SPRING Working Group
Internet-Draft
Intended Status: Informational
Expires: January 16, 2019

R. Gandhi, Ed.
C. Filsfils
S. Soni
Cisco Systems, Inc.
D. Voyer
Bell Canada
S. Salsano
Universita di Roma "Tor Vergata"
P. L. Ventre
CNIT
M. Chen
Huawei

July 15, 2018

Performance Measurement in Segment Routing Networks with MPLS Data Plane draft-gandhi-spring-sr-mpls-pm-02

Abstract

RFC 6374 specifies protocol mechanisms to enable the efficient and accurate measurement of packet loss, one-way and two-way delay, as well as related metrics such as delay variation in MPLS networks using probe messages. This document reviews how these mechanisms can be used for Delay and Loss Performance Measurements (PM) in Segment Routing (SR) networks with MPLS data plane (SR-MPLS), for both SR links and end-to-end SR Policies. The performance measurements for SR links are used to compute extended Traffic Engineering (TE) metrics for delay and loss and are advertised in the network using routing protocols.

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1. Introduction

Service provider's ability to satisfy Service Level Agreements (SLAs) depend on the ability to measure and monitor performance metrics for packet loss and one-way and two-way delay, as well as related metrics such as delay variation. The ability to monitor these performance metrics also provides operators with greater visibility into the performance characteristics of their networks, thereby facilitating planning, troubleshooting, and network performance evaluation.

[RFC6374] specifies protocol mechanisms to enable the efficient and accurate measurement of these performance metrics in MPLS networks using probe messages. The One-Way Active Measurement Protocol (OWAMP) defined in [RFC4656] and Two-Way Active Measurement Protocol (TWAMP) defined in [RFC5357] provide capabilities for the measurement of various performance metrics in IP networks. However, mechanisms defined in [RFC6374] are more suitable for Segment Routing (SR) when using MPLS data plane (SR-MPLS). In addition, [RFC6374] also supports IEEE 1588 timestamps [IEEE1588] and "direct mode" Loss Measurement (LM), which are required in SR networks.

[RFC7876] specifies the procedures to be used when sending and processing out-of-band performance measurement probe replies over an UDP return path when receiving RFC 6374 based probe queries. These procedures can be used to send out-of-band PM replies for both SR links and SR Policies for one-way measurement.

This document reviews how probe based mechanisms defined in [RFC6374] can be used for Delay and Loss Performance Measurements (PM) in SR networks with MPLS data plane, for both SR links and end-to-end SR Policies. The performance measurements for SR links are used to compute extended Traffic Engineering (TE) metrics for delay and loss and are advertised in the network using routing protocols.

2. Conventions Used in This Document

2.1. Abbreviations

ACH: Associated Channel Header.

DFLag: Data Format Flag.

DM: Delay Measurement.

ECMP: Equal Cost Multi-Path.

G-ACh: Generic Associated Channel (G-ACh)

GAL: Generic Associated Channel (G-ACh) Label

LM: Loss Measurement.

MPLS: Multiprotocol Label Switching.

PM: Performance Measurement.

PTP: Precision Time Protocol.

SID: Segment ID.

SR: Segment Routing.

TC: Traffic Class.

TE: Traffic Engineering.

URO: UDP Return Object.

2.2. Reference Topology

In the reference topology shown in Figure 1, the querier node R1 initiates a performance measurement probe query and the responder node R5 sends a probe response for the query message received. The probe response is sent to the querier node R1. The nodes R1 and R5 may be directly connected via a link enabled with Segment Routing or there exists an SR Policy [I-D.spring-segment-routing-policy] on node R1 with destination to node R5.

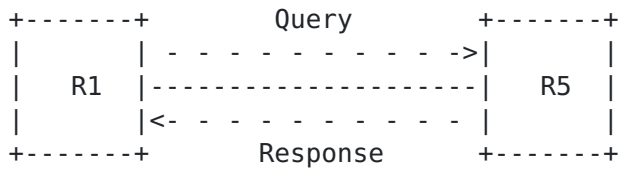


Figure 1: Reference Topology

Both delay and loss performance measurement is performed for the traffic traversing between node R1 and node R5. One-way delay and two-way delay measurements are defined in Section 2.4 of [RFC6374]. Transmit and Receive packet loss measurements are defined in Section 2.2 of [RFC6374]. One-way loss measurement provides transmit packet loss whereas two-way loss measurement provides both transmit and receive packet loss.

3. Probe Query and Response Packets

3.1. Probe Packet Header for SR-MPLS Policies

As described in Section 2.9.1 of [RFC6374], MPLS PM probe query and response messages flow over the MPLS Generic Associated Channel (G-ACh). A probe packet for an end-to-end measurement for SR Policy contains SR-MPLS label stack [I-D.spring-segment-routing-policy], with the G-ACh Label (GAL) at the bottom of the stack. The GAL is followed by an Associated Channel Header (ACH), which identifies the message type and the message payload following the ACH as shown in Figure 2.

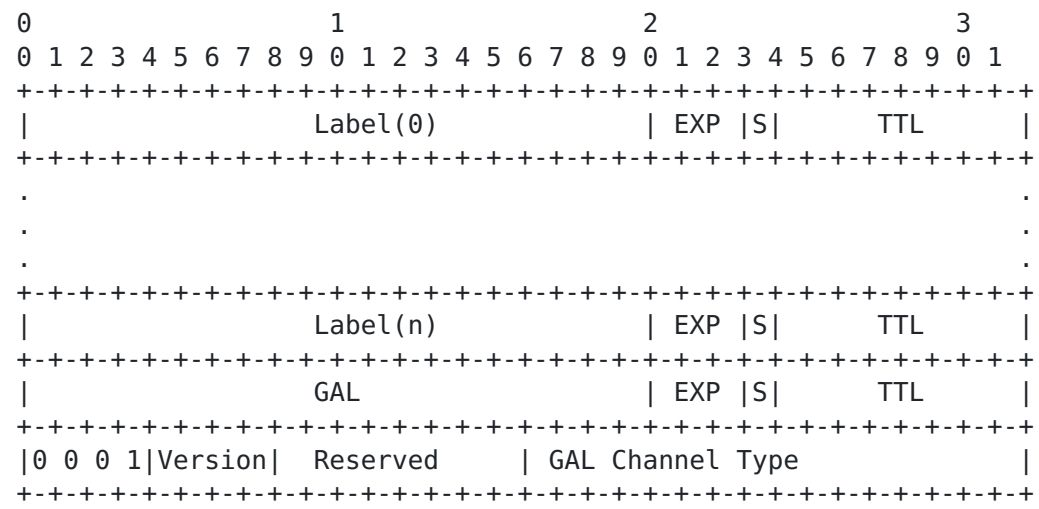
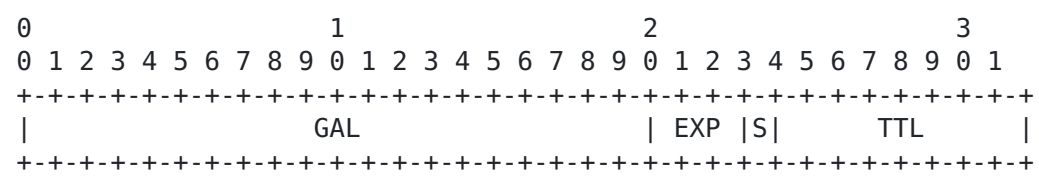


Figure 2: Probe Packet Header for an End-to-end SR-MPLS Policy

The SR-MPLS label stack can be empty to indicate Implicit NULL label case.

3.2. Probe Packet Header for SR-MPLS Links

As described in Section 2.9.1 of [RFC6374], MPLS PM probe query and response messages flow over the MPLS Generic Associated Channel (G-ACh). A probe packet for SR-MPLS links contains G-ACh Label (GAL). The GAL is followed by an Associated Channel Header (ACH), which identifies the message type, and the message payload following the ACH as shown in Figure 3.



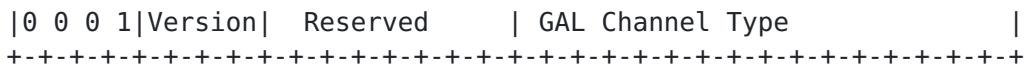


Figure 3: Probe Packet Header for an SR-MPLS Link

3.3. Probe Response Message for SR-MPLS Links and Policies

3.3.1. One-way Measurement Probe Response Message

For one-way performance measurement [RFC7679], the PM querier node can receive "out-of-band" probe replies by properly setting the UDP Return Object (URO) TLV in the probe query message. The URO TLV (Type=131) is defined in [RFC7876] and includes the UDP-Destination-Port and IP Address. In particular, if the querier sets its own IP address in the URO TLV, the probe response is sent back by the responder node to the querier node. In addition, the "control code" in the probe query message is set to "out-of-band response requested".

3.3.2. Two-way Measurement Probe Response Message

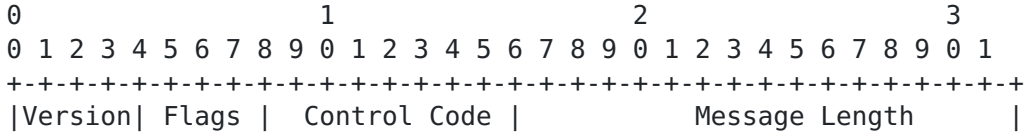
For two-way performance measurement [RFC6374], when using a bidirectional channel, the probe response message is sent back to the querier node in-band on the reverse direction SR Link or SR Policy using a message with format similar to their probe query message. In this case, the "control code" in the probe query message is set to "in-band response requested".

4. Performance Delay Measurement

4.1. Delay Measurement Message Format

As defined in [RFC6374], MPLS DM probe query and response messages use Associated Channel Header (ACH) (value 0x000C for delay measurement) [RFC6374], which identifies the message type, and the message payload following the ACH. For both SR links and end-to-end measurement for SR Policies, the same MPLS DM ACH value is used.

The DM message payload as defined in [RFC6374] is used for SR-MPLS delay measurement, for both SR links and end-to-end SR Policies. The DM message payload format is defined as following in [RFC6374]:



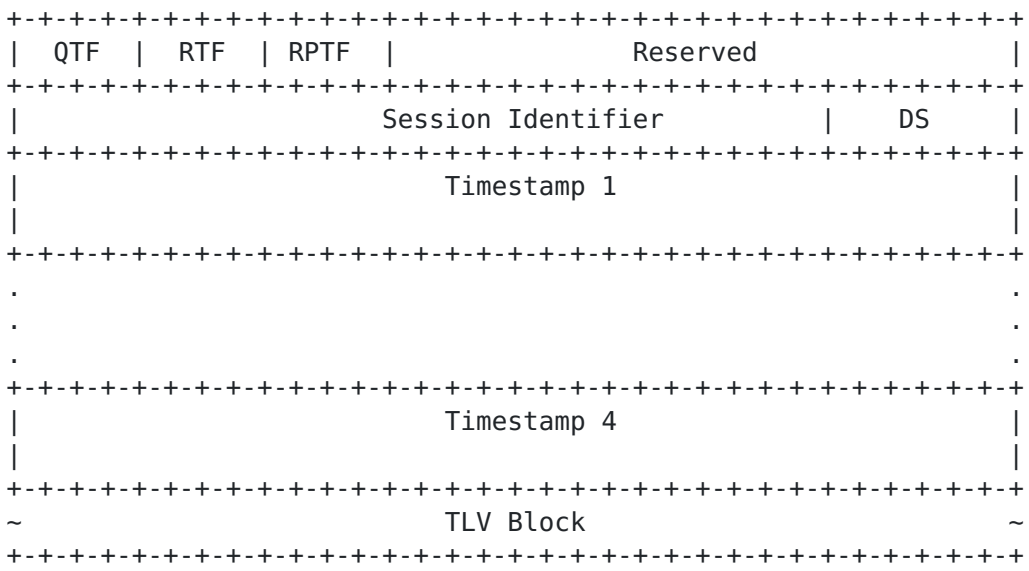


Figure 4: Delay Measurement Message Payload Format

The meanings of the fields are summarized in the following table, see [RFC6374] for details.

Field	Meaning
Version	Protocol version
Flags	Message control flags
Control Code	Code identifying the query or response type
QTF	Querier timestamp format (see Section 3.4 of [RFC6374])
RTF	Responder timestamp format (see Section 3.4 of [RFC6374])
RPTF	Responder's preferred timestamp format
Reserved	Reserved for future specification
Session Identifier	Set arbitrarily by the querier
Differentiated Services (DS) Field	Differentiated Services Code Point (DSCP) being measured
Timestamp 1-4	64-bit timestamp values (see Section 3.4 of [RFC6374])

TLV Block	Optional block of Type-Length-Value fields

4.2. Timestamp

The Section 3.4 of [RFC6374] defines timestamp format that can be used for delay measurement. The IEEE 1588 Precision Time Protocol (PTP) timestamp format [IEEE1588] is used by default as described in Appendix A of [RFC6374], but it may require hardware support. As an alternative, Network Time Protocol (NTP) timestamp format can also be used [RFC6374].

Note that for one-way delay measurement, clock synchronization between the querier and responder nodes using the methods detailed in [RFC6374] is required. The two-way delay measurement does not require clock to be synchronized between the querier and responder nodes.

5. Performance Loss Measurement

The LM protocol can perform two distinct kinds of loss measurement as described in Section 2.9.8 of [RFC6374].

- In inferred mode, LM will measure the loss of specially generated test messages in order to infer the approximate data plane loss level. Inferred mode LM provides only approximate loss accounting.

- In direct mode, LM will directly measure data plane packet loss. Direct mode LM provides perfect loss accounting, but may require hardware support.

For both of these modes of LM, path segment identifier [I-D.spring-mpls-path-segment] can be used for measuring traffic on the egress node.

5.1. Loss Measurement Message Format

As defined in [RFC6374], MPLS LM probe query and response messages use Associated Channel Header (ACH) (value 0x000A for direct loss measurement or value 0x000B for inferred loss measurement), which identifies the message type, and the message payload following the ACH. For both SR links and end-to-end measurement for SR Policies, the same MPLS LM ACH value is used.

The LM message payload as defined in [RFC6374] is used for SR-MPLS loss measurement, for both SR links and end-to-end SR Policies. The LM message payload format is defined as following in [RFC6374]:

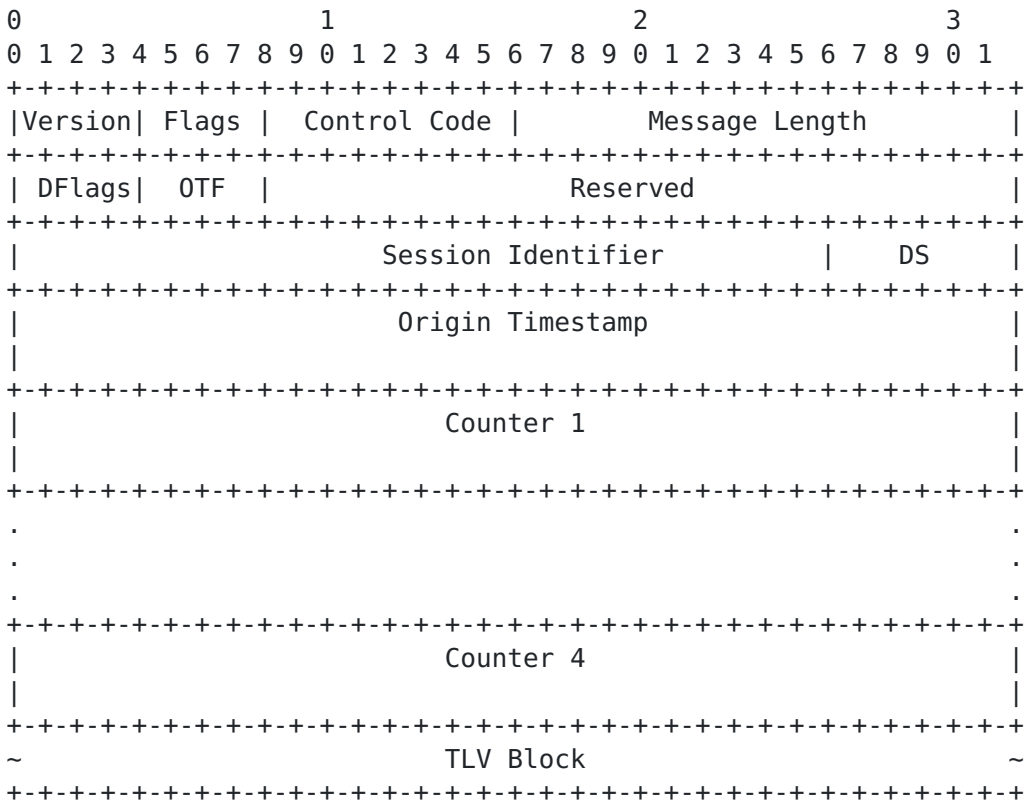


Figure 5: Loss Measurement Message Payload Format

The meanings of the fields are summarized in the following table, see [RFC6374] for details.

Field	Meaning
Version	Protocol version
Flags	Message control flags
Control Code	Code identifying the query or response type
Message Length	Total length of this message in bytes
Data Format Flags (DFlags)	Flags specifying the format of message data
Origin Timestamp Format (OTF)	Format of the Origin Timestamp field
Reserved	Reserved for future specification

Session Identifier	Set arbitrarily by the querier
Differentiated Services (DS) Field	Differentiated Services Code Point (DSCP) being measured
Origin Timestamp	64-bit field for query message transmission timestamp
Counter 1-4	64-bit fields for LM counter values
TLV Block	Optional block of Type-Length-Value fields

6. SR Link Extended TE Metrics Advertisements

The extended TE metrics for SR link delay and loss computed using the performance measurement procedures reviewed in this document can be advertised in the routing domain as follows:

- For OSPF, ISIS, and BGP-LS, protocol extensions defined in [RFC7471], [RFC7810] [I-D.lsr-isis-rfc7810bis], and [I-D.idr-te-pm-bgp] are used, respectively for advertising the extended TE link metrics in the network.
- The extended link delay metrics advertised are minimum-delay, maximum-delay, average-delay and delay-variance for one-way.
- The delay-variance is computed as specified in Section 4.2 of [RFC5481].
- The one-way delay metrics can be computed using two-way measurement by dividing the measured delay values by 2.
- The extended TE link loss metric advertised is one-way percentage packet loss.

7. Security Considerations

This document reviews the procedures for performance measurement for SR-MPLS networks, for both SR-MPLS links and end-to-end SR-MPLS Policies using the mechanisms defined in [RFC6374]. This document does not introduce any additional security considerations other than those covered in [RFC6374], [RFC7471], [RFC7810].

8. IANA Considerations

This document does not require any IANA actions.

9. References

9.1. Normative References

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[RFC7876] Bryant, S., Sivabalan, S., and Soni, S., "UDP Return Path for Packet Loss and Delay Measurement for MPLS Networks", RFC 7876, July 2016.

9.2. Informative References

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[RFC7679] Almes, G., et al., "A One-Way Delay Metric for IP Performance Metrics (IPPM)', RFC 7679, January 2016.

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[RFC7810] Previdi, S., et al., "IS-IS Traffic Engineering (TE) Metric Extensions", RFC 7810, May 2016.

[I-D.lsr-isis-rfc7810bis] Ginsberg, L., et al., "IS-IS Traffic Engineering (TE) Metric Extensions", draft-ietf-lsr-isis-rfc7810bis, work in progress.

[I-D.idr-te-pm-bgp] Ginsberg, L. Ed., et al., "BGP-LS Advertisement of IGP Traffic Engineering Performance Metric Extensions", draft-ietf-idr-te-pm-bgp, work in progress.

[I-D.spring-segment-routing-policy] Filsfils, C., et al., "Segment Routing Policy Architecture", draft-ietf-spring-segment-routing-policy, work in progress.

[I-D.spring-mpls-path-segment] Cheng, W., et al., 'Path Segment in MPLS Based Segment Routing Network', draft-cheng-spring-mpls-path-segment, work in progress.

Acknowledgments

To be added.

Contributors

Patrick Khordoc
Cisco Systems, Inc.
Email: pkhordoc@cisco.com

Zafar Ali
Cisco Systems, Inc.
Email: zali@cisco.com

Daniel Bernier
Bell Canada
Email: daniel.bernier@bell.ca

Authors' Addresses

Rakesh Gandhi (editor)
Cisco Systems, Inc.
Canada
Email: rgandhi@cisco.com

Clarence Filsfils
Cisco Systems, Inc.
Email: cfilsfil@cisco.com

Sagar Soni
Cisco Systems, Inc.
Email: sagsoni@cisco.com

Daniel Voyer
Bell Canada
Email: daniel.voyer@bell.ca

Stefano Salsano
Universita di Roma "Tor Vergata"
Italy

Email: stefano.salsano@uniroma2.it

Pier Luigi Ventre
CNIT
Italy
Email: pierluigi.ventre@cnit.it

Mach(Guoyi) Chen
Huawei
Email: mach.chen@huawei.com