MPLS Working Group                                     O. Aboul-Magd
Internet Draft                                         Sandra Ballare
Document: draft-ietf-mpls-ldp-optical-uni-01.txt       Ewart Tempest
                                                       Nortel Networks

                                                       Raj Jain
                                                       Nayna Networks

                                                       LiangYu Jia
                                                       ONI Systems

                                                       Bala Rajagopalan
                                                       Tellium Inc.

                                                       Robert Rennison
                                                       Laurel Networks

                                                       Yangguang Xu
                                                       Lucent Technology

                                                       Zhensheng Zhang
                                                       Sorrento Networks

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   LDP Extensions for Optical User Network Interface (O-UNI) Signaling


Status of this Memo

1. Abstract

   In OTNs using overlay model, clients request network services
   through a user network interface (UNI). This draft describes LDP
   necessary extensions for signaling support across the optical UNI

(O-UNI). LDP extensions are those needed to satisfy the main
functions supported at the O-UNI. Those functions are: connection
create, connection delete, connection modify, and connection status
enquiry.


## 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 [2].


## 3. Introduction

Several models have been discussed for the support of IP traffic
over the transport layer (L1/L0) [3]. Three models are identified
and are differentiated based on the amount of routing/topological
information exchanged between the optical transport network (OTN)
and its clients. Those models are overlay, peer, and augmented
models.

In an overlay network architecture such as the ITU-T automatic
switched OTN (ASTN) [4], there is a clear boundary between the
client and the network layers. Routing and topological information
does not cross this boundary in the sense that each layer is running
its own instant of a routing protocol, e.g. OSPF or entirely
different routing protocols. Network clients request network
services, e.g. connections, across a well-defined interface. This
interface is generally called the optical user network interface (O-
UNI).

MPLS based protocols have already been proposed for the realization
of the optical layer control plane in what is termed as generalized
MPLS (GMPLS) [5]. Both CR-LDP [6] and RSVP-TE [7] have been extended
for possible use as the control plane signaling protocols. It
therefore makes sense to use the same set of protocols for the
implementation of the O-UNI. This draft introduces the necessary LDP
[8] extensions to support the basic O-UNI functionality.

At the O-UNI, four O-UNI actions are provided. Those actions are:

- Connection Create: Creates an end-to-end connection across the OTN
  with specified connection attributes such as bandwidth, diversity,
  etc. Numerous connection attributes have been articulated in [9]

- Connection Delete: Deletes an already existing connection.

- Connection Modify: Modifies one or more of the connection
  attributes of the existing connections. Connection Modify is not
  supported in this version of the draft.

- Status Enquiry: Allows the client to enquire the status of a
  connection or a group of connections. A connection can be in one

of a number of states such as, active, redialing, etc [9]. This
operation also allows querying connection information in order to
recover connection state.

Tightly related to the O-UNI, and any UNI in general, is the need to
uniquely identify clients and their points of attachment to the
network. An addressing scheme for the OTN has been discussed in [9].
Client identification is based on a transport network address (TNA)
that is globally unique and is assigned to the client by the network
provider. The scope of the TNA could be on a one-to-one basis with
logical links that the network provider provision between an OTN
network element (NE) and an OTN client, or it could be a single TNA
per OTN (optical transport network) client. In the latter case there
is the need to introduce a logical port identifier (LPI) to
differentiate between multiple logical links between an OTN client
and an OTN NE that share the same TNA address. Similar to the TNA,
LPI is assigned to the client by the network provider. Protocol
extensions are required to support signaling of the TNA and LPI.

O-UNI reference models have been discussed in [9]. The client side
of the O-UNI has been denoted as UNI-C, while the term UNI-N has
been used to identify the network side of the O-UNI. One or more
signaling channels exist between the UNI-C and UNI-N. The UNI
control channel MUST support the transport of IP protocols. This
capability is necessary since IP based protocols, e.g. LDP, are
proposed for O-UNI signaling.

4.0 LDP for the O-UNI

In extending LDP for implementation at the O-UNI, there have been
two main guiding principles. Firstly every effort was made to limit
the introduction of new LDP messages. New messages are only
introduced whenever the desired functionality could not be supported
by existing messages, and have been limited to only those required
to support the status enquiry function of the O-UNI.

Secondly care has been taken not to violate any of the LDP semantics
as defined in [8]. Therefore LDP O-UNI extensions could easily be
implemented as a simple add-on to the already existing LDP
implementations.

The mode of operation of the LDP at the O-UNI is downstream on
demand label advertisement with ordered control.

4.1 LDP Session Initialization

For the O-UNI the LDP session is established between UNI-C and UNI-
N. Furthermore the client (UNI-C) MUST play the active role during
the LDP session initialization phase. Moreover, if all logical links
are in the same O-VPN,:

- There will be a single LDP session between an OTN client and an
  OTN NE, regardless of the number of logical links between them.

- In the case of proxy signaling, there will be a single LDP session between a proxy agent and an OTN NE regardless of the number of OTN clients and logical links the proxy agent signals on behalf of.

The LDP Hello and Extended Hello SHALL be used for neighbor discovery as specified in [8].

An LDP session starts by UNI-C sending an LDP Initialization message to its neighbor UNI-N over the TCP session. In addition to the parameters described in [8], the Initialization message from the UNI-C to the UNI-N contains all the O-UNI version numbers that are supported by the UNI-C.

The UNI-N follows the procedure specified in section 2.5.3 of [8] for the passive LSR. It replies with an Initialization message to propose the parameters it wishes to use. Those parameters MUST include the highest version number from the list advertised by the UNI-C that the UNI-N supports. If the UNI-C and UNI-N have no UNI version in common, the LDP session establishment will fail.

The Initialization message also includes a Contract ID TLV. Contract ID is determined by the network provider and identifies the contract agreement between the OTN client and the OTN operator. Its format is determined by the OTN operator.

Maintaining the LDP session at the O-UNI MUST follow the procedure explained in section 2.5.6 of [8].

4.2 Connection Create using LDP

In LDP, the connection create request is implemented using the Label Request message as defined in [8]. The Label Request message is from the source UNI-C to the source UNI-N. At the other end of the network the Label Request message is sent from the destination UNI-N to destination UNI-C.

The requested connection might need to support a number of attributes. Extensions are needed to the Label Request message to support the client signaling of those attributes.

OTN connections are usually bi-directional. As in GMPLS, a bi-directional connection is signaled at the O-UNI by the inclusion of the Upstream Label in the Label Request message. Reception of the Label Request message by the destination UNI-C signifies the reservation success, i.e. all the requested connection attributes can be satisfied, of the bi-directional connection. However it doesnÆt imply that the connection is available for data transport. Connection is only available when configuration of intermediate cross connects is complete. The Configuration of any intermediate cross connect likely to require some time to complete and, depending on the technology used, this delay may be significant, e.g. in the order of 10's or 100's of ms.

The destination UNI-C sends a Label Mapping message in response to
the Label Request message, only once it has setup its own switch
fabric. If it so desires, the destination UNI-C MAY indicate to the
source UNI_C that a reservation confirmation indication is needed.
The reservation confirmation indication is implemented using the LDP
Notification message with the status code ôreservation_confirmö. In
general, Uni-directional connections do not require a reservation
confirmation indication, and depending on the nature of the
application on the destination OTN client that terminates the OTN
connection, maybe not even in the case of bi-directional
connections.

Contention for labels may occur between two bidirectional connection
setup requests traveling in opposite directions.  This contention
occurs when both sides allocate the same resources (labels) at
effectively the same time. To resolve contention, the node with the
higher node ID will win the contention and it MUST issue a
NOTIFICATION message with a "Routing problem/Label allocation
failure" indication.  Upon receipt of such an error, the node SHOULD
try to allocate a different Upstream label (and a different Suggested
Label if used) to the bidirectional path.  However, if no other
resources are available, the node must proceed with standard error
handling.

Similarly the source UNI-N sends a Label Mapping message to the
source UNI-C. At this instant the transport connection is available
to the source UNI-C for use provided that its own switch fabric have
been setup. Figure 1 shows a timing diagram for a successful
establishment of a bi-directional connection.

```
              UNI-C     UNI-N            UNI-N     UNI-C
                |         |                |         |
                |         |                |         |
      Label     |------->|                |         |
      Request   |         |-------------->|         | Label
                |         |                |------->| Request
                |         |                |         |
                |         |                |         |
                |         |                |<-------| Label
      Label     |         |<--------------|         | Mapping
      Mapping   |<------|                 |         |
                |         |                |         |
  Reservation   |------->|                |         | Reservation
    Confirm     |         |                |------->| Confirm
                |         |                |         |
```
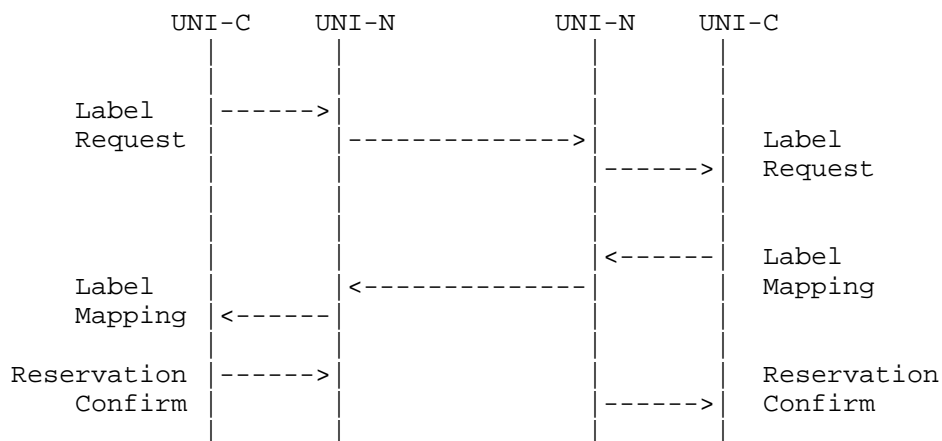
            Figure 1: Successful Setup of Bi-Directional Connection

The connection create request might fail for a number of reasons,
e.g. no bandwidth available, no physical connectivity, SLA
violation, connection rejected by far end OTN client. In this case
failure of the create request is indicated to the source UNI-C using
the LDP Notification message with the status code reflecting the

reason for the failure. Figure 2 shows a create request rejection by
the netwok.

```
            UNI-C     UNI-N            UNI-N     UNI-C
              |         |                |         |
              |         |                |         |
    Label     |------->|                |         |
    Request   |         |                |         |
              |         |                |         |
              |         |                |         |
Notification  |<------|                 |         |
              |         |                |         |
```
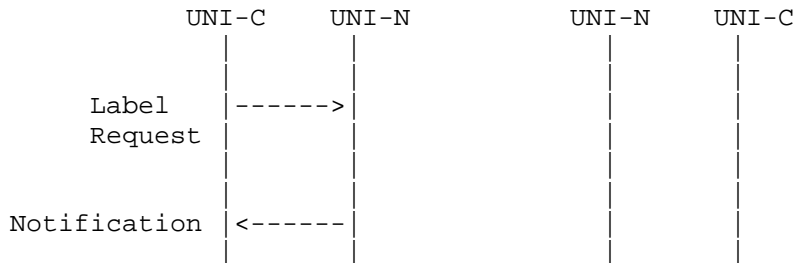
          Figure 2: Connection Setup Rejection by the Network

Should a client desire to abort the connection create process after
sending the Label Request message, an LDP Abort message MUST be sent
as defined in section 3.5.9. of [8]. Specifically the Message ID
used in the Label Request Message is used in the Abort Message as
the temporary local connection identifier.

4.3 Connection Deletion Using LDP

LDP employs two mechanisms for an LSR (label switched router) to
inform its peer to stop using a particular label. The first method
is based on the use of Label Withdraw message and it is used to
signal to a peer that the peer may not continue to use a specific
label mapping that the LSR has previously advertised. The second
method is based on the use of Label Release message and it is sent
to signal to a peer that the LSR no longer needs a specific label
mapping previously requested and/or advertised by the peer.

The O-UNI LDP extensions make use of the Label Release and Label
Withdraw messages for connection deletion. The choice of which
message to use depends on the entity that initiates the deletion.
The Label Withdraw message is used for the case where the connection
deletion is in the upstream direction. As per the LDP procedure in
section 3.5.10 of [8], Label Release message is used in this case to
acknowledge the delete request.

The Label Release message is used for the cases where connection
deletion is in the downstream direction. In this case the delete
request is confirmed by the use of LDP Notification message with the
status code "delete_success".

Figures 3 and 4 show graceful connection deletion requested by the
source UNI-C and the destination UNI-C respectively.

```
            UNI-C     UNI-N            UNI-N     UNI-C
              |         |                |         |
              |         |                |         |
Notification  |------->|                |         |
              |         |-------------->|          |
```

```
              |        |                    |------>| Notification
              |        |                    |       |
              |        |                    |<------| Label Withdraw
              |        |<-------------      |       |
Label Withdraw|<------ |                    |       |
Label release |------> |                    |       |
              |        |------------->|     |       |
              |        |                    |------>| Label Release
              |        |                    |       |
```
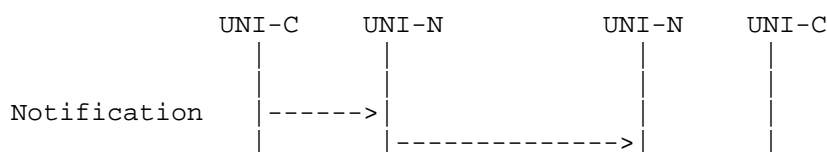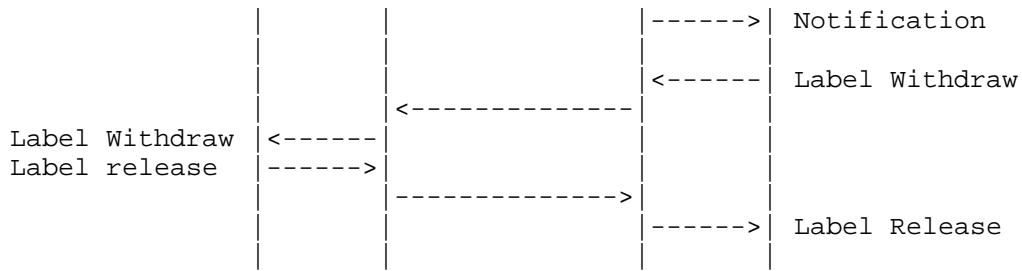
              Figure 3: Graceful Connection Deletion by the Source UNI-C


```
           UNI-C    UNI-N            UNI-N     UNI-C
              |        |                |        |
              |        |                |<------ | Notification
              |        |<-------------  |        |
Notification  |<------ |                |        |
Label Release |------> |                |        |
              |        |------------->  |        |
              |        |                |------> | Label Release
              |        |                |<------ | Notification
              |        |<-------------  |        |
Notification  |<------ |                |        |
              |        |                |        |
```
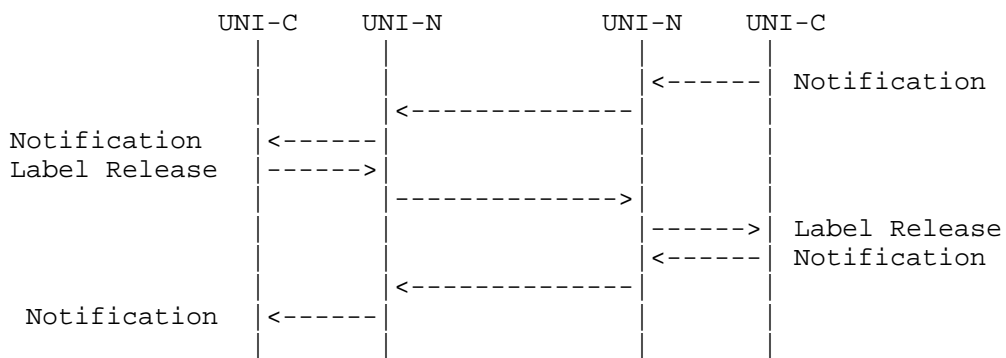
            Figure 4: Graceful Connection Deletion by the Destination UNI-C


Figure 3 shows that the delete request is preceded by an LDP
Notification message with status code ôdelete_indicationö. In all
optical networks, loss of light will propagate faster than the
delete request. Thus downstream NE will detect loss of light and
potentially alarm on it. This alarm could be used to incorrectly
trigger restoration and/or protection. To address this issue, a
Notification message SHOULD be sent along the connection's route to
inform all nodes of the intended deletion. Upon the receipt of this
message, each node SHOULD disable its alarm reporting and protection
mechanisms on the indicated connection.

Figure 5 shows a connection deletion scenario initiated by the
network, or a force deletion requested from an OAM entity. In this
case both Label Withdraw and Label Release messages are used to
initiate the deletion request.


```
           UNI-C    UNI-N            UNI-N     UNI-C
              |        |                |        |
              |        |                |        |
    Label     |<------ |                |------> | Label
  Withdraw     |        |                |        |  Release
              |        |                |        |
    Label     |------> |                |<------ |
```

```
      Release |           |              |     |Notification
              |           |              |     |
```
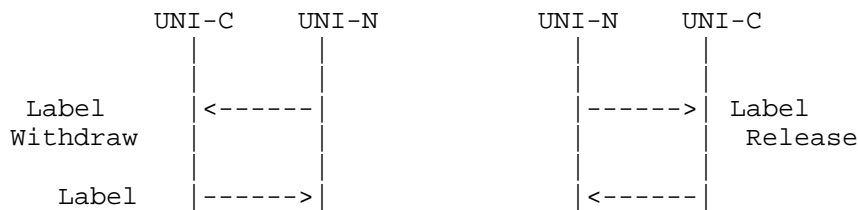
          Figure 5: Connection Deletion Initiated by the Network

4.4 Failure Detection and Recovery Using LDP

   In optical transport networks, failures in the out-of-fiber
   signaling communication or optical UNI control plane should not have
   service impact on the existing optical connections. Under such
   circumstances, a mechanism MUST exist to detect a signaling
   communication failure and a recovery procedure SHALL guarantee
   connection integrity at both UNI-C and UNI-N.

   The LDP Keep Alive mechanism MUST be used to detect signaling
   communication failures between a UNI-C and a UNI-N, unless an
   alternative mechanism is in place to detect such failures more
   efficiently. During the signaling communication failure all active
   connections are maintained (the bearer connection is active) and all
   transient connections (in-progress) are cleared.

   Upon signaling communication re-establishment (i.e. re-establishment
   of LDP Keep Alive) a resynchronization period is required in order
   to synchronize connection state information across the UNI. This
   synchronization period shall be performed prior to processing new
   connection requests.

   The resynchronization period starts by the UNI-C either querying the
   network (UNI-N) for the (summary or detailed) states of all
   connections associated with a particular logical link, or otherwise
   (implicitly or explicitly) deleting them. In the former case, the
   UNI-N will respond with appropriate status information. The OTN is
   the master of all oTN connection information. An OTN connection,
   once created, remains within the OTN until implicitly or explicitly
   deleted by either of the terminating OTN clients through UNI
   signaling, or via OTN operator intervention. Specifically the burden
   is on the OTN client to resynchronize with the OTN. Under no
   circumstances will the OTN resynchronize with its OTN connection
   view with that of an OTN client.

   There are three cases to consider during recovery:

   a) Both UNI-C and UNI-N have retained connection information during
      the signaling communication failure.  In this case, the recovery
      consists of synchronizing connection state information.  This
      synchronization process requires UNI-C to send Status Enquiry
      messages requesting summary connection information.

   b) The client device lost all connection information in its UNI-C
      control plane during the signaling communication failure. In this
      case, the recovery procedure requires the UNI-C to query each
      connection to its peer UNI-N in order to rebuild the connection
      state information. This can be performed using the Status Enquiry

     message(s) requesting detailed connection information based on LDP
     session, logical link or TNA address.

  c) The client device lost all connection information in its UNI-C
     control plane and requires all OTN connections to be deleted on:

     - A per LDP session basis.
     - A specific logical link
     - All logical links that share a specified TNA address

     In this case, the synchronization is a simple restart process that
     can be achieved by sending a Label Release message with the
     corresponding TNA and optional logical port parameters. Figure 6
     shows the scenario for graceful and forced deletion of all
     connection in this case (for the purpose of simplicity, the
     diagram assumes that the OTN connections to be deleted all
     terminate on the same destination OTN client. In reality, this
     will almost certainly not be the case). Graceful deletion is
     indicated by source UNI-N sending a Notification message
     indicating the intended delete. This Notification message is
     OPTIONALLY sent in response to the source UNI-C Label Release
     message. For multiple destinations a separate Notification message
     SHLL be sent per destination.


```
                 UNI-C     UNI-N            UNI-N     UNI-C
                   |         |                |         |
 Label Release     |------>|                |         |
                   |         |-------------->|         |
                   |         |                |------>| Notification
                   |         |                |<------| Label Withdraw
                   |         |<--------------|         |
                   |         |                |         |
                   |         |-------------->|         |
                   |         |                |         |
                   |         |                |------>| Label Release
 Notification      |<------|                |         |
                   |         |                |         |
```
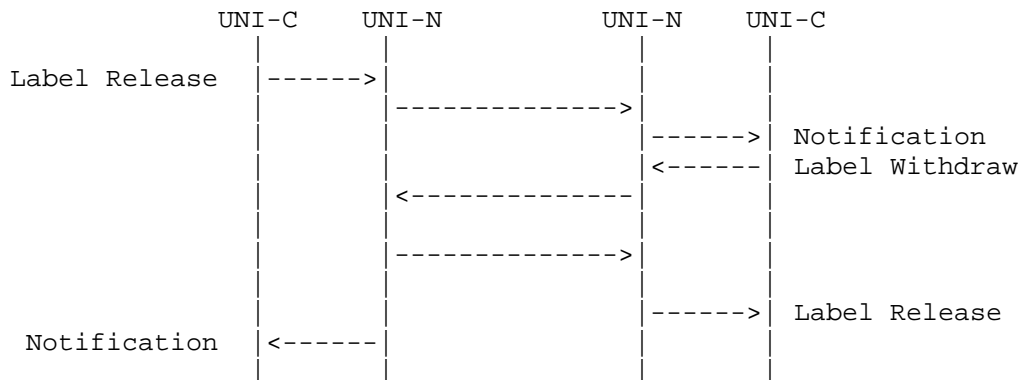
              Figure 6: Deletion of All Connections

  Resynchronization is deemed to be complete between a given OTN
  client and OTN NE when each connection for which OTN NE knows about
  is either queried or deleted by the OTN client. Until such time, no
  new connections can be established for which the OTN client would be
  a terminating point.

5.0 LDP Extensions for O-UNI

  This section describes LDP extensions specific for the support of
  signaling across the optical UNI.

5.1 TLV Encoding for Commonly Used Parameters

The TLV encoding described in section 3.4 of [8] and in [10] MUST be
applicable at the O-UNI. This section describes the O-UNI specific
TLV encoding.

5.1.1 Src ID TLV

A client used the Src ID TLV to indicate its identification
parameters. The Src ID TLV MUST contain the source TNA, and
OPTIONALLY contain a Logical Link ID. The encoding for the Src ID
is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|    Src TNA Value        |            Length               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                          Src TNA                              ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Logical Port ID                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Src TNA:
  Src TNA can be in one of three formats [9]. It can be in either
  IPv4, IPv6, or NSAP format. Only TNA addresses of the same type
  can be compared for equivalence. The Src TNA values are:

        Value               Type
        -------             -------
        0x960               IPv4
        0x961               IPv6
        0x962               NSAP

  The NSAP format is structured according to ISO/IEC 8348, 1993
  (identical to ITU X.213, 1992)

  Only TNA addresses of the same type SHOULD be compared for
  equality.

Logical Port ID:
  A 32-bit unsigned number indicating identifying a logical port at
  the source OTN NE. Logical Port ID is OPTIONAL and, as such, may
  not be present.

5.1.2 Dest ID TLV

Dest ID TLV is used to identify the destination end of the
connection. The Dest ID TLV encoding is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|    Dest TNA Value       |            Length               |
```

```
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    ~                          Dest TNA                             ~
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                       Logical Port ID                         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Dest TNA:
  Similar to the Src TLV, the following values MUST be supported

```
        Value              Type
        -------            -------
        0x963              IPv4
        0x964              IPv6
        0x965              NSAP
```

  The NSAP format is structured according to ISO/IEC 8348, 1993
  (identical to ITU X.213, 1992)

  Only TNA addresses of the same type SHOULD be compared for
  equality.

Logical Port ID:
  A 32-bit unsigned number indicating identifying a logical port at
  the destination client device. Logical Port ID is OPTIONAL and, as
  such, may not be present.

5.1.3 Egress Label TLV

  Egress Label TLV is an OPTIONAL O-UNI defined TLV. Egress Label TLV,
  when present, indicates the egress label to be used at the
  destination end of the O-UNI. The encoding for the Egress Label is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|   Egress Lbl (0x0957)   |          Length                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Reserved                            |L|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                           Label                               ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

L-bit:
  If L=0, then the Label value MUST be copied into Label Set TLV in
  the corresponding outgoing Label Request message from the
  destination UNI-N to destination UNI-C. If L=1, then the Label
  value MUST be copied into an Upstream Label TLV in corresponding
  outgoing Label Request message from the destination UNI-N to the
  destination UNI-C. As such, the Label Request message originated

by the source UNI-C may contain up to two Egress Label TLVs, one
with the L-bit set, and the other with the L-bit not set.

5.1.4. Connection ID TLV

The Connection ID TLV is used to uniquely identify a connection
established by the network. The format of the Connection ID TLV is
as follows:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F| Connection ID (0x0952)    |        Length                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Reserved                                 |C|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                      Connection ID                            ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

C-bit:
  The value of the C bit is set by the destination UNI-C whenever a
  reservation confirmation indication is needed.

Connection ID:
  Connection ID has a variable length in multiple of 32, and is at
  least 64 bits wide.

5.1.5 Diversity TLV

Diversity TLV lists all the other connections from which the
requested connection MUST be diverse. It also specifies the type of
diversity. The encoding of the Diversity TLV is as follows:
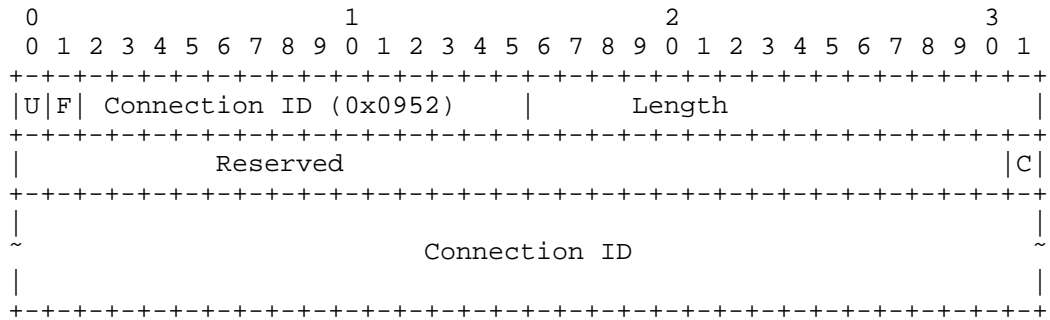
```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F| Diversity TLV (0x0954)    |        Length                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Connection ID TLV 1                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Reserved                   | DivT  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                         . . . . . .                           ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Connection ID TLV n                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Reserved                   | DivT  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
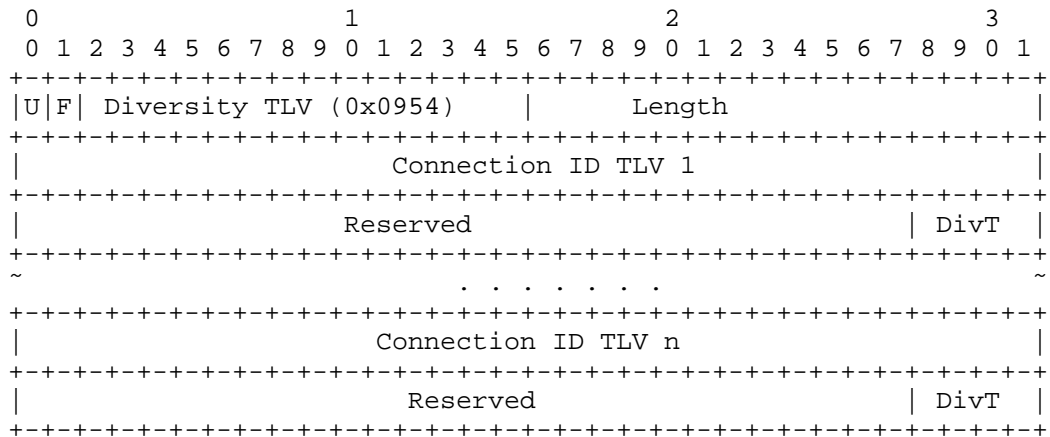
Connection ID TLV i:
  This is the Connection ID of an existing connection from which
  the requested connection must be diverse.

DivT (Diversity Type):
   DivT specifies the manner by which the requested connection
   should be diverse. The allowed values are:

   0x0 = Link diverse
   0x1 = Node diverse
   0x2 = Shared Risk Link Group (SRLG) diverse
   0x3 = Link non-diverse
   0x4 = Node non-diverse
   0x5 = SRLG non-diverse

5.1.6 Contract ID TLV


```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|Contract ID TLV (0x0956)     |       Length                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                        Contract ID                            ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
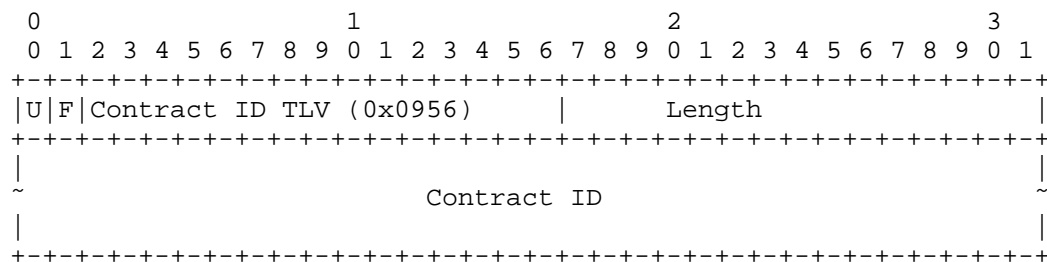

Contract ID:
   This is a variable-length string of characters whose format will
   be determined by the OTN provider. Contract ID identifies the
   contracted service level agreement (SLA) that the OTN client has
   with the OTN operator, and in whose context the connection setup
   request is made. Contract IDs therefore only have local
   significance between an OTN client and an OTN NE.

5.1.8 O-UNI Service TLV

   The O-UNI Service TLV describes connection attributes in terms of
   restoration and routing diversity. The encoding of the O-UNI Service
   TLV is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|   O-UNI Service (0x0953)   |       Length                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Reserved             |       Service Level          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Diversity TLV                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
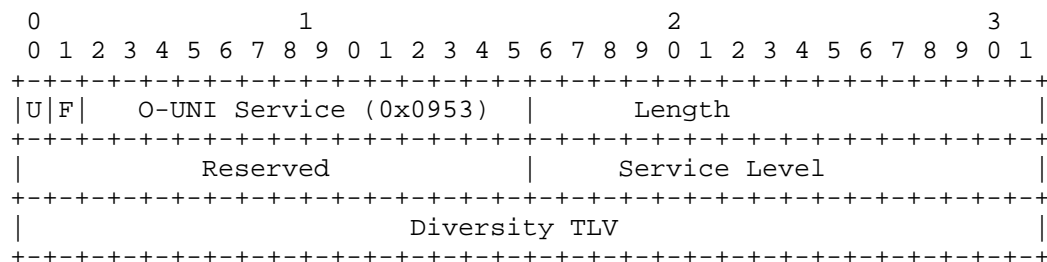
   Service Level:
     A Service Level corresponds to carrier-defined characteristics
     such as time to restore, BER, bumping priority, etc.

5.1.9 O-UNI Version Number TLV

The O-UNI Version Number TLV is of the form:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F|Version Num TLV (0x0955)  |          Length               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Major Vesrion Number      |      Minor Version Number    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
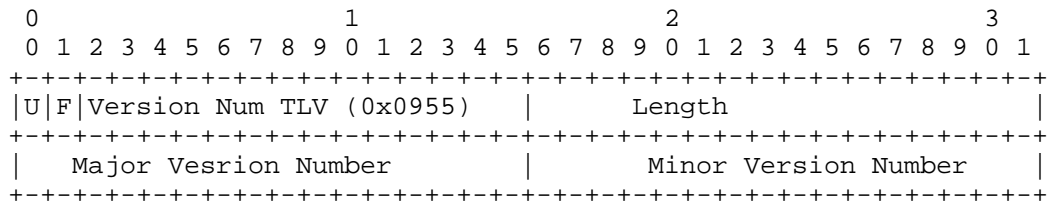
Minor version number is set relative to the major version number.
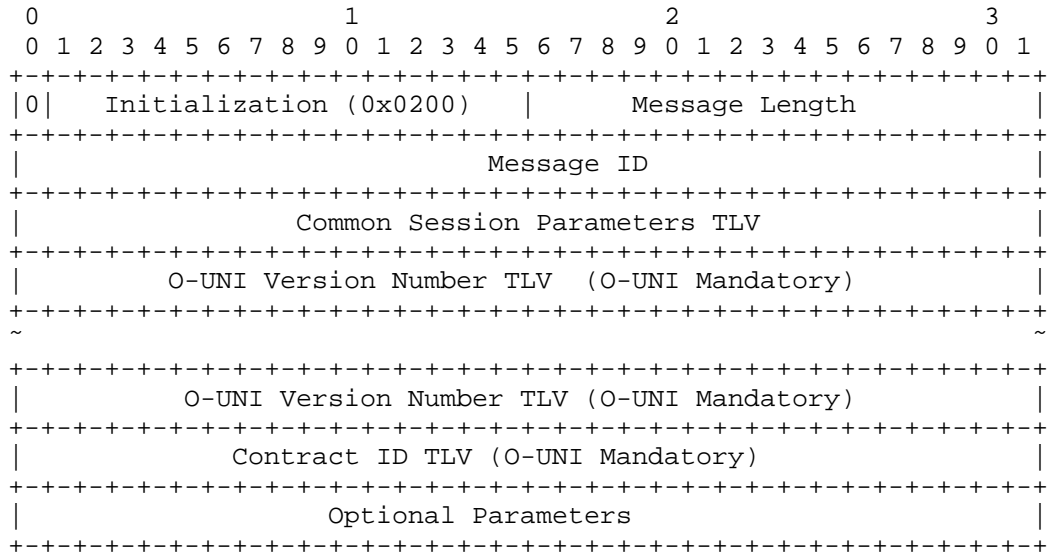
## 5.2 LDP Message Extensions for O-UNI

This section describes the necessary extensions for LDP messages for the support of signaling across the O-UNI. This section also includes the definition of the two new messages needed for status enquiry. Those messages are Status Enquiry message and Status Response Message.

## 5.2.1 Hello Message

The format and the procedure for the Hello message is as defined in section 3.5.2 in [8].

## 5.2.2 Initialization Message

The encoding for the Initialization message is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0|   Initialization (0x0200)  |      Message Length           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Message ID                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Common Session Parameters TLV               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          O-UNI Version Number TLV  (O-UNI Mandatory)         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                                                              ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         O-UNI Version Number TLV (O-UNI Mandatory)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Contract ID TLV (O-UNI Mandatory)                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Optional Parameters                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The initialization message procedure is as described in section 2.5. in [8] and section 4.1 of this draft.

Message ID is as defined in section 3.5. in [8]. Common Session Parameter TLV is as defined in section 3.5.3 in [8].
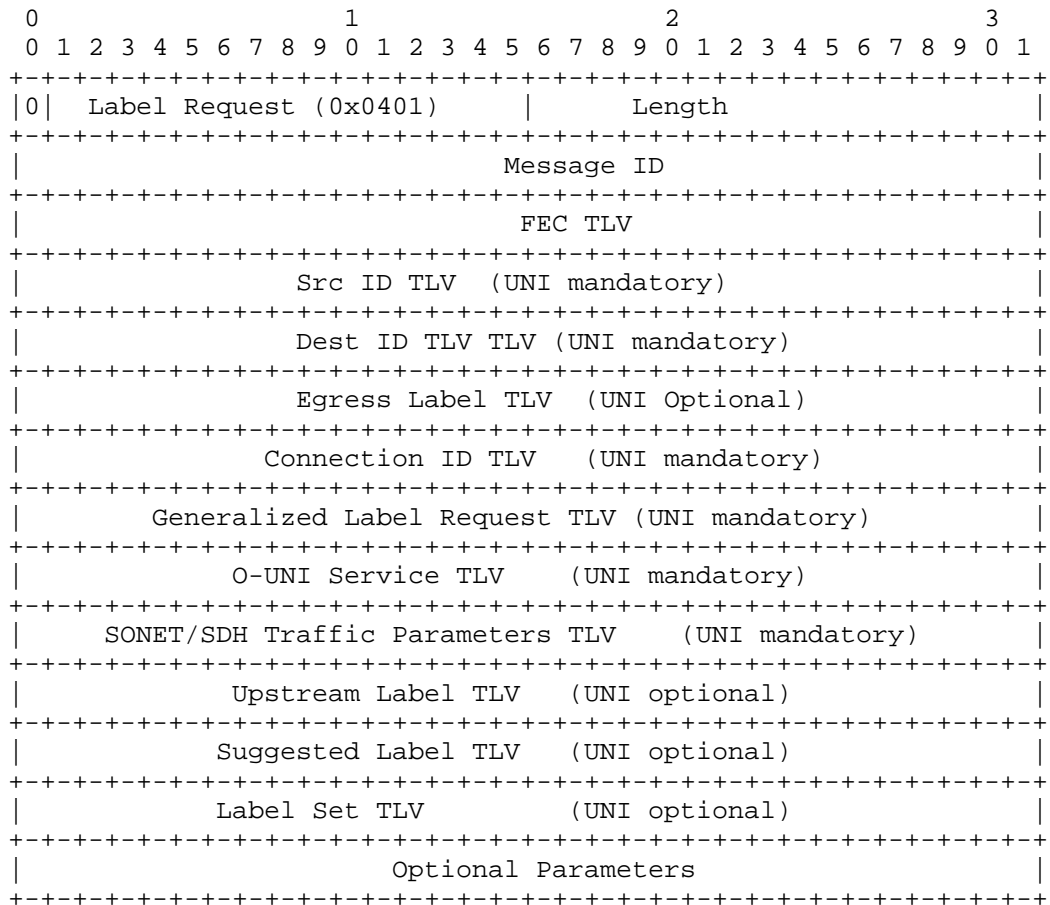
The currently defined values for the O-UNI version Number are:

    For OIF Demo UNI:
        Major Version Number = 0x0000, Minor Version Number = 0x0001

    For OIF UNI 1.0:
        Major Version Number = 0x0001, Minor Version Number = 0x0000

5.2.3 Label Request Message

    The encoding of the Label Request Message for O-UNI is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0|  Label Request (0x0401)     |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Message ID                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           FEC TLV                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              Src ID TLV  (UNI mandatory)                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Dest ID TLV TLV (UNI mandatory)                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Egress Label TLV  (UNI Optional)                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Connection ID TLV   (UNI mandatory)                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Generalized Label Request TLV (UNI mandatory)         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            O-UNI Service TLV    (UNI mandatory)               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      SONET/SDH Traffic Parameters TLV    (UNI mandatory)      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Upstream Label TLV   (UNI optional)                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Suggested Label TLV   (UNI optional)               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Label Set TLV         (UNI optional)                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Optional Parameters                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

    The Label Request Message is sent from:

    - the source UNI-C to source UNI-N to indicate an outgoing
      connection request;
    - the destination UNI-N to the destination UNI-C to indicate an
      incoming connection request.

How the Label Request message is propagated through OTN from the
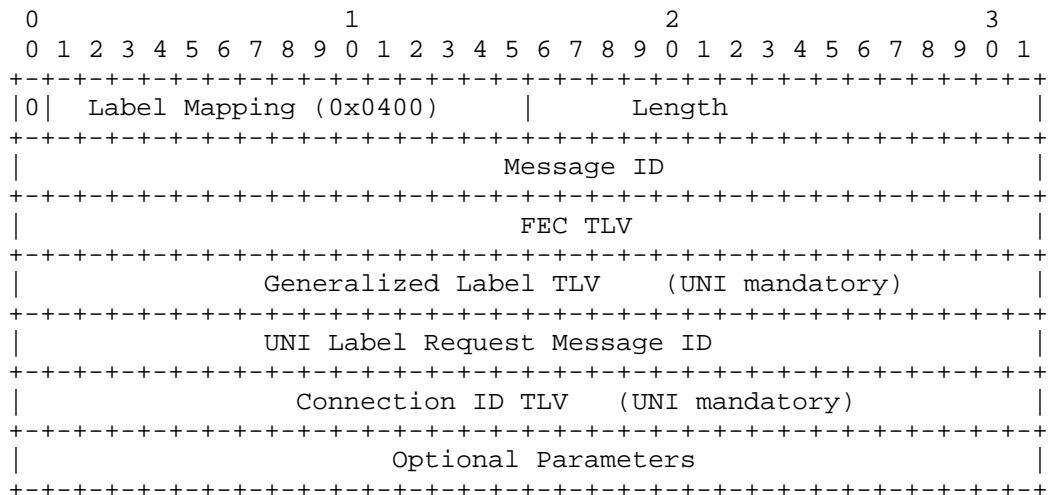source UNI-N to the destination UNI-N is outside the scope of this
specification.

In the Label Request Message, the initiating UNI-C identifies the
two connection termination points (Src and Dest ID TLVs). The UNI-N
is expected to assign a Connection ID that is unique within the
transport network. The Connection ID is passed to the terminating
UNI-C in the Label Request Message by the destination UNI-N.

Upon the reception of the Label Request Message, the source UNI-N
should verify that the signaled attributes (including the validity
of the Source and the Destination IDs) can be supported. Failure to
support one or more of the connection attributes triggers the
generation of the Notification Message with the appropriate error
code.

The Label Request message Message ID should be used as a local
connection identifier, until such a time when the network-assigned
Connection ID is sent back to the source client. As stated in [8],
since LSRs use Label Request message IDs as transaction identifiers,
an LSR SHOULD NOT reuse the Message ID of a Label Request message
until the corresponding transaction completers. Thus the local
connection identifier has a very limited lifespan.

## 5.2.4 Label Mapping Message

The format of the Label Mapping message for the O-UNI is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0|  Label Mapping (0x0400)      |           Length              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Message ID                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            FEC TLV                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|            Generalized Label TLV    (UNI mandatory)           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             UNI Label Request Message ID                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|              Connection ID TLV    (UNI mandatory)             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Optional Parameters                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The Label Mapping message procedure for the O-UNI is limited to
downstream on demand ordered control mode. The UNI Label Mapping
Message flows between:

- The destination UNI-C to destination UNI-N in response to a Label
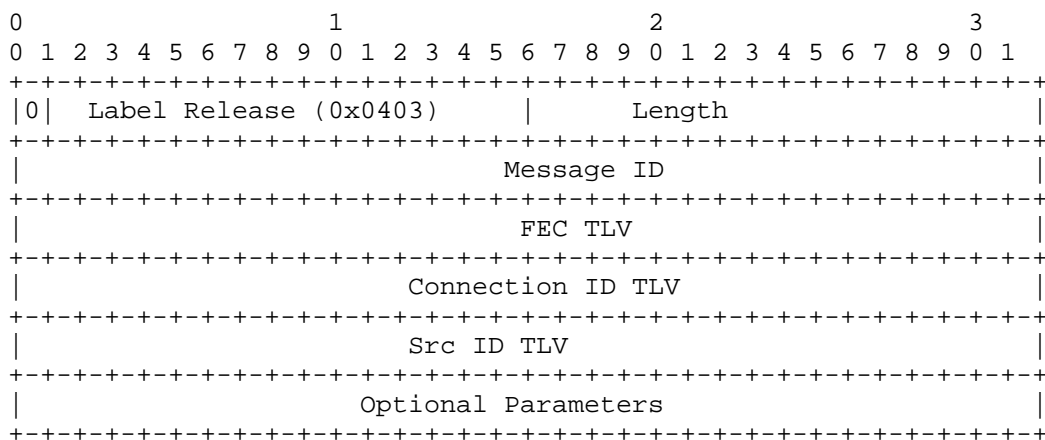  Request message;

    - The source UNI-N to the source UNI-C to indicate the successful
      establishment of a connection requested previously.

    The network transports the assigned Connection ID to the calling
    client (source UNI-C) in the Label Mapping Message.

    A terminating UNI-C that desires to receive a reservation
    confirmation from the initiating UNI-C MUST set the C-bit in the
    Connection ID TLV.

5.2.5 Label Release Message

    The encoding for the Label Release message at the O-UNI is:

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0| Label Release (0x0403)     |           Length              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Message ID                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           FEC TLV                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Connection ID TLV                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Src ID TLV                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Optional Parameters                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

    The LDP Label Release Message is used for connection deletion in the
    downstream direction, e.g. when the connection termination is
    initiated by the destination UNI-C (graceful OTN connection
    deletion) / source UNI-C (non-graceful OTN connection deletion). The
    O-UNI Label Release Message is sent by:

    - The source UNI-C to source UNI-N to request the deletion a
    connection;

    - The destination UNI-N to a destination UNI-C to indicate the
      deletion of a connection by the network.

    For the optical UNI, the receiver of the Label Release Message must
    respond with a Notification Message with the appropriate status code
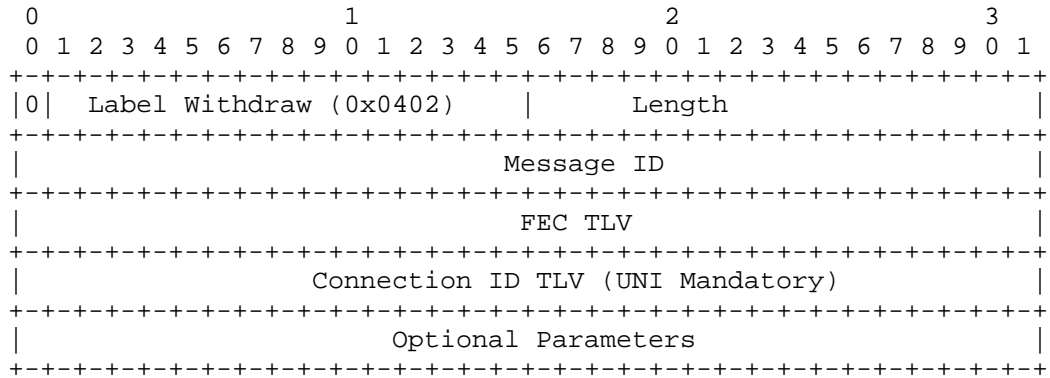    indicating the success of the delete request.

    Either the Connection ID TLV or the Src ID TLV MUST be included in
    the Label Release Message. When the Connection ID TLV is included,
    it is an indication that the connection identified by this ID is the
    one to be deleted. The Src ID TLV will only be present if a forced
    (i.e. non graceful) OTN connection deletion is to be performed.

    When the Src ID TLV is included, it is an indication to the network
    that the source UNI-C requires deletion of all the connections

associated with the specified logical link. This feature is
primarily used for forced deletion of connections in failure
recovery.

5.2.6 Label Withdraw Message

The encoding for the Label Withdraw message at the O-UNI is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0| Label Withdraw (0x0402)     |       Length                 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Message ID                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          FEC TLV                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Connection ID TLV (UNI Mandatory)                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Optional Parameters                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The LDP Label Withdraw message is used for connection deletion in
the upstream direction, e.g. when the connection termination is
initiated by the destination UNI-C (non-graceful OTN connection
deletion) / source UNI-C (graceful OTN connection deletion). The UNI
Label Withdraw Message is sent by:

- The destination UNI-C to destination UNI-N to request the deletion
  of a connection
- The source UNI-N to the source UNI-C to indicate the deletion of
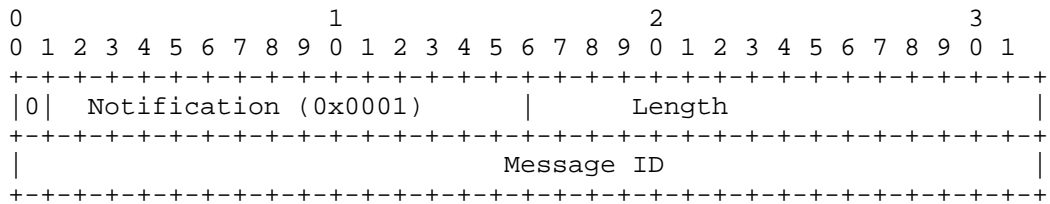  the connection by the network.

The procedure for the Label Withdraw Message is defined in section
3.5.10 of [8]. The recipient of the Label Withdraw Message MUST
respond with a Label Release message as in [8]. The Label Withdraw
message for UNI carries a mandatory Connection ID.

5.2.7 Label Abort Message

The format and the procedure of the Label Abort message are as given
in section 3.5.9 of [8].

5.2.8 Notification Message

The format of the Notification for the O-UNI is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|0| Notification (0x0001)       |      Length                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Message ID                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
|                    Connection ID TLV                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 Label Request Message ID TLV              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Status TLV                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Optional Parameters                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The UNI Notification Message must be forwarded towards the entity
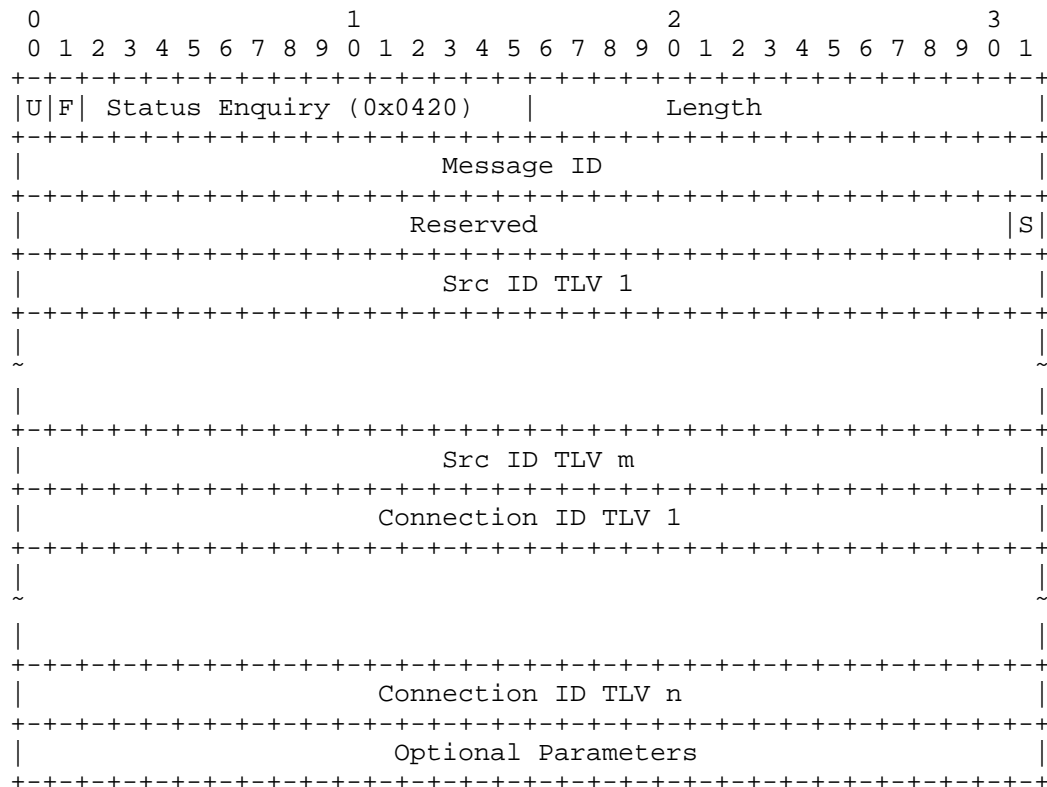originating the Label Request, Label Release, Status Enquiry, or
Abort.

The Notification message plays a number of roles within the O-UNI:

- A failed connection setup event is indicated to the source UNI-C
  using a Notification message. In this case, the Notification
  message is generated in response to a Label Request message before
  the source client has been made aware of its associated Connection
  ID. Therefore, in this case, the Notification message MUST include
  the Label Request Message ID TLV that specifies the Message ID of
  the Label Request message of the failed setup (and which
  constitutes the source OTN client local connection identifier).
  The Status TLV MUST include the status code for the cause of the
  failed setup, e.g. "no_bandwidth_available".

- A Notification message is needed to initiate graceful deletion of
  a single OTN connection. In this case the Notification message
  MUST include the Connection ID of the connection to be deleted.
  The "delete_indication" status code must be included.

- A Notification message is sent in response to a connection
  deletion in the downstream direction, i.e. initiated by a Label
  Release message. In this case the Status TLV MUST include the
  status code for "delete_success". The Notification message can be
  sent in response to a single connection deletion or the deletion
  of all the connection associated with a source identification
  point (LDP session, logical link, or TNA address). For single
  connection deletion the Notification message MUST include the
  Connection ID of the deleted connection. When used to acknowledge
  the deletion of a group of connections, the Notification message
  MUST not contain IDs of any of the connections that were deleted.

- A Notification message is sent for those cases where the
  destination UNI-C requests a reservation confirmation indication
  from the source UNI-C. In this case the status TLV MUST include
  the "reserv_confirm" status code.

- A Notification message is sent for those cases where the source
  UNI-C attempts to abort a connection request after sending the
  Label Request Message. The Notification message is sent in
  response to an Abort message. In this case the Notification
  message MUST include the Label Request Message ID TLV.

The use of the Notification message for the O-UNI includes those
procedures that are specified in [8].

5.2.9 Status Enquiry Message

The Status Enquiry is a new LDP message that is defined specifically
for LDP applications for O-UNI signaling. The encoding for the
Status Enquiry Message is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F| Status Enquiry (0x0420)   |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Message ID                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Reserved                           |S|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Src ID TLV 1                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                                                               ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Src ID TLV m                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Connection ID TLV 1                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                                                               ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Connection ID TLV n                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Optional Parameters                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The Status Enquiry message allows a client to enquire about the
status of a connection or group of connections for which the client
is an end point.

When a Src ID TLV is present in the Status Enquiry message, the
client is in effect requesting the status of all connections
associated with the specified logical link.

When a Connection ID TLV is present in the Status Enquiry message,
the client is requesting the status of this particular connection.

Status Enquiry can be generated by the client at any time. The
Status Enquiry message is used to enquire about status of already
existing connections.

S-bit:

Whenever the S bit is set, S=1, it indicates that the Status
Enquiry message is for summary information. In that case the
Status Response message contains summary information (Connection
ID and connection Status) of the specified connections. Otherwise,
S=0, detailed information is requested.

5.2.10 Status Response Message

The Status Response message is a new LDP message that is defined
specifically for LDP applications for O-UNI. The encoding for the
Status Response message is:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F| Status Response (0x0421)  |             Length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Message ID                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Connection ID TLV 1                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Src ID TLV                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Dest ID TLV TLV                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Egress Label TLV                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       O-UNI Service TLV                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 SONET/SDH Traffic Parameters TLV              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Label TLV                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Upstream Label TLV                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Status TLV                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~                                                               ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Connection ID TLV n                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Src ID TLV                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Dest ID TLV TLV                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Egress Label TLV                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       O-UNI Service TLV                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                 SONET/SDH Traffic Parameters TLV              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Label TLV                            |
```

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Upstream Label TLV                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          Status TLV                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Optional Parameters                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

The Status Response message is generated in response to a Status
Enquiry message. The Status Response message contains information
regarding the status of those connections (implicitly or explicitly)
specified in the Status Enquiry message to which it is a response.
The amount information included in the Status Response message
depends on the whether the Status Enquiry is for summary or detailed
information.

6.0 Status Code Summary

The following are the status codes defined for this version of LDP
O-UNI protocol.

```
0x000000xx = destination_not_reachable
0x000000xx = invalid_destination_TNA
0x000000xx = bandwidth_unavailable
0x000000xx = protection_mode_unavailable
0x000000xx = routing_directive_unavailable
0x000000xx = Failure_to_delete_connection
0x000000xx = Encoding_unavailable
0x000000xx = bad_egress_label
0x000000xx = delete_indication
0x000000xx = delete_success
0x000000xx = reserv_confirm
0x000000xx = abort_complete


0x000000xx = Connection active
0x000000xx = Connection doesn't exist
0x000000xx = Connection unavailable
0x000000xx = Connection dropped by far end
0x000000xx = Connection Pending
```

7. IANA Consideration

This draft requires the use of a number of new messages, TLVs, and
status codes from the number spaces within the LDP protocol.

The two new messages (sections 5.2.9 and 5.2.10) and the eight new
TLVs (sections 5.1.1 to 5.1.8) should be considered as part of LDP
base protocol and be assigned message and TLV types accordingly as
outlined in [8]. All the values given in this draft should be
interpreted as advisory. There does not exist a preference to what
values should be used.

The authors' current understanding is that MPLS status codes are not sub-divided into specific ranges for different types of error. Hence, the numeric status code values assigned for this draft should simply be the next available values at the time of writing and may be substituted for other numeric values. See section "Status Codes" for details of the status codes defined in this draft.

8. Security Considerations

This draft doesn't introduce any new security issues other than those in [8].

9. References

1  Bradner, S., "The Internet Standards Process -- Revision 3", BCP 9, RFC 2026, October 1996.

2  Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997

3  B. Rajagopalan, "IP over Optical Networks: A Framework", draft-ietf-ipo-framework-oo.txt, work in progress, July 2001.

4  Mayer, M. Ed., "Requirements for Automatic Switched Transport Networks (ASTN)", ITU G.807/Y.1301, V1.0, May 2001.

5  Ashwood-Smith, P. et. al., "Generalized MPLS- Signaling Functional Description", draft-ietf-mpls-generalized-signaling-04.txt, work in progress, May. 2001

6  Ashoowd-Smith, P. et. al., "Generalized MPLS Signaling: CR-LDP Extensions", draft-ietf-mpls-generalized-cr-ldp-03.txt, work in progress, May 2001

7  Ashwood-Smith, P. et. al., "Generalized MPLS Signaling: RSVP-TE Extensions", draft-ietf-mpls-generalized-rsvp-te-03.txt, work in progress, May 2000.

8  Anderson, L., et. al., "LDP Specification", RFC 3036, January 2001.

9  Rajagopalan, B. Editor, "User Network Interface (UNI) 1.0 Signaling Specifications", OIF Contribution, OIF2000.125.5, June 2001

10 Jamoussi, B., "Constraint-Based LSP Setup using LDP", draft-ietf-mpls-cr-ldp-04.txt, work in progress, July 2000.

10. Author's Addresses

    Osama S. Aboul-Magd
    Nortel Networks
    P.O. Box 3511, Station ôCö
    Ottawa, Ont, K1Y-4H7
    Tel : 613-763-5827
    e.mail :osama@nortelnetworks.com

    Sandra Ballarte
    Nortel Networks
    P.O. Box 3511, Station C
    Ottawa, Ontario, Canada
    K1Y-4H7
    Phone: 613-763-9510
    Email: ballarte@nortelnetworks.com

    Ewart Tempest
    Nortel Networks
    P.O. Box 3511, Station C
    Ottawa, Ontario, Canada
    K1Y-4H7
    Phone: 613-768-0610
    Email: ewart@nortelnetworks.com

    Raj Jain
    Nayna Networks, Inc.
    157 Topaz St.
    Milpitas, CA 95035
    Phone: 408-956-8000x309
    Fax: 408-956-8730
    Email:raj@nayna.com

    Liangyu Jia
    ONI Systems Corp.
    166 Baypoints Parkway
    San Jose, CA 95134
    Tel: 408-965-2743
    Fax: 408-965-2660
    e.mail:ljia@oni.com

    Bala Rajagopalan
    Tellium, Inc.
    2 Crescent Place
    Ocean Port, NJ 07757
    Email :braja@tellium.com

    Robert Rennison
    Laurel Networks
    2607 Nicholson Road
    Sewickley, PA 15143, USA
    Tel: +1 724-933-7330
    Email:robren@laurelnetworks.com

Yangguang Xu
Lucent Technologies Inc.
21-2A41
1600 Osgood St.
N. Anderson, MA 01845
Tel : 978-960-6105
e.mail :xuyg@Lucent.com

Zhensheng Zhang
Sorrento Networks
9990 Mesa Rim Road
San Diego, CA 92121
Tel: 858-646-7195
e.mail:zzhang@sorrentonet.com

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