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S. Previdi, Ed.
Cisco Systems, Inc.
S. Giacalone
Thomson Reuters
D. Ward
Cisco Systems, Inc.
J. Drake
A. Atlas
Juniper Networks
C. Filsfils
Cisco Systems, Inc.
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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 TE [[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

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).

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.

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
TBD1	Unidirectional Link Delay
TBD2	Unidirectional Delay Variation
TBD3	Unidirectional Packet Loss
TBD4	Unidirectional Residual Bandwidth Sub TLV
TBD5	Unidirectional Available Bandwidth Sub TLV

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

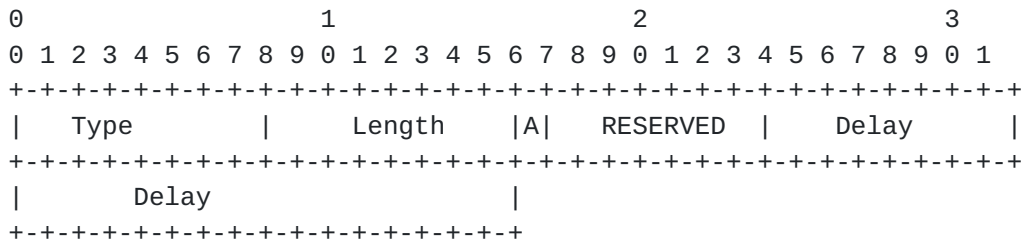
The use of TE Metric Extensions SubTLVs is not confined to the TE context. In other words, IS-IS TE Metric Extensions SubTLVs defined in this document can also be used for computing paths in the absence of a TE subsystem.

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:



This sub-TLV has a type of TBD1.
The length is 4.

Where:

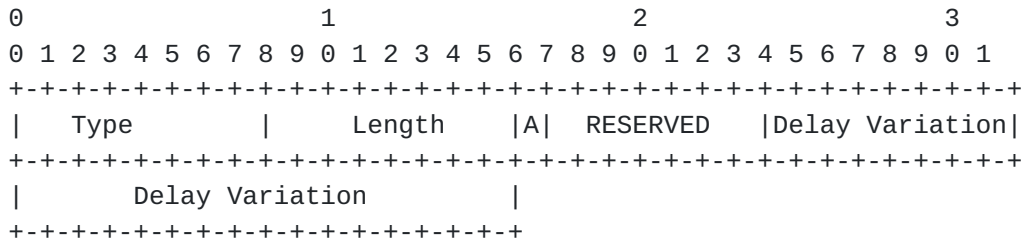
"A" represents the Anomalous (A) bit. The A bit is set when the measured value of this parameter exceeds its configured maximum threshold. The A bit is cleared when the measured value falls below its configured reuse threshold. If the A bit is clear, the sub-TLV represents steady state link performance.

The "Reserved" field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

"Delay Value" is a 24-bit field carries the average link delay 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.

4.2. 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:



This sub-TLV has a type of TBD2.
The length is 4.

Where:

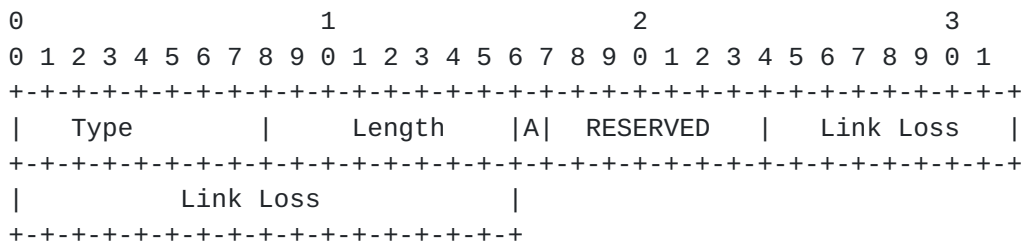
"A" represents the Anomalous (A) bit. The A bit is set when the measured value of this parameter exceeds its configured maximum threshold. The A bit is cleared when the measured value falls below its configured reuse threshold. If the A bit is clear, the sub-TLV represents steady state link performance.

The "Reserved" field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

"Delay Variation" is a 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.

4.3. 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:



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

Where:

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.

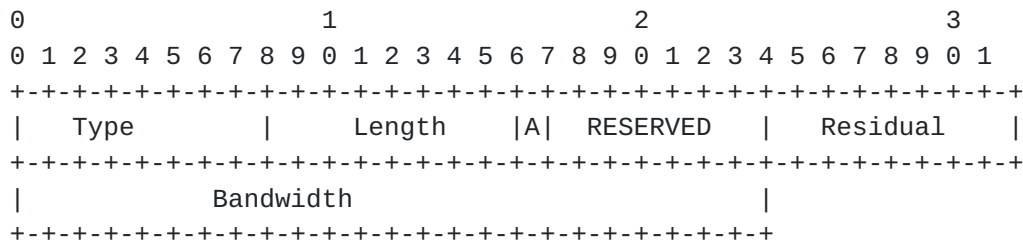
"Reserved" field is reserved for future use. It MUST be set to 0 when sent and MUST be ignored when received.

"Link Loss" is a 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.

4.4. 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 sub-TLV to its neighbor. The format of this sub-TLV is shown in the following diagram:



This sub-TLV has a type of TBD4.
The length is 5.

Where:

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.

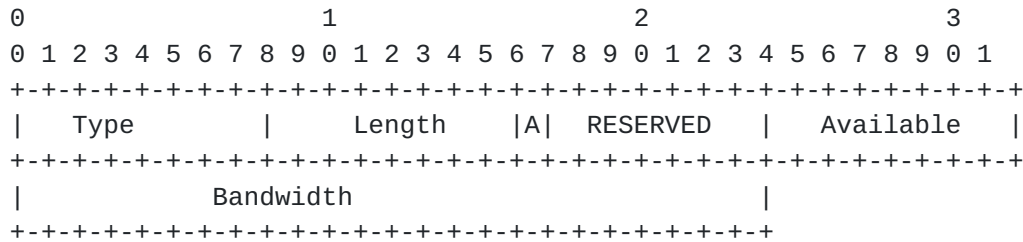
"Residual Bandwidth" is the residual bandwidth in IEEE floating point format in units of bytes per second. The link may be a single link, forwarding adjacency [RFC4206], or bundled link. For a link or forwarding adjacency, residual bandwidth is defined to be Maximum Link Bandwidth [RFC5305] minus the 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.

Note that although it may seem possible to calculate Residual Bandwidth using the existing sub-TLVs in [RFC5305], this is not a consistently reliable approach and hence the Residual Bandwidth sub-TLV has been added here. For example, because the Maximum Reservable

Bandwidth [[RFC5305](#)] can be larger than the capacity of the link, using it as part of an algorithm to determine the value of the Maximum Link Bandwidth [[RFC5305](#)] minus the bandwidth currently allocated to RSVP-TE Label Switched Paths cannot be considered reliably accurate.

4.5. Unidirectional Available Bandwidth Sub-TLV

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



This sub-TLV has a type of TBD5.
The length is 5.

Where:

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.

"Available Bandwidth" is a field that 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 (see [Section 4.4](#)) 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.

5. Announcement Thresholds and Filters

The values advertised in all sub-TLVs MUST be controlled using an exponential filter (i.e. a rolling average) with a configurable

measurement interval and filter coefficient.

Implementations are expected to provide separately configurable advertisement thresholds. All thresholds **MUST** be configurable on a per sub-TLV basis.

The announcement of all sub-TLVs that do not include the A bit **SHOULD** be controlled by variation thresholds that govern when they are sent.

Sub-TLVs that include the A bit are governed by several thresholds. Firstly, a threshold **SHOULD** be implemented to govern the announcement of sub-TLVs that advertise a change in performance, but not an SLA violation (i.e. when the A bit is not set). Secondly, implementations **MUST** provide configurable thresholds that govern the announcement of sub-TLVs with the A bit set (for the indication of a performance violation). Thirdly, implementations **SHOULD** provide reuse thresholds. These thresholds govern sub-TLV re-announcement with the A bit cleared to permit fail back.

6. Announcement Suppression

When link performance average values change, but fall under the threshold that would cause the announcement of a sub-TLV with the A bit set, implementations **MAY** suppress or throttle sub-TLV announcements. All suppression features and thresholds **SHOULD** be configurable.

7. Network Stability and Announcement Periodicity

To mitigate concerns about stability, all values (except residual bandwidth) **MUST NOT** be instantaneous measurements. The period to compute statistics, whether rolling average, rolling 98th percentile, or network custom, **MUST** be a configurable period of time. Announcements **MUST** also be able to be throttled using configurable inter-update throttle timers. The minimum announcement periodicity is 1 announcement per second.

8. Compatibility

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

9. Security Considerations

This document does not introduce security issues beyond those

discussed in [[RFC3630](#)] and [[RFC5329](#)].

10. 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.

11. Acknowledgements

The authors would like to recognize Ayman Soliman and Les Ginsberg for their contributions.

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Authors' Addresses

Stefano Previdi (editor)
Cisco Systems, Inc.
Via Del Serafico 200
Rome 00191
IT

Email: sprevidi@cisco.com

Spencer Giacalone
Thomson Reuters
195 Broadway
New York, NY 10007
USA

Email: Spencer.giacalone@thomsonreuters.com

Dave Ward
Cisco Systems, Inc.
3700 Cisco Way
SAN JOSE, CA 95134
US

Email: wardd@cisco.com

John Drake
Juniper Networks
1194 N. Mathilda Ave.
Sunnyvale, CA 94089
USA

Email: jdrake@juniper.net

Alia Atlas
Juniper Networks
1194 N. Mathilda Ave.
Sunnyvale, CA 94089
USA

Email: akatlas@juniper.net

Clarence Filsfils
Cisco Systems, Inc.
Brussels
Belgium

Email: cfilsfil@cisco.com

