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Signaling Requirements at the Optical UNI

1. Status of this Memo

2. Abstract

This draft considers the optical network service model referred to as the "domain services" model [1]. Under this model, the optical network provides a set of well-defined services to clients (IP and others). The signaling and routing interface between the client and optical networks is referred to as the User-Network Interface (UNI). This draft describes the services provided over the UNI, and the requirements on any signaling protocol used to invoke the services.

This draft reflects ongoing work at the Optical Interworking Forum (OIF) and the Optical Domain Service Interconnect (ODSI) coalition on the optical UNI [2]. The relevance of this draft to the IETF is two-fold. First, for the signaling portion of the optical UNI, extensions of two MPLS signaling protocols are presently under consideration in the OIF: RSVP with TE extensions and LDP. The objective of this draft is to guide the adaptation of these protocols for UNI signaling. Second, to harmonize the signaling of UNI originated lightpath requests and peer model lightpath establishment mechanisms [1], alignment between OIF, ODSI and IETF lightpath parameters and signaling functionality is desirable. This draft aims to serve this purpose. The content of this draft is expected to evolve as work progresses on the optical UNI.

3. Introduction

The network model considered in this draft consists of client networks (IP and others) attached to an optical core network, and connected to their peers over dynamically established switched lightpaths. The optical core itself is assumed to be incapable of processing individual IP packets.

The optical network is assumed to consist of multiple optical sub-networks interconnected by optical links in a general topology (referred to as an optical mesh network). This network may be multi-vendor. Each sub-network itself contains a mesh-connected set of optical cross-connects (OXCs). This network model is shown in Figure 1.

There are two logical control interfaces identified in Figure 1. These are the client-optical network interface, and the optical sub-network interface. These interfaces are also referred to as the User-Network Interface (UNI) and the Network-Network Interface (NNI). The services defined at these interfaces to a large degree determine the type and amount of control flow across them. It is possible to have a unified service definition across both these interfaces such that there is virtually no difference in the control flow across them. In this draft, however, these interfaces are treated as distinct and the focus is on the UNI.

```
                             Optical Network
                        +---------------------------------------+
                        |                                       |
   +--------------+     |                                       |
   |              |     | +------------+        +------------+  |
   |   IP         |     | |            |        |            |  |
   |   Network    +--UNI--+   Optical  +---NNI--+   Optical  |  |
   |              |     | | Subnetwork |        | Subnetwork |  |
   +--------------+     | |            |  +-----+            |  |
                        | +------+-----+  |     +------+-----+  |
                        |        |        |            |        |
                        |       NNI      NNI          NNI       |
   +--------------+     |        |        |            |        |
   |              |     | +------+-----+  |     +------+-----+  |
   |   IP         +--UNI--|            +--+     |            |  |
   |   Network    |     | |   Optical  |        |   Optical  |  |
   |              |     | | Subnetwork +---NNI--+ Subnetwork |  |
   +--------------+     | |            |        |            |  |
                        | +------+-----+        +------+-----+  |
                        |        |                     |        |
                        +-------UNI-------------------UNI-------+
                                 |                     |
                                 |                     |
                          +------+-------+     +------------+
                          |              |     |            |
                          | Other Client |     |Other Client|
                          |   Network    |     |   Network  |
                          | (e.g., ATM)  |     |            |
                          +--------------+     +------------+
```

Figure 1: Optical Network Model

The physical control structure used to realize these logical interfaces may vary. For instance, for the client-optical interface, some of the possibilities are:

1.
   Direct Interface: An in-band or out-of-band IP control channel (IPCC) may be implemented between a client and each OXC that it connects to. With in-band signaling, the signaling messages are carried over a logical communication channel embedded in the physical optical links between the client device and OXC. For example, this could be the overhead bytes in SONET framing or a dedicated optical wavelength. With out-of-band signaling, the signaling messages are transmitted over a separate communication infrastructure that is independent of the optical data links between the client devices and OXC. For example, this could be a LAN/WAN based management network infrastructure separate from the optical network.

   This control channel, in-band or out-of-band, is used for exchanging signaling and routing messages directly between the client and the OXC. With a direct interface, the client and the OXC it connects to support the control plane information exchange. This is shown in Figure 2.

```
+-----------------------------+      +-----------------------------+
|                             |      |                             |
|  +-----------------------+  |      |  +-----------------------+  |
|  |                       |  |      |  |                       |  |
|  |     UNI Signaling     |  |      |  |     UNI Signaling     |  |
|  |                       |  |      |  |                       |  |
|  +-----+-----------+-----+  |      |  +-----+-----------+-----+  |
|        |           |        |      |        |           |        |
|        |           |        |      |        |           |        |
|     +--+-----------+---+    |      |     +--+-----------+---+    |
|     |                  |    |      |     |                  |    |
|     |     IP Layer     +......IPCC.......+     IP Layer     |    |
|     |                  |    |      |     |                  |    |
|     +------------------+    |      |     +------------------+    |
|                             |      |                             |
|          Client             |      |             OXC             |
+-----------------------------+      +-----------------------------+
```

Figure 2: Direct Interface

The type of signaling information exchange across the direct interface would vary depending on the service definition. In addition, routing information may be exchanged at this interface. Some choices for the routing protocol are OSPF/ISIS (with traffic engineering extensions) or BGP. Other directory-based routing information exchanges are also possible in the near term. The details of how the IP control channel is realized is outside the scope of this draft.

2.
Indirect interface: An out-of-band IP control channel may be implemented between the client and a controlling device in the optical network to signal service requests and responses. For instance, a control plane server in the optical network may receive service requests from clients. Similarly, out-of-band signaling may be used between a device in the client network (e.g., a management system) and the OXC, or between devices in client and optical networks to signal service requests. In these cases, there is no direct control interaction between clients and respective OXCs. One reason to have an indirect interface would be that the OXCs and/or clients do not support a direct interface.

3.
Provisioned interface: In this case, the optical network services are provisioned and there is no control interactions between the client and the optical network.

It is essential that both direct and indirect interfaces be supported by any UNI signaling protocol. Under both these

interfaces, the entity that performs UNI signaling on the client side is referred to as UNI-C. The corresponding entity on the network side is referred to as UNI-N. In the case of the direct interface, each client device attached to the optical network will have an UNI-C instance and each OXC attached to a client will have an UNI-N instance. In the case of the indirect interface, these entities may be located outside of the client device and OXC, as per the description in (2) above.

In the following, the service definition and signaling requirements for realizing the UNI are described.

4. Optical Network Services

The optical network primarily offers discrete capacity, high bandwidth connectivity in the form of lightpaths. A lightpath is established between two termination points in the optical network, to which client devices are attached. The properties of the lightpaths are defined by the attributes specified during lightpath establishment or via acceptable modification requests.

The notion of "user groups" are considered as integral to lightpath establishment in this draft. A user group defines a community of client devices with restrictions on connectivity from devices outside this group. The requirements on lightpath termination point and user group identification are described in the next section.

The following actions support lightpath services:

1. Lightpath creation: This action allows a lightpath with the specified attributes to be created between a pair of termination points. Each lightpath is assigned a unique identifier by the optical network, called the lightpath ID, which is used in UNI signaling messages to reference the lightpath in further transactions. Lightpath creation may be subject to network-defined policies (e.g., user group connectivity restrictions) and security procedures.

2. Lightpath deletion: This action allows an existing lightpath (referenced by its ID) to be deleted.

3. Lightpath modification: This action allows certain parameters of the lightpath (referenced by its ID) to be modified. Lightpath modification may be subject to network-defined policies. Lightpath modification must be non-destructive, i.e., the success or failure of the modification procedure must not result in the loss of the original lightpath.

4. Lightpath status enquiry: This service allows the status of certain parameters of the lightpath (referenced by its ID) to be queried.

Additionally, the following "neighbor discovery" procedures may be made available over the UNI:

1. Client Registration: This service allows a client to register its address(es) and user group identifier(s) with the optical network.

2. Client De-Registration: This service allows a client to withdraw its address(es) and user group identifier(s) from the optical network.

The registration procedure aids in verifying local port connectivity between the optical and client devices, and allows each device to learn the IP address of the other to establish a UNI control channel. Also, it aids the implementation of a directory service (if desired) that would allow clients to learn about the reachability of other remote clients belonging to the same user group. Routing information exchange between client and optical networks across the UNI is considered in [3].

Finally, a "service discovery" procedure may be employed as a precursor to obtaining UNI services. Service discovery allows a client to determine the static parameters of the interconnection with the optical network, including the UNI signaling protocols supported. The protocols for neighbor and service discovery are different from the UNI signaling protocol itself (for example, see LMP [6]). The focus of this draft is only on UNI signaling.

5. Identification of Lightpath Termination Points and User Groups

It is assumed that each OXC in an optical network has one or more IP addresses assigned to it. The address assigned to an OXC is assumed to be unique within the service domain that supports the UNI. Lightpath termination points are identified by internal optical network interface identifiers. It is possible that a physical OXC interface may in fact contain more than one logical interface on which lightpaths terminate. For instance, an OC-192 port may terminate four OC-48 lightpaths. Also, depending on the granularity of bandwidth allocation, a lightpath may refer to a sub-channel in a multiplexed stream. The concept of a logical port may be used to generically identify the local termination point of a lightpath at an OXC. The complete termination point is therefore identified by the pair, {IP address, logical port ID}, where the IP address is associated with the OXC that contains the physical interface and the logical port ID is an (optional) addressing structure used to identify a logical port in the OXC. The logical port ID structure will consist of physical port, channel and sub-channel identifiers. Because the logical port ID is of local significance only, it must be unique only with respect to a specific OXC. Furthermore, the logical port ID is not used for routing a lightpath within the optical network, but only to identify a termination point within an OXC. It is, however, possible to directly assign an IP address to physical or logical ports. In this case, the logical port ID need not be used.

It is required that every client be assigned one or more user group identifiers. User group identification allows the formation of closed user groups, or virtual private networks of clients. The user group identifier(s) for each client-optical interface is required to be registered during UNI neighbor discovery. The format of the user group identifier may be taken to be the same as the VPN identifier defined in [4].

6. Signaling Requirements

This section describes the mechanisms that must be available in a UNI signaling protocol.

6.1 UNI Control Channel

The transport of UNI signaling messages require a UNI control channel between the UNI-C and the corresponding UNI-N entities. To implement the control channel, it is necessary for UNI-C and UNI-N to know each other’s IP address. In the case of the direct interface, the UNI neighbor discovery protocol can be used for this. The same protocol would allow the optical network to identify the client and apply any policies that may relate to the establishment of the UNI control channel. In the case of the indirect interface, the IP address information must be obtained administratively.

An in-band or an out-of-band transport link should exist between UNI-C and UNI-N to establish the control channel. To use such a link for the UNI control channel, the following requirements must be met:

- o The link must be able to carry IP packets from UNI-C to UNI-N;
- o The bit rate and minimum transfer size (in bytes) of the link must be adequate to support this function;
- o The link must be secure, or UNI-C and UNI-N must implement procedures to recognize authorized messages and to prevent unauthorized access;
- o It must be possible for both UNI-C and UNI-N to detect the failure of the link quickly.

In the case of direct interface, there could be multiple interfaces between the client and the OXC. In this case, there need be only a single UNI control channel between them. This control channel can utilize any one of the many in-band and/or out-of-band transport links between the devices. Furthermore, as long as there is at least one link available, the UNI control channel must be maintained without break.

The UNI-C and UNI-N entities must be able to determine quickly the failure of an already established UNI control channel. The failure of the control channel or the unreachability of the peer UNI signaling entity does not imply the removal of established lightpaths. On the other hand, since signaling can be initiated from either side of the lightpath for lightpath deletion or modification of certain parameters, it is possible for the lightpath state information to be different in the network and client sides when the UNI control channel is not functional. Thus, when the UNI control channel is affected by a failure (e.g., the failure of the transport link or the unreachability of the peer UNI signaling module), a procedure to synchronize lightpath state must be implemented after recovery.

6.2 UNI Signaling (Abstract) Messages

The UNI signaling messages that must be supported are described below. These messages are denoted "abstract", in reference to the fact that they may be realized in different ways depending on the signaling protocol used. In the following description, the terms "initiating UNI-C" and "terminating UNI-C" are used to identify the entities at two ends of a lightpath that initiate and terminate signaling actions. With the direct interface, a UNI-C entity at either end of a lightpath can initiate a signaling action. The UNI-C entity at the other end then becomes the terminating client. With some indirect interfaces, the initiating and terminating UNI-C could be the same entity.

1. Lightpath Create Request: Sent from the initiating UNI-C to UNI-N to create a lightpath.

2. Lightpath Create Response: Sent from

   a. the terminating UNI-C to UNI-N to accept an incoming lightpath create request.

   b. the UNI-N to the initiating UNI-C to indicate the successful creation of (or failure to create) the lightpath as requested in (1).

3. Lightpath Delete Request: Sent from

   a. the initiating UNI-C to UNI-N to delete a lightpath.

   b. the UNI-N to a UNI-C to indicate the deletion of a lightpath by the network.

4. Lightpath Delete Response: Sent from

   a. the terminating UNI-C to UNI-N to acknowledge an incoming lightpath delete request.

   b. the UNI-N to the initiating UNI-C to indicate the successful deletion of the lightpath as requested in (3).

5. Lightpath Modification Request: Sent from the initiating UNI-C to UNI-N to modify the specified lightpath parameters. Modification must be non-destructive.

6. Lightpath Modification Response: Sent from UNI-N to the initiating UNI-C to indicate the successful modification of (or failure to modify) the lightpath parameters requested in (5).

7. Lightpath Status Enquiry: Sent from

   a. the initiating UNI-C to UNI-N to enquire about the status and/or the parameters of the specified lightpath, or all lightpaths owned by the UNI-C.

   b. the UNI-N to either UNI-C to enquire about the status of the parameters of the specified lightpath, or all lightpaths owned by the UNI-C.

8. Lightpath Status Response: Sent from the UNI-N to the initiating UNI-C to indicate the status of lightpath parameters as requested in (7). Multiple "Lightpath Status Response" messages (one per lightpath) may be sent by UNI-N when the initiating UNI-C requests the status of all lightpaths terminating at a particular interface.

9. Notification: This message is sent autonomously by UNI-N to UNI-C to indicate a change in the status of the lightpath (e.g., unrestorable lightpath failure).

How these messages are mapped to actions within the optical network, and the signaling protocol used within the optical network to realize the actions are not concerns at the UNI. Furthermore, the resolution of conflicts when UNI signaling is concurrently invoked on both sides of a lightpath to perform certain actions (e.g., modify with conflicting parameters) is not considered to be a UNI signaling issue.

6.3 UNI (Abstract) Message Parameters

The following parameters must be encoded in UNI signaling messages. Formats for the parameters must be reconciled with the format of similar parameters being developed for MPLambdaS signaling [5]. The list below may evolve based on ongoing work in OIF/ODSI UNI signaling.

6.3.1 Identification

1. Lightpath ID: A network-wide unique identifier for a lightpath. This identifier is assigned by the optical network. It consists of the IP address of an OXC along with a locally unique index.

2. Contract ID: A carrier-assigned identification that identifies the service contract.

3. Source/destination lightpath termination point ID: This is a composition of two IDs, an identifier indicating OXC/physical or logical port (an IP address) and (optional) logical port information. The latter consists of a port index, a channel

4. User group ID: A VPN identifier as defined in [4].

5. UNI-C ID: IP address of the UNI-C entity.

6.3.2 Service-Related

1. Directionality: Flag that indicates whether the lightpath is uni or bi-directional. Default is bi-directional.

2. Framing: Framing specifies the format of the signal to be transported across the UNI. The valid framing options considered are:

   - PDH
   - SONET
   - SDH
   - Digital Wrapper
   - LAN Ethernet
   - WAN Ethernet

   Note that framing represents the framing of the service to be carried across the optical network. There are often a variety of physical interfaces and framing formats which can carry the signal across the UNI between the client and the OXC. For instance, a DS-3 can be carried in a T3 or within an STS-1 in an OC-48. So for example, the source UNI may have a PDH T3 physical line carrying a DS-3 whereas the destination UNI may have a SONET OC-48 interface. A DS-3 connection between the source and destination would be delivered within an STS-1 of the OC-48 at the destination. The framing of such a lightpath would be of type PDH. Two SONET intefaces may request either any STS-1 or a DS-3, depending on whether the optical network and client devices distinguish between the two cases.

3. Bandwidth: This specifies the bandwidth of the service and is interpreted w.r.t. the framing. Note that this is the bandwidth of the service, not the bandwidth of the physical interfaces. The latter may differ on each end of the connection.

- For PDH, the options are DS-0, DS-1, DS-3 ...,E1, E3, ...,
- For SONET, the options are STS-1, STS-2, STS-3, ..., STS-N
- For SDH, the options are STM-1, STM-2, ... STM-N
- For digital wrapper, the options are TBD, possible values are 2.5 Gbps, 10 Gbps and 40 Gbps.
- For LAN Ethernet the options are 10 Mbps, 100 Mbps, 1 Gbps, and 10 Gbps
- For WAN Ethernet the options are 10 Gbps

4. Transparency: This is interpreted w.r.t. the framing.

- For SONET/SDH Framing, the options are: PLR-C, STE-C, and LTE-C.

  PLR-C: Physical Layer Regenerator Circuit (PLR-Circuit); A PLR-Circuit is a SONET/SDH rate and framed point-to-point circuit. The circuit preserves all SONET/SDH overhead bytes between clients. The SONET/SDH signal may be concatenated or channelized but cannot be SONET/SDH TDM de-multiplexed or multiplexed within the optical internetwork.

  STE-C: An STE-Circuit is a SONET/SDH rate and framed point-to-point circuit. The circuit preserves all SONET/SDH line overhead bytes between clients but is not required to preserve the section overhead bytes. The SONET/SDH signal may be concatenated or channelized but cannot be SONET/SDH TDM de-multiplexed or multiplexed within the optical network.

  LTE-C: An LTE-Circuit is a SONET/SDH rate and framed point-to-point circuit between two UNIs. The circuit preserves the SONET/SDH payload, but is not required to preserve the section or line overhead bytes. The SONET/SDH signal may be concatenated or channelized and may be SONET/SDH TDM de-multiplexed or multiplexed within the optical network to allow the subrate circuits to be individually routed, or to allow multiple LTE-Circuits to be multiplexed within the network to better utilize a network link. Thus, an LTE-Circuit implies timing and synchronization requirements not required in PLR-Circuits or STE-Circuits.

It is part of the call acceptance process of the optical network to determine if the requested service, bandwidth, and transparency, can be supported by the network and the physical interfaces at the UNI. For instance, if the requested circuit is a SONET OC-48c and both physical interfaces are SONET OC-48 interfaces, then it may be possible for the network to support

PLR-C transparency. However, if one of the two interfaces is an OC-192 interface, then LTE-C is the only currently defined option.

- o There are no transparency options for PDH, Digital Wrapper, LAN Ethernet, WAN Ethernet.

5. Propagation delay: This specifies the maximum acceptable propagation delay in milliseconds. Defaults to infinity.

6. Service level: An integer specifying the service level requested for the lightpath. Different service levels may be defined by the optical network service provider, encompassing priority, preemption, protection and other service-distinguishing parameters. The "service level" parameter encodes the service type and it is interpreted by the provider. Some values (e.g., 0-255) should be reserved for future use. The remaining values are provider specific. Default set by provider.

   It is also possible that priority, preemption, etc., could be separately specified as (optional) parameters.

6.3.3 Routing-related

1. Diversity: A list of n lightpath IDs from which the present lightpath must be physically diverse in the network. For each lightpath ID it may specified whether the diversity desired is link, node or SRLG [1] disjointness.

6.3.4 Miscellaneous

1. Result Code: A code indicating success or failure of certain operations. For example, a lightpath create request could result in success or failure. This code may indicate the result as well as the reason for failure.

2. Status: A code that indicates the status of a lightpath in the "Lightpath Status Response" message.

6.3.5 Security-related

These parameters are TBD, since the security features provided by individual protocols (RSVP/LDP) should be used where possible.

6.3.6 Policy, accounting and authorization related

These parameters are TBD.

6.4 Contents of UNI Abstract Messages

The message contents described below may evolve based on ongoing work, and on the development of security, policy, accounting and other parameters.

6.4.1 Lightpath Create Request

This message contains:

1. Source Termination Point, IP address (mandatory)
2. Destination Termination Point, IP address (mandatory)
3. Source Termination Point, Port, Channel, Sub-channel IDs (optional)
4. Destination Termination Point, Port, Channel, Sub-channel IDs (optional)
5. Source User Group Identifier (mandatory)
6. Destination User Group Identifier (mandatory)
7. Contract ID (mandatory)
8. Framing (mandatory)
9. Bandwidth (mandatory)
10. Transparency (mandatory)
11. Directionality (optional)
12. Propagation Delay (optional)
13. Service level (optional)
14. Diversity (optional)

UNI-N may assign the channel and/or the sub-channel for the lightpath being established and return it to the terminating UNI-C (in the destination channel, sub-channel parameters).

6.4.2 Lightpath Create Response

This message contains:

1. Source Termination Point, IP address (mandatory)
2. Destination Termination Point, IP address (mandatory)
3. Source Termination Point, Port, Channel, Sub-channel IDs (optional)
4. Destination Termination Point, Port, Channel, Sub-channel IDs (optional)
5. Source User Group Identifier (mandatory)
6. Destination User Group Identifier (mandatory)
7. Lightpath ID (mandatory)
8. Result code (mandatory)

The lightpath ID is filled in by UNI-N and conveyed to both initiating and terminating clients. In addition, UNI-N may assign the channel and/or the sub-channel for the lightpath being established and return it to the initiating UNI-C (in the source logical port ID feild).

6.4.3 Lightpath Delete Request

This message contains:

1. Lightpath ID (mandatory)

6.4.4 Lightpath Delete Response

This message contains:

1. Lightpath ID (mandatory)
2. Result Code (mandatory)

6.4.5 Lightpath Modify Request

This message contains:

1. Lightpath ID (mandatory)
2. Contract ID (mandatory)
3. Lightpath Bandwidth (optional)
4. Service Level (optional)
5. Diversity (optional)

These parameters specify the new values desired for the lightpath identified.

6.4.6 Lightpath Modify Response

This message contains:

1. Lightpath ID (mandatory)
2. Lightpath Bandwidth (optional)
3. Service Level (optional)
4. Diversity (optional)
5. Result code (mandatory)

These parameters indicate the new values of the parameters after the success or failure of the modificiation attempt (as indicated in the result code)

6.4.7 Lightpath Status Enquiry

This message contains:

1. Lightpath ID (optional)
2. UNI-C ID (optional, mandatory if (1) is not present)

If the lightpath ID is not present, then the parameters of all lightpaths owned by the UNI-C is returned by the network. Otherwise, the status of the indicated lightpath is returned.

6.4.8 Lightpath Status Response

This message contains:

1. Status (mandatory)
2. Lightpath ID (optional)
3. Source Termination Point, IP address (optional)
4. Destination Termination Point, IP address (optional)

5. Source Termination Point, Logical Port ID (optional)
6. Destination Termination Point, Logical Port ID (optional)
7. Source User Group Identifier (optional)
8. Destination User Group Identifier (optional)
9. Contract ID (optional)
10. Framing (optional)
11. Bandwidth (optional)
12. Transparency (optional)
13. Directionality (optional)
14. Propagation Delay (optional)
15. Service level (optional)
16. Diversity (optional)

The status parameter indicates the lightpath status, up/non-existant/failed/in recovery, etc. Other parameters are returned if necessary (see 6.4.7)

6.4.9 Notification

This message contains:

1. Lightpath ID (mandatory)
2. Status (mandatory)

7. Summary and Conclusion

This draft described the domain services model and the signaling requirements at the client-optical interface, called the UNI. The objective of this draft are two-fold: to guide the adaptation of RSVP/LDP for UNI signaling and to harmonize the signaling mechanisms and parameter encoding under UNI signaling and peer model lightpath set-up [1]. This draft reflects the ongoing work at the OIF and the ODSI, and the contents are expected to evolve as work progresses on UNI signaling.

8. References

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