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A. D'Alessandro
Telecom Italia
L. Andersson
Huawei Technologies
M. Paul
Deutsche Telekom
S. Ueno
NTT Communications
K. Arai
Y. Koike
NTT

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Enhanced path segment monitoring
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Abstract

The MPLS transport profile (MPLS-TP) has been standardized to enable carrier-grade packet transport and complement converged packet network deployments. Among the most attractive features of MPLS-TP there are OAM functions, which enable network operators or service providers to provide various maintenance characteristics, such as fault location, survivability, performance monitoring and in-service/ out of service measurements.

One of the most important mechanisms which is common for transport network operation is fault location. A segment monitoring function of a transport path is effective in terms of extension of the maintenance work and indispensable particularly when the OAM function is effective only between end points. However, the current approach defined for MPLS-TP for the segment monitoring (SPME) has some drawbacks. This document elaborates on the problem statement for the Sub-path Maintenance Elements (SPMEs) which provides monitoring of a portion of a set of transport paths (LSPs or MS-PWs). Based on the problems, this document specifies new requirements to consider a new improved mechanism of hitless transport path segment monitoring named Enhanced Path Segment Monitoring (EPSM).

Status of This Memo

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1. Introduction

A packet transport network enables carriers or service providers to use network resources efficiently, reduces operational complexity and provides carrier-grade network operation. Appropriate maintenance functions, supporting fault location, survivability, performance monitoring and preliminary or in-service measurements, are essential to ensure quality and reliability of a network. They are essential in transport networks and have evolved along with TDM, ATM, SDH and OTN.

As legacy technologies, also MPLS-TP does not scale when an arbitrary number of OAM functions are enabled.

According to the MPLS-TP OAM requirements RFC 5860 [RFC5860], mechanisms MUST be available for alerting a service provider of a fault or defect affecting services. In addition, to ensure that faults or degradations can be localized, operators need a method to analyze or investigate the problem being end-to-end monitoring insufficient. In fact using end-to-end OAM monitoring, an operator is not able to localize a fault or degrade.

Thus, a specific segment monitoring function for detailed analysis, by selecting and focusing on a specific portion of a transport path, is indispensable to promptly and accurately localize the fault.

For MPLS-TP, a path segment monitoring function has been defined to perform this task. However, as noted in the MPLS-TP OAM Framework RFC 6371 [RFC6371], the current method for segment monitoring function of a transport path has implications that hinder the usage in an operator network.

This document elaborates on the problem statement for the path segment monitoring function and proposes to consider a new improved method for segment monitoring, following up the work done in RFC 6371 [RFC6371]. Moreover, this document explains detailed requirements on the new temporal and hitless segment monitoring function which are not covered in RFC 6371 [RFC6371].

2. Conventions used in this document

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].

2.1. Terminology

EPSM - Enhanced Path Segment Monitoring

LSP - Label Switched Path

LSR - Label Switching Router

ME - Maintenance Entity

MEG - Maintenance Entity Group

MEP - Maintenance Entity Group End Point

MIP - Maintenance Entity Group Intermediate Point

OTN - Optical Transport Network

PST - Path Segment Tunnel

TCM - Tandem connection monitoring

SDH - Synchronous Digital Hierarchy

SPME - Sub-path Maintenance Element

2.2. Definitions

None.

3. Network objectives for segment monitoring

There are two required network objectives for MPLS-TP segment monitoring as described in section 3.8 of RFC 6371 [RFC6371].

1. The monitoring and maintenance of current transport paths has to be conducted in-service without traffic disruption.

2. Segment monitoring must not modify the forwarding of the segment portion of the transport path.

4. Problem Statement

Sub-Path Maintenance Element (SPME) is defined in RFC 5921 [RFC5921] to monitor, protect, or manage portions of transport paths, such as LSPs in MPLS-TP networks. The SPME is defined between the edges of the portion of the transport path that needs to be monitored, protected, or managed. This SPME is created by stacking the shim

header (MPLS header) according to RFC 3031 [RFC3031] and is defined as the segment where the header is stacked. OAM messages can be initiated at the edge of the SPME and sent to the peer edge of the SPME or to a MIP along the SPME by setting the TTL value of the label stack entry (LSE) and interface identifier value at the corresponding hierarchical LSP level in case of per-node model.

This method has the following drawbacks, which impact on operation costs:

(P-1) Lowering the bandwidth efficiency by increasing the overhead by shim headers stacking

(P-2) Increasing network management complexity, as a new sublayer and new MEPs and MIPs need to be configured for the SPME

Problem (P-1) comes from shim headers stacking that increase the overhead.

Problem (P-2) is related to identifiers management issue. The identification of each sub-layer in case of label stacking is required for the segment monitoring in a MPLS-TP network. When SPME is applied for on-demand OAM functions in MPLS-TP networks in a similar manner to TCM for OTN or Ethernet transport networks, a possible rule of differentiating those SPME/TCMs operationally will be necessary at least within an administrative domain. This enforces operators to create an additional permanent layer identification policy only for temporal path segment monitoring. Moreover, from the perspective of operation, increasing the managed addresses and the managed layers is not desirable to keep transport networks as simple as possible. Reducing the managed identifiers and managed sub-layers should be the fundamental direction in designing the architecture.

The analogy for SPME in legacy transport networks is Tandem Connection Monitoring (TCM), which is on-demand and does not change the transport path.

Moreover, using currently defined methods, the temporal setting of SPMEs also causes the following problems due to label stacking:

(P-3) Changing the original condition of transport path by changing the length of MPLS frames and changing the value of exposed label

(P-4) Disrupting client traffic over a transport path, if the SPME is configured on demand.

Problem (P-3) has impacts on network objective (2). The monitoring function should monitor the status without changing any conditions of the targeted monitored segment or transport path. Changing the settings of the original shim header should not be allowed because those changes correspond to creating a new portion of the original transport path, which differs from the original data plane conditions. If the conditions of the transport path change, the measured value or observed data will also change. This may make the monitoring meaningless because the result of the monitoring would no longer reflect the reality of the connection where the original fault or degradation occurred.

Figure 1 shows an example of SPME setting. In the figure, X means the label value expected on the tail-end node D of the original transport path. "210" and "220" are label allocated for SPME. The label values of the original path are modified as well as the values of stacked label. As shown in Figure 1, SPME changes both the length of MPLS frames and label value(s). This is no longer the monitoring of the original transport path but the monitoring of a different path. Particularly, performance monitoring measurement (e.g. Delay measurement and packet loss measurement) are sensitive to those changes.

```
(Before SPME settings)
 ---     ---     ---     ---     ---
|   |   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |   |
 ---     ---     ---     ---     ---
 A---100--B--110--C--120--D--130--E  <= transport path
 MEP                             MEP

(After SPME settings)
 ---     ---     ---     ---     ---
|   |   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |   |
 ---     ---     ---     ---     ---
 A---100--B-----------X---D--130--E  <= transport path
 MEP     \                 /    MEP
          --210--C--220--            <= SPME
         MEP'          MEP'
```

Figure 1: An Example of a SPME setting

Problem (P-4) can be avoided if the operator sets SPMEs in advance until the end of life of a transport path, which is neither temporal nor on demand. Furthermore SMPEs cannot be set arbitrarly because overlapping of path segments is limited to nesting relationship. As a result, possible SPME patterns of portions of an original transport path are limited due to the characteristic of SPME shown in Figure 1, even if SPMEs are pre- configured.

Although the make-before-break procedure in the survivability document RFC 6372 [RFC6372] seemingly supports the hitless configuration for monitoring according to the framework document RFC 5921 [RFC5921], the reality is that configurating an SPME is impossible without violating network objective (2). These concerns are reported in section 3.8 of RFC 6371 [RFC6371].

Moreover, make-before-break approach might not be effective under the static model without a control plane because the make-before-break is a restoration application based on the control plane. So management systems should provide support for SPME creation and for coordinated traffic switching from original transport path to the SPME.

Other potential risks are also envisaged. Setting up a temporal SPME will result in the LSRs within the monitoring segment only looking at the added (stacked) labels and not at the labels of the original LSP. This means that problems stemming from incorrect (or unexpected) treatment of labels of the original LSP by the nodes within the monitored segment could not be found when setting up SPME. This might include hardware problems during label look-up, mis-configuration etc. Therefore operators have to pay extra attention to correctly setting and checking the label values of the original LSP in the configuration. Of course, the inversion of this situation is also possible, e.g., incorrect or unexpected treatment of SPME labels can result in false detection of a fault where none of the problem originally existed.

The utility of SPMEs is basically limited to inter-carrier or inter-domain segment monitoring where they are typically pre-configured or pre-instantiated. SPME instantiates a hierarchical transport path (introducing MPLS label stacking) through which OAM packets can be sent. SPME construct monitoring function is particularly important mainly for protecting bundles of transport paths and carriers' carrier solutions. SPME is expected to be mainly used for protection purpose within one administrative domain.

To summarize, the problem statement is that the current sub-path maintenance based on a hierarchical LSP (SPME) is problematic for pre-configuration in terms of increasing bandwidth by label stacking and managing objects by layer stacking and address management. A on-

demand/temporal configuration of SPME is one of the possible approaches for minimizing the impact of these issues. However, the current method is unfavorable because the temporal configuration for monitoring can change the condition of the original monitored transport path. To avoid the drawbacks discussed above, a more efficient approach is required for MPLS-TP transport network operation to overcome or minimize the impact of the above described drawbacks. A monitoring mechanism, named on-demand Enhanced Path Segment Monitoring (EPSM), supporting temporal and hitless path segment monitoring is proposed.

5. OAM functions supported in segment monitoring

OAM functions that may useful exploited across on-demand EPSM are basically limited to on-demand performance monitoring functions which are defined in OAM framework document RFC 6371 [RFC6371]. Segment performance monitoring is used to evaluate the performance and hence the status of transport path segments. The "on-demand" attribute is generally temporal for maintenance operation.

Packet loss and packet delay are OAM functions strongly required in hitless and temporal segment monitoring because these functions are supported only between end points of a transport path. If a defect occurs, it might be quite hard to locate the defect or degradation point without using the segment monitoring function. If an operator cannot locate or narrow the cause of the fault, it is quite difficult to take prompt actions to solve the problem.

Other on-demand monitoring functions, (e.g. and Delay variation measurement) are desirable but not as necessary as the previous mentioned functions.

Regarding out-of-service on-demand performance management functions (e.g. Throughput measurement), there seems no need for EPSM. However, OAM functions specifically designed for segment monitoring should be developed to satisfy network objective (2) described in section 3.

Finally, the solution for EPSM has to cover both per-node model and per- interface model which are specified in RFC 6371 [RFC6371].

6. Requirements for enhanced segment monitoring

In the following clauses, mandatory (M) and optional (O) requirements are for the new segment monitoring function are listed.

6.1. Non intrusive segment monitoring

One of the major problem of legacy SPME that has been highlighted in Sec. 4 is that it does not monitor the original transport path and it could distrupt service traffic when set-up on demand.

(M1) EPSM must not change the original condition of transport path (e.g. must not change the lenght of MPLS frames, the exposed label values, etc.)

(M2) EPSM must be set on demand without traffic dispruption

6.2. Single and multiple levels monitoring

The new segment monitoring function is supposed to be applied mainly for on-demand diagnostic purpose. We can differentiate this monitoring from the proactive segment monitoring as on-demand multi-level monitoring. The most serious problem at the moment is that there is no way to localize the degraded portion of a path without changing the conditions of the original path. Therefore, as a first step, single layer segment monitoring not affecting the monitored path is required for a new on-demand and hitless segment monitoring function. A combination of multi-level and simultaneous segment monitoring is the most powerful tool for accurately diagnosing the performance of a transport path. However, on field, a single level approach may be enough.

(M3) Single-level segment monitoring is required

(O1) Multi-level segment monitoring is desirable

Figure 2 shows an example of a multi-level on-demand segment monitoring.

```
  ---     ---     ---     ---     ---
 |   |   |   |   |   |   |   |   |   |
 | A |   | B |   | C |   | D |   | E |
  ---     ---     ---     ---     ---
  MEP                            MEP <= ME of a transport path
          *------------------*       <=On-demand segm. monit. level 1
            *-------------*          <=On-demand segm. monit. level 2
                  *-*                <=On-demand segm. monit. level 3
```

Figure 2: Example of multi-level on-demand segment monitoring

6.3. EPSM and end-to-end proactive monitoring independence

The necessity of simultaneous monitoring of current end-to-end proactive monitoring and new on-demand path segment monitoring is here below considered. Normally, the on-demand path segment monitoring is configured in a segment of a maintenance entity of a transport path. In such an environment, on-demand single-level monitoring should be done without disrupting pro-active monitoring of the targeted end- to-end transport path to avoid missing user traffic performance monitoring.

Accordingly,

(M4) EPSM shall be established without changing or interfering with the already in place end-to-end pro-active monitoring of transport path

```
    ---     ---     ---     ---     ---
   |   |   |   |   |   |   |   |   |   |
   | A |   | B |   | C |   | D |   | E |
    ---     ---     ---     ---     ---
    MEP                             MEP <= ME of a transport path
      +----------------------------+   <= Proactive E2E monitoring
            *------------------*        <= On-demand segment monitoring
```

Figure 3: Independency between proactive end-to-end monitoring and on-demand segment monitoring

6.4. Arbitrary segment monitoring

The main objective of on-demand segment monitoring is to diagnose the fault points. One possible realistic diagnostic procedure is to fix one end point of a segment at the MEP of the transport path under observation and change progressively the length of the segments. This example is shown in Figure 4.

```
    ---     ---     ---     ---     ---
   |   |   |   |   |   |   |   |   |   |
   | A |   | B |   | C |   | D |   | E |
    ---     ---     ---     ---     ---
    MEP                             MEP <= ME of a transport path
      +-----------------------------+   <= Proactive E2E monitoring
      *-----*                        <= 1st on-demand segment monitoring
      *-------*                      <= 2nd on-demand segment monitoring
      *------------*                 <= 3rd on-demand segment monitoring
           |                                |
           |                                |
      *-----------------------*      <= 6th on-demand segment monitoring
      *-----------------------------*<= 7th on-demand segment monitoring
```

Figure 4: A procedure to localize a defect by consecutive on-demand segments monitoring

Another possible scenario is depicted in Figure 5. In this case, the operators want to diagnose a transport path from a transit node that is located at the middle, because the end nodes(A and E) are located at customer sites and consist of cost effective small box supporting only a subset of OAM functions. In that case, if the source entities of the diagnostic packets are limited to the position of MEPs, on-demand segment monitoring will be ineffective because not all the segments can be diagnosed (e.g. segment monitoring 3 in Figure 5 is not available and it is not possible to precisely localize the fault point).

Accordingly,

(M5) EPSM shall be set in an arbitrary segment of a transport path and diagnostic packets should be inserted/terminated at any of intermediate maintenance points of the original ME.

```
              ---     ---     ---
      ---    |   |   |   |   |   |    ---
     | A |   | B |   | C |   | D |   | E |
      ---     ---     ---     ---     ---
      MEP                             MEP <= ME of a transport path
        +-----------------------------+   <= Proactive E2E monitoring
        *-----*                        <= On-demand segment monitoring 1
              *-----------------------*<= On-demand segment monitoring 2
              *---------*              <= On-demand segment monitoring 3
```

Figure 5: HSPM is configured at arbitrary segments

6.5. Fault while EPSM is in place

Node or link failures may occur while EPSM is active. In that case, if no resiliency mechanism is set-up on the subtended transport path, there is no particular requirement for EPSM while if the trasport path is protected, EPSM function should be terminated to avoid monitoring a new segment when a protection or restoration path is in place. Therefore

(M5) EPSM function should avoid monitoring an unintended segment when failures occur

The folowing examples are reported for clarification only and shall not be intended to restrict any solution for meeting the requirements of EPSM. A Protection scenario A is shown in figure 6. In this scenario, a working LSP and a protection LSP are set. EPSM is set between A and E. Considering a fault happens between nodes B and C, the EPSM is not affected by protection and continues in the working LSP path. As a result, requirement (M5) is satisfied.

```
      A - B - C - D - E - F
        \               /
          G - H - I - L

      Where:
      - e2e LSP: A-B-C-D-E-F
      - working LSP: A-B-C-D-E-F
      - protection LSP: A-B-G-H-I-L-F
      - EPSM: A-E
      ---------------
```

Figure 6: Protection scenario A

Differently, figure 7 shows a scenario where only a portion of a transport path is protected. In this case, when a fault happen between node B and C along the working sub-path, traffic is switched to protection sub-path B-G-H-D. In the hypotesis that OAM packets termination depend only on TTL value of MPLS label header, the target node of EPSM changes from E to D due to the difference of hop counts between the working path route (ABCDE: 4 hops) and protection path route (ABGHDE: 5 hops). As a result, requirement (M5) is not satisfied.

```
       A - B - C - D - E - F
             \     /
              G - H

    - e2e LSP: A-B-C-D-E-F
    - working sub-path: B-C-D
    - protection sub-path: B-G-H-D
    - EPSM: A-E
    ---------------
```

Figure 7: Protection scenario B

6.6. EPSM maintenance points

An intermediate maintenance point supporting the EPSM has to be able to generate and inject OAM packets. Although maintenance points for the EPSM do not necessarily have to coincide with MIPs or MEPs in terms of the architecture definition,

(M7) The same identifiers for MIPs and/or MEPs should be applied to EPSM maintenance points

7. Summary

An enhanced monitoring mechanism is required to support temporal and hitless segment monitoring which meets the two network objectives described in section 3.8 of RFC 6371 [RFC6371] and reported in Section 3 of this document.

The enhancements should minimize the issues described in Section 4, i.e., P-1, P-2, P-3 and P-4.

The solution for the temporal and hitless segment monitoring has to cover both per-node model and per-interface model which are specified in RFC 6371 [RFC6371].

The temporal and hitless segment monitoring solutions shall support on-demand Packet Loss Measurement and Packet Delay Measurement functions and optionally other performance monitoring /fault management functions (e.g. Throughput measurement, Delay variation measurement, Diagnostic test measurement, etc.).

8. Security Considerations

The security considerations defined for RFC 6378 apply to this document as well. As this is simply a re-use of RFC 6378, there are no new security considerations.

9. IANA Considerations

There are no requests for IANA actions in this document.

Note to the RFC Editor - this section can be removed before publication.

10. Acknowledgements

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11. Normative References

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

[RFC3031] Rosen, E., Viswanathan, A., and R. Callon, "Multiprotocol Label Switching Architecture", RFC 3031, DOI 10.17487/RFC3031, January 2001, <http://www.rfc-editor.org/info/rfc3031>.

[RFC5860] Vigoureux, M., Ed., Ward, D., Ed., and M. Betts, Ed., "Requirements for Operations, Administration, and Maintenance (OAM) in MPLS Transport Networks", RFC 5860, DOI 10.17487/RFC5860, May 2010, <http://www.rfc-editor.org/info/rfc5860>.

[RFC5921] Bocci, M., Ed., Bryant, S., Ed., Frost, D., Ed., Levrau, L., and L. Berger, "A Framework for MPLS in Transport Networks", RFC 5921, DOI 10.17487/RFC5921, July 2010, <http://www.rfc-editor.org/info/rfc5921>.

[RFC6371] Busi, I., Ed. and D. Allan, Ed., "Operations, Administration, and Maintenance Framework for MPLS-Based Transport Networks", RFC 6371, DOI 10.17487/RFC6371, September 2011, <http://www.rfc-editor.org/info/rfc6371>.

[RFC6372] Sprecher, N., Ed. and A. Farrel, Ed., "MPLS Transport Profile (MPLS-TP) Survivability Framework", RFC 6372, DOI 10.17487/RFC6372, September 2011, <http://www.rfc-editor.org/info/rfc6372>.

Authors' Addresses

Alessandro D'Alessandro
Telecom Italia

Email: alessandro.dalessandro@telecomitalia.it

Loa Andersson
Huawei Technologies

Email: loa@mail01.huawei.com

Manuel Paul
Deutsche Telekom

Email: Manuel.Paul@telekom.de

Satoshi Ueno
NTT Communications

Email: satoshi.ueno@ntt.com

Kaoru Arai
NTT

Email: arai.kaoru@lab.ntt.co.jp

Yoshinori Koike
NTT

Email: koike.yoshinori@lab.ntt.co.jp