A proposal to decouple connectivity from media access

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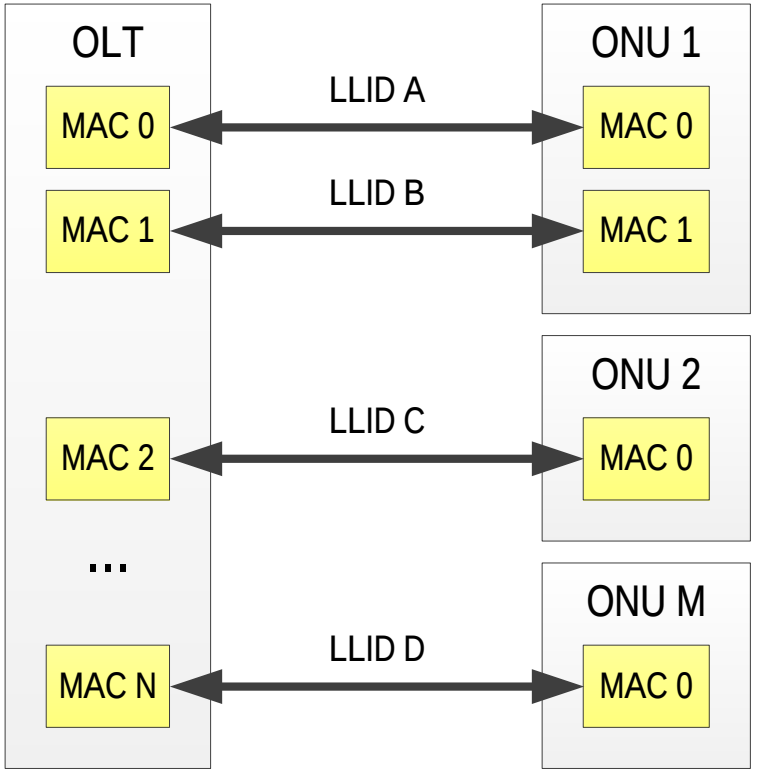
Version List

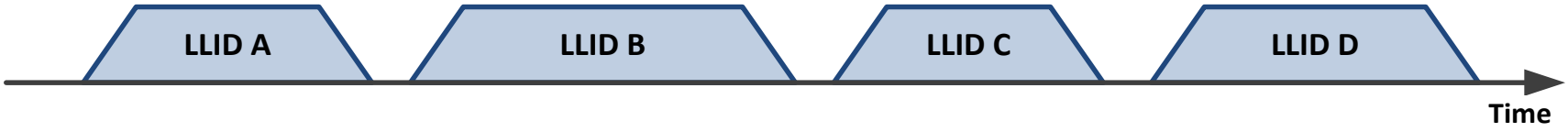
Ver.	Description
1.0	Initial version as we presented/discussed on a TF call on 8/18/2016
2.0	• GrantLength field is removed from GATE2 • Use of multi-PDU messages is clarified • Bulk Granting feature is introduced
2.1	Refined MPCPDU format, specified field sizes
2.2	Group Link ID (GLID) is introduced. Further optimization of MPCPDU format

Duality of LLID

- LLID as a Connectivity Element
  - LLID represents a logical point-to-point link (for point-to-point emulation over shared medium)
  - Employs a tag in the preamble to segregate traffic belonging to different services, subscribers, etc.
  - Analogous to VLAN, but with zero-overhead and local to PON (user data still can be double-tagged).



- LLID as a Media Access Element
  - Reporting and Granting is done per LLID
  - Significant overhead per each access to the media
    - Laser on/off, sync time, burst delimiters, GATE/REPORT messages



Why Duality of LLIDs is a problem?

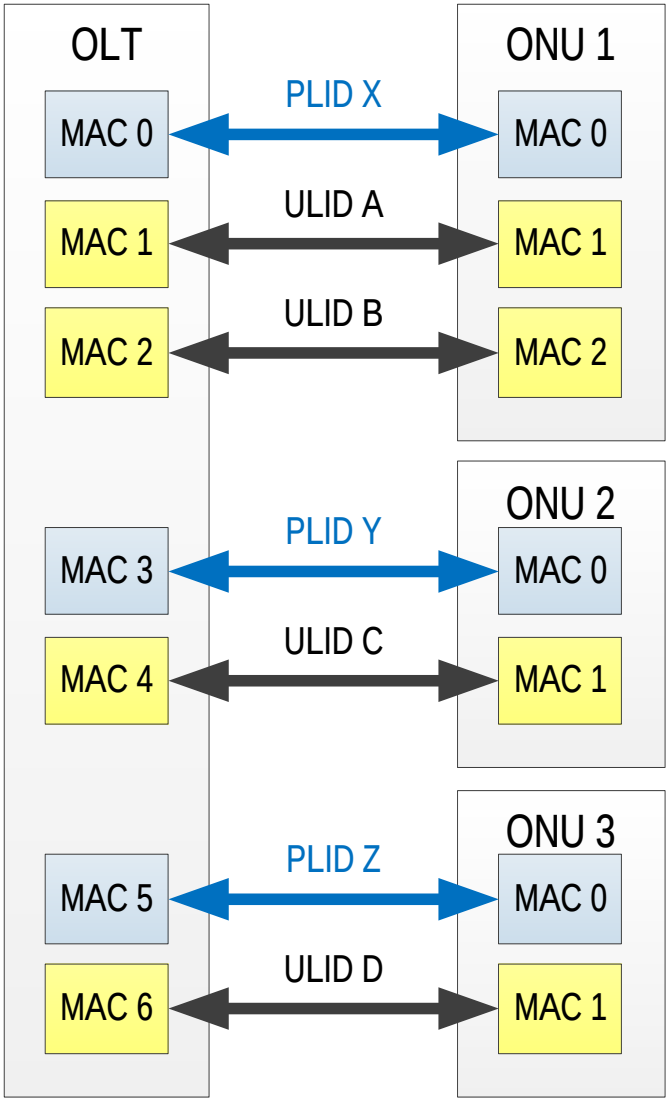
- To serve a large number of subscribers and support multiple services, it is desirable to support a very large number of LLIDs per NG-EPON
  - Full 2^{16} range is reasonable and useful
- To eliminate excessive overhead, it is desirable to reduce the number of elements accessing the media to a minimum
  - Minimum number of elements accessing the media is the number of physical ONUs

Proposed solution: PLID

- Separate LLIDs into two sub-classes:
  1. ***User Link ID (ULID)*** – logical link between a pair of MACs in OLT and ONUs used to carry user traffic
  2. ***Physical Layer ID (PLID)*** – logical link between the OLT and a physical ONU
- ULIDs and PLIDs share the same 2^{16} space

Example LLID value allocation:

Tag Value	Pool Size	Description
0x0000	1	Reserved
0x0001	1	Broadcast PLID used for broadcasting administrative traffic (MPCPDU, OAMPDU) to all ONUs and for ONU discovery.
0x0002 – 0x0FFF	4094	Values represent PLID. The number of PLIDs is limited by number of physical ONUs on the PON.
0x1000 – 0xEFFF	57343	Values represent unicast (bidirectional) or multicast (downstream only) ULIDs.
0xF000 – 0xFFFE	4095	Reserved
0xFFFF	1	Broadcast ULID is used for broadcasting user traffic. This ULID is not used for PON administrative traffic or for discovery.



Proposed Solution: GATE2

- Definition of a new **GATE2** message
  - Transmitted on PLID logical link
  - **Channel Assignment:**
    - **Bits 0-3 –** a bitmap representing the wavelength channel(s) to transmit on.
    - **Bits 4-7** - reserved.
  - **Grant Start Time** – grant start time (in TQ)
  - **<Grant Item>** is a tuple consisting of LLID and Grant Length (unit is TBD). It tells the ONU how many bytes to transmit for each LLID.
- One 64-byte GATE2 message can accommodate up to 7 Report items.
  - If the ONU has more than 7 LLIDs, send separate GATE2 messages

Term “LLID” means either “PLID” or “ULID”

6	DA	
6	SA	
2	Length/Type = 0x88-08	
2	Opcode = 0x00-12	
4	Timestamp	
1	Channel Assignment	
4	Grant Start Time	
2	LLID	Grant item #1
3	Grant Length	
2	LLID	[Grant item #2]
3	Grant Length	
2	LLID	[Grant item #3]
3	Grant Length	
2	LLID	[Grant item #4]
3	Grant Length	
2	LLID	[Grant item #5]
3	Grant Length	
2	LLID	[Grant item #6]
3	Grant Length	
2	LLID	[Grant item #7]
3	Grant Length	
0...30	Pad = 0	
4	FCS	

Proposed Solution: REPORT2

- Definition of a new **REPORT2** message
  - Transmitted on PLID logical link
  - Represents all LLIDs in a given ONU
  - Only the LLIDs that have queued data are reported.
  - **Multi-Part Report** - Number of additional REPORT2 MPCPDUs waiting in the ONU
  - **Report time** - MPCP time at which the Queue Lengths in this message were taken (in TQ).
  - **Queue Length** – total queue length

- One 64-byte REPORT2 message can accommodate up to 7 Report items.
  - If the ONU has more than 7 LLIDs with data, send multiple REPORT2 messages

Term “LLID” means either “PLID” or “ULID”

6	DA	
6	SA	
2	Length/Type = 0x88-08	
2	Opcode = 0x00-13	
4	Timestamp	
1	Multi-Part Report	
4	Report Time	
2	LLID	[Report item #1]
3	Queue Length	
2	LLID	[Report item #2]
3	Queue Length	
2	LLID	[Report item #3]
3	Queue Length	
2	LLID	[Report item #4]
3	Queue Length	
2	LLID	[Report item #5]
3	Queue Length	
2	LLID	[Report item #6]
3	Queue Length	
2	LLID	[Report item #7]
3	Queue Length	
0...35	Pad = 0	
4	FCS	

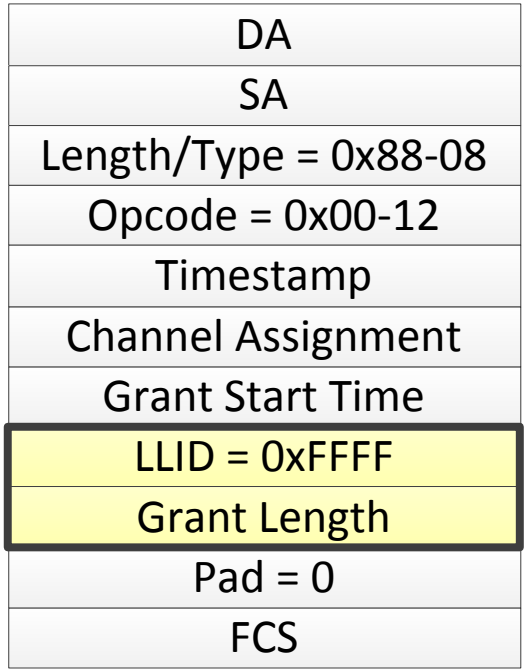
Multi-PDU Messages

- In some configurations, a REPORT2 may need to report more than 7 LLIDs, and GATE2 needs to grant more than 7 LLIDs. In such cases, MPCP would generate multiple MPCPDUs.
  - In case of multiple REPORT2 MPCPDUs, each message indicates the queue sizes of a subset of ULIDs.
  - In case of multiple GATE2 MPCPDUs, each message indicates the grant sizes for a subset of ULIDs. The following cases are distinguished:
    - Multiple GATE2 MPCPDUs carry the same value of Grant Start Time – The ONU treats these messages as representing the same grant, and will transmit the data from LLIDs granted in multiple GATE2 MPCPDUs contiguously (back-to-back).
    - Multiple GATE2 MPCPDUs carry different values of Grant Start Time – The ONU treats these messages are representing separate grants. Each grant will start at its specific start time.

Bulk Granting

- The scheduler at the OLT may decide to let ONU divide bandwidth across any of its LLIDs.

- This is accomplished by issuing the GATE2 with broadcast ULID (0xFFFF) or some special reserved ULID value in the Grant Item tuple.



A Smarter Bulk Granting

- Define ***Group Link ID (GLID)*** to be a collection of ULIDs within an ONU.
- One or many GLIDs can be provisioned in each ONU by management. For example:
  - GLID1 → {ULID1, ULID2, ULID5}
  - GLID2 → {ULID3, ULID4}
  - GLID3 → {ULID5, ULID6, ULID7, ULID8 }
- The scheduler may grant individual ULIDs and/or GLIDs in the same message.

Tag Value	Pool Size	Description
0x0000	1	Reserved
0x0001	1	Broadcast PLID used for broadcasting administrative traffic (MPCPDU, OAMPDU) to all ONUs and for ONU discovery.
0x0002 – 0x0FFF	4094	Values represent PLID. The number of PLIDs is limited by number of physical ONUs on the PON.
0x1000 – 0xEFFF	57343	Values represent unicast (bidirectional) or multicast (downstream only) ULIDs.
0xF000 – 0xFEFF	3839	Reserved
0xFF00 – 0xFFFE	255	GLIDs – used for group granting only
0xFFFF	1	Broadcast ULID is used for broadcasting user traffic.

DA
SA
Length/Type = 0x88-08
Opcode = 0x00-12
Timestamp
Channel Assignment
Grant Start Time
GLID1
600
ULID1
150
ULID2
0
ULID3
200
ULID4
50
FCS

GLID Use Examples

- ONU has 8 ULIDs (ULID1-ULID8). All ULIDs reported ample data.

Example 1: Received GATE2 (GLID1 = {ULID1, ULID2, ULID5})

LLID:	GLID1	ULID1	ULID2	ULID3	ULID4	ULID5	ULID6	ULID7	ULID8
Length	600	150	0	200	50	Not listed	Not listed	Not listed	Not listed

- **Resulting Grant Allocation**

LLID:	Total	ULID1	ULID2	ULID3	ULID4	ULID5	ULID6	ULID7	ULID8
Length	1000	150 + 200	0 + 200	200	50	0 + 200	0	0	0

Example 2: Received GATE2 (GLID3 = {ULID5, ULID6, ULID7, ULID8})

LLID:	GLID3	ULID1	ULID2	ULID3	ULID4	ULID5	ULID6	ULID7	ULID8
Length	600	150	0	200	50	Not listed	Not listed	Not listed	Not listed

- **Resulting Grant Allocation**

LLID:	Total	ULID1	ULID2	ULID3	ULID4	ULID5	ULID6	ULID7	ULID8
Length	1000	150	0	200	50	150	150	150	150

Provisioning of GLID

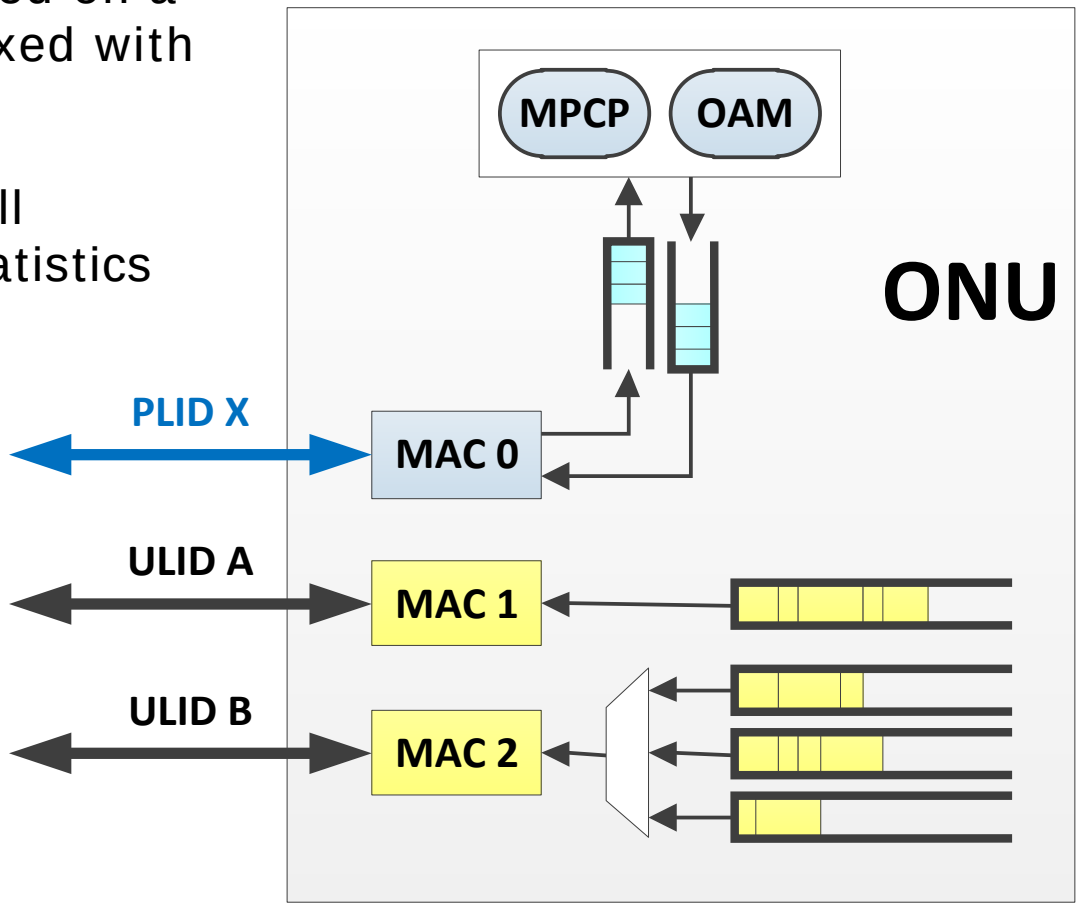
- When GLIDs are provisioned for the ONU, the OAM attribute may also indicate how the grant space is to be allocated to each ULID under this GLID.
- This management attribute (TLV) is out-of-scope for 802.3ca, but it may look like this:

Field	Size (bytes)	Description
Branch	1	Branch
Leaf	2	Leaf
Length	2	Length (Value = 3 + 3N)
GLID	2	Assigned GLID value (range: 0xFF00 – 0xFFFE)
Allocation Mode	1	0x00 – Strict Priority (*ULID Parameter* is interpreted as priority) 0x01 – Weighted Allocation (*ULID Parameter* is interpreted as weight) Other policies?
ULID[0]	2	Value of ULID[0] that is part of this granting group
Parameter[0]	1	
…		
ULID[N-1]	2	
Parameter[N-1]	1	

Benefits of this proposal

Segregation of user data and network control

- A PLID never carries user traffic
- All OAMPDUs, MPCPDUs, and future Wavelength Control Protocol data units (WCPDUs) are exchanged on a given PLID and are never mixed with user traffic on ULIDs.
- ULID byte/frame counters will represent true user traffic statistics
- A PLID has a dedicated pair of vMACs at the OLT and each ONU



Improved Discovery / Registration

- **Current situation**
  - Every LLID goes through registration process, so the OLT/NMS can learn RTT and MAC address
    - All RTTs from the same physical ONU are the same
- **New proposal**
  - Only ONUs (PLIDs) are discovered/registered via the normal MPCP discovery process.
  - Once PLID is registered, multiple unicast or multicast ULIDs are assigned via eOAM → no time/bandwidth is wasted for discovery
    - Mechanism to assign LLIDs already exists in 1904.1
  - Near-zero penalty/cost per ULID → A very large number of ULIDs can be assigned per ONU
  - Assignment of an ULID is near instant → ULIDs can be assigned statically or dynamically per service/session.
  - The size of a discovery window can be reduced because much fewer instances (PLIDs) compete for discovery
  - Once all connected ONUs are registered, the discovery attempts can cease altogether
    - PLIDs would remain registered, while ULIDs are assigned and revoked as needed.

Improved PON Efficiency

- **Current situation**
  - Every LLID exchanges GATE/REPORT messages.
  - Every LLID establishes an OAM connection and in absence of OAM queries, exchanges keep-alive OAMPDUs
- **New proposal**
  - GATEs/REPORTs are exchanged only on PLID and apply to all ULIDs in the ONU → Overall number of GATE/REPORT transmissions is reduced.
  - OAM connections are established on PLIDs only → No unnecessary OAM keep-alives on any ULIDs

Discussion points from the call on 8/18/2016

1. For self-install situations, discovery windows may need to be issued periodically, but with a much decreased frequency.
2. Polling Period
   - Only PLIDs (ONUs) are being polled.
   - There is only one polling period per ONU.
   - Polling period of a PLID should be determined by the most strict latency requirement of any of the ULIDs in the ONU.
3. MAC addresses in ONU
   - MAC addresses are conserved!!!
     - ULIDs only carry L2 user traffic that originates outside of ONU.
     - ULIDs do not need to have unique MAC addresses
   - ONU needs only one MAC address, which will be associated with PLID
     - PLIDs MAC addresses need to be globally unique, so that multiple PONs can be managed by a common management master.

Thank You