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Applicability of Abstraction and Control of Traffic Engineered Networks (ACTN) to Packet Optical Integration (POI) extensions to support Router Optical interfaces.

draft-mix-teas-actn-poi-extension-00

Abstract

This document extends the draft-ietf-teas-actn-poi-applicability to the use case where the DWDM optical coherent interface is equipped on the Packet device. It identifies the YANG data models being defined by the IETF to support this deployment architecture and specific scenarios relevant for Service Providers. Existing IETF protocols and data models are identified for each multi-layer (packet over optical) scenario with a specific focus on the MPI (Multi-Domain Service Coordinator to Provisioning Network Controllers Interface)in the ACTN architecture.

Status of This Memo

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1. Introduction

The full automation of the multilayer/multidomain network is a topic of high importance in the industry and the service providers community. Typically, the layers composing such network are the IP/MPLS, (with Segment Routing) and the Optical ones. The requirements of high bandwidth availability and dynamic control of the networks are of capital importance too. The draft-ietf-teas-actn-poi-applicability specifies very well how to control and manage multilayer/multidomain networks using the Abstraction and Control of TE Networks (ACTN) architecture, see also Figure 1 .

New DWDM Coherent pluggable optics, such as ZR [OIF-400ZR-01-0] and ZR+ [Open_ZR-Plus_MSA], are enabling new multilayer network use cases where the DWDM interface is located within the packet domain equipment instead of being part of the Optical domain Figure 2 .

ZR and ZR+ (and also CFP2-DCO) deployment in routers has already started and are expanding significantly. The way the DWDM pluggable are in general managed is not yet completely specified and defined by any standard and it is becoming an urgent matter to cover for Service Providers. Full end-to-end management solution of these DWDM coherent pluggable optics, leveraging on ACTN hierarchical architecture, is becoming critical to allow a wider deployment beyond simple point-to-point high capacity link scenarios between two IP/ MPLS routers.

Figure 1 The ACTN architecture, defined in [RFC8453], is used to control the multi-domain network shown in Figure 2 , where each Packet PNC (P-PNC) is responsible for controlling its IP domain, which can be either an Autonomous System (AS), [RFC1930], or an IGP area within the same operator network. Each Optical PNC (O-PNC) in the below topology is responsible for controlling its own Optical Domain.

```
                              +----------+
                              |   MDSC   |
                              +-----+----+
                                    |
      MPI interf. +-----------+-----+------+-----------+
                  |           |            |           |
             +----+----+ +----+----+  +----+----+ +----+----+
             | P-PNC 1 | | O-PNC 1 |  | O-PNC 2 | | P-PNC 2 |
             +----+----+ +----+----+  +----+----+ +----+----+
                  |           |            |           |
                  |           \            /           |
        +-------------------+  \          /  +-------------------+
   CE1 / P.N.1         P.N.2 \  |        /  / P.N.3         P.N.4 \ CE2
   o--/---o               o---\-|-------|--/---o               o---\--o
      \   :               :   / |       |  \   :               :   /
       \  : PKT Domain 1  :  /  |       |   \  : PKT Domain 2  :  /
        +-:---------------:-+   |       |    +-:---------------:-+
          :               :     |       |      :               :
          :               :     |       |      :               :
        +-:---------------:------+     +-------:---------------:--+
       /  :               :       \   /        :               :   \
      /   o...............o  O.N.  \ /    O.N. o...............o    \
      \     Optical Domain 1       / \       Optical Domain 2       /
       \                          /   \                            /
        +------------------------+     +--------------------------+
```

Figure 1: Reference multilayer/multidomain Scenario

Figure 2 shows how the Packet Node DWDM coherent Ports are connected to the ROADM ports.

```
      +------+       +------+  _________  +------+       +------+
      |P.N.1 |       | O.N. | /        /\ | O.N. |       |P.N.2 |
      |    P1| ----- |      ||        |  ||      | ----- |P1    |
    ==|    P2| ----- |      ||Optical |  ||      | ----- |P2    |==
    ==|    P3| ----- |      ||Network |  ||      | ----- |P3    |==
      |    P4| ----- |      ||        |  ||      | ----- |P4    |
      |      |       | ROADM| \________\/ | ROADM|       |      |
      +------+       +------+             +------+       +------+
       Packet                  Optical                    Packet
       Layer                   Layer                      Layer
```

P.N. = Packet Node (ROADM)
O.N. = Optical DWDM Node
ROADM = Lambda/Spectrum switch
Px = DWDM (coherent pluggable) Router ports

Figure 2: Cross layer interconnection

2. Reference architecture and network scenario

As described in Figure 1 and according to the Packet Optical Integration (POI) draft [draft-ietf-teas-actn-poi-applicability] in which ACTN hierarchy is deployed [RFC8453], the PNCs are in charge to control a single domain (e.g. Packet or Optical) while the MDSC is responsible to coordinate the operations across the different domains having the visibility of the whole network multi-domain and multi-layer network topolgy.

A specific standard interface (MPI) allows the MDSC to interact with the different Provisioning Network Controller (O/P-PNCs). Although the MPI interface should present an abstracted topology to the MDSC (hiding technology-specific aspects of the network and hiding topology details depending on the policy chosen) in the case of DWDM coherent pluggable located in the PN some information related to the physical component must be shared on MPI. The above statement is assumed as the Domain PNC (e.g. O-PNC) may not be able to get information from or set parameters to a node belonging to a different domain (e.g. P-PNC).

The reason of this change is due to the following statements:

O-PNC routing and wavelength assignment
The MDSC can ask the O-PNC to set an optical circuit between two ROADM ports (A and Z). The O-PNC having the full Optical Topology network knowledge can calculate the Optical Path, the wavelength assignment (RWA), etc. K-circuits may be calculated and sorted based on some parameters (e.g. number of hops, path length, OSNR, etc.)

Optical Circuit Feasibility
O-PNC can calculate the estimated OSNR for the A to Z circuits and sort them from the best to the worse performance or select the most suitable performance circuit. To verify the circuit feasibility the O-PNC needs to know the Transceiver optical characteristics, e.g. OSNR Robustness, DC capability, supported PDL, FEC, etc. For more details refer to draft-ietf-ccamp-dwdm-if-param-yang. The above parameters may not be directly retrieved from Packet Node by the O-PNC, (e.g. because the Packet Node supports only proprietary models or the Packet Nodes is not able to support dual writing operation), then they must be read by the P-PNC, shared to MDSC via MPI and finally to O-PNC. Other parameters like central frequency and transmit power are calculated by the O-PNC and must be provisioned to the Pluggable optics when the circuit is set-up.

Central frequency
After having verified the Circuit Optical feasibility the O-PNC shares the channel central frequency to MDSC so that the MDSC can ask P-PNC to provision the Lambda to Router Pluggable.

FEC Coding
This parameter indicate what Forward Error Correction (FEC) code is used at Ss and Rs (R/W) (not mentioned in G.698.2), it is used by the O-PNC to calculate the optical feasibility. The FEC coding list (FEC can be many) supported by the pluggable is an input for O-PNC, one coding is selected for a specific circuit and is shared (as output) to MDSC for pluggable provisioning.

Modulation format
This parameter indicates the list of supported Modulation Formats and the provisioned Modulation Format. It is an input for O-PNC

Transmitter Output power
This parameter provisions the Transceiver Output power.

Receiver input power range
This parameter is the Min and Max input power supported by the Transceiver, i.e. Receiver Sensitivity. It is an input for O-PNC to properly calculate the optical power to set at ROADM port

Receiver input power

This parameter is the measured input power at the receiver. It is an input for O-PNC to properly check the patchcord (between transceiver and ROADM) loss comparing it with the ROADM port received power.

operational-mode

In order to make the MPI communication more efficient and improve the abstraction, the above (and more) parameters can be summarised by the operational-mode parameter. The operational-mode can be either standard ("application code" defined by ITU-T G.698.2) or organization/vendor specific. In both cases are strings of characters defined by ITU-T or by vendors. A pluggable may support several operational modes, those values are collected by the P-PNC and notified to O-PNC through the MDSC. They are used, by O-PNC, to check the circuit optical feasibility. For each transceiver the O-PNC will select only one operational-mode to be set, together with central frequency and TX power, in the pluggable though MDSC and P-PNC.

The above optocal parameters are related to the Edge Node Transceiver and are used by the Optical Network control plane in order to calculate the optical feasibility and the spectrum allocation. The parameters are read by the P-PNC from the DWDM pluggable and shared with MDSC to give the visibility of the pluggable characteristics. MDSC can use the info to understand the client capability and, again, share the same info to O-PNC for the impairment verification. On the opposite direction O-PNC can send to MDSC the values (e.g. operational mode, lambda, TX power) to provision the Client (Packet) DWDM Pluggable. The pluggable provisioning will be done by the P-PNC. For more details on the optical interface parameters see: [I-D.ietf-ccamp-dwdm-if-param-yang].

In summary the pluggable parameters exchanged by P-PNC, MDSC and O-PNC for end to end service provisioning are:

- Pluggable Service source port-ID
- Pluggable Service destination port-ID
- Central Frequency (Lambda) (common to source and destination)
- TX Output power (source port-ID)
- TX Output power (destination port-ID)
- Operational-mode (compatible)
- Vendor OUI (if the operational mode in not standard)
- Pluggable part number (if the operational mode in not standard)
- Admin-state (common ?)

3. Use Cases

The different services supported by the network are shown in Figure 3. This draft is focused on the inter-layer link, the DCO links setting through the MC-links setting although the POI first goal is to set an IP service.

Figure 3

```
+-------------+                                   +-------------+
|     IP      |                                   |     IP      |
|             |              IP-link              |             |
|   <------------------------------------------------------->   |
|             |                                   |             |
|             |                                   |             |
|  +-------+  |              Eth-link             |  +-------+  |
|  |  <--------------------------------------------------->  |  |
|  |       |  |                                   |  |       |  |
|  |       |  |              DCO-link             |  |       |  |
|  |  DCO <-------------------------------------------> DCO  |  |
+--+-------+--+                                   +--+-------+--+
       ^                                                 ^
       |       +-------+                 +-------+       |
       |       |  OLS  |                 |  OLS  |       |
       |       |       |                 |       |       |
       +-----> | <-----------------------------> |<------+
  inter-layer  |       |    MC-link      |       | inter-layer
     link      |       |                 |       |    link
               +-------+                 +-------+
```

IP-link = IP service, out of this document scopo
Eth-link = Ethernet connection
DCO-link = Pluggable connection (OTSi connection)
MC-link = Media Channel link (MC optical circuit)

Figure 3: Cross layer interconnection

The use cases supported by the models are:

Inter Layer Link discovery and provisioning
The inter-layer links are the interconnections (fiber) between the pluggable ports (in the Packet Layer) and the ROADM ports (in the Optical Layer). They are set in the Packet and DWDM nodes either manually (e.g. CLI) or via PNCs. The values identifying the inter layer links may be defined by MDSC which has the visibility of both IP and Optical layers.

Network topology discovery and provisioning
MDSC retrieves the packet network topology from the P-PNC and the optical network topology from the O-PNC. MDSC collects and rebuilds the service topology based on the services information coming from P-PNC and O-PNC as described in draft-ietf-teas-actn-poi- applicability. [I-D.draft-ietf-teas-actn-poi-applicability]

End to End Packet service provisioning / deletion
MDSC is asked to set a Packet service between two Routers requiring additional connectivity bandwidth.

Optical Circuit provisioning / deletion
MDSC is asked to set an Optical Circuit between two router ports (O-PNC will receive the same request from MDSC). This is specially needed during the network installation to provide Connectivity between two Routers, the IP link will be set up later using this optical circuit.

LAG extension
MDSC is asked to extend a service bandwidth. This may require more Router optical connectivity.

Optical Restoration
O-PNC detects an optical network failure and reroutes the optical circuits to a different path (and lambda).

Network Maintenance Operations
MDSC is asked to isolate part of the optical network for maintenance and coordinate the O-PNC and P-PNC to preserve the traffic during the maintenance operation.

3.1. Inter Layer Link discovery and provisioning

The inter-layer links are set in the Packet and DWDM nodes either manually (e.g. via CLI or NMS) during the installation phase when the operator connects the Pluggable Transceiver to the ROADM port via fiber patch cord or is defined by the MDSC controller and provisioned via the PNCs. One method and model to define the Inter Layer Link is, for example, to assign a value to the patchcord (for Tx and RX directions) and store those values in the Pluggable and ROADM port

provisioning when the fiber is connected between the two ports. This allows the PNCs to retrieve the values and share them with the MDSC for the correlation and check. Other smarter and automatic methods of patchcord discovery may be defined but are outside of this draft scope.

The inter-layer link must be set (or clear) any time a new pluggable module is installed (or removed) and it is connected to the ROADM port with the fiber patchcord. When a new DCO is installed an inventory notification must be reported to the PNC and MDSC, the reported info are:

- Pluggable port-ID (e.g. rack/shelf/slot/port or UUID)
- Supported Operational-modes
- Vendor OUI (if the operational mode in not standard)
- Pluggable part number (if the op-mode in not standard)
- Manufacturing data

It would be also possible to auto-discover the inter-layer (inter-domain) links between DWDM coherent pluggables and ROADM ports by checking the input/output power levels (and probably switching on/off the lasers of the pluggables). This would require the help of MDSC, O-PNC and P-PNC. The same methoc could be used to verify the provisioned connectivty. For further study in this draft.

3.2. Network topology discovery and provisioning

The first operation executed by the P-PNC and O-PNC is to discover the network topology and share it with the MDSC via the MPI. The PNCs will discover and share also the inter-layer links (or connections) so that the MDSC can rebuild the full network topology associating the DWDM Router ports to the ROADM ports. Once the association is discovered the P-PNC must share the characteristics of Pluggable module with the MDSC and then MDSC with the O-PNC. At this point the Hierarchical controller (MDSC) and the domain controllers have all the information to commit and honour any service request coming from the OSS/orchestrator. The details of the general operations are described in draft-ietf-teas-actn-poi-applicability, while this draft describes how to operate the Pluggable module during the optical circuit set-up operation. As the Pluggable can be inserted or remove at any time it is relevant to have admin and operational state notification from the network to the PNC and MDSC.

3.3. End to End service provisioning / deletion

The End to End service provisioning is a multilayer provisioning involving both the packet layer and the optical layer. The MDSC plays a key role as it has the full network visibility and can co-ordinate the different domain controllers' operations. The service request can be driven by the operator using the MDSC UI or the MDSC receives the service request from the operator OSS/Orchestrator.

The workflow for the creation of an end to end service is composed by the following steps:

```
   1. MDSC receives an end to end service request from OSS/Orchestrator
   2. MDSC starts computing the different operations to implement the
      service.
   3. First MDSC starts to compute the routing, the bandwidth, the
      constrains of the packet service.
   4. If the Packer network can support the service without additional
      connections among the Routers
     4.1. then the packet service is commissioned through the P-PNC
     4.2. a notification with all the service info is sent to OSS.
   5. If more optical connectivity is needed
     5.1. the MDSC notifies the operator about the extra bandwidth need
     5.2. optionally, automatically identifies the spare router ports
          to be used for the connection extension (e.g. A and Z).
     5.3. The Router ports (pluggable) must be connected to A' and Z'
          ROADM ports and must be compatible (in terms of optical
          parameters, etc.).
   6. MDSC (autonomously or under operator demand) asks to O-PNC to set
      an optical circuit between ROADM ports A' and Z' providing
      information on:
     6.1. the pluggable supported parameters (A and Z)
              - Pluggable Service source port-ID
              - Pluggable Service destination port-ID
              - Operational-mode (compatible)
              - Vendor OUI (if the operational mode in not standard)
              - Pluggable part number (if the op-mode in not standard)
              - Admin-state (common ?)
     6.2. the bandwidth (e.g. 100G or 400G, etc.)
     6.3. the routing constraints (e.g. SRLG XRO, etc)
   7. O-PNC calculates the optical route, selects the Lambda, verifies
      the optical feasibility, calculates the pluggable TX power.
     7.1.  If all is OK, provisions the optical circuit in ROADM.
     7.2.  If anything went wrong the O-PNC rejects the MDSC request.
   8. O-PNC updates the MDSC of successful circuit provisioning
      including the path, the Lambda, the operational mode (or the
      explicit optical parameters), the TX power, SRLG, etc.
      The optical circuit at this point is provisioned but not yet
      operational (no power coming from the transceiver yet)
   9. The MDSC updates the service DB and forward the pluggable
      provisioning parameters to P-PNC to complete the optical set-up.
   10. MDSC is then ready to commission the packet service through P-PNC
      10.1. has the visibility of end to end optical circuit (active)
      10.2. the packer service is commissioned
      10.3. MDSC service DB is updated
   11. The MDSC notifies the OSS of successful end to end service set-up
```

NOTE: the Optical service may not be feasible due to optical impairments calculation failure. In this case the O-PNC will reject the optical circuit creation request to MDSC. It is up to the operator (through MDSC) to scale down (e.g. propose a 300Gb/s instead of a 400Gb/s service) the request or plan a network upgrade.

Another point to note is the information sent by MDSC to O-PNC about the pluggable characteristics. In reality this info should be known by the O-PNC at network commissioning time when the Inter Layer Link is set or discovered. The pluggable information may have multiple instances when the pluggable support multiple bit rate (e.g. ZR+). In case of multiple bit rate (and multiple operational mode) the O-PNC can decide to propose to MDSC a different bit rate (higher or lower) calculated in base of the optical validation algorithms. That is: MDSC ask for a 400Gb/s bit rate while O-PNC proposer a 300Gb/s bit rate, instead of rejecting the circuit request.

3.4. Optical Circuit provisioning / deletion

Upon receiving an optical service request from the OSS/Orchestrator, the MDSC starts performing the different operations to implement the optical service (e.g. from A to Z). As an alternative the service request can be driven by the operator using the MDSC UI.

The steps of the workflow are:

1. MDSC receives an end to end service request from the OSS/Orchestr.
2. MDSC starts computing the different operations to implement the service.
3. to check whether the optical connectivity is feasible
   - 3.1. automatically identifies the router ports to be used for the optical connection (e.g. A and Z).
   - 3.2. The Router ports (pluggable) must be connected to A' and Z' ROADM ports and must be compatible (in terms of optical parameters, etc.).
4. MDSC asks to O-PNC to set the optical circuit between ROADM ports A' and Z' providing information on:
   - 4.1. the pluggable supported parameters (A and Z)
     - Pluggable Service source port-ID
     - Pluggable Service destination port-ID
     - Operational-mode (compatible)
     - Vendor OUI (if the operational mode in not standard)
     - Pluggable part number (if the op-mode in not standard)
     - Admin-state (common ?)
   - 4.2. the bandwidth (e.g. 100G or 400G, etc.)
   - 4.3. the routing constraints (e.g. SRLG XRO, etc)
5. O-PNC calculates the optical route, selects the Lambda, verifies the optical feasibility, the pluggable TX power.
   - 5.1. If all is OK, provisions the optical circuit
6. O-PNC updates the MDSC of successful circuit provisioning including the path, the Lambda, the operational mode (or the explicit optical parameters), the TX power, etc.
7. The MDSC updates the service DB and forward the pluggable provisioning parameters to P-PNC to complete the optical set-up.
8. MDSC verifies the end to end optical circuits (active)
9. The MDSC notifies the OSS of successful optical circuit set-up.

NOTE: the Optical service may not be feasible due to optical impairments calculation failure. In this case the O-PNC will reject the optical circuit creation request to MDSC. It is up to the operator (through MDSC) to scale down the request or plan a network upgrade.

Another point to note is the information sent by MDSC to O-PNC about the pluggable characteristics. In reality that info should be known by the O-PNC at network commissioning time when the Inter Layer Link is set or discovered. The pluggable information may have multiple instances when the pluggable support multiple bit rate (e.g. ZR+). In case of multiple bit rate (and multiple operational mode) the O-PNC can decide to propose to the MDSC a different bit rate (higher or lower) calculated on the basis of the optical validation algorithms. That is: MDSC ask for a 400Gb/s bit rate while O-PNC proposer a 300Gb/s bit rate, instead of rejecting the circuit request.

3.5. LAG extension

Upon receiving a LAG service request from OSS/Orchestrator, the MDSC start computing the different operations to implement the request.

The MDSC would determine if an existing multi-layer connection exists between the routers participating in the LAG. If so, the MDSC would request the P-PNC to configure and add the new LAG bundle member link using this existing connection, and notify the OSS confirmation of the additional link. If more optical connectivity is needed, then the procedures defined in section 3.3 would be followed.

3.6. Optical Restoration

For this use case the trigger for the Domain controller and MDSC to take actions is coming from the optical data plane when the O-PNC detects or is notified about an optical network failure (e.g. a fiber cut or a node failure). This kind of events affect the traffic and a number of optical circuits are lost.

1. First action is taken by the O-PNC to identify what are the affected circuits enabled to restoration
2. For the circuits enabled to restoration O-PNC starts to compute
   2.1. the restore paths
   2.2. their feasibility and any optical parameter change (e.g. lambda retuning, TX power, etc.)
3. If the restore path and all parameters are OK for the optical feasibility
   3.1. the restore path is provisioned
   3.2. modifications to MDSC are sent to notify the new circuits data
      - circuit path + SRLG
      - Pluggable Service source port-ID
      - Pluggable Service destination port-ID
      - Operational-mode (compatible)
      - Admin-state (common ?)
4. The MDSC updates the circuit DB and forward any pluggable provisioning change to P-PNC
5. P-PNC will take care to apply the new provisioning data to the pluggables (e.g. lambda, operational data, TX power, etc.)
6. The Restoration process is then completed and the IP connection between the routers is recovered.

NOTE: the restoration may not be feasible due to optical impairments calculation failure. In this case the O-PNC will notify the optical circuit restoration failure to MDSC. It is up to the operator (through MDSC) to take actions and/or plan a network upgrade.

In case the optical circuit restoration is revertible, is again O-PNC responsibility to monitor the failure after the fix and start the revert procedure to bring the restore path to the original route.

3.7. Network Maintenance Operations

The maintenance operation is requested by the OSS when a part of the network needs a maintenance activity. There could be Packet network maintenance or Optical network Maintenance. As an alternative the maintenance request can be driven by the operator using the MDSC UI.

The Packet network maintenance is simple and is addressed by the MDSC in cooperation with the P-PNC.

The optical network maintenance is more complex and needs the MDSC coordination to ask the P-PNC to move away the traffic from the resources under maintenance in the optical network. That means MDSC has to search in the service DB whether a service is using a definite optical link and re-route the service to a part of the optical network not affected by the maintenance operation. Upon maintenance completion the MDSC will bring all the traffic back to the original route.

4. Optical Interface for external transponder in a WDM network

This document proposes an augmentation to the ietf-interface module called ietf-ext-xponder-wdm-if. The ietf-ext-xponder-wdm-if [author note: define the model] is an augment to the ietf-interface. It allows the user to set the operating mode of transceivers as well as other operational parameters. The module also provides threshold settings and notifications to supervise measured parameters and notify the client.

5. Structure of the Yang Module

ietf-ext-xponder-wdm-if is a top-level model for the support of this feature.

6. Security Considerations

RSVP-TE message security is described in [RFC5920]. IPsec and HMAC-MD5 authentication are common examples of existing mechanisms. This document only defines new UNI objects that are carried in existing UNI messages, thus it does not introduce new security considerations.

7. IANA Considerations

// [TEMPLATE TODO] In order to comply with IESG policy as set forth
// in http://www.ietf.org/ID-Checklist.html, every Internet-Draft
// that is submitted to the IESG for publication MUST contain an IANA
// Considerations section. The requirements for this section vary
// depending what actions are required of the IANA. See "Guidelines
// for Writing an IANA Considerations Section in RFCs" [RFC8126]. and
// see [RFC4181] section 3.5 for more information on writing an IANA
// clause for a MIB module internet draft.

This document registers a URI in the IETF XML registry [RFC3688]. Following the format in [RFC3688], the following registration is requested to be made:

URI: urn:ietf:params:xml:ns:yang:ietf-interfaces:ietf-ext-xponder-wdm-if

Registrant Contact: The IESG.

XML: N/A, the requested URI is an XML namespace.

This document registers a YANG module in the YANG Module Names registry [RFC6020].

This document registers a YANG module in the YANG Module Names registry [RFC6020].

prefix: ietf-ext-xponder-wdm-if reference: RFC XXXX

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9. References

9.1. Normative References

[RFC7698] Gonzalez de Dios, O., Ed., Casellas, R., Ed., Zhang, F., Fu, X., Ceccarelli, D., and I. Hussain, "Framework and Requirements for GMPLS-Based Control of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) Networks", RFC 7698, DOI 10.17487/RFC7698, November 2015, <https://www.rfc-editor.org/info/rfc7698>.

[RFC7699] Farrel, A., King, D., Li, Y., and F. Zhang, "Generalized Labels for the Flexi-Grid in Lambda Switch Capable (LSC) Label Switching Routers", RFC 7699, DOI 10.17487/RFC7699, November 2015, <https://www.rfc-editor.org/info/rfc7699>.

[RFC6205] Otani, T., Ed. and D. Li, Ed., "Generalized Labels for Lambda-Switch-Capable (LSC) Label Switching Routers", RFC 6205, DOI 10.17487/RFC6205, March 2011, <https://www.rfc-editor.org/info/rfc6205>.

[RFC7792] Zhang, F., Zhang, X., Farrel, A., Gonzalez de Dios, O., and D. Ceccarelli, "RSVP-TE Signaling Extensions in Support of Flexi-Grid Dense Wavelength Division Multiplexing (DWDM) Networks", RFC 7792, DOI 10.17487/RFC7792, March 2016, <https://www.rfc-editor.org/info/rfc7792>.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[ITU.G698.2]
International Telecommunications Union, "Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces", ITU-T Recommendation G.698.2, November 2009.

[ITU.G694.1]
International Telecommunications Union, ""Spectral grids for WDM applications: DWDM frequency grid"", ITU-T Recommendation G.698.2, February 2012.

[ITU.G872] International Telecommunications Union, "Architecture of optical transport networks", ITU-T Recommendation G.872, January 2017.

[OIF-400ZR-01-0]
Optical Internetworking Forum (OIF), "Implementation Agreement 400ZR", OIF OIF-400ZR-01-0, March 2020.

[Open_ZR-Plus_MSA]
OpenZR+ Multi-Source Agreement, "400ZR+ Multi-Source Agreement", OpenZR+ Open ZR+ MSA, September 2020.

[I-D.ietf-ccamp-dwdm-if-param-yang]
Galimberti, G., Kunze, R., Burk, A., Hiremagalur, D., and G. Grammel, "A YANG model to manage the optical interface parameters for an external transponder in a WDM network", Work in Progress, Internet-Draft, draft-ietf-ccamp-dwdm-if-param-yang-08, 24 October 2022, <https://www.ietf.org/archive/id/draft-ietf-ccamp-dwdm-if-param-yang-08.txt>.

[I-D.draft-ietf-teas-actn-poi-applicability]
"Applicability of Abstraction and Control of Traffic Engineered Networks (ACTN) to Packet Optical Integration (POI)", Work in Progress, Internet-Draft, draft-ietf-teas-

actn-poi-applicability-07, 10 July 2022,
<https://www.ietf.org/archive/id/draft-ietf-teas-actn-poi-applicability-07.txt>.

9.2. Informative References

[RFC3410] Case, J., Mundy, R., Partain, D., and B. Stewart, "Introduction and Applicability Statements for Internet-Standard Management Framework", RFC 3410, DOI 10.17487/RFC3410, December 2002, <https://www.rfc-editor.org/info/rfc3410>.

[RFC2629] Rose, M., "Writing I-Ds and RFCs using XML", RFC 2629, DOI 10.17487/RFC2629, June 1999, <https://www.rfc-editor.org/info/rfc2629>.

[RFC4181] Heard, C., Ed., "Guidelines for Authors and Reviewers of MIB Documents", BCP 111, RFC 4181, DOI 10.17487/RFC4181, September 2005, <https://www.rfc-editor.org/info/rfc4181>.

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