Temporal and hitless path segment monitoring
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Abstract

The MPLS transport profile (MPLS-TP) is now being standardized to enable carrier-grade packet transport and complement converged packet network deployments. One of the most attractive features in MPLS-TP is OAM functions, which enable network operators or service providers to provide various maintenance characteristics, such as prompt fault location, substantial survivability, performance monitoring, and preliminary or in-service measurements, inherent in circuit-based transport networks.

One of the important characteristics which are common in transport network operation is the 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 for the segment monitoring (SPME) has some fatal issues. This document elaborates on the problem statement on the path segment monitoring function. Moreover, this document also requests to add network objectives to solve or improve the issues and proposes to reconsider the new improved method of the segment monitoring.

This document is a product of a joint Internet Engineering Task Force (IETF) / International Telecommunications Union Telecommunications Standardization Sector (ITU-T) effort to include an MPLS Transport Profile within the IETF MPLS and PWE3 architectures to support the capabilities and functionalities of a packet transport network.
1. Introduction

A packet transport network will enable carriers or service providers to use network resources efficiently and reduce network cost. For carrier-grade network operation, appropriate maintenance characteristics, such as prompt fault location, substantial survivability, performance monitoring, and preliminary or in-service measurement, 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.

Unlike in SDH or OTN networks, where OAM is an inherent part of every frame and frames are also transmitted in idle mode, it is not possible to constantly monitor the status of individual connections in packet networks. Packet-based OAM functions are flexible and selectively configurable to operator needs.

According to the MPLS-TP OAM requirements [1], mechanisms MUST be available for alerting a service provider of a fault or defect affecting the service(s) it provides. In addition, to ensure that faults or degradations can be localized, operators need a method to analyze or investigate the problem. From the fault localization perspective, end-to-end monitoring or management is not enough as a maintenance tool. In end-to-end OAM monitoring, when one problem occurs in an MPLS-TP network, the operator can detect the fault, but cannot solve the issue efficiently. As the operator cannot localize the point, he/she has no choice but to thoroughly search by trial and error by replacing packages or changing configuration by disrupting the connection service provided to customers. This is very inefficient and far from a carrier-grade network.

As a result, a specific segment monitoring function for detailed analysis, by focusing on and selecting a specific portion of a transport path, is indispensable to promptly and efficiently localize the fault point. This is an important characteristic in transport networks. However, a few fatal missing features, which are normally met in transport network operation, were found regarding the segment monitoring function of a transport path in the on-going MPLS-TP OAM standard.

This document elaborates on the problem statement on the path segment monitoring function. Moreover, this document also requests to add network objectives to solve or improve the issues and proposes to reconsider the new improved method of the segment monitoring.

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 [1].

2.1. Terminology

LSP  Label Switched Path
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 monitoring

There are two indispensable network objectives in the current ongoing MPLS-TP standard as described in section 3.8 of [5].

(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.

It was agreed in ITU-T SG15 that Network objective (1) is mandatory and that regarding Network objective (2) the monitoring shall be hitless and not change the forwarding behavior.

4. Problem statement

To monitor, protect, or manage a portion of a transport path, such as LSP in MPLS-TP networks, the Sub-Path Maintenance Element (SPME) is defined in [2]. The SPME is defined between the edges of the portion of the LSP that needs to be monitored, protected, or managed. This SPME is created by stacking the shim header (MPLS header) [3] 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 a per-node model.

This method can cause the following problems due to label stacking, which are fatal in terms of cost and operation.

(P-1) Increasing the bandwidth by the stacking shim header(s)

(P-2) Increasing the address management of all MEPs and MIPs newly configured for SPME in the old MEG

Problem (P-1) increases the operation cost and wastes bandwidth. As the number of segments for monitoring increases, the number of label stacking increases. Moreover this is a permanent monitoring element, which should be set in advance, not a temporal setting. This prevents the operator from securing the shared bandwidth for efficient monitoring. However, the best solution is not to increase the bandwidth for monitoring.

Problem (P-2) is related to an identifier issue, of which the discussion is still continuing and not so fatal at the moment, but can be quite inefficient if the policy of allocating the identifier is independent in each layer. Moreover, from the perspective of operation, increasing the managed addresses and the managed layer is not desirable in terms of simplified operation featured by current transport networks. Reducing the managed identifier and managed layer should be the fundamental direction in designing the architecture.

The most familiar example of the SPME in the transport network standard is tandem connection monitoring (TCM), which is used for a carrier’s carrier solution shown in Fig. 17 of the framework document[2]. However, in this case, the SPMEs have to be pre-configured. If this solution is applied to specific segment monitoring within one operator domain, all the necessary specific segments have to be pre-configured. This setting increases the managed objects as well as the necessary bandwidth, shown as Problem (P-1) and (P-2).

To avoid these issues, the temporal setting of the SPME(s) only when necessary seems reasonable and efficient for monitoring in MPLS-TP transport network operation. Unfortunately, the method of temporal settings of SPMEs also cause the following problems due to label stacking, which are fatal in terms of intrinsic monitoring and service disruption.
(P’-1) Changing the condition of the original transport path by changing the length of the MPLS frame (delay measurement and loss measurement can be sensitive)

(P’-2) Disrupting client traffic over a transport path, if the SPME is temporally configured.

Problem (P’-1) is a fatal problem in terms of intrinsic monitoring. The monitoring function checks the status without changing any conditions of the targeted monitored segment or the transport path. If the conditions of the transport path change, the measured value or observed data will also change. This can make the purpose of the monitoring meaningless because it seems very possible that the result of the monitoring does not reflect the data when the original fault or degradation occurred.

In addition, changing the settings of the original shim header should not be allowed because those changes correspond to creating a portion of the original transport path, which is completely different from the original circumstances.

Figure 1 shows an example of SPME setting. In the figure, X means the one label 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. This is not the monitoring of the original transport path but the monitoring of a different path.

(Before SPME settings)
---     ---     ---     ---     ---
|   |   |   |   |   |   |   |   |   |
---     ---     ---     ---     ---
A--100--B--110--C--120--D--130--E
MEP     MEP

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

Figure 1 : An Example of a SPME setting
Problem (P’-2) was not fully discussed, although the make-before-break procedure in the survivability document [4] seemingly supports the hitless configuration for monitoring according to the framework document [2]. The reality is the hitless configuration of SPME is impossible without affecting the circumstances of the targeted transport path, because the make-before-break procedure is premised on the change of the label value. This means changing one of the settings in MPLS shim header and should not be allowed as explained in (P’-1) above.

Moreover, this 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. The removal of SPME whose segment is monitored could have the same impact (disruption of client traffics) as creation of an SPME on the same LSP.

The 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 on 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 may disappear when you set 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 way MPLS works requires use of SPMEs to be designed in advance, hence the utility of SPMEs is basically limited.

To summarize, the problem statement is that the current sub-path maintenance based on a hierarchical LSP (SPME) is problematic in terms of increasing bandwidth by label stacking and managing objects by layer stacking and address management. A temporal configuration of SPME is one of the possible approaches for minimizing the impact of these issues; however, the current method is not applicable because the temporal configuration for monitoring can change the condition of the original monitored transport path and disrupt the in-service customer traffic. From the perspective of monitoring in transport network operation, the solution for avoiding those issues or minimizing their impact should be reconsidered.
5. OAM functions for segment monitoring

OAM functions in which segment monitoring is required are basically limited to on-demand monitoring which are defined in OAM framework document [5], because those segment monitoring functions are basically used to locate the fault/degraded point or diagnose the status for detailed analyses, especially when a problem occurred.

Packet loss and packet delay measurements are OAM functions in which hitless and temporal segment monitoring are strongly required because these functions are supported only between end points of a transport path. If a fault or defect occurs, there is no way to locate the fault or defect 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 action to solve the problem. Therefore, temporal and hitless monitoring for packet loss and packet delay measurements are indispensable for transport network operation.

Regarding other on-demand monitoring functions, segment monitoring is desirable, but not as urgent as the packet loss and packet delay measurements.

Regarding out-of-service on-demand monitoring functions, such as diagnostic tests, there is no need of hitless settings. However, specific segment monitoring is necessary for enabling the flexibility in diagnostic test patterns.

Note:

The reason only on-demand OAM functions are discussed at this point is because the characteristic of "on-demand" is generally temporal for maintenance operation, and those operations are not reasonable and should not be based on pre-configuration. Pre-design and pre-configuration of PST/TCM (label stacking) for all the possible patterns for the on-demand (temporal) usage are not reasonable, because these tasks will additionally increase the operator’s burden, although pre-configuration of PST for pro-active usage may be accepted considering the agreement thus far. Therefore, the solution for temporal and hitless segment monitoring does not need to be limited to label stacking mechanisms, such as PST/TCM(label stacking), which can cause the issues (P-1) and (P-2) described in Section 4.

Note that the issue of SPME is now under discussion in OAM framework draft [5]. The results of the discussion will have to be considered eventually. The solution for temporal and hitless
segment monitoring has to cover both per-node model and per-interface model in the draft [5].

6. Further consideration of requirements for enhanced segment monitoring

An existing segment monitoring function relates to SPME that 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. From this perspective, monitoring function related to can be considered “proactive multi-layer monitoring,” which has already been determined by consensus to be mandatory in MPLS-TP.

6.1. Necessity of on-demand single-layer monitoring

In contrast to the “proactive multi-layer monitoring” so called “SPME,” the new segment monitoring function is supposed to be applied mainly for diagnostic purpose on-demand. We can differentiate this monitoring from the proactive segment monitoring as on-demand (multi-layer) monitoring. The most serious problem at the moment is that there is no way to localize the degradation point on 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-layer and simultaneous monitoring is the most powerful tool for accurately diagnosing the performance of a transport path. However, considering the balance of estimated implementation difficulties and the substantial benefits to operators, a strict monitoring function such as in a test environment in a laboratory does not seem to be necessary in the field. To summarize, on-demand and in-service (hitless) single-layer segment monitoring is required, but the need for on-demand and in-service multi-layer segment monitoring is not as urgent at the moment. Figure 2 shows an example of a multi-layer on-demand segment monitoring.
6.2. Necessity of on-demand monitoring independent from proactive monitoring

As multi-layer simultaneous monitoring only in layers for on-demand monitoring was already discussed in section 6.1, we consider the necessity of simultaneous proactive and on-demand monitoring. Normally, on-demand segment monitoring is configured in a segment of a maintenance entity of a transport path. In this environment, on-demand single-layer monitoring should be done irrespective of the status of pro-active monitoring of the targeted end-to-end transport path.

If operators have to disable the pro-active monitoring during ‘‘on-demand and in-service’’ segment monitoring, the network operation system might miss any performance degradation of user traffic. This kind of inconvenience should be avoided in the network operations. From this perspective, the ability for on-demand single layer segment monitoring is required without changing or interfering the proactive monitoring of the original end-to-end transport path.

---     ---     ---     ---     ---
| A |   | B |   | C |   | D |   | E |
---     ---     ---     ---     ---
MEP                             MEP
+-----------------------------+ <= Proactive E2E monitoring
*------------------*        <= On-demand segment monitoring
*-------------*           <= segment monitoring layer1
*-*                 <= segment monitoring layer2
*-*                 <= segment monitoring layer3

Figure 3 : Relation between proactive end-to-end monitoring and on-demand segment monitoring
6.3. On-demand diagnostic procedures

The main objective of on-demand segment monitoring is to diagnose the fault point. One possible diagnostic procedure is to fix one end point of a segment at the MEP of a transport path and change progressively the length of the segment in order. This example is shown in Fig. 4. This approach is considered as a common and realistic diagnostic procedure. In this case, one end point of a segment can be anchored at MEP at any time.

Other scenarios are also considered, one shown in Fig. 5. In this case, the operators want to diagnose a transport path from a transit node located at the middle of the path. In this case, the on-demand monitoring at both end points is not sufficient because the end points are located at customer sites and consist of cost effective small box in which a subset of OAM functions are supported. In this case, if one end point and an originator of the diagnostic packet are limited to the position of MEP, on-demand segment monitoring will be ineffective because all the segments cannot be diagnosed (for example, segment monitoring 3 in Fig. 5 is not available and it is not possible to localize the fault point).

Accordingly, on-demand monitoring of arbitrary segments is mandatory in the case in Fig. 5. As a result, on-demand and in-service segment monitoring should be set in an arbitrary segment of a transport path. Diagnostic packets should be inserted from at least any of intermediate maintenance points of the original MEP.

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7. Conclusion

We request that the above two network objectives in Section 3 are included in the MPLS-TP OAM framework. In addition, We also request that the necessity of temporal and hitless path segment monitoring is also described in the MPLS-TP OAM framework[5]. In addition, the solution should be specified in other document and should minimize the problems mentioned in Section 4, i.e., P-1, P-2, P’-1 and P’-2, to meet those two network objectives. The solution is needed to become normative in RFC for the consent of G.8113.x(G.tpoam) in December 2011.

In addition, the following requirements should be considered for the new enhanced temporal and hitless path segment monitoring function.

- An on-demand and in-service ‘’single-layer’’ segment monitoring is proposed. Multi-layer segment monitoring is optional.
- ‘’On-demand and in-service’’ single layer segment should be done without changing or interfering any condition of pro-active monitoring of an original ME of a transport path.
- On-demand and in-service segment monitoring should be able to set in an arbitrary segment of a transport path.

8. Security Considerations

This document does not by itself raise any particular security considerations.

9. IANA Considerations

There are no IANA actions required by this draft.
10. References

10.1. Normative References


10.2. Informative References

None

11. Acknowledgments

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