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GMPLS Routing and Signalling Framework for ODUCn
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Abstract

This document provides a framework to address the GMPLS routing and signalling issues to support Generalized Multi-Protocol Label Switching (GMPLS)control of Optical Transport Networks (OTNs) as specified in ITU-T Recommendation G.709 as published in 2016.

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1. Introduction

Currently, Optical Transport Networks (OTNs) is widely used in the transport network. Some operators already use control-plane capabilities based on GMPLS to control optical transport network to improve the network management efficiency.

The GMPLS signalling extensions defined in [RFC4328] provide the mechanisms for basic GMPLS control of OTN based on the 2001 revision of the G.709 specification. The 2012 revision of the G.709 specification, [G709-2012], introduce some new features, and the GMPLS control of OTN based on the 2012 revision of the G.709 specification is covered in [RFC7062], [RFC7096], [RFC7138] and [RFC7139]. The 2016 revision of the G.709 specification includes some new features, such as OTUCn, ODUCn and OPUCn. The OTUCn contains an optical data unit (ODUCn) and the ODUCn contains an optical payload unit (OPUCn). OTUCn, ODUCn and OPUCn are presented in an interface independent manner, by means of n OTUC, ODUC and OPUC instances that are marked #1 to #n through inverse multiplexing.

This document reviews relevant aspects of OTN technology evolution that affect the GMPLS control-plane protocols, examines why and how to update the mechanisms described in former G.709 related documents and describes the framework and solution for GMPLS control of ODUCn network.

For the purposes of the control plane, the OTN can be considered to be comprised of ODU and wavelength (Optical Channel (OCh)/ Optical Tributary Signal (OTSi)) layers. This document focuses on the control of the ODU layer, with control of the wavelength layer considered out of the scope.

1.1. Requirements Language

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 [RFC2119].

2. Terminology

OPUCn Optical Payload Unit-Cn

ODUCn Optical Data Unit-Cn

OTUCn completely standardized Optical Transport Unit-Cn

OTUCn-M Optical Transport Unit-Cn with n OxUC overhead instances and M 5G tributary slots

OTUCn completely standardized Optical Transport Unit-Cn

3. G.709 Optical Transport Network

This section provides an informative overview of the aspects of the OTN impacting control-plane protocols. This overview is based on the ITU-T Recommendations that contain the normative definition of the OTN. Technical details regarding OTN architecture and interfaces are provided in the relevant ITU-T Recommendations.

3.1. OTN ODUCn layer network

Figure 1 shows a simplified signal hierarchy of OTN ODUCn, which illustrates the layers that are related to control plane.

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                    client signal (OTN clients)
                              |
                                    ODUCn
                                      |
                                    OTUCn
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Figure 1: OTN ODUCn Signal Hierarchy

ODUCn can no be used to support non-OTN client signal. OTN client signals (e.g. ODU0, ODU1, ODU2, ODU2e, ODU3, ODU4, ODUflex) are mapped into an ODUCn container, ODUCn container is then multiplexed into OTUCn. The approximate bit rates of these signals are defined in [G709-2016] and are reproduced in Figure 2.

ODU Type	ODU nominal bit rate
ODU0	1,244,160 Kbps
ODU1	239/238 x 2,488,320 Kbps
ODU2	239/237 x 9,953,280 Kbps
ODU3	239/236 x 39,813,120 Kbps
ODU4	239/227 x 99,532,800 Kbps
ODUCn	n x 239/226 x 99 532 800 kbit/s
ODU2e	239/237 x 10,312,500 Kbps
ODUflex for Constant Bit Rate Client signals	239/238 x client signal bit rate
ODUflex for Generic Framing Procedure - Framed (GFP-F) Mapped client signal	Configured bit rate
ODUflex for IMP mapped client signals	s x 239/238 x 5 156 250 kbit/s s = 2, 8, n x 5 with n >= 1
ODUflex for FlexE aware client signals	103 125 000 x 240/238 x n/20 kbit/s (n = n1 + n2 + .. + np)

Figure 2: ODU Types and Bit Rates

3.2. Time Slot Granularity

The initial versions of G.709 referenced by [RFC4328] only provided a single TS granularity, nominally 2.5 Gbps. [G709-2012] added an additional TS granularity, nominally 1.25 Gbps. [G709-2012] added another 5 Gbps TS granularity specially for ODUCn. The number of tributary slots (TS) defined in [G709-2016] for each ODU are reproduced in Figure 3.

ODU Server	Nominal TS capacity		
	1.25 Gbit/s	2.5 Gbit/s	5 Gbit/s
ODU0	1	N/A	N/A
ODU1	2	N/A	N/A
ODU2	8	4	N/A
ODU3	32	16	N/A
ODU4	80	N/A	N/A
ODUCn	N/A	N/A	20*n

Figure 3: Number of tributary slots (TS)

3.3. Structure of MSI Information

When multiplexing an OTN client signal into ODUCn, [G.709-2016] specifies the information that has to be transported in-band in order to allow for correct demultiplexing. This information, known as MSI, is transported in the OPUCn overhead and is local to each link.

The MSI information is organized as a set of entries, with n entries for each OPUC TS. The MSI indicates the ODTU content of each tributary slot of an OPU. Two bytes are used for each tributary slot. The information carried by each entry is:

- TS availability bit 1 indicates if the tributary slot is available or unavailable.

- The TS occupation bit 9 indicates if the tributary slot is allocated or unallocated.

- Payload Type: the type of the transported payload.

- TPN: the port number of the OTN client signal transported by the ODUCn. The TPN is the same for all the TSs assigned to the transport of the same OTN client signal.

3.4. OTUCn sub rates (OTUCn-M)

An OTUCn with a bit rate that is not an integer multiple of 100 Gbit/s is described as an OTUCn M, it carries n instances of OTUC overhead, ODUC overhead and OPUC overhead together with M 5Gbit/s OPUCn TS. An ODUCn M and OPUCn M are not defined. When an OTUCn M is used to carry an ODUCn (20n-M) TS are marked as unavailable, in the OPUCn multiplex structure identifier (MSI), since they cannot be used to carry a client.

4. Connection Management of ODUCn

ODUCn based connection management is concerned with controlling the connectivity of ODUCn paths. As described in [G.872], The ODUk subnetwork does not support an ODUCn, which means intermediate ODUCn points do not support the switching of ODUCn time slot, intermediate ODUCn point only functions as a forwarding point. Once an ODUCn path is used to transport client signal, the TS occupied will not changed across the ODUCn network.

5. GMPLS Implications

The purpose of this section is to provide a set of requirements to be evaluated for extensions of the current GMPLS protocol suite to encompass OTN enhancements and connection management.

5.1. Implications for GMPLS Signalling

As described in Section 3, [G709-2016] introduced some new features, such as OTUCn, ODUCn and OPUCn. The mechanisms defined in [RFC4328] and [RFC7139] do not support such new OTN features, and protocol extensions will be necessary to allow them to be controlled by a GMPLS control plane. The following signaLling aspects should be considered:

- Support for specifying new signal types and related traffic information. The traffic parameters should be extended in a signalling message to support the new ODUCn

- Support for LSP setup using different TS granularity

- Support for LSP setup of new ODUCn containers with related mapping and multiplexing capabilities

- Support for TPN allocation and negotiation

- Support for LSP setup of OTUCn sub rates (OTUCn-M) path

Note: ODU Virtual Concatenation (VCAT) and Link Capacity Adjustment Scheme (LCAS) is not supported in ODUCn network.

5.2. Implications for GMPLS Routing

The path computation process needs to select a suitable route for an ODUCn connection request. In order to perform the path computation, it needs to evaluate the available bandwidth on one or more candidate links. The routing protocol should be extended to convey sufficient information to represent ODU Traffic Engineering (TE) topology. Following requirements should be considered:

- Support for Tributary Slot Granularity advertisement

- Support for carrying the link multiplexing capability

The routing protocol should be able to indicate which link supports the ODUCn forwarding.

- Support for advertisement of OTUCn sub rates support information

5.3. Implications for Control-Plane Backward Compatibility

TBD

6. Solutions

TBD

7. Security Considerations

TBD

8. IANA Considerations

TBD

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