 Adjacency Formation Rules

The Area Hierarchy TLV MUST be present in a Level N Point-to-point
IS to IS hello PDU or a Level N LAN IS to IS Hello PDU and the TLV
content MUST adhere to the definition in [Section 4.1](). Beginning with
the lowest level supported by the receiving node on this circuit and
including all higher levels for which the receiver has an assigned
LSAI regardless as to whether the higher levels are supported on
this circuit, the set of LSAIs defined on the receiving node is
compared against the set of LSAIs advertised in the received TLV. A
matching LSAI MUST be found for each level.

If all of the checks pass then a new adjacency is formed or an
existing adjacency is maintained.

NOTE: The absence of the advertisement of an LSAI for a given level
is considered as a failure to find a matching LSAI.

On a Point-to-Point circuit, a single adjacency is formed which
supports all of the levels supported by both nodes on this circuit.

On a LAN circuit, an adjacency is formed supporting only the level
specified by the PDU type.

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

4.2.2. Special Level-1 and Level-2 Adjacency Formation Rules

The Area Hierarchy TLV MAY appear in a Point-to-point IS to IS hello
PDU, Level 1 LAN IS to IS Hello PDU, or Level 2 LAN IS to IS Hello
PDU (PDUs specified in [ISO10589]). In such a case, the neighbor may
or may not support the Area Hierarchy TLV. The following sub-
sections define modified adjacency formation rules for point-to-
point and LAN circuits.

4.2.2.1. Actions on a Point-to-Point Circuit

If the Area Hierarchy TLV is present, then in addition to the checks
specified in [ISO10589] the checks specified in Section 4.2.1 MUST
be performed for all levels for which the receiver has an assigned
LSAI beginning with Level 2. If those checks fail an adjacency MUST
NOT be formed and any existing matching adjacency MUST transition to
DOWN state.

4.2.2.2. Actions on a LAN Circuit

Adjacency formation MUST follow the rules defined in [ISO10589]. If
the Area Hierarchy TLV is present in the Level 1 or Level 2 LAN IS
to IS Hello PDU then the checks specified in Section 4.2.1 SHOULD be
performed for all levels for which the receiver has an assigned LSAI
beginning with Level 2. If those checks fail an error SHOULD be
reported, but the level specific adjacency is still allowed. This
prevents violation of the assumption of transitivity on the LAN in
the presence of systems which do not support the extensions defined
in this document.

4.2.2.3. Reporting of Mismatched Area Hierarchies

When forming adjacencies at Level-1 and/or Level-2, it is possible
to have a mixture of legacy nodes (which do NOT support the
extensions defined in this document) and new nodes which do support
the extensions.

In Point-to-Point mode, legacy nodes will not advertise the new Area
Hierarchy TLV and will not have an assigned LSAI for Level-2. It
then becomes possible for new nodes with mismatched Area Hierarchies
to form adjacencies with legacy nodes and form an L1 or L2 area
where not all new nodes have a matching Area Hierarchy. This cannot
be detected when forming adjacencies if the new nodes are not
directly connected - but it can be detected after the adjacencies
have been formed by inspecting the set of Area Hierarchy TLVs in the
level specific LSPs of all routers in the area.

Similarly in LAN mode, the transitivity requirement means that new
nodes MUST form adjacencies with all nodes connected to the LAN even
when the Area Hierarchy TLV mismatch check fails (see Section
4.2.2.2). This can occur both at Level-1 and Level-2.

New nodes MUST report these inconsistencies.

5. New Flooding Scopes

For levels 3-8, all link state information, PSNPs, and CSNPs are
relayed in conformance with [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
```

The final octet of the header of a Flooding Scoped LSP as defined in
[RFC7356] contains Reserved/LSPDBOL/IS Type information. This field
is redefined for the new flooding scopes defined in this document as
follows:

Reserved/ATT/LSPDBOL

  Bits 8-5 Reserved
   Transmitted as 0 and ignored on receipt
  Bit 4 ATT
    If set to 1 indicates that the sending IS is attached to
    routers in other Level N areas via Level N+1
  Bit 3 LSDBOL
    As defined in RFC7356
  Bits 2-1
    Transmitted as 0 and ignored on receipt.

  Note that the levels supported (analogous to the IS-type information
  in L1 and L2 LSPs) can be obtained from the Area Hierarchy TLV
  advertised in the associated LSP #0.

  Note that the definition of the ATT bit specified above also applies
  to L2 LSPs. Previously this bit would have no meaning as [ISO10589]
  does not define support for Level 3.

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. The authors would also
like to thank Tony Pryzienda for his careful review and excellent
suggestions.

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 Hierarchy: 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] ISO, "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, November 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>.

[RFC8174]   Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

Appendix A. Preventing Cross Branching in the Hierarchy

The use of additional levels requires careful interconnection of routers which support multiple levels. Consistent association of LSAIs is required not only for validating the connections between routers in a level specific area but also for all levels above a given level to which any of the routers may be connected (directly or indirectly). Failure to do so can result in interconnecting different branches of a tree leading to interarea loops. This leads to the requirement that all routers advertise an LSAI for all levels regardless of whether a given router is configured to participate in a given level or not.

At first glance it may seem that it would be sufficient for each router to advertise LSAIs only for the levels that the router is

configured to support. However, the following simple example
illustrates why this is problematic.

```
+------------+   +------------+   +------------+
| Rtr  A     |   | Rtr  B     |   | Rtr  C     |
| L3 Area 30 |---| L3 Area 30 |---| L3 Area 30 |
| L4 Area 40 |   |            |   | L4 Area 44 |
+------------+   +------------+   +------------+
```

Since Router B does not support Level 4, it chose not to advertise
any Area for Level 4. This means that neither Router A nor Router C
can tell by inspecting hellos that not all routers in Level 3 area
30 have been configured to support the same Level 4 area. It is
possible for Rtr A and Rtr C to discover the LSAIs advertised by all
routers by inspecting the Level 3 LSPs - however this requires that
Level 3 adjacencies be formed and maintained even when routing
cannot be safely performed via all adjacencies in a given area. It
then needs to be decided how routing over existing adjacencies
should be limited. A number of possibilities exist:

    Treat the area as if it were two partitions. In the example
    Router A would be in one partition and Router C would be in
    another partition. But Router B could belong to either partition.

    Select a winning Level 4 Area among the set of Level 4 areas
    advertised in L3 LSPs and only allow leaking of routes to/from
    that level

But either of these options introduce the possibility that a
previously fully connected hierarchy becomes partially disconnected
as a result of a single configuration change on a single router and/
or the bringup of a new router.

The choice made was then to require all routers suppporting the
extensions in this document to advertise an LSAI for all levels
regardless of what specific levels an individual router is
configured to support. This guarantees that any inconsistency
between the intended connectivity of a router at all levels - direct
and indirect - can be detected during exchange of hellos and
therefore adjacency bringup can always be blocked when necessary.

Appendix B. Guidelines for Introducing a new level

It is desirable to be able to introduce support for a new level
without disruption. This section discusses ways to do this.

Initial deployment may require only the support of one additional
level (Level 3). However, in the future increased network scale may
make introduction of an additional level (Level 4) desirable. It is

suggested that all routers be configured to advertise a single
candidate LSAI for Level 4 - for the purposes of the example let's
use LSAI 44. When ready to deploy Level 4, it is then only necessary
to enable Level 4 on those routers who will be participating in the
additional level.

However, perhaps at the time of deploying Level 3 the administrator
has no idea what LSAI will be used for Level 4 in the future. In
such a case a "dummy" LSAI should be configured for Level 4 on all
routers - let's use "0" in this example. In this case, what needs to
be done when ready to enable Level 4 is to go to every router
(regardless of whether it will actively participate in the new
level) and configure the intended LSAI for Level 4. If LSAI 45 is
the intended Level 4 area, then LSAI 45 is configured on each
router. Each router is then advertising two LSAIs for Level 4: (0,
45). Once this is completed, go to every router and remove the
"dummy" Level 4 LSAI (0) and the network is now ready to have this
Level 4 area enabled.

In the event that support for a new level needs to be introduced and
no LSAI was ever advertised for that level, the introduction of LSAI
for the new level will cause temporary adjacency flaps as the
advertisement of the LSAI for the new level is introduced. To avoid
this, implementations would need to introduce support for temporary
disablement of the LSAI check for the new level until the
configuration of the new LSAI is complete on all nodes. Support for
this transition mode is outside the scope of this document. The need
for a transition mode can be avoided if an LSAI is configured for
levels 2-8 from day one.

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