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Requirements for OAM in MPLS Transport Networks
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Status of this Memo

Abstract

   This document lists the requirements for Operations, Administration
   and Maintenance functionality in MPLS networks that are used for
   packet transport services and network operations.

   These requirements are derived from the set of requirements specified
   by ITU-T and first published in the ITU-T Supplement Y.Sup4 [5].

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].

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1. Introduction

   This document lists the requirements for Operations, Administration
   and Maintenance functionality in MPLS networks that are used for
   packet transport services and network operations.

1.1. Terminology

AC   Attachment Circuit

CSF   Client Signal Fail

FCAPS Fault, Configuration, Accounting, Performance, Security

LER   Label Edge Router

LSP   Label Switched Path

LSR   Label Switching Router

ME   Maintenance Entity

MEP   Maintenance End Point

MIP   Maintenance Intermediate Point

MP   Maintenance Point

MS-PW Multi Segment Pseudowire

OAM   Operations, Administration and Maintenance

PE   Provider Edge

PSN   Packet Switched Network

PW   Pseudowire

SLA   Service Level Agreement

SS-PW Single Segment Pseudowire

S-PE   PW Switching Provider Edge

T-PE   PW Terminating Provider Edge

TCME   Tandem Connection Maintenance Entity

1.2. 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 [3].

   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 [3].

   In this document, we refer to MPLS Transport Profile (MPLS-TP) as the
   set of MPLS functions used to support packet transport services and
   network operations.

   In this document we refer to a MPLS Section as a network segment
   between two LSRs that are immediately adjacent at the MPLS layer.

   For definitions of OAM functional components such as Maintenance
   Point, Maintenance End Point and Maintenance Intermediate Point,
   please refer to [7].
   Additional definitions can also be found in [8].

1.3. Context and Motivations

   Important attributes of MPLS-TP are that

   o it is able to function regardless of which client signals are
      using its connectivity service or over which transmission media it
      is running. The client, transport network and server layers are,
      from a functional point of view, independent layer networks. That
      is, demarcation points exist between MPLS-TP and the client layer,
      and between MPLS-TP and the underlying server layer.

   o it provides means to commit to Service Level Agreements (SLAs)
      negotiated with customers, as well as means to monitor compliance
      with these SLAs.

   o it is consistent with existing transport network OAM models.

   In the context of MPLS-TP, the rationale for 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 his 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 SLA parameters (i.e. 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 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 to, for example, packet delay or packet loss.

This is achieved through the support of FCAPS functionality, as
described in ITU-T M.3400 [2], itself relying on OAM related
information.

2. OAM Requirements

This section lists the requirements by which the OAM functionality of
MPLS-TP should abide. Some requirements for this application are
similar to some of those listed in RFC 4377 [6].

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. However, the specified solution MUST
inter-work with the existing MPLS and PW OAM protocols.

2.1. Architectural Requirements

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 pseudowire may emulate.

The set of OAM functions operated on each Maintenance Entity SHOULD be independent one from another.
Note that independence should not be understood here in terms of isolation but in terms of separate running processes. There should be one OAM process running per Maintenance Entity but different OAM running processes could interact (e.g. alarm summarization).

OAM functionality MAY be deployed in a variety of environments. In some of these IP routing and forwarding capabilities are inherently present (e.g. IP/MPLS) and the OAM functionality MUST also support their use. Other deployment scenarios exist where IP routing and forwarding capabilities are not necessarily present (e.g. MPLS-TP). In these latter cases, the operation of OAM functions MUST NOT rely on IP routing and forwarding capabilities. Further, it is REQUIRED by this document that OAM interoperability is achieved across these environments. It is also REQUIRED by this document that the two above requirements are still met and still hold when interoperability is achieved.

Furthermore, in case OAM packets need to incorporate identification information of source and/or destination nodes, an IP addressing structure MUST be supported.

When MPLS-TP is run with IP routing and forwarding capabilities, all existing IP/MPLS OAM functionality (e.g. LSP-Ping, BFD and VCCV) MUST be able to operate seamlessly.

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 (LSP or PW) management. Note that means for configuring OAM functions and for connectivity management are outside the scope of this document.

The service emulated by a single segment or a multi-segment pseudowire 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 of a PW or of a LSP. This is referred to as segment (or tandem connection) monitoring (see [7]). Furthermore, in case of a fault or defect on the service, means MUST be available for the service provider to be informed of the fault even if the fault is located outside of his domain.

OAM functions operate in the data plane. OAM packets MUST run in-band. That is, OAM packets for a specific Maintenance Entity MUST follow the exact same data path as user traffic of that Maintenance Entity. This is known as fate sharing.

It MUST be possible to discriminate data 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 MIPs or MEPs targeted by these OAM packets.

As part of the design of OAM mechanisms for MPLS-TP, a mechanism that enables the realization of a channel for general purpose signalling, e.g. for control, management and OAM information, associated with the data plane paths, MUST be provided. Such mechanism SHOULD support the operation of existing IP/MPLS OAM.

OAM functions MUST be able to be used for PWs, LSPs and Sections. Furthermore, since LSPs MAY be stacked, OAM functions MUST be able to run on each LSP, regardless of the label stack depth.

2.2. Functional Requirements

Hereafter are listed the required functions composing the MPLS-TP OAM tool-set. 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. Furthermore, the design of OAM mechanisms for MPLS-TP MUST allow the ability to support vendor specific and experimental OAM functions. Vendor specific and experimental OAM functions MUST be disabled by default and explicitly enabled by a service provider or network operator, between nodes that support them.

Moreover, the use of OAM functions SHOULD be optional for the service provider or network operator. A network operator or service provider SHOULD be able to choose which OAM functions to use and which Maintenance Entities to apply them to.

Note that the functions listed below can serve the purpose of fault and/or performance management. For example, connectivity verification can be used for fault management application by detecting failure conditions, but may also be used for performance management 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, 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.

In the case of the PW Maintenance Entity, OAM mechanisms SHOULD be
provided to ensure that customers do not have to detect faults. The
OAM functions SHOULD allow the service provider to automatically
detect and notify the faults associated with a PW Maintenance Entity.

2.2.2. Connectivity and Continuity Verification

The MPLS-TP OAM tool-set MUST provide a function to enable service
providers to detect loss of continuity but also mis-connectivity
between two points of a Maintenance Entity.

2.2.3. Client Failure Indication

The MPLS-TP OAM tool-set MUST provide a function to enable a MEP to
propagate a client failure indication to its peer MEP when alarm
suppression in the client layer is not supported.

In cases where the OAM of the native service of an AC or a PW type
does not provide mechanisms to propagate failure condition
information, while a downstream indication of such state is needed,
MPLS-TP OAM SHOULD provide mechanisms for propagating AC failures and
their clearance across a MPLS-TP domain.

2.2.4. Remote Defect Indication

The MPLS-TP OAM tool-set MUST provide a function to enable a MEP to
notify its peer MEP of the detection of a defect on a bi-directional
connection between them.

2.2.5. Alarm Suppression

The MPLS-TP OAM tool-set MUST provide a function to enable a server
layer MEP to notify a failure condition or an administrative locking
to its client layer MEP(s) in order to suppress alarms that may be
generated by maintenance domains of the client layer as a result of
the failure condition or of the administrative locking in the server
layer.

The MPLS-TP OAM tool-set MUST allow the client layer to differentiate between a defect condition and an administrative locking action at the server layer ME.

The server layer MEP and the client layer MEPs MAY reside on the same node or on different nodes. A mechanism MUST be provided for both cases.

An alarm suppression and summarization mechanism MUST be provided. For example, a fault detected at the LSP level MUST NOT trigger various alarms at the PW level.

2.2.6. Packet Loss

The MPLS-TP OAM tool-set MUST provide a function to enable service providers to measure packet loss ratio between a pair of MEPs. Packet loss ratio is the ratio of the user-plane packets not delivered to the total number of user-plane packets transmitted during a defined time interval. The number of user-plane packets not delivered is the difference between the number of user-plane packets transmitted by the source node and the number of user-plane packets received at the destination node.

2.2.7. Delay Measurement

The MPLS-TP OAM tool-set MUST provide a function to enable service providers to measure the one-way or two-way delay of a packet transmission between a pair of MEPs. Where,

o   One-way packet delay is the time elapsed from the start of transmission of the first bit of the packet by a source node until the reception of the last bit of that packet by the destination node.

o   Two-way packet delay is the time elapsed from the start of transmission of the first bit of the packet by a source node until the reception of the last bit of the loop-backed packet by the same source node, when the loopback is performed at the packet's destination node.

2.2.8. Route Determination

The MPLS-TP OAM tool-set MUST provide a function to enable service providers to determine the route of a connection across the MPLS transport network.

2.2.9. **Diagnostic**

   The MPLS-TP OAM tool-set MUST provide a function to enable service
   providers to verify bandwidth throughput (and other diagnostic tests)
   between a pair of MEPs.

2.3. **Operational Requirements**

   OAM functions such as connectivity and continuity verification MUST
   NOT rely on user traffic. Dedicated OAM flows SHOULD be used to
   detect connectivity and continuity defects. See also ITU-T G.806 .
   [3].
   This document does not mandate the use of a particular OAM function,
   however, it is RECOMMENDED that connectivity and continuity
   verification is performed on every Maintenance Entity in order to
   reliably detect connectivity defects.

   OAM functions MUST be applicable to bidirectional point-to-point
   connections, and a subset of these OAM functions MUST be applicable
   to unidirectional point-to-point and point-to-multipoint connections.
   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, on which Maintenance Entity and
   between which points of the Maintenance Entity SHOULD the required
   OAM functions be applied. In these tables, MEP stands for monitoring
   from MEP to MEP, MIP stands for monitoring from MEP to MIP, U stands
   for unidirectional, B stands for bidirectional. 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       |      proactive       |
                        |--------------------+--------------------|
                        |    MEP    |    MIP    |    MEP    |    MIP    |
                        |---------+---------+---------+---------|
                        | P2P |P2MP| P2P |P2MP| P2P |P2MP| P2P |P2MP|
                        |-----+----+---------+---------+-----+----|
                        |U |B | U |U |B | U |U |B | U |U |B | U  |
   +---------------------+--+--+----+--+--+----+--+--+----+--+--+----|
   | cc verification    |  |x |    |  |x |    |x |x | x |  |  |    |
   |---------------------+--+--+----+--+--+----+--+--+----+--+--+----|
   | client fail. indic. |  |  |    |  |  |    |  |x |    |  |  |    |
   |---------------------+--+--+----+--+--+----+--+--+----+--+--+----|
   | remote defect indic. |  |  |    |  |  |    |  |x |    |  |  |    |
   |---------------------+--+--+----+--+--+----+--+--+----+--+--+----|
   | alarm suppression  |  |  |    |  |  |    |x |x | x |  |  |    |
   |---------------------+--+--+----+--+--+----+--+--+----+--+--+----|
   | packet loss measure |  |1 |    |  |  |    |x |2 | x |  |  |    |
   |---------------------+--+--+----+--+--+----+--+--+----+--+--+----|
   | delay measurement   |x |3 | x |  |  |    |  |  |    |  |  |    |
   |---------------------+--+--+----+--+--+----+--+--+----+--+--+----|
   | route determination |  |x |    |  |x |    |  |  |    |  |  |    |
   |---------------------+--+--+----+--+--+----+--+--+----+--+--+----|
   | diagnostic          |x |x | x |  |  |    |  |  |    |  |  |    |
   +---------------------+---------------------------------------------+
   1: single-ended packet loss measurements

   2: in both directions of the bi-directional connection

   3: one-way and two-way packet delay measurements
```

        Table 1 : OAM functions and their applicability scope

2.4. Performance Requirements

   OAM functions SHOULD continue to meet their objectives regardless of
   congestion conditions. See also ITU-T Y.1541 [4].

   Additional requirements will be incorporated in a future revision of
   this document.

3. Security Considerations

   Mechanisms SHOULD be provided to ensure that unauthorized access is
   prevented from triggering any OAM function.

OAM messages MAY be authenticated.

An OAM packet for a Maintenance Entity MUST NOT leak out of the ME, i.e. go beyond the terminating MEP.

[4](). Congestion Considerations

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

[5](). IANA Considerations

There are no IANA actions required by this draft.

[6](). Acknowledgments

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