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Requirements for OAM in MPLS Transport Networks
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Abstract

   This document lists the requirements for the Operations,
   Administration and Maintenance functionality of MPLS Transport
   Profile. These requirements apply to pseudowires, Label Switched
   Paths, and Sections. Architectural, functional and operational
   requirements are covered in 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 [1].

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1. Introduction

In the context of MPLS Transport Profile (MPLS-TP, see [5] and [6]),
the rationales for Operations, Administration and Maintenance (OAM)
mechanisms are twofold as they can serve:

o as a network-oriented mechanism (used by a transport network
   operator) to monitor his network infrastructure and to implement
   internal mechanisms in order to enhance the general behaviour and
   the level of performance of his network (e.g., protection
   mechanism in case of node or link failure). For example fault
   localization is typically associated to this use case.

o as a service-oriented mechanism (used by a transport service
   provider) to monitor offered services to end customers in order to
   be able to react rapidly in case of a problem and to be able to
   verify some of the Service Level Agreements (SLAs) parameters
   (e.g., using performance monitoring) negotiated with the end
   customer. Note that a transport service could be provided over
   several networks or administrative domains that may not be all
   owned and managed by the same transport service provider.

More generally, OAM is an important and fundamental functionality in
transport networks as it contributes to:

o the reduction of operational complexity and costs, by allowing
   efficient and automatic detection, localisation, handling, and
   diagnosis of defects, and by minimizing service interruptions and
   operational repair times.

o the enhancement of network availability, by ensuring that defects,
   for example resulting in misdirected customer traffic, and faults,
   are detected, diagnosed and dealt with before a customer reports
   the problem.

o meet service and performance objectives, by running OAM
   functionality which allows SLA verification in a multi-maintenance
   domain environment and allows the determination of service
   degradation due, for example, to packet delay or packet loss.

This document lists the requirements for the OAM functionality of
MPLS-TP. These requirements apply to pseudowires (PWs), Label
Switched Paths (LSPs), and Sections.

These requirements are derived from a set of requirements specified
by ITU-T and first published in the ITU-T Supplement Y.Sup4 [7].

By covering transport specificities, these requirements stand as a

complement to those identified in RFC 4377 [8].

1.1. Definitions

In this document we refer to a fault as the inability of a function
to perform a required action. This does not include an inability due
to preventive maintenance, lack of external resources, or planned
actions. See also ITU-T G.806 [2].

In this document we refer to a defect as the situation for which
density of anomalies has reached a level where the ability to perform
a required function has been interrupted. See also ITU-T G.806 [2].

In this document we refer to a Label Edge Router (LER), for a given
LSP or Section, and to a PW Terminating Provider Edge (T-PE), for a
given PW, as an End Point. Further, we refer to a Label Switching
Router (LSR), for a given LSP, and to a PW Switching Provider Edge
(S-PE), for a given PW, as an Intermediate Point. This document does
not make any distinction between End Points (e.g., source and
destination) as it can be inferred from the context of the sentences.

In this document we use the term "node" as a general referral to End
Points and Intermediate Points.

Other definitions, relating to MPLS-TP, can be found in [6].

1.2. Contributing Authors

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2. OAM Requirements

This section lists the requirements by which the OAM functionality of
MPLS-TP should abide. Note that some requirements for this
application of MPLS are similar to some of those listed in RFC 4377
[8].

The requirements listed below may be met by one or more OAM
protocols; the definition or selection of these protocols is outside
the scope of this document.

2.1. **Architectural Requirements**

2.1.1. **Independence**

   OAM functions SHOULD be independent of the underlying tunnelling or
   point-to-point technology or transmission media.

   OAM functions SHOULD be independent of the service a PW may emulate.

   The set of OAM functions operated on a PW, LSP or Section SHOULD be
   independent of the set of OAM functions operated on a different PW,
   LSP or Section. In other words, only the OAM functions available for
   e.g., a LSP should be used to achieve the OAM objectives for that
   LSP. Note that independence should not be understood here in terms
   of isolation as there can be interactions between OAM functions
   operated on e.g., a LSP and on another LSP or on a PW.

   OAM functions MUST operate and be configurable even in the absence of
   a control plane. Conversely, OAM functions SHOULD be configurable as
   part of connectivity (e.g., LSP or PW) management. Means for
   configuring OAM functions and for connectivity management are outside
   the scope of this document.

2.1.2. **Addressing, Routing and Forwarding**

   The OAM functionality may be deployed in a variety of environments.

   o In some environments (e.g., IP/MPLS environments), IP routing and
      forwarding capabilities are inherently present. In this case, the
      OAM functionality MUST support the use of IP routing and
      forwarding capabilities.

   o In some environments (e.g., MPLS-TP environments), IP routing and
      forwarding capabilities may not necessarily be present. In this
      case, the OAM functions and their operation MUST NOT require
      relying on IP routing and forwarding capabilities.

   In case OAM messages need to incorporate identification information
   (e.g., of source and/or destination nodes), the protocol solution
   MUST at least support an IP addressing structure and MUST also be
   extensible to support additional addressing schemes.

2.1.3. **Interoperability and Interworking**

   It is REQUIRED by this document that OAM interoperability is achieved
   across the environments described in Section 2.1.2. It is also
   REQUIRED by this document that the two first requirements of Section
   2.1.2 still hold and MUST thus still be met when interoperability is

achieved.

When MPLS-TP is run with IP routing and forwarding capabilities, it
MUST be possible to operate any of the existing IP/MPLS and PW OAM
functionalities (e.g., LSP-Ping [3], MPLS-BFD [9], VCCV [4] and VCCV-
BFD [10]).

The protocol solution(s) developed to meet the requirements listed in
this document MUST interwork with the existing IP/MPLS and PW OAM
protocols.

2.1.4. Data Plane

OAM functions operate in the data plane. OAM packets MUST run in-
band; that is, OAM packets for a specific PW, LSP or Section MUST
follow the exact same data path as user traffic of that PW, LSP or
Section.

It MUST be possible to discriminate user traffic from OAM packets.
This includes a means to differentiate OAM packets from user traffic
as well as the capability to apply specific treatment, to OAM
packets, at the nodes targeted by these OAM packets.

As part of the design of OAM protocol solutions for MPLS-TP, a
mechanism enabling to encapsulate and differentiate OAM messages, on
a PW, LSP or Section, MUST be provided. Such mechanism MUST also
support the encapsulation and differentiation of existing IP/MPLS and
PW OAM messages.

2.1.5. Scope

The service emulated by a single segment or a multi-segment PW may
span multiple domains. A LSP may also span multiple domains. It
MUST be possible to perform OAM functions on a per domain basis and
across multiple domains. More generally it MUST be possible to
perform OAM functions between any two switching elements (e.g., LSR
or S-PE) of a LSP or of PW. This is referred to as (concatenated)
segment monitoring.

2.2. Functional Requirements

Hereafter are listed the required functions composing the MPLS-TP OAM
toolset. The list may not be exhaustive and as such the OAM
mechanisms developed in support of the identified requirements SHALL
be extensible and thus SHALL NOT preclude the definition of
additional OAM functions, in the future.

The design of OAM mechanisms, for MPLS-TP, MUST allow the ability to

support vendor specific and experimental OAM functions. These
functions MUST be disabled by default.

The use of any OAM function MUST be optional for the service provider
or network operator and a network operator or service provider MUST
be able to choose which OAM function(s) to use and on which PW, LSP
or Section to apply it(them) to.

It is RECOMMENDED by this document that a protocol solution,
realizing a given function, effectively provides a fully featured
function, i.e., a function which is applicable to all the cases
identified in the table in Section 2.3, for that function.

The OAM functions MUST be able to be operated on PWs, LSPs and
Sections.

Note that the functions listed below can be used for fault
management, performance monitoring and/or protection switching
applications. For example, connectivity verification can be used for
fault management application by detecting failure conditions, but may
also be used for performance monitoring application through its
contribution to the evaluation of performance metrics (e.g.,
unavailability time). Nevertheless, it is outside the scope of this
document to specify which function should be used for which
application.

2.2.1. General Requirements

If a defect or fault occurs on a PW, LSP or Section, mechanisms MUST
be provided to detect it, diagnose it, localize it, and notify the
appropriate entities. Corrective actions SHOULD be taken according
to the type of defect or fault.

Furthermore, in case of a fault or defect, affecting a service
provided by a service provider, mechanisms MUST be available for the
service provider to be informed of the fault or defect even if the
fault or defect is located outside of his domain.

2.2.2. Continuity Checks

The MPLS-TP OAM toolset MUST provide a function to enable service
providers and network operators to detect loss of continuity, but
also unintended connectivity, on a PW, LSP or Section.

This function SHOULD be performed pro-actively.

This function SHOULD be performed between End Points of PWs, LSPs and
Sections.

Means MUST be available to parameterize the frequency at which is performed this function as well as to parameterize the criteria, if any (e.g., number of consecutive OAM messages not received), based on which loss of continuity or unintended connectivity is detected. A default value MAY be defined.

2.2.3. Connectivity Verifications

The MPLS-TP OAM toolset MUST provide a function to enable service providers and network operators to verify the connectivity of a PW, LSP or Section.

This function SHOULD be performed on-demand.

This function SHOULD be performed between End Points and Intermediate Points of PWs and LSPs, and between End Points of PWs, LSPs and Sections.

Note that, this function is sometime referred to as loopback as End Points expect to receive some level of information as a result of their action.

2.2.4. Diagnostic

The MPLS-TP OAM toolset MAY provide a function to enable service providers and network operators to perform diagnostic tests (e.g., verify bandwidth throughput) on a PW, LSP or Section.

This function SHOULD be performed on-demand.

This function SHOULD be performed between End Points and Intermediate Points of PWs and LSPs, and between End Points of PWs, LSPs and Sections.

This function MAY be provided as part of the Connectivity Verifications function (see Section 2.2.3).

2.2.5. Adjacency

The MPLS-TP OAM toolset MUST provide a function to enable an End Point to request, to, and receive from, any node along a PW, LSP or Section, a certain level of information (e.g., identification, distance in hops).

This function SHOULD be performed on-demand.

This function SHOULD be performed between End Points and any node of a PW, LSP and Section.

This function MAY be provided jointly with the Route Tracing function
(see Section 2.2.6).

2.2.6. Route Tracing

The MPLS-TP OAM toolset MUST provide a function to enable service
providers and network operators to trace the route a PW, LSP or
Section. The information collected SHOULD include identifiers
related to the nodes composing that route and MAY include interface
identifiers.

This function SHOULD be performed on-demand.

This function SHOULD be performed between End Points and Intermediate
Points of PWs and LSPs, and between End Points of PWs, LSPs and
Sections.

This function MAY be provided jointly with the Adjacency function
(see Section 2.2.5).

2.2.7. Lock

The MPLS-TP OAM toolset MAY provide a function enabling to
administratively shut down a PW, LSP or Section; that is, to stop
user traffic being sent over that PW, LSP or Section.

This function SHOULD be performed on-demand.

This function SHOULD be performed between End Points of PWs, LSPs and
Sections.

2.2.8. Alarm Notification

The MPLS-TP OAM toolset MUST provide a function to enable server
layer End Points to notify a fault condition or an administrative
locking to the client layer End Points affected by this status. This
would enable to suppress alarms that may be generated in the client
layer as a result of the fault condition or of the administrative
locking in the server layer.

The MPLS-TP OAM toolset MUST allow for the distinction between a
fault condition and an administrative locking action.

The server layer End Points generating the notification and the
client layer End Points receiving the notification may or may not be
the same nodes. A mechanism MUST be provided to support both cases.

This function SHOULD be performed pro-actively.

This function SHOULD be performed between the End Points of PWs, LSPs and Sections and the End Points of the PWs and/or LSPs affected by the fault condition or administrative locking.

2.2.9. Client Failure Indication

The MPLS-TP OAM toolset MUST provide a function to enable the propagation of client fault condition information, across the MPLS-TP network, if the client layer OAM mechanisms do not provide an alarm notification/propagation mechanism.

This function SHOULD be performed pro-actively.

This function SHOULD be performed between End Points of PWs, LSPs and Sections.

2.2.10. Remote Defect Indication

The MPLS-TP OAM toolset MUST provide a function to enable an End Point to notify its associated End Point of the detection of a fault or defect that it detects on a PW, LSP or Section between them.

This function SHOULD be performed pro-actively.

This function SHOULD be performed between End Points of PWs, LSPs and Sections.

2.2.11. Packet Loss

Packet loss ratio is the ratio of the user packets not delivered to the total number of user packets transmitted during a defined time interval. The number of user packets not delivered is the difference between the number of user packets transmitted by an End Point and the number of user packets received at an End Point.

The MPLS-TP OAM toolset MUST provide a function to enable service providers and network operators to derive packet loss ratio over a PW, LSP or Section.

This OAM function MUST support the configurability of the interval of time during which the measure is performed.

This function SHOULD be performed pro-actively.

This function SHOULD be performed between End Points of PWs, LSPs and Sections.

2.2.12. Delay Measurement

   The MPLS-TP OAM toolset MUST provide a function to enable service
   providers and network operators to measure the one-way, and if
   appropriate, the two-way, delay of a PW, LSP or Section.

   o One-way delay is the time elapsed from the start of transmission
      of the first bit of an OAM packet by an End Point until the
      reception of the last bit of that OAM packet by the other End
      Point.

   o Two-way delay is the time elapsed from the start of transmission
      of the first bit of an OAM packet by a End Point until the
      reception of the last bit of that OAM packet by the same End
      Point, when the loopback is performed at the other End Point.

   This function SHOULD be performed on-demand.

   This function SHOULD be performed between End Points of PWs, LSPs and
   Sections.

2.3. Operational Requirements

   The OAM functions MUST NOT rely on user traffic to achieve their
   objectives; that is, dedicated OAM messages MUST be used.

   Some OAM functions require certain parameters for their operation.
   These parameters MUST be configurable. A default value MAY be
   defined.

   The specification of certain parameters' values SHOULD be such that
   it accounts, at the design phase, for various possible network
   conditions (e.g., the continuity check function should continue to
   meet its objective (i.e. detect failures) even in the context of high
   traffic load (e.g., congestion)).

   This document does not mandate the use of a particular OAM function.
   However, it is RECOMMENDED that MPLS-TP enables continuity checks to
   be performed on every PW, LSP and Section in order to reliably detect
   connectivity defects and faults.

   OAM functions MUST be applicable to bidirectional point-to-point PWs,
   LSPs and Sections, and a subset of these OAM functions MUST be
   applicable to unidirectional point-to-point and point-to-multipoint
   PWs, LSPs and Sections. This subset is based on the nature of both
   the OAM functions and the connections to which they can apply.

The following table describes how, between which points of PWs, LSPs
and Sections SHOULD the required OAM functions be applied. In these
tables U stands for unidirectional; B stands for bidirectional; EP
stands for an OAM function being performed between End Points; IP
stands for an OAM function being performed between End Points and
Intermediate Points. Crosses (x) indicate the way the considered
function should be applied; numbers indicate the way the considered
function should be applied while pointing to a footnote providing
additional details.

	on-demand						pro-active				
	MEP		MIP			MEP			MIP		
	P2P		P2MP	P2P		P2MP	P2P		P2MP	P2P		P2MP
	U	B	U	U	B	U	U	B	U	U	B	U
c. checks							x	x	x			
c. verifications	1	x	1	1	x	1						
diagnostic	x	x	x	2	2	2						
adjacency	1	x	1	1	x	1						
route tracing	1	x	1	1	x	1						
lock	x	x	x									
alarm notification							x	x	x			
client fail. indic.							2	x	2			
remote defect indic.							1	x	1			
packet loss	2	3	2				x	4	x			
delay measurement	x	x	x				2	2	2			

1: the function MAY be provided if a return path exists
2: the function MAY be performed
3: the function SHOULD be performed in one direction
4: the function SHOULD be performed in both directions

OAM functions and their applicability scope

[3]. Congestion Considerations

A mechanism (e.g., rate limiting) MUST be provided to prevent OAM
packets from causing congestion in the PSN.

[4]. Security Considerations

This document, as itself, does not imply any security consideration
but OAM, as such, is subject to several security considerations. OAM
messages can reveal sensitive information such as passwords,
performance data and details about e.g., the network topology.

The nature of OAM therefore suggests having some form of
authentication, authorization and encryption in place. This will
prevent unauthorized access to MPLS-TP equipment and it will prevent
third parties from learning about sensitive information about the
transport network.

In general, mechanisms SHOULD be provided to ensure that OAM
functions cannot be accessed unauthorized.

Further, OAM messages MAY be authenticated to prove their origin and
to make sure that they are destined for the receiving node.

An OAM packet received over a PW, LSP or Section MUST NOT be
forwarded beyond the End Point of that PW, LSP or Section, so as to
avoid that the OAM packet leaves the current administrative domain.

[5]. IANA Considerations

There are no IANA actions required by this draft.

[6]. Acknowledgements

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MPLS-TP Ad Hoc Group in ITU-T) involved in the definition and
specification of MPLS-TP.

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