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IS-IS Traffic Engineering (TE) Metric Extensions
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Abstract

   In certain networks, such as, but not limited to, financial
   information networks (e.g. stock market data providers), network
   performance criteria (e.g. latency) are becoming as critical to data
   path selection as other metrics.

   This document describes extensions to IS-IS Traffic Engineering
   Extensions (RFC5305) such that network performance information can be
   distributed and collected in a scalable fashion. The information
   distributed using ISIS TE Metric Extensions can then be used to make
   path selection decisions based on network performance.

   Note that this document only covers the mechanisms with which network
   performance information is distributed. The mechanisms for measuring
   network performance or acting on that information, once distributed,
   are outside the scope of this document.

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].

   In this document, these words will appear with that interpretation
   only when in ALL CAPS. Lower case uses of these words are not to be
   interpreted as carrying RFC-2119 significance.

Status of This Memo

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1. Introduction

   In certain networks, such as, but not limited to, financial
   information networks (e.g. stock market data providers), network
   performance information (e.g. latency) is becoming as critical to
   data path selection as other metrics.

   In these networks, extremely large amounts of money rest on the
   ability to access market data in "real time" and to predictably make
   trades faster than the competition. Because of this, using metrics
   such as hop count or cost as routing metrics is becoming only
   tangentially important. Rather, it would be beneficial to be able to
   make path selection decisions based on performance data (such as
   latency) in a cost-effective and scalable way.

   This document describes extensions to IS-IS Extended Reachability TLV
   defined in [RFC5305] (hereafter called "IS-IS TE Metric Extensions"),
   that can be used to distribute network performance information (such
   as link delay, delay variation, packet loss, residual bandwidth, and
   available bandwidth).

   The data distributed by the TE Metric Extensions proposed in this
   document is meant to be used as part of the operation of the routing
   protocol (e.g. by replacing cost with latency or considering
   bandwidth as well as cost), by enhancing Constrained-SPF (CSPF), or
   for other uses such as supplementing the data used by an ALTO server
   [I-D.ietf-alto-protocol]. With respect to CSPF, the data distributed
   by ISIS TE Metric Extensions can be used to setup, fail over, and
   fail back data paths using protocols such as RSVP-TE [RFC3209];
   [I-D.atlas-mpls-te-express-path] describes some methods for using
   this information to compute Label Switched Paths (LSPs) at the LSP
   ingress.

   Note that the mechanisms described in this document only disseminate
   performance information. The methods for initially gathering that
   performance information, such as [RFC6375], or acting on it once it
   is distributed are outside the scope of this document. Example

mechanisms to measure latency, delay variation, and loss in an MPLS
network are given in [RFC6374]. While this document does not specify
how the performance information should be obtained, the measurement
of delay SHOULD NOT vary significantly based upon the offered traffic
load. Thus, queuing delays SHOULD NOT be included in the delay
measurement. For links, such as Forwarding Adjacencies, care must be
taken that measurement of the associated delay avoids significant
queuing delay; that could be accomplished in a variety of ways,
including either by measuring with a traffic class that experiences
minimal queuing or by summing the measured link delays of the
components of the link's path.

2. TE Metric Extensions to IS-IS

This document proposes new IS-IS TE sub-TLVs that can be announced in
ISIS Extended Reachability TLV (TLV-22) to distribute network
performance information. The extensions in this document build on
the ones provided in IS-IS TE [RFC5305] and GMPLS [RFC4203].

IS-IS Extended Reachability TLV 22 (defined in [RFC5305]), Inter-AS
reachability information TLV 141 (defined in [RFC5316]) and MT-ISN
TLV 222 (defined in [RFC5120]) have nested sub-TLVs which permit the
TLVs to be readily extended. This document proposes several
additional sub-TLVs:

```
   Type          Value
   ----------------------------------------------
   TBA           Unidirectional Link Delay

   TBA           Low/High Unidirectional Link Delay

   TBA           Unidirectional Delay Variation

   TBA           Unidirectional Packet Loss

   TBA           Unidirectional Residual Bandwidth

   TBA           Unidirectional Available Bandwidth

   TBA           Unidirectional Bandwidth Utilization
```

As can be seen in the list above, the sub-TLVs described in this
document carry different types of network performance information.
The new sub-TLVs include a bit called the Anomalous (or "A") bit.
When the A bit is clear (or when the sub-TLV does not include an A
bit), the sub-TLV describes steady state link performance. This
information could conceivably be used to construct a steady state

performance topology for initial tunnel path computation, or to
verify alternative failover paths.

When network performance violates configurable link-local thresholds
a sub-TLV with the A bit set is advertised. These sub-TLVs could be
used by the receiving node to determine whether to fail traffic to a
backup path, or whether to calculate an entirely new path. From an
MPLS perspective, the intent of the A bit is to permit LSP ingress
nodes to:

A) Determine whether the link referenced in the sub-TLV affects any
   of the LSPs for which it is ingress. If there are, then:

B) Determine whether those LSPs still meet end-to-end performance
   objectives. If not, then:

C) The node could then conceivably move affected traffic to a pre-
   established protection LSP or establish a new LSP and place the
   traffic in it.

If link performance then improves beyond a configurable minimum value
(reuse threshold), that sub-TLV can be re-advertised with the
Anomalous bit cleared. In this case, a receiving node can
conceivably do whatever re-optimization (or failback) it wishes to do
(including nothing).

Note that when a sub-TLV does not include the A bit, that sub-TLV
cannot be used for failover purposes. The A bit was intentionally
omitted from some sub-TLVs to help mitigate oscillations. See
Section 5 for more information.

Consistent with existing IS-IS TE specifications [RFC5305], the
bandwidth advertisements defined in this draft MUST be encoded as
IEEE floating point values. The delay and delay variation
advertisements defined in this draft MUST be encoded as integer
values. Delay values MUST be quantified in units of microseconds,
packet loss MUST be quantified as a percentage of packets sent, and
bandwidth MUST be sent as bytes per second. All values (except
residual bandwidth) MUST be calculated as rolling averages where the
averaging period MUST be a configurable period of time. See
Section 5 for more information.

3. Interface and Neighbor Addresses

The use of TE Metric Extensions SubTLVs is not confined to the TE
context. In other words, IS-IS TE Metric Extensions SubTLVs defined
in this document can also be used for computing paths in the absence
of a TE subsystem.

   However, as for the TE case, Interface Address and Neighbor Address
   SubTLVs (IPv4 or IPv6) MUST be present. The encoding is defined in
   [RFC5305] for IPv4 and in [RFC6119] for IPv6.

4. Sub TLV Details

4.1. Unidirectional Link Delay Sub-TLV

   This sub-TLV advertises the average link delay between two directly
   connected IS-IS neighbors. The delay advertised by this sub-TLV MUST
   be the delay from the local neighbor to the remote one (i.e. the
   forward path latency). The format of this sub-TLV is shown in the
   following diagram:

```
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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type        |    Length     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|A|   RESERVED  |                  Delay                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
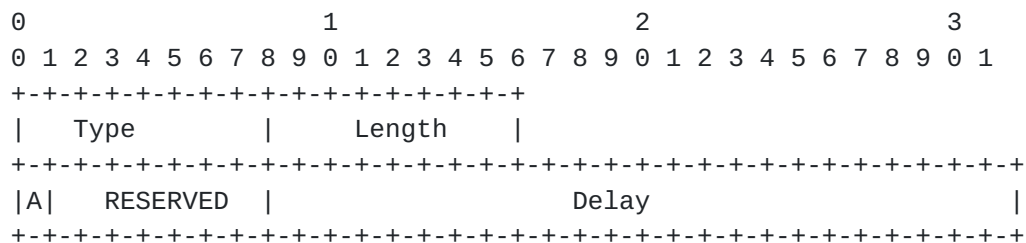
   where:

                               Figure 1

   Type: TBA

   Length: 4

   A-bit. The A-bit represents the Anomalous (A) bit. The A-bit is set
   when the measured value of this parameter exceeds its configured
   maximum threshold. The A bit is cleared when the measured value
   falls below its configured reuse threshold. If the A-bit is clear,
   the sub-TLV represents steady state link performance.

   RESERVED. This field is reserved for future use. It MUST be set to
   0 when sent and MUST be ignored when received.

   Delay. This 24-bit field carries the average link delay over a
   configurable interval in micro-seconds, encoded as an integer value.
   When set to the maximum value 16,777,215 (16.777215 sec), then the
   delay is at least that value and may be larger. If there is no value
   to send (unmeasured and not statically specified), then the sub-TLV
   should not be sent or be withdrawn.

4.2. Min/Max Unidirectional Link Delay Sub-TLV

   This sub-TLV advertises the minimum and maximum delay values between
   two directly connected IS-IS neighbors. The delay advertised by this
   sub-TLV MUST be the delay from the local neighbor to the remote one
   (i.e. the forward path latency). The format of this sub-TLV is shown
   in the following diagram:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type        |    Length     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|A|  RESERVED   |                 Low Delay                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    RESERVED   |                High Delay                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   where:

                              Figure 2

   Type: TBA

   Length: 8

   A-bit. The A-bit represents the Anomalous (A) bit. The A-bit is set
   when the measured value of this parameter exceeds its configured
   maximum threshold. The A bit is cleared when the measured value
   falls below its configured reuse threshold. If the A-bit is clear,
   the sub-TLV represents steady state link performance.

   RESERVED. This field is reserved for future use. It MUST be set to
   0 when sent and MUST be ignored when received.

   Low Delay. This 24-bit field carries minimum measured link delay
   value (in microseconds) over a configurable interval, encoded as an
   integer value.

   High Delay. This 24-bit field carries the maximum measured link
   delay value (in microseconds) over a configurable interval, encoded
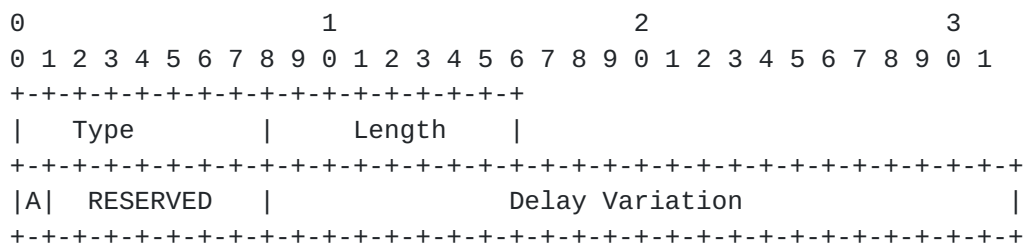   as an integer value.

   Implementations MAY also permit the configuration of a static (non
   dynamic) offset value (in microseconds) to be added to the measured
   delay value, to facilitate the communication of operator specific
   delay constraints.

It is possible for the high delay and low delay to be the same value.

When the delay value (Low or High) is set to maximum value 16,777,215 (16.777215 sec), then the delay is at least that value and may be larger.

4.3. Unidirectional Delay Variation Sub-TLV

This sub-TLV advertises the average link delay variation between two directly connected IS-IS neighbors. The delay variation advertised by this sub-TLV MUST be the delay from the local neighbor to the remote one (i.e. the forward path latency). The format of this sub-TLV is shown in the following diagram:

```
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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Type       |     Length    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|A|  RESERVED   |             Delay Variation                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

                              Figure 3
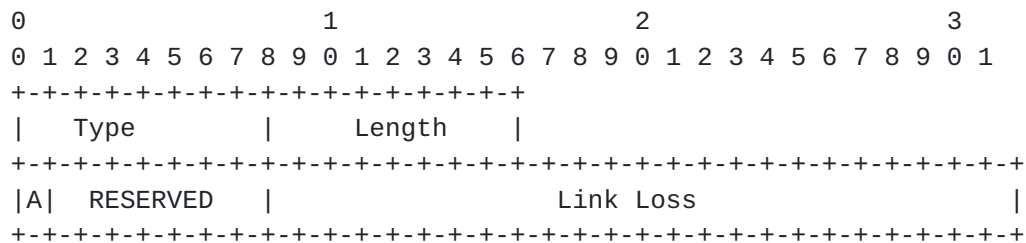
Type: TBA.

Lenght: 4.

A-bit. The A-bit represents the Anomalous (A) bit. The A-bit is set when the measured value of this parameter exceeds its configured maximum threshold. The A bit is cleared when the measured value falls below its configured reuse threshold. If the A-bit is clear, the sub-TLV represents steady state link performance.

RESERVED. This field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

Delay Variation. This 24-bit field carries the average link delay variation over a configurable interval in micro-seconds, encoded as an integer value. When set to 0, it has not been measured. When set to the maximum value 16,777,215 (16.777215 sec), then the delay is at least that value and may be larger.

4.4. **Unidirectional Link Loss Sub-TLV**

   This sub-TLV advertises the loss (as a packet percentage) between two
   directly connected IS-IS neighbors. The link loss advertised by this
   sub-TLV MUST be the packet loss from the local neighbor to the remote
   one (i.e. the forward path loss). The format of this sub-TLV is
   shown in the following diagram:

```
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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type        |     Length    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|A|  RESERVED   |                Link Loss                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

      This sub-TLV has a type of TBD3.
      The length is 4.

   where:

   Type: TBA.

   Length: 4.

   A-bit. The A-bit represents the Anomalous (A) bit. The A-bit is set
   when the measured value of this parameter exceeds its configured
   maximum threshold. The A bit is cleared when the measured value
   falls below its configured reuse threshold. If the A-bit is clear,
   the sub-TLV represents steady state link performance.

   A-bit. The A-bit represents the Anomalous (A) bit. The A-bit is set
   when the measured value of this parameter exceeds its configured
   maximum threshold. The A bit is cleared when the measured value
   falls below its configured reuse threshold. If the A-bit is clear,
   the sub-TLV represents steady state link performance.

   RESERVED. This field is reserved for future use. It MUST be set to
   0 when sent and MUST be ignored when received.

   Link Loss. This 24-bit field carries link packet loss as a
   percentage of the total traffic sent over a configurable interval.
   The basic unit is 0.000003%, where (2^{24} - 2) is 50.331642%. This
   value is the highest packet loss percentage that can be expressed
   (the assumption being that precision is more important on high speed
   links than the ability to advertise loss rates greater than this, and
   that high speed links with over 50% loss are unusable). Therefore,
   measured values that are larger than the field maximum SHOULD be

encoded as the maximum value. When set to a value of all 1s (2^24 -
1), the link packet loss has not been measured.

[4.5](#). Unidirectional Residual Bandwidth Sub-TLV

This TLV advertises the residual bandwidth between two directly
connected IS-IS neighbors. The residual bandwidth advertised by this
sub-TLV MUST be the residual bandwidth from the system originating
the LSA to its neighbor.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Type        |     Length    |A|   RESERVED   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Residual Bandwidth                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

Type: TBA.

Length: 4.

A-bit. The A-bit represents the Anomalous (A) bit. The A-bit is set
when the measured value of this parameter exceeds its configured
maximum threshold. The A bit is cleared when the measured value
falls below its configured reuse threshold. If the A-bit is clear,
the sub-TLV represents steady state link performance.

RESERVED. This field is reserved for future use. It MUST be set to
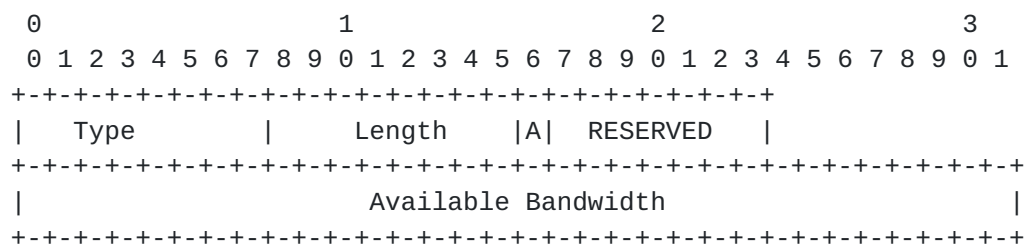0 when sent and MUST be ignored when received.

Residual Bandwidth. This field carries the residual bandwidth on a
link, forwarding adjacency [[RFC4206](#)], or bundled link in IEEE
floating point format with units of bytes per second. For a link or
forwarding adjacency, residual bandwidth is defined to be Maximum
Bandwidth [[RFC3630](#)] minus the bandwidth currently allocated to RSVP-
TE LSPs. For a bundled link, residual bandwidth is defined to be the
sum of the component link residual bandwidths.

The calculation of Residual Bandwidth is different than that of
Unreserved Bandwidth [[RFC3630](#)]. Residual Bandwidth subtracts tunnel
reservations from Maximum Bandwidth (i.e. the link capacity)
[[RFC3630](#)] and provides an aggregated remainder across QoS classes.
Unreserved Bandwidth [[RFC3630](#)], on the other hand, is subtracted from
the Maximum Reservable Bandwidth (the bandwidth that can
theoretically be reserved) [[RFC3630](#)] and provides per-QoS-class

remainders. Residual Bandwidth and Unreserved Bandwidth [RFC3630]
can be used concurrently, and each has a separate use case (e.g. the
former can be used for applications like Weighted ECMP while the
latter can be used for call admission control).

4.6. Unidirectional Available Bandwidth Sub-TLV

This Sub-TLV advertises the available bandwidth between two directly
connected IS-IS neighbors. The available bandwidth advertised by
this sub-TLV MUST be the available bandwidth from the system
originating this Sub-TLV. The format of this Sub-TLV is shown in the
following diagram:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type        |    Length     |A|  RESERVED   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Available Bandwidth                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

                            Figure 4

Type: TBA.

Length: 4.

A-bit. The A-bit represents the Anomalous (A) bit. The A-bit is set
when the measured value of this parameter exceeds its configured
maximum threshold. The A bit is cleared when the measured value
falls below its configured reuse threshold. If the A-bit is clear,
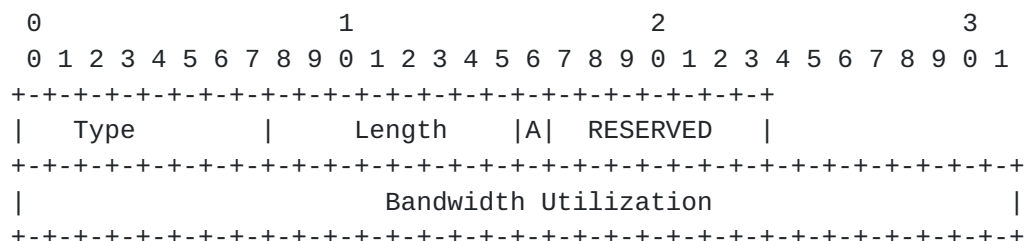the sub-TLV represents steady state link performance.

RESERVED. This field is reserved for future use. It MUST be set to
0 when sent and MUST be ignored when received.

Available Bandwidth. This field carries the available bandwidth on a
link, forwarding adjacency, or bundled link in IEEE floating point
format with units of bytes per second. For a link or forwarding
adjacency, available bandwidth is defined to be residual bandwidth
minus the measured bandwidth used for the actual forwarding of non-
RSVP-TE LSP packets. For a bundled link, available bandwidth is
defined to be the sum of the component link available bandwidths
minus the measured bandwidth used for the actual forwarding of non-
RSVP-TE Label Switched Paths packets. For a bundled link, available

bandwidth is defined to be the sum of the component link available
bandwidths.

4.7. Unidirectional Utilized Bandwidth Sub-TLV

This Sub-TLV advertises the bandwidth utilization between two
directly connected IS-IS neighbors. The bandwidth utilization
advertised by this sub-TLV MUST be the bandwidth from the system
originating this Sub-TLV. The format of this Sub-TLV is shown in the
following diagram:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type        |     Length     |A|  RESERVED    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Bandwidth Utilization                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

where:

                          Figure 5

Type: TBA.

Length: 4.

A-bit. The A-bit represents the Anomalous (A) bit. The A-bit is set
when the measured value of this parameter exceeds its configured
maximum threshold. The A bit is cleared when the measured value
falls below its configured reuse threshold. If the A-bit is clear,
the sub-TLV represents steady state link performance.

RESERVED. This field is reserved for future use. It MUST be set to
0 when sent and MUST be ignored when received.

Bandwidth Utilization. This field carries the bandwidth utilization
on a link, forwarding adjacency, or bundled link in IEEE floating
point format with units of bytes per second. For a link or
forwarding adjacency, bandwidth utilization represent the actual
utilization of the link (i.e.: as measured in the router). For a
bundled link, bandwidth utilization is defined to be the sum of the
component link bandwidth utilization.

[5]. Announcement Thresholds and Filters

The values advertised in all sub-TLVs (except Low/High delay and residual bandwidth) MUST represent an average over a period or be obtained by a filter that is reasonably representative of an average. For example, a rolling average is one such filter.

Low or High delay MAY be the lowest and/or highest measured value over a measurement interval or MAY make use of a filter, or other technique to obtain a reasonable representation of a low and high value representative of the interval with compensation for outliers.

The measurement interval, any filter coefficients, and any advertisement intervals MUST be configurable per sub-TLV.

In addition to the measurement intervals governing re-advertisement, implementations SHOULD provide per sub-TLV configurable accelerated advertisement thresholds, such that:

1. If the measured parameter falls outside a configured upper bound for all but the low delay metric (or lower bound for low-delay metric only) and the advertised sub-TLV is not already outside that bound or,

2. If the difference between the last advertised value and current measured value exceed a configured threshold then,

3. The advertisement is made immediately.

4. For sub-TLVs which include an A-bit (except low/high delay), an additional threshold SHOULD be included corresponding to the threshold for which the performance is considered anomalous (and sub-TLVs with the A-bit are sent). The A-bit is cleared when the sub-TLV's performance has been below (or re-crosses) this threshold for an advertisement interval(s) to permit fail back.

To prevent oscillations, only the high threshold or the low threshold (but not both) may be used to trigger any given sub-TLV that supports both.

Additionally, once outside of the bounds of the threshold, any readvertisement of a measurement within the bounds would remain governed solely by the measurement interval for that sub-TLV.

6. Announcement Suppression

   When link performance values change by small amounts that fall under
   thresholds that would cause the announcement of a sub-TLV,
   implementations SHOULD suppress sub-TLV readvertisement and/or
   lengthen the period within which they are refreshed.

   Only the accelerated advertisement threshold mechanism may shorten
   the re-advertisement interval. All suppression and re-advertisement
   interval backoff timer features SHOULD be configurable.

7. Network Stability and Announcement Periodicity

   Section 5 and Section 6 provide configurable mechanisms to bound the
   number of re-advertisements. Instability might occur in very large
   networks if measurement intervals are set low enough to overwhelm the
   processing of flooded information at some of the routers in the
   topology. Therefore care SHOULD be taken in setting these values.

   Additionally, the default measurement interval for all sub-TLVs
   SHOULD be 30 seconds.

   Announcements MUST also be able to be throttled using configurable
   inter-update throttle timers. The minimum announcement periodicity
   is 1 announcement per second. The default value SHOULD be set to 120
   seconds.

   Implementations SHOULD NOT permit the inter-update timer to be lower
   than the measurement interval.

   Furthermore, it is RECOMMENDED that any underlying performance
   measurement mechanisms not include any significant buffer delay, any
   significant buffer induced delay variation, or any significant loss
   due to buffer overflow or due to active queue management.

8. Enabling and Disabling Sub-TLVs

   Implementations MUST make it possible to individually enable or
   disable each sub-TLV based on configuration.

9. Static Metric Override

   Implementations SHOULD permit the static configuration and/or manual
   override of dynamic measurements data on a per sub-TLV, per metric
   basis in order to simplify migrations and to mitigate scenarios where
   measurements are not possible across an entire network.

[10](#). Compatibility

As per [[RFC5305](#)], unrecognized Sub-TLVs should be silently ignored

[11](#). Security Considerations

This document does not introduce security issues beyond those
discussed in [[RFC3630](#)] and [[RFC5329](#)].

[12](#). IANA Considerations

IANA maintains the registry for the sub-TLVs. IS-IS TE Metric
Extensions will require one new type code per sub-TLV defined in this
document.

[13](#). Acknowledgements

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[14.1](#). Normative References

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