Contribution Number: **OIF2000.140.1**

Working Group: **Signaling**

TITLE: **LDP Extensions for UNI 1.0**

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DATE: **November 1, 2000**

ABSTRACT:

This contribution describes extensions to the Label Distribution Protocol (LDP) to fulfill the role of signaling mechanism for OIF UNI 1.0. The contribution is based on the IETF draft <draft-ietf-mpls-ldp-optical-uni-00.txt> that has been recently submitted to the IETF MPLS WG.

This contribution draws heavily on other OIF contributions, in particular OIF2000.125, OIF2000.155, OIF2000.188, and OIF2000.61. It is expected that this

contribution will continue to evolve in relationship to others, as attributes definitions and other requirements become available.

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I. Abstract

General requirements for signaling across the Optical UNI (O-UNI) are discussed in [1]. This contribution describes extensions to the LDP protocol [2] to support those requirements. The LDP extensions described here address two areas:

- The addition of new TLVs to support the attributes required for lightpath establishment at the O-UNI
- Two new LDP messages to allow for the exchange of lightpath status information across the UNI.

II. Use of LDP for O-UNI

This draft describes how LDP with extensions will be used as a signaling mechanism for the O-UNI. Several O-UNI abstract messages are defined in [1]. This draft specifies how to use the existing LDP messages for that purpose. Two new LDP messages are introduced to meet the requirements for the exchange of status information across the O-UNI.

II.A. Overview

LDP is one of the candidate protocols mentioned in [1] for O-UNI signaling implementation. Applying LDP at the O-UNI allows for:

- The reuse of already defined LDP messages and message formats
- The reuse of LDP session management and control procedures
- Additions to the already specified procedures for notification of errors.
- The reuse of the LDP security mechanism

Support for the O-UNI signaling requirements depends upon the use of the following LDP behaviors and mechanisms as defined in.

- Use of Basic and/or Extended discovery mechanisms.
- Use of the Label Request Message in downstream on demand label advertisement mode with ordered control.
- Use of the Label Mapping Message in downstream on demand label advertisement mode with ordered control.
- Use of the Notification Message.
- Use of the Withdraw and Release Messages.

Additional messages are defined to support the propagation of lightpath status information as defined in.

III. O-UNI Session Management and Control

LDP messages that relevant to the O-UNI session management and control are Hello Message, Initialization Message, and KeepAlive Message.

III.A. Hello Message

This draft does not change the format or the procedures of the LDP Hello Message as described in section 3.5.2. of [2].

III.B. KeepAlive Message

This draft does not change the format or the procedures of the LDP KeepAlive Message as defined in section 3.5.4 of [2].

III.C. Initilaization Message

The Initilaization Message is as defined in section 3.5.3 of [2] with the following modifications:

- The Label Advertisement Discipline (the "A" bit) is always set at 1 to indicate Downstream on Demand label distribution mode. Downstream on Demand is the only label distribution mode supported at the O-UNI. The assignment A=0 should result in generating a Notification Message with the appropriate error code.
- Loop Detection is always disabled, D=0. The assignment D=1 should result in generating a Notification Message with the appropriate error code.

IV. The Use of LDP Messages for O-UNI

A set of abstract O-UNI messages is defined in [1]. Those abstract messages support the basic functions of the optical UNI. Those functions are,

- Lightpath Create: Creates a lightpath with certain attributes between two ends in the optical networks

- Lightpath Delete: Deletes an already existing lightpath

- Lightpath Modify: Modifies one or more of the attributes of already existing lightpath

- Lightpath Status Enquiry: Enquires about the status of an already existing lightpath

Each of the above functions is accomplished by a set of O-UNI messages using LDP protocol.The procedures for handling LDP messages across the optical UNI are augmented to add the additional O-UNI functionality. Common across the O-UNI are:

- The LDP FEC TLV should be ignored at the O-UNI since it has no significance, and
- The use of LDP messages for O-UNI does not change the semantics of the LDP Message ID.

IV.A. Lightpath Create Action

Lightpath Create Action requires two messages, the lightpath Create Request and the Lightpath Create Response. The mapping of the LDP messages to fulfill the lightpath create action is:

- Lightpath Create Request: The create request function is achieved by the LDP Label Request Message. The Generalized Label Request TLV defined in is used to convey some lightpath attributes to the network side.
- Lightpath Create Response: The create response function is achieved by the use of the LDP Label Mapping Message. The create response function makes use of the Generalized label defined in. The Label Mapping procedures are limited to downstream on demand, ordered control mode with conservative label retention mode.

IV.B. Lightpath Delete Action

Lightpath Delete Action requires two messages, the Lightpath Delete Request and the Lightpath Delete Response. The mapping of the LDP messages to fulfill the function of the lightpath delete action is:

- Lightpath Delete Request: The delete request is achieved by the LDP Label Release Request Message. The Label Release Message is sent from the client or the network at any time after the establishment of the lightpath to delete it.
- Lightpath Delete Response: The delete Response is achieved by the LDP Label Withdraw Message. The Label Withdraw Message is sent from the client or the network in response to a Label Release Request.

IV.C. Lightpath Modify Action

(lightpath modification action is not needed for OIF UNI 1.0)

After a lightpath is setup, some of its attributes, e.g. bandwidth, may need to be changed by the network operator due to new requiremenst for the traffic carried on that lightpath. Lightpath Modify Action does not require the definition of new LDP messages. The modify action follows the procedure described in [3].

Lightpath modification can only be allowed when the lightpath is already established. The procedure described in [3] allows for modification of lightpath attributes without service interruption. Only modifications requested by the owner of a particular lightpath are allowed.

The procedure described in [3] for lightpath modification relies on the introduction of the Action Flag (ActFlg) field in the Lightpath Id TLV (see section 6.1.3). Similar to the case in CR-LDP [4], the ActFlg field indicates if the signaled Lightpath Request is an initial lightpath setup or a modification request.

IV.D. Lightpath Status Action

Lightpath Status Actionrequires two messages, Lightpath Status Enquiry and Lightpath Status Response

The Lightpath Status Enquiry and Lightpath Status Response functions require the definition of two new LDP messages, The Status Enquiry Message and the Status Response Message. The encoding of the new messages is defined in sections 6.6 and 6.7 of this contribution.

IV.E. Notification Action

The Notification function is similar in scope to that of the CR-LDP Notification Message. Hence the LDP Notification message is used across the O-UNI for this purpose.

V. LDP Message Extensions

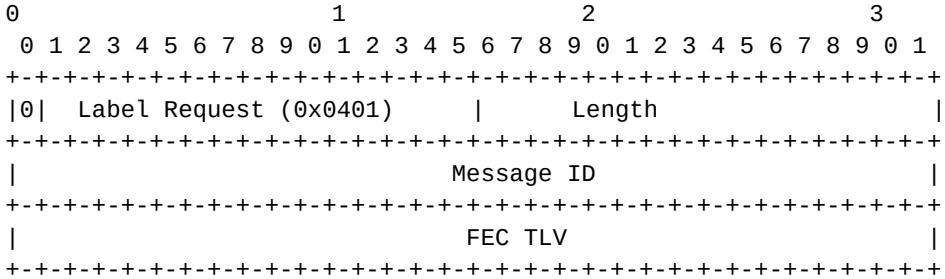
This section gives detailed description of LDP message extensions for the support of O-UNI.

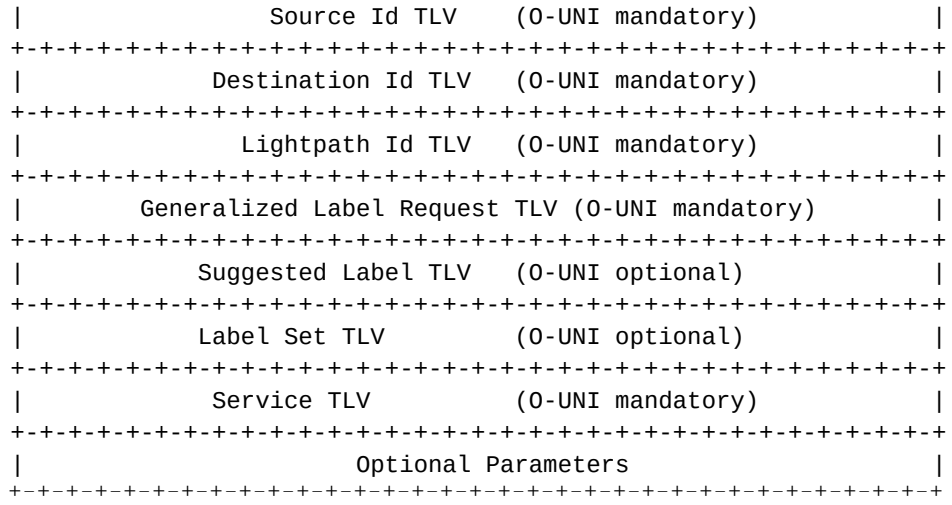
V.A. Label Request Message

The LDP Label Request Message is as defined in 3.5.8. of [2] with the following modifications (required only if any of O-UNI TLVs is included in the Label Request Message):

- The FEC TLV is ignored at the O-UNI
- The procedures to handle the Label Request Message are augmented by the procedures for processing of the O-UNI TLVs as defined in this section

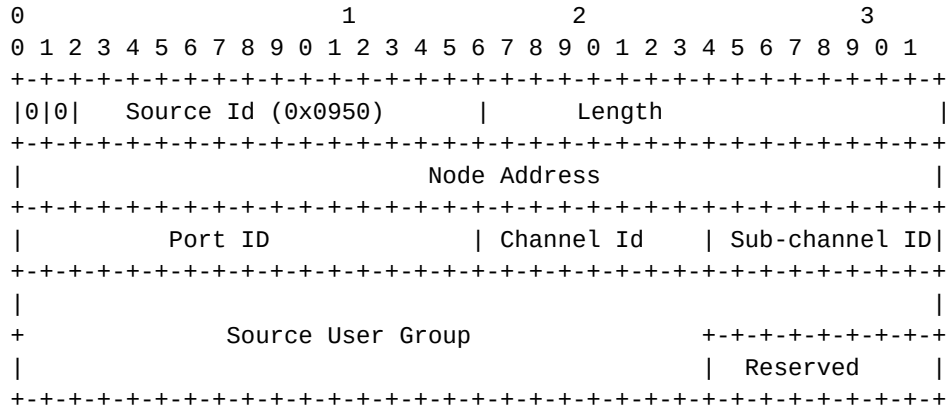
The encoding for the O-UNI LDP Label Request Message is as follows:





V.A.1. Source Id TLV

The Source Id TLV is an object that specifies the initiator (the calling party) of the lightpath creation request. The encoding of the Source Id TLV is:



Node Address:

The Node Address is the IPv4 address associated with the optical network element

Port Id:

Port Id is a two-octet unsigned integer indicating the port number in an optical network element

Channel Id:

Channel Id is a single octet unsigned integer indicating a channel with respect to the specified Port Id.

Sub-Channel Id:

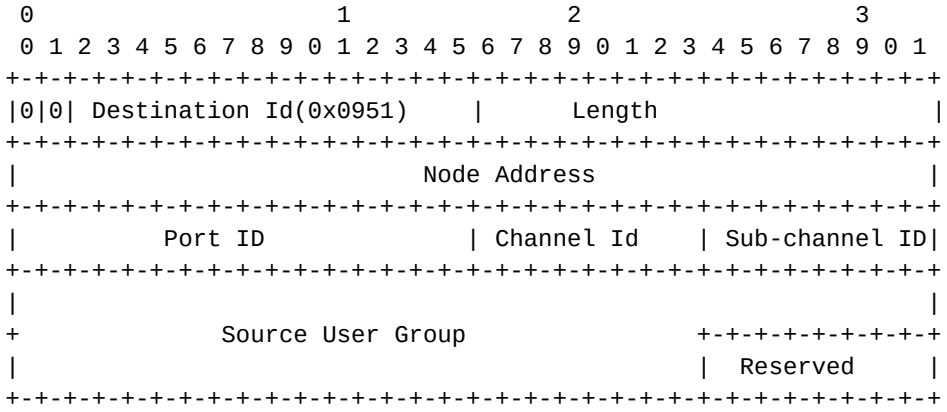
Sub-Channel Id is a single octet unsigned integer indicating a sub-channel with respect to the specified Channel Id.

Source User Group:

The Source User Group identifies the logical network or group to which the optical client belongs. The Source User group is the 7-octet structure as defined in [5].

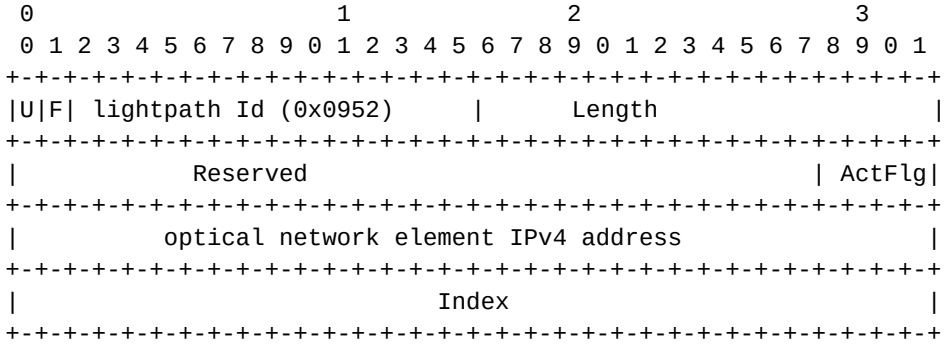
V.A.2. Destination Id TLV:

The Destination Id TLV has the same structure as the Source Id TLV. The format of the Destination Id TLV is:



V.A.3. Lightpath Id TLV

The format of the Lightpath Id is as follows:



ActFlag:

A 4-bit field that explicitly indicates the action that should be taken on an already existing lightpath. A set of indicator code points is proposed as follows

0x0 = initial lightpath setup
0x1 = modify lightpath

Optical Network Element Ipv4 Address:

The IPv4 address of the optical network element

Index:

A 4-octet field uniquely identifies a lightpath.

V.A.4. Generalized Label Request TLV

The Generalized Label TLV format and procedure are as defined in section 3.1 of [6]. It supports communication of characteristics (attributes) required for the lightpath(LSP) being requested. These characteristics include the desired link protection, the lightpath (LSP) encoding, and the lightpath (LSP) payload.

V.A.5. Suggested Label TLV

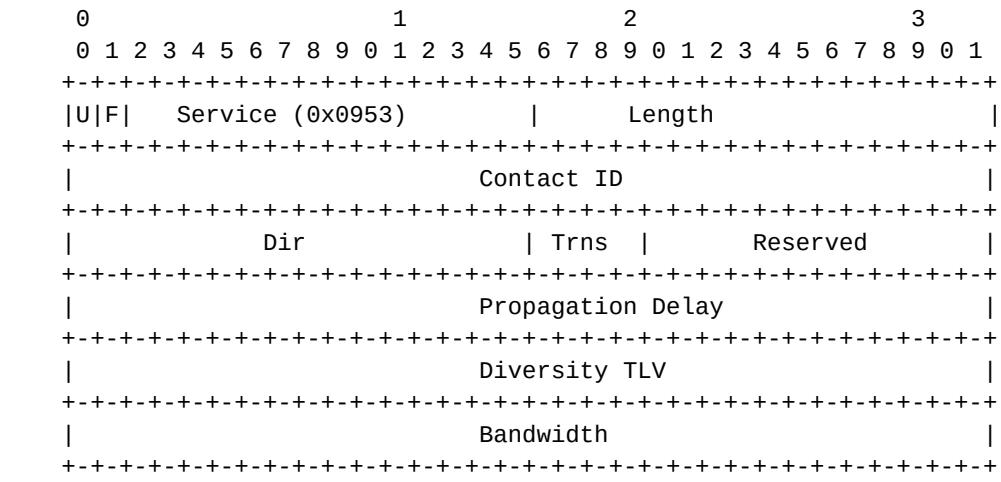
The Suggested Label TLV format and procedure are as defined in section 3.4. of [6].

V.A.6. Label Set TLV

The format and the procedure of the Label Set TLV is as described in section 3.5. of [6].

V.A.7. Service TLV

The Service TLV defines the service attributes requested by the network client. The Service TLV is composed from lightpath attributes as defined in [7-8]. The encoding for the Service TLV is as follows:



Contact Id:

Contact Id is a 4-octet unsigned integer that uniquely identifies the lightpath owner. It is administratively used for call acceptance, billing, policy decisions, etc.

Dir, Directionality:

Dir is 16-bit field that specifies the directionality of the requested lightpath. The allowed values are:

0x0000 = Uni-directional
0x0001 = Bi-directional

0x000n = Multi-Cast with n destinations

Trans, Transparency:

Transparency is interpreted with respect to the LSP encoding and bandwidth. Trans is a 4-bit field that defines transparency requirements of the lightpath. For SONET/SDH the allowed values are:

0x0 = PLR-C
0x1 = STE-C
0x2 = LTE-C

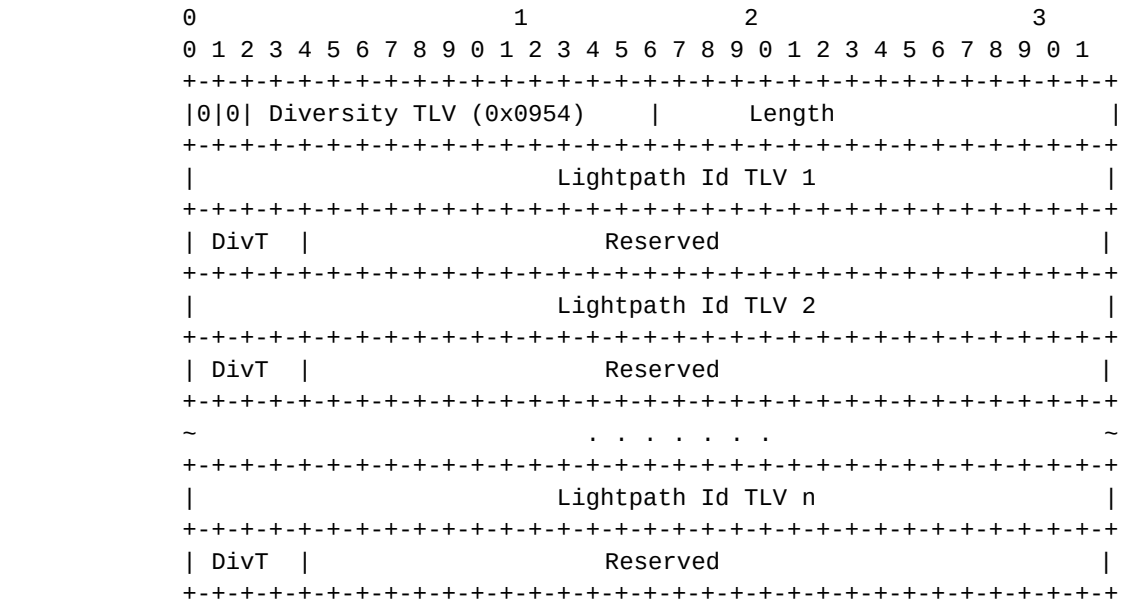
There are no transparency options for PDH, Digital Wrapper, and Ethernet.

Propagation Delay:

Propagation Delay is a 4-octet field. It indicates the maximum acceptable propagation delay in ms. The recommended encoding for this parameter is the 4-octet IEEE floating point number.

Diversity TLV:

Diversity TLV lists all the other lightpaths from which the requested lightpath MUST be diverse. It also specifies the type of diversity. Diversity is only valid within a single routing domain. The encoding of the Diversity TLV is as follows:



Lightpath TLV n:

is the Lightpath Id of the LSP from which the requested ligthpath must be diverse.

DivT, Diversity Type:

DivT specifies the manner by which the requested lightpath should be diverse. The allowed values are:

0x0 = Link diverse
0x1 = Node diverse
0x2 = Shared Risk Link Group (SRLG) diverse

Bandwidth:

It defines the lightpath bandwidth. Bandwidth is a 4-Octet number in the IEEE floating point format (the unit is bytes per second). Some bandwidth values are enumerated in section 3.1.4. of [6]

V.A.8. Procedure

The O-UNI Label Request Message flows between an optical network client and the edge optical network element. Upon initiating the Label Request Message, the optical client sets the addresses in the optical network for the two ends of the lightpath (Source Id and Destination Id TLVs). For initial setup (ActFlg=0), the lightpath Id is set to all 0s when sent from the client to the network. The lightpath Id is assigned by the optical networks. It is globally unique within the optical network. The Lightpath Id is obtained by combining the IPv4 address associated with the optical network element and an integer index that is locally unique. The Lightpath Id is passed to the called client in the Label Request Message from the network to the optical client.

Upon the reception of the O-UNI Label Request Message, the edge optical network element might consult with a policy server to verify that the signaled attributes (including the verification of the Source and the Destination Ids) can be supported. Failure to support one or more of the lightpath attributes triggers the generation of the Notification Message with the appropriate error code.

After passing the edge optical network verification process, the edge optical network constructs the generalized MPLS message for lightpath aetup across the optical network. The generalized Label Request Message extracts information from the O-UNI Label Request Message with regard to the Generalized Label Request TLV, the Suggested Label TLV, and the Label Set TLV, whenever applicable. The methods and procedures described in [6] are then followed for end-to-end path setup.

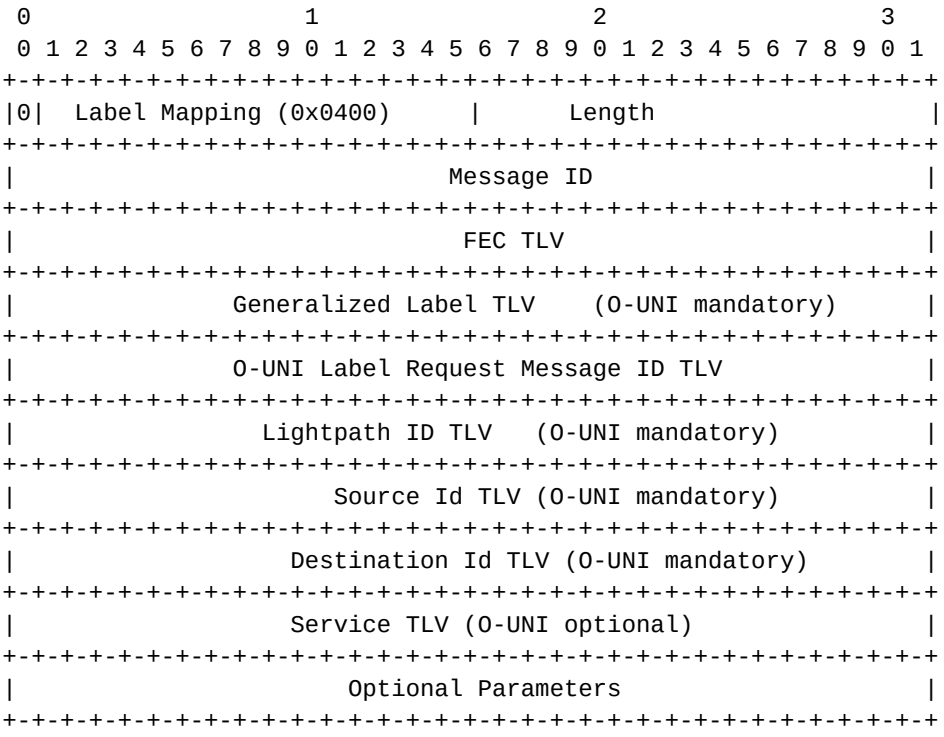
Lightpath modification request is achieved by the owner client sending a Label Request Message with ActFlg=1. In this case the lightpath Id is left unchanged as initially assigned by the network.

V.B. Label Mapping Message

The Label Mapping Message is as defined in 3.5.7 of [2] with the following modifications:

- The Label Mapping Message procedures are limited to downstream on demand ordered control mode.

The encoding of the O-UNI Label Mapping Message is as follows:



V.B.1. Generalized Label TLV

The Generalized Label TLV format and procedures are as in section 3.2. of [6].

V.B.2. O-UNI Label Request Message ID TLV

The O-UNI Label Request Message ID TLV has the same format and procedures as described in [4].

V.B.3. Procedure

The O-UNI Label Mapping Message flows between an optical network client and the edge optical network element.

The reception of the O-UNI Label Mapping Message signifies the successful establishment of a lightpath with the desired attributes. It also signifies the successful modification of one or more of the lightpath attributes.

The network transports the assigned Lightpath Id to the calling client in the Label Mapping Message. This Lightpath Id value is used by the client and the network for the exchange of lightpath status information.

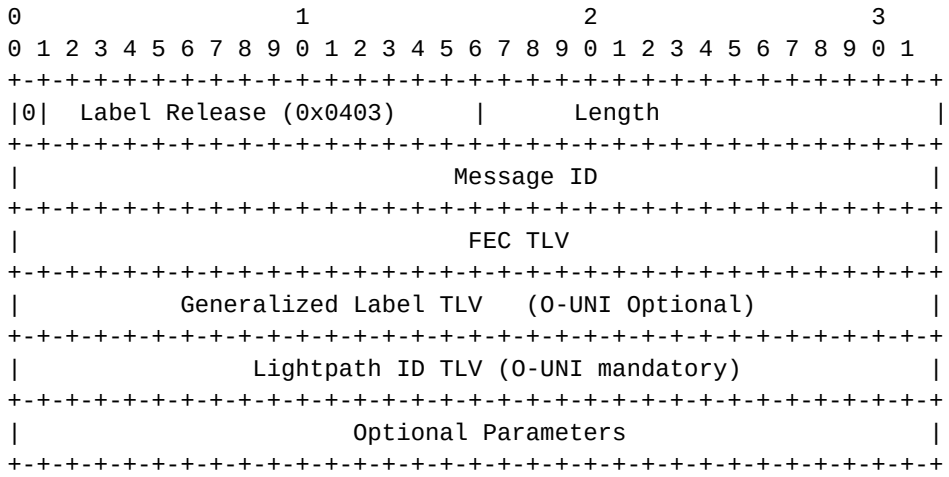
The O-UNI Label Mapping Message also includes a Generalized Label TLV. Its purpose is to indicate to the client label value, e.g. which wavelength, to be used.

The O-UNI Label Mapping Message optionally includes a Service TLV that summarizes the level of service extended from the optical network to its client. The Service TLV

must be included for the cases where reserved lightpath attributes, e.g. its bandwidth, are different from those requested by the customer.

V.C. The Label Release Message

The format of the O-UNI Label Release Message is as follows:

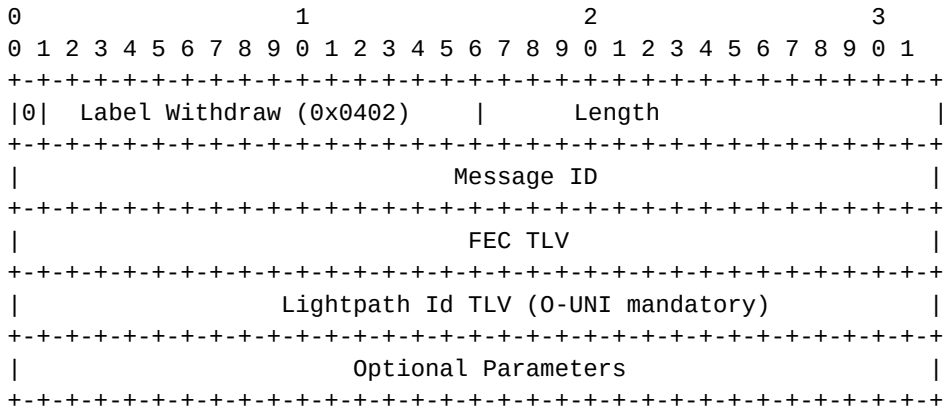


V.C.1. Procedure

The procedure for the O-UNI Label Release Message is as described in section 3.5.11. of [2]. The O-UNI Label Release Message is sent by either the client or the network to indicate the desire to delete an already established lightpath. The O-UNI Label Release Message carries a mandatory lightpath Id to indicate which lightpath should be terminated.

V.D. The Label Withdraw Message

The format for the O-UNI Label Withdraw Message is as follows:



V.D.1. Procedure

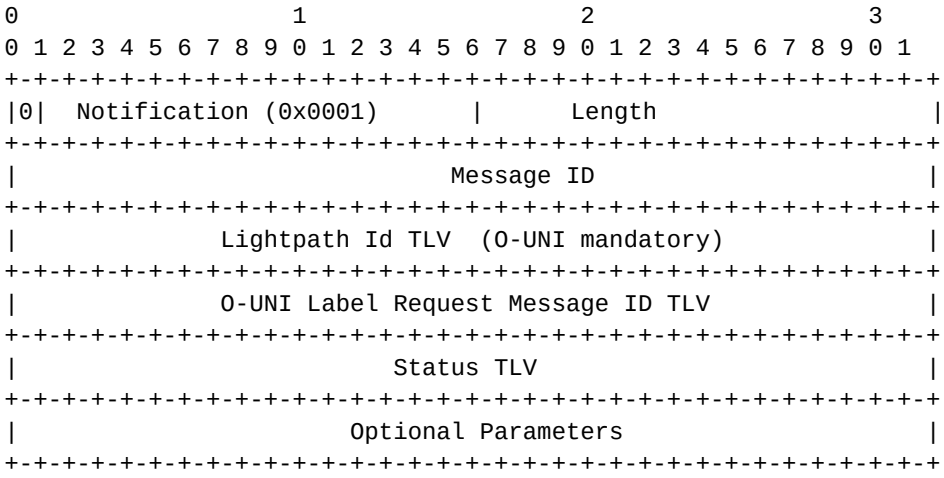
The procedure for the Label Withdraw Message follows that defined in section 3.5.10 of [2]. The Label Withdraw Message is sent by the network or the client in response to a Label Release Request.

The Label withdraw Message for O-UNI carries a mandatory lightpath Id. The reception of the Label Withdraw Message acts as an indication to the client or the network that the lightpath defined by its Lightpath Id has been terminated.

V.E. The Notification Message

The Notification Message is as defined in section 3.5.1. of [2] with the following modifications:

- The O-UNI Notification Message is sent autonomously from the network side of the O-UNI to the client to indicate the status of the lightpath request.
- The O-UNI Notification Message includes a mandatory Lightpath Id TLV



The Status TLV is as defined in section 3.4.6. of .

V.E.1. Procedure

The O-UNI Notification Message is used by the optical network to signal to its clients failure condition during or after the connection establishment phase. New Status codes relevant to lightpath operation are:

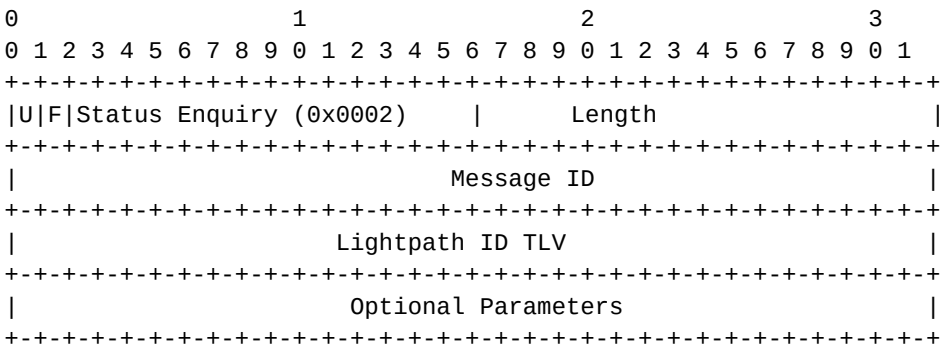
0x00001000 = not able to connect to destination user group
0x00001001 = invalid destination address
0x00001002 = invalid port Id
0x00001003 = invalid channel Id
0x00001004 = invalid sub-channel Id
0x00001005 = bandwidth unavailable
0x00001006 = protection mode unavailable
0x00001007 = routing directive unavailable
0x00001008 = failure to create lightpath

0x00001009 = failure to modify lightpath
0x0000100A = Failure to delete lightpath
0x0000100B = Encoding unavailable

If it has been already set, the Notification Messages includes the Lightpath Id TLV. If not set, e.g. for initial set up, the Lightpath Id TLV is set to 0. If the Lightpath Id is not set, the Notification Message MUST includes an O-UNI Label Request Message ID TLV as defined in section 6.2.2.

V.F. The Status Enquiry Message

The Status Enquiry Message is a new LDP message. The encoding for the Status Enquiry Message is:

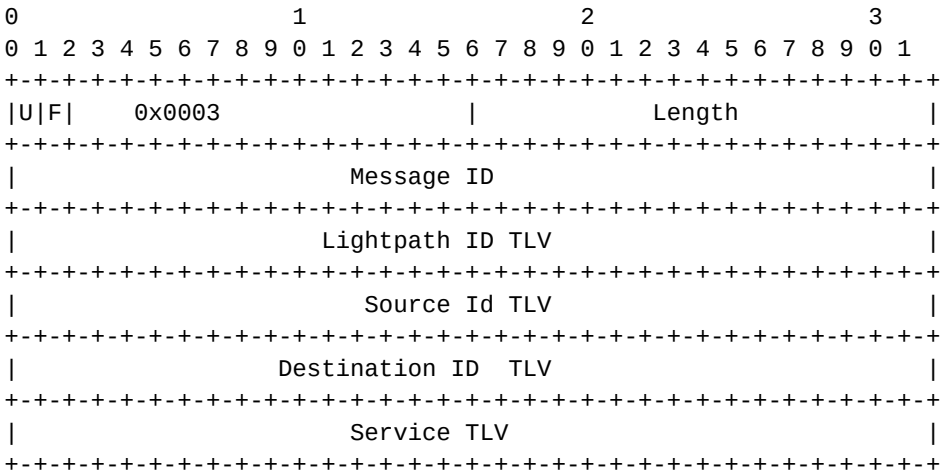


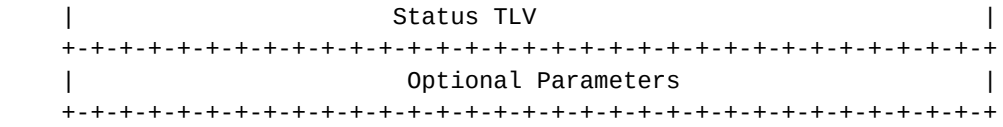
V.F.1. Procedure

The Status Enquiry Message is sent by the client or the network at any time to solicit a Status Response Message from its peer. The lightpath under consideration is identified by the Lightpath Id TLV.

V.G. The Status Response Message

The Status Response Message is a new LDP message. The encoding for the Status Response Message is:





V.G.1. Procedure

The Status Response Message is sent by either the client or the network in response to Status Enquiry Message. The Status TLV carries information that describes the current status of a connection (ligtpath) as defined by the Lightpath Id TLV. The status of the connection is encoded using the LDP Status TLV.

The Status Response Message could optionally include lightpath attributes as defined by Source Id, Destination Id, and the level of service.

V.G.1.a) Lightpath States

Connection States at the client side of the interface are:

- Null: no call exists
- Call Initiated: this state exist for an outgoing call when the client sends the Label Request Message, but has't yet received the Label Mapping Message from the network
- Call Present: this state exist for an incoming call when the client receives the Label Request Message from the network, but hasn't yet responded to it
- Active: This state exists for an incoming call when the client sends the Label Mapping Message to the network. The state also exist for an outgoing call when the initiating client receives the Label Mapping Message from the network.
- Release Request: this state exists when the client has requested the network to clear the end-to-end lightpath, i.e. the client sending the Label Release Message.
- Release Indication: this state exists when the client has received an disconnect indication because the network has already disconnected the lightpath, i.e. when the client receives the Label Release Message.

Similar connection states exist at the network side of the interface.

The Status codes for the lightpath states are:

0x0000100C = Null
0x0000100D = Call Initiated
0x0000100E = Call Present
0x0000100F = Active
0x00001010 = Release Request
0x00001011 = Release Indication

The lightpath states defined here form a subset of the connection states defined in [9].

VI. References

[1] Aboul-Magd, O~~B~~. et. al., "Signaling Requirements at the IP-Optical Interface (UNI)" draft-mpls-optical-uni-signaling-00.txt, work in progress, July 2000.

[2] Andersson, L., et. al., "LDP Specifications", draft-ietf-mpls-ldp-08.txt, work in progress, June 2000.

[3] Ash, J., et, al., "LSP Modification Using CR-LDP", draft-ietf-mpls-crlsp-modify-01.txt, work in progress, Feb. 2000.

[4] Jamoussi, B. Editor, "Constraint-Based LSP Setup Using LSP", draft-ietf-mpls-cr-ldp-04.txt, work in progress, July 2000.

[5] Fox, B. and Gleeson, B., "VPN Identifiers", IETF RFC-2685, Sept. 1999.

[6] Ashwood-Smith, P. et. Al., "Generalized MPLS - ~~Optical/Switching~~ Signaling Functional Description" ~~IETF Draft~~draft-ietf-mpls-generalized-signaling-00.txt, Work in Progress, ~~June~~ October 2000.

[7] Barry, R., "Lightpath Attributes Proposal", OIF2000.188, August 15, 2000.

[8] McAdams, L. and Yates, J., "User to Network Interface (UNI) Service Definition and Lightpath Attributes", OIF2000.61.4, Feb. 2000.

[9] ITU-T, "B-ISDN Application Protocols for Access Signaling"- Q.2931 Specifications, Feb., 1995.

VII. Appendix: LDP Fundamentals

VII.A. Overview

The Label Distribution Protocol (LDP) defined in [2] is a new protocol defined for distributing labels in the context of Multi-Protocol Label Switching (MPLS) architecture. It is the set of procedures and messages by which Label Switched Routers (LSRs) establish Label Switched Paths (LSPs) through a network by mapping network-layer routing information directly to data-link layer switched paths. These LSPs may have an endpoint at a directly attached neighbor (comparable to IP hop-by-hop forwarding), or may have an endpoint at a network egress node, enabling switching via all intermediary nodes.

LDP associates a Forwarding Equivalence Class (FEC) with each LSP it creates. The FEC associated with an LSP specifies which packets are "mapped" to that LSP. LSPs are extended through a network as each LSR "splices" incoming labels for a FEC to the outgoing label assigned to the next hop for the given FEC.

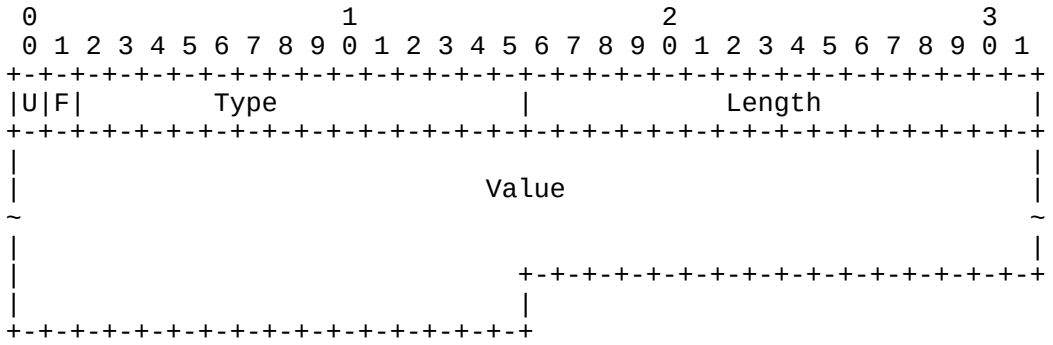
The LDP can operate in a number of modes depending on label distribution mode (independent or ordered), label retention mode (conservative or liberal), and label advertisement mode (downstream on demand or downstream unsolicited).

VII.B. LDP Peers

Two LSRs which use LDP to exchange label/FEC mapping information are known as "LDP Peers" with respect to that information and we speak of there being an "LDP Session" betweeen them. A single LDP sessio allows each peer to learn the other's label mappings; i.e., the protocol is bi-directional.

VII.C. LDP Message Structure

All LDP messages have a common structure that uses a Type-Length-Value (TLV) encoding scheme; see Section "Type-Length-Value" encoding. The Value part of a TLV-encoded object, or TLV for short, may itself contain one or more TLVs.



VII.D. LDP Message Exchange

There are four categories of LDP messages:

- Discovery messages, used to announce and maintain the presence of an LSR in a network.

- Session messages, used to establish, maintain, and terminate sessions between LDP peers.

- Advertisement messages, used to create, change, and delete label mappings for FECs.

- Notification messages, used to provide advisory information and to signal error information.

Discovery messages provide a mechanism whereby LSRs indicate their presence in a network by sending a Hello message periodically. This is transmitted as a UDP packet to the LDP port at the `all routers on this subnet' group multicast address. When an LSR chooses to establish a session with another LSR learned via the Hello message, it uses the LDP initialization procedure over TCP transport. Upon successful completion of the initialization procedure, the two LSRs are LDP peers, and may exchange advertisement messages.

When to request a label or advertise a label mapping to a peer is largely a local decision made by an LSR. In general, the LSR requests a label mapping from a neighboring LSR when it needs one, and advertises a label mapping to a neighboring LSR when it wishes the neighbor to use a label.

Correct operation of LDP requires reliable and in order delivery of messages. To satisfy these requirements LDP uses the TCP transport for session, advertisement and notification messages; i.e., for everything but the UDP-based discovery mechanism.

The LDP Messages defined in [2] are:

Message Name	Function
Notification Message	LSR notification of advisory or error information
Hello Message	Peer discovery
Initialization Message	LDP session establishment
KeepAlive Message	Monitors the integrity of the LDP session transport connection
Address Message	Advertise interface addresses
Address Withdraw Message	Withdraw previously advertised addresses
Label Mapping Message	Advertise FEC-label binding
Label Request Message	Request a binding (mapping) for a FEC

Label Abort Request Message	Abort an outstanding request
Label Withdraw Message	Breaks up the mapping between the FEC and the labels
Label Release Message	Signals the no need for specific FEC-label mapping.

VII.E. Constraint Route Label Distribution Protocol (CR-LDP)

LDP by itself does not have enough features to allow for the specification of an explicit route (ER) on an end-to-end basis. The additional features are specified in [4]. Those features allows for the specification of a constraint-based routed LSP (CR-LSP) initiated by the ingress device. It also specifies the mechanisms to provide means for reservation of resources using LDP. The added features could be summarized as:

- Strict and loose explicit routing
- Specification of traffic parameters
- Route pinning
- CR-LSP pre-emption through setup/holding priorities
- Handling failures
- Resource classes