INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.1710

(11/2002)

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Internet protocol aspects – Operation, administration and maintenance

Requirements for Operation & Maintenance functionality for MPLS networks

ITU-T Recommendation Y.1710

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ITU-T Recommendation Y.1710

Requirements for Operation & Maintenance functionality for MPLS networks

Summary

This Recommendation provides the motivations and requirements for user-plane OAM (Operation and Maintenance) functionality for Multiprotocol Label Switched (MPLS) networks.

Source

ITU-T Recommendation Y.1710 was revised by ITU-T Study Group 13 (2001-2004) and approved under the WTSA Resolution 1 procedure on 8 November 2002.

Keywords

Defect, failure, LSP, MPLS, network performance, OAM, security, SLA.

FOREWORD

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NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Requirements for Operation & Maintenance functionality for MPLS networks

1 Scope

This Recommendation provides the motivations and requirements for user-plane OAM (Operation and Maintenance) [1] functionality for Multiprotocol Label Switched (MPLS) networks. MPLS OAM is designed to be independent of services.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[1] ITU-T Recommendation I.610 (1999), *B-ISDN operation and maintenance principles and functions*.

[2] ITU-T Recommendation M.20 (1992), *Maintenance philosophy for telecommunication networks*.

[3] ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

[4] IETF RFC 3032 (2001), *MPLS Label Stack Encoding*.

[5] IETF RFC 3031 (2001), *Multiprotocol Label Switching Architecture*.

3 Definitions

This Recommendation introduces some functional architecture terminology that is required to discuss the network components associated with OAM. Since functional architecture terminology may not be familiar to all readers, the relevant terms are defined below.

3.1 defect: Interruption of the capability of a transport entity (e.g. network connection) to transfer user or OAM information [2].

3.2 failure: Termination of the capability of a transport entity to transfer user or OAM information. A failure can be caused by a persisting defect [2].

4 Symbols and abbreviations

This Recommendation uses the following abbreviations.

ATM	Asynchronous Transfer Mode
DoS	Denial of Service
FR	Frame Relay
IP	Internet Protocol
LSN	Label Switching Node
LSP	Label Switched Path

MPLS	Multiprotocol Label Switched
NMS	Network Management System
OAM	Operation and Maintenance
OTN	Optical Transport Network
SDH	Synchronous Digital Hierarchy
SLA	Service Level Agreement

5 Introduction

The motivations for this Recommendation arose from the need, expressed by network operators,for architecturally correct defect handling of MPLS Label Switched Paths (LSPs), noting that LSPs can support many different client layer networks (eg IP, FR, ATM) and can in turn be supported on many different server layer networks (eg SDH/SONET, OTNs). User-plane OAM mechanisms are also required to verify that LSPs maintain correct connectivity and can deliver customer traffic against measurable availability and network performance Service Level Agreements (SLAs).

NOTE – Network performance metrics are not covered by this Recommendation.

The requirements presented in this Recommendation include (but are not limited to):

- Mechanisms to efficiently detect, identify, and localize defects arising within the MPLS layer networks.
- Mechanisms for defect notification and defect handling, e.g. suppress alarm storms in nested LSP scenarios.
- Specification of the criteria for defining the availability (entry/exit) of LSPs and the relationship of availability and network performance metrics.
- Provide a trigger mechanism for protection switching when failures occur.

6 Motivations for MPLS OAM functions

It is recognized that OAM functionality is important in public networks for ease of network operation, for verifying network performance, and to reduce operational costs. OAM functionality is especially important for networks that are required to deliver (and hence be measurable against) network performance and availability objectives.

The major motivations for MPLS OAM are further discussed below.

a) MPLS introduces a unique layer network capability, and hence there will be failure modes that are only relevant to MPLS layer networks. Lower-layer (server-layer) or higher-layer (client-layer) OAM mechanisms of non-MPLS technologies cannot act as a substitute for MPLS layer OAM functionality. This observation is also critical to ensure network layer technologies can evolve independently. The MPLS nesting capability (realized through label stack encoding [5]) allows the creation of multiple layer networks in their own right, within the framework of the MPLS technology. It should be noted that there is no fixed hierarchy in MPLS and, in theory (at least), the nesting depth can be unlimited. MPLS user-plane defects are those that are encountered during the transport of customer traffic.

   Although MPLS control-plane OAM functions may be available (though not always), Network Operators cannot rely exclusively on the control-plane to detect all user-plane defects. Some reasons for this are:

   – The user-plane carrying customer traffic and the control-plane carrying the signalling protocols might not necessarily have the same routing and they will certainly not be subject to the same processing within nodes or indeed the same failure mechanisms.

Therefore, the behaviour of the control-plane protocols, or the control-plane it is transported over, cannot be relied upon to indicate the health of the user-plane carrying customer traffic.

– It is possible for an MPLS network not to have control-plane signalling at all, i.e. when LSPs are set up statically.

– The control-plane itself could fail but this might not have any impact on the customer traffic carrying user-plane.

Further, as is required for the case of supporting (and being supported by) different client (and server layer) technologies, it is essential that the MPLS user-plane OAM mechanisms are independent of the control-plane protocols to allow each set of protocols to evolve independently. Indeed, in the general case, it should be observed that both the user-plane carrying the control-plane traffic, and the control-plane protocols themselves, need their own independent OAM mechanisms.

The key requirement that should be deduced from the above discussion, is that operators want a single MPLS OAM solution that is architecturally correct and control-plane independent under all network scenarios.

b) Operators need an ability to determine LSP availability and network performance noting that network performance metrics are only meaningful when the LSP is in the available state. This information may also be used for accounting and billing purposes to ensure that customers are not inappropriately charged for degraded service or service outages.

c) Reduce operating costs, by allowing efficient detection handling, and diagnosis of defects. Lack of automatic defect detection and handling forces operators to increase their engineering and support workforce, hence increasing overall operating costs.

d) Reduce the duration of defects and thus improve the availability performance.

e) Demonstrate a commitment to providing customer traffic security/confidentiality by ensuring that any defects that result in misdirected customer traffic are detectable/diagnosable and lead to appropriate actions, e.g. squelching of traffic where relevant.

f) Minimize the number of defects that are not automatically detected and still require a customer to report a problem. Pro-active maintenance actions like this also help drive down operating costs by minimizing the opportunity for incorrect defect diagnosis, and (like the previous item) they also promote customer trust of an operator.

g) Allow differentiation of defects arising from lower layers from those originating from within the concerned LSP, in order to achieve more intelligent protection-switching actions.

7 Requirements for MPLS OAM functions

The following requirements should be satisfied by MPLS OAM:

a) Both on-demand and continuous connectivity verification of LSPs to confirm that defects do not exist on the monitored LSPs.

b) If a defect occurs, it is necessary to detect it, diagnose it, localize it, notify the NMS and take corrective actions appropriate to the type of defect. The primary objective here is to reduce operating costs by minimizing service interruptions, operational repair times and operational resource. In some cases, service interruptions can be minimized by providing the network with sufficient information to take corrective actions to bypass the defect; for example, through protection switching or restoration.

c) The OAM mechanisms provided should ensure (as far as reasonably practicable) that customers should not have to act as failure detectors. It is therefore necessary that defects be detected and notified automatically.

d) At least the following defect types should be automatically detected, with well-defined entry/exit criteria and appropriate consequent actions:

- simple loss of LSP connectivity, be this from below or within the MPLS fabric (it should also be possible to distinguish between these);
- swapped LSPs;
- unintended LSP replication of one LSP's traffic into another LSP's traffic (with or without the offending LSP's traffic being impacted);
- unintended self-replication (e.g., looping, DoS attack).

e) A defect event in a given layer network should not cause multiple alarm events to be raised, nor cause unnecessary corrective actions to be taken in any higher level client-layer networks. This applies to all client layer network types that an MPLS LSP is required to carry. There should clearly never be any impact to network layers below the level at which the defect occurs.

f) OAM functions should be simple and easily configured (ideally, automatically) to allow efficient scaling to large size networks.

g) The use of MPLS OAM functions should be optional for the operator. Network operators should be able to choose which OAM functions to use and which LSPs they apply them to.

h) MPLS OAM functions should be backward compatible. Label Switching Nodes (LSNs) that do not support such functions should silently discard the OAM packets without disturbing the user traffic or causing unnecessary actions [5].

i) There should be a capability to measure availability and network performance of an LSP. Since network performance metrics are only meaningful when the LSP is in the available state, then the entry/exit of the available state, and all appropriate consequent action (like the starting/stopping of network performance metric aggregation), should be specified.

j) The OAM functionality of an MPLS layer network should not be dependent on any specific server or client-layer network. This is architecturally critical to ensure that layer networks can evolve (or new/old layer networks be added/removed) without impacting other layer networks.

k) The user-plane OAM functionality of an MPLS layer should be sufficiently independent on any specific control-plane such that changes in the control plane do not impose changes in user-plane OAM (including the case of no control-plane). Like the previous requirement, this is also architecturally critical to ensure that user-plane and control-plane protocols can evolve (or new/old control-plane protocols added/removed) without impacting each other.

l) Connectivity status assessment should not be dependent on the dynamic behaviour of customer traffic.

m) The OAM function should perform reliably even under degraded link conditions, e.g. error events. This requires bit error correction or detection mechanisms for OAM packets.

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23051

Printed in Switzerland
Geneva, 2003