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Link Management Protocol (LMP) extensions for G.709  
Optical Transport Networks

[draft-zhang-ccamp-gmpls-g709-lmp-discovery-06.txt](#)

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#### Abstract

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Recent progress of the Optical Transport Network (OTN) has introduced new signal types (i.e., ODU0, ODU4, ODU2e and ODUFlex) and new Tributary Slot granularity (1.25Gbps).

Since equipments deployed prior to recently defined ITU-T recommendations only support 2.5 Gbps Tributary Slot granularity and ODU1, ODU2 and ODU3 containers, the compatibility problem should be considered. In addition, a Higher Order ODU (HO ODU) link may not support all the types of Lower Order ODU (LO ODU) signals defined by the new OTN standard because of the limitation of the devices at the two ends of a link. In these cases, the control plane is required to run the capability discovering functions for the evolutive OTN.

This document describes the extensions to the Link Management Protocol (LMP) needed to discover the capability of HO ODU link, including the granularity of Tributary Slot to be used and the LO ODU signal types that the link can support.

#### 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 [[RFC2119](#)].

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## [1.](#) Introduction

The Link Management Protocol (LMP) defined in [[RFC4204](#)] is being developed as part of the Generalized MPLS (GMPLS) protocol suite to manage Traffic Engineering (TE) links.

Recently, great progress has been made for the Optical Transport Networking (OTN) technologies in ITU-T. New ODU containers (i.e., ODU0, ODU4, ODU2e and ODUflex) and a new Tributary Slot (TS) granularity (1.25Gbps) have been introduced by the [[G709-V3](#)], enhancing the flexibility of OTNs.

With the evolution and deployment of G.709 technology, the backward compatibility problem requires to be considered. In data plane, the equipment supporting 1.25Gbps TS can combine the specific Tributary Slots together (e.g., combination of TS#i and TS#i+4 on a HO ODU2 link) so that it can interwork with other equipments which support 2.5Gbps TS. From the control plane point of view, it is necessary to discover which type of TS is supported at both ends of a link, so that it can choose and reserve the TS resources correctly in this link for the connection.

Additionally, the requirement of discovering the signal types of Lower Order ODU (LO ODU) that can be supported by a Higher Order ODU (HO ODU) should be taken into account. Equipment at one end of a HO ODU link may not support to transport some types of LO ODU signals (e.g., may not support the ODUflex). In this case, this HO ODU link should not be selected for those types of LO ODU connections.

From the perspective of control plane, it is necessary to discover the capability of a HO ODUk or OTUk link including the granularity of TS to be used and the LO ODU signal types that the link can support. Note that this capability information can be, in principle, discovered by routing. Since in certain case, routing is not present (e.g., UNI case) we need to extend link management protocol

capabilities to cover this aspect. Obviously, in case of routing presence, the discovering procedure by LMP could also be optional.

This document extends the LMP and describes the solution of discovering HO ODU link capability.

## [2.](#) Terminology

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 [[RFC2119](#)].

## [3.](#) Overview of the Evolutive G.709

The traditional OTN standard [[ITUT-G709](#)] describes the optical transport hierarchy (OTH) and introduces three ODU signal types (i.e., ODU1, ODU2 and ODU3). The ODU<sub>j</sub> can be mapped into one or more Tributary Slots (with a granularity of 2.5Gbps) of OPU<sub>k</sub> where  $j < k$ . The ODU<sub>j</sub> can also be mapped into OTU<sub>j</sub> ( $j=1, 2$  or  $3$ ) directly.

Recent revisions of ITU-T Recommendation G.709 have introduced new features for the evolutive Optical Transport Networks (OTN). New ODU signals, including ODU0, ODU4, ODU2e and ODUFlex, are described in [[G709-V3](#)]. This document also defines the new multiplexing hierarchy for the evolutive OTN. In this multiplexing hierarchy, LO ODU<sub>j</sub> can be mapped into an OTU<sub>j</sub>, or multiplexed into a HO ODUK (where  $j < k$ ) by occupying several tributary slots.

In case of LO ODU<sub>j</sub> mapping into OTU<sub>j</sub>, the following mappings are defined:

- ODU1 into OTU1 mapping
- ODU2 into OTU2 mapping
- ODU3 into OTU3 mapping
- ODU4 into OTU4 mapping

In case of LO ODU<sub>j</sub> multiplexing into HO ODU<sub>k</sub>, a new Tributary Slot granularity (i.e., 1.25Gbps) is introduced in [G709-V3]. For the evolutive OTN, the multiplexing of ODU<sub>j</sub> ( $j = 0, 1, 2, 2e, 3, \text{flex}$ ) into an ODU<sub>k</sub> ( $k > j$ ) signal can be depicted as follows:

- ODU<sub>0</sub> into ODU<sub>1</sub> multiplexing (with 1,25Gbps TS granularity)
- ODU<sub>0</sub>, ODU<sub>1</sub>, ODU<sub>flex</sub> into ODU<sub>2</sub> multiplexing (with 1.25Gbps TS granularity)
- ODU<sub>1</sub> into ODU<sub>2</sub> multiplexing (with 2.5Gbps TS granularity)
- ODU<sub>0</sub>, ODU<sub>1</sub>, ODU<sub>2</sub>, ODU<sub>2e</sub> and ODU<sub>flex</sub> into ODU<sub>3</sub> multiplexing (with 1.25Gbps TS granularity)

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- ODU<sub>1</sub>, ODU<sub>2</sub> into ODU<sub>3</sub> multiplexing (with 2.5Gbps TS granularity)
- ODU<sub>0</sub>, ODU<sub>1</sub>, ODU<sub>2</sub>, ODU<sub>2e</sub>, ODU<sub>3</sub> and ODU<sub>flex</sub> into ODU<sub>4</sub> multiplexing (with 1.25Gbps TS granularity)

Note that If TS auto-negotiation is supported, a node supporting 1.25Gbps TS can interwork with the other nodes that supporting 2.5Gbps TS by combining specific TSs together in data plane, as descirbied in [OTN-frwk].

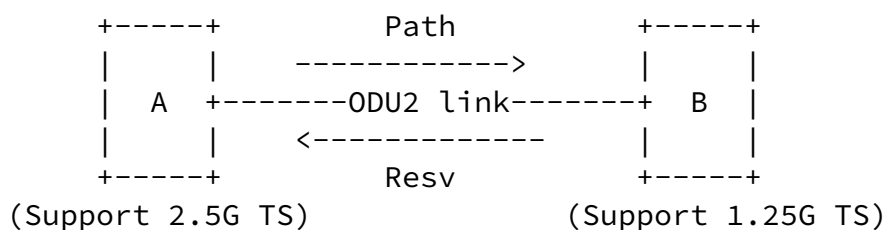
## [4. Link Capability Discovery Requirements](#)

### [4.1. Discovering the Granularity of the TS](#)

As described in [section 3.1](#), if the two ends of a link use different granularities of TS, The LO ODU must be mapped into specific combined Tributary Slots in the end of link with TS of 1.25Gbps.

From the perspective of control plane, when creating a LO ODU connection, the node MUST select and reserve specific TS for the connection if the two ends of a link use different granularities of TS. For example, for an ODU<sub>2</sub> link, we suppose that node A only supports the 2.5Gbps TS while node B supports the 1.25Gbps TS. When node B receives a Path message from node A requesting an ODU<sub>1</sub> connection, node B MUST reserve the TS#*i* and TS#*i*+4 (where  $i \leq 4$ ) (with the granularity of 1.25Gbps) and tell node A via the label carried in the Resv message that the TS#*i* (with the granularity of

2.5Gbps) among the 4 slots has been reserved for the ODU1 connection. Otherwise, the reservation procedure will fail.



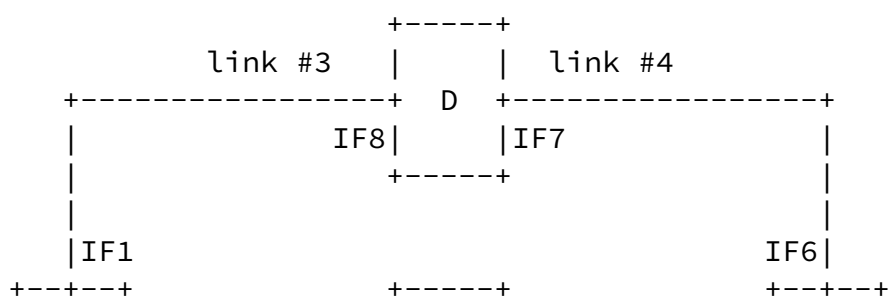
Therefore, for an ODU2 or ODU3 link, in order to reserve TS resources correctly for a L0 ODU connection, the control plane of the two ends MUST know which granularity the other end can support before creating the L0 ODU connection.

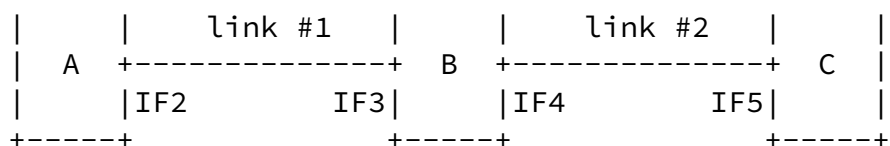
#### [4.2. Discovering the Supported L0 ODU Signal Types](#)

Many new ODU signal types are introduced by [\[G709-V3\]](#), such as ODU0, ODU4, ODU2e and ODUFlex. It is possible that equipment does not always support all the L0 ODU signal types introduced by [\[G709-V3\]](#).

If one end of a H0 ODU link can not support a certain L0 ODU signal type and there is no H0 ODU FA LSP able to support this L0 ODU signal, the H0 ODU link/FA LSP can not be selected to carry such type of L0 ODU connection.

For example, in the following figure, if the interfaces IF1, IF2, IF8, IF7, IF5 and IF6 can support ODUFlex signals, while the interfaces IF3 and IF4 can not support ODUFlex signals. In this case, if one ODUFlex connection from A to C is requested, and there is no H0 ODU FA LSP from node A to C through node B, link #1 and #2 should be excluded, link #3 and link #4 are the candidates (the possible path could be A-D-C through link #3 and link #4).





Therefore, it is necessary for the two ends of a HO ODU link to discover which types of LO ODU can be supported by the HO ODU link. After discovering, the capability information can be flooded by IGP, so that the correct path for an ODU connection can be calculated.

## 5. Extensions: LMP Link Summary Message

[RFC4204] defines the Link Management Protocol (LMP) which consists of four main procedures: control channel management, link property correlation, link connectivity verification, and fault management. As part of LMP, the link property correlation is used to verify the consistency of the TE and data link information on both sides of a link. This document extends the link property correlation procedure to discover the capability of both sides of a HO ODU link.

The designated HO ODU overhead bytes (e.g., the GCC1 and GCC2 overhead bytes) can be used as the control channel to carry the LMP

message after the HO ODU link is created. The out-of-band Data Communication Network (DCN) can also be used.

### 5.1. Message Extension

Three messages are used for link property correlation: LinkSummary, LinkSummaryAck and LinkSummaryNack Message. This document does not change the basic procedure of LMP but just add a new subobject (HO ODU Link Capability) in the DATA\_LINK object to carry the capability of one end of a HO ODU link.

The formats of LinkSummary, LinkSummaryAck and LinkSummaryNack messages are defined in [RFC4204].

#### 5.1.1. LinkSummary Message

The local end of a TE link can send a LinkSummary message to the remote end to start the negotiation about the capability that the TE

link can support.

One new Subobject named HO ODU Link Capability Subobject in the DATA\_LINK object is introduced by this document. This new subobject is used to tell the remote end of the HO ODU link which TS granularity and which LO ODU signal types that the local end can support. When the DATA\_LINK object carries the new HO ODU Link Capability Subobject, the N flag SHOULD be set to 1 which means that the subobject is negotiable.

### 5.1.2. LinkSummaryAck Message

The LinkSummaryAck message is used to tell the remote end that it has the same capability as the remote end after the LinkSummary message is received by the local end.

### 5.1.3. LinkSummaryNack Message

The LinkSummaryNack message is used to tell the remote end that it has different capability from the remote end after the LinkSummary message is received by the local end. The LinkSummaryNack message also carries the H0 ODU Link Capability subobject in the DATA\_LINK object to tell the remote end the exact capability of the H0 ODU link after negotiation, i.e., the granularity of TS and the types of L0 ODU that both side of the H0 ODU link can support.

## 5.2. Object Definitions

A new HO ODU Link Capability subobject type is introduced to the DATA LINK object to carry the HO ODU link capability information. The format of the new subobject is defined as follow:

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	2	3	4	5	6	7	8	9																																								
Type																Length																OD(T)Uk																T																Reserved															
A B C D E F G																LO ODU Flags																																Reserved																															

Type (8 bits):



The value of this subobject type is TBD.

Length (8 bits):

The Length field contains the total length of the subobject in bytes, including the Type and Length fields. As for [RFC 4204](#), the Length MUST be at least 4, and MUST be a multiple of 4. Value of this field is 8.

OD(T)Uk (4 bits):

This field is used to indicate the HO ODU link type (in case of LO ODU<sub>j</sub> multiplexing into HO ODU<sub>k</sub>, wherein  $j < k$ ) or the OTU link type (in case of LO ODU<sub>k</sub> mapping into OTU<sub>k</sub>).

OD(T)Uk field	Signal type of HO ODU <sub>k</sub> or OTU <sub>k</sub>
-----	-----
0	Reserved (for future use)
1	HO ODU1 or OTU1
2	HO ODU2 or OTU2
3	HO ODU3 or OTU3
4	HO ODU4 or OTU4
5-15	Reserved (for future use)

T (2 bits):

The T bits are used to indicate the granularity of the TS of the HO ODU link.

T field	TS type
-----	-----
00	Meaningless
01	1.25Gbps TS granularity
10	2.5Gbps TS granularity
11	Reserved (for future use)

In case that an OTU<sub>k</sub> link only support ODU<sub>j</sub> ( $j=k$ ) into OTU<sub>k</sub> mapping and does not support any ODU<sub>j</sub> into ODU<sub>k</sub> ( $j < k$ ) multiplexing, then the T field is not meaningful and MUST be filled with 0 and be ignored on receipt.

L0 ODU flags (A|B|C|D|E|F|G) (16 bits):

These flags are used to indicate which L0 ODU signal types that one end or the both end can support. The flags will be set to 1 if the corresponding L0 ODU signal types are supported to be mapped or multiplexed into the OTUk or HO ODUk link.

This rule imposes that:

- At least one flag is set to 1.
- When the ODU<sub>j</sub> (j=k) flag corresponding to the signal type HO ODU<sub>k</sub>/OTU<sub>k</sub> is set to 1, then the signal type OD(T)U<sub>k</sub> has to be intended as L0 ODU<sub>k</sub> and direct mapping over OTU<sub>k</sub> is supported.
  - \* Furthermore, if only the ODU<sub>j</sub>(j=k) flag is set to 1, it means that the HO ODU<sub>k</sub>/OTU<sub>k</sub> link only supports ODU<sub>j</sub>(j=k) into OTU<sub>k</sub> mapping. In other words, the link does not support any ODU<sub>j</sub> into ODU<sub>k</sub> (j<k) multiplexing (i.e., payload type != 20/21), but may support carrying various non-ODU client signals listed in Table 15-8 of [\[G709-V3\]](#).
- When an ODU<sub>j</sub> (j<k) flag not corresponding to the signal type HO ODU<sub>k</sub>/OTU<sub>k</sub> is set to 1 then the signal type OD(T)U<sub>k</sub> has to be intended as HO ODU<sub>k</sub> and multiplexing of L0 ODU<sub>j</sub> over HO ODU<sub>k</sub> is supported.

Flag A: indicates whether L0 ODU<sub>0</sub> is supported.

Flag B: indicates whether L0 ODU<sub>1</sub> is supported.

Flag C: indicates whether L0 ODU<sub>2</sub> is supported.

Flag D: indicates whether L0 ODU<sub>3</sub> is supported.

Flag E: indicates whether L0 ODU<sub>4</sub> is supported.

Flag F: indicates whether L0 ODU<sub>2e</sub> is supported.

Flag G: indicates whether L0 ODUflex is supported.

For example, if one end of an OTU<sub>2</sub> link supports L0 ODU<sub>0</sub>, L0 ODU<sub>1</sub>, L0 ODUflex into HO ODU<sub>2</sub> multiplexing and supports L0 ODU<sub>2</sub> into OTU<sub>2</sub>

mapping, the flags A, B, C, and G will be set to 1.

As a further example, if one end of an OTU2 link supports only L0 ODU2 into OTU2 mapping but no multiplexing, only flag C will be set to 1.

The remaining flags are reserved for future use and MUST be set to 0.

### 5.3. Procedures

The Link Summary messages used for capability discovery for H0 ODUk or OTUk link are sent between adjacent nodes after the H0 ODU link is created or driven by some events (e.g., an operator command). The procedure is described below:

- o The local end of the H0 ODU link sends a LinkSummary message including one or more DATA\_LINK objects, each of which contains the Local\_Interface\_Id, the Remote\_Interface\_Id, and the H0 ODU link capability subobject. This subobject carries the capability that the local end can support, i.e., the granularity of TS and the set of L0 ODU signal types that the local end can support. The LinkSummary message is sent to the remote end.
- o On receipt of the LinkSummary message, the remote end of the H0 ODU link firstly determines whether the local/remote Interface\_Id mappings match those that are stored locally as described in [\[RFC4204\]](#), and then obtains the H0 ODU link capability subobject and determines the capability of the H0 ODU link that both ends can support. The detail procedures are as follow:
  - Only if both ends support the 1.25Gbps TS, the remote end would choose the 1.25Gbps as the negotiated granularity for the H0 ODU link. In other cases, the 2.5Gbps TS MUST be used (e.g., if the local end can support 1.25Gbps, and the remote end can support 2.5Gbps, and then the local end should imitate 2.5Gbps).
  - The remote end compares the two sets of L0 ODU signal types that the local end and the remote end can support, and calculates the intersection of them, i.e., extracts all the L0

ODU signal types that both two ends can support. This intersection is the set of L0 ODU signal types that the H0 ODU link can support.

- o If both the two ends support the same capability, i.e., they support the same granularity of TS and the same LO ODU signal types, the remote end replies a LinkSummaryAck message to the local end. So the both ends know what capability the HO ODU link can support.
- o If the two ends support different capabilities, i.e., they support different granularities of TS or different LO ODU signal types, the remote end replies a LinkSummaryNack message to the local end. The LinkSummaryNack message carries an ERROR\_CODE object and one or more DATA\_LINK objects. The ERROR\_CODE "Renegotiate LINK\_SUMMARY parameters" (see [[RFC4204](#)]) indicates that the two ends of the HO ODU link support different capabilities, and the DATA\_LINK object carries the HO ODU link capability subobject which contains the negotiated granularity of TS and the set of LO ODU signal types that both ends can support. The local end can learn the HO ODU link capability after receiving the LinkSummaryNack message.
- o If the remote end does not support the HO ODU link capability negotiation procedure, the LinkSummaryNack message MUST be responded with an ERROR\_CODE "Not support of HO ODU Link Capability subobject" (TBA) indicating the reason of rejection.

## [6](#). Security Considerations

TBD.

## [7](#). IANA Considerations

TBD.

## [8](#). Acknowledgments

TBD.

## 9. References

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- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
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- [ITU-T-G709] ITU-T, "Interface for the Optical Transport Network (OTN)", G.709 Recommendation, March 2003.
- [G709-V3] ITU-T, "Interfaces for the Optical Transport Network (OTN)", G.709 Recommendation, December 2009.

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