LLIDs (PHY_IDs) in EPONs

Vincent Bemmel, Alloptic
Logical Link Identifiers (LLIDs)

**What they are:**
- Introduced for **802.1D Bridge compliance**
- Identification of an ONU from a Bridging perspective (P2PE)
- 1:1 association between single ONU and OLT Bridge port
  - Allow for filtering of ONU-ONU bridged traffic
- Carried in the preamble in either direction on the PON
  - Stripped off before frame enters MAC
- A.k.a. “PHY_IDs”, etc.

**What they are not (and shouldn’t try to be):**
- Required for OAM processing
- Required for per-User port service segregation
- N:1 association between single ONU and OLT Bridge port
- ONU User port IDs, CPE IDs, etc.
- Passing through MACs, bridges, switches, and beyond the PON segment
- An alternative to VLANs
Current proposal for ONU...

Many Questions...
- Does LLID represent ONU.. or user port?
- Why not use VLANs for segregation?
- How are LLIDs exposed above the OLT?
- What does the layering architecture really look like?
- How does this model scale?
  - etc...

802.3ah Meetings, Edinburgh
Traffic Segregation & QOS

- Key mechanisms for consistent QOS:
  - Packet classification
  - Traffic & service segregation
  - Prioritization
  - BW management, traffic management, rate limiting, ...

- 802.1Q VLANs
  - Only standardized way to segregate traffic in Ethernet networks
  - Span multiple Ethernet segments
  - Encapsulated into Ethernet frames
  - VLAN tags directly map to IP networks in VLAN-aware routers
  - 802.1P priorities are exposed to L2 → effective BW management
  - VLAN tags can be used to classify packets

- ...but addressing space is limited to 4K 😞
- ...no standard for ‘transparent VLAN’ to date 😞

General issue with all Ethernet in MAN/WAN

Address this in 802.1Q!
A closer look at VLANs

<table>
<thead>
<tr>
<th>Preamble</th>
<th>SFD</th>
<th>DA</th>
<th>SA</th>
<th>Tag type</th>
<th>Tag</th>
<th>IP Packet</th>
<th>FCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(7B)</td>
<td>(1B)</td>
<td>(6B)</td>
<td>(6B)</td>
<td>(2B)</td>
<td>(2B)</td>
<td></td>
<td>(4B)</td>
</tr>
</tbody>
</table>

8100  (12 bits)

802.1Q Type  802.1P Priority  802.1Q VLAN ID

Application

VLAN-aware Router

Standard Router

802.3ah Meetings, Edinburgh
EFM & VLANs

EFM: L2 Subscriber Access Network

Terminated VLANs

EFM: L2 Subscriber Access Network

4K VLAN IDs per router

EFM aware Router

Standard Router

End User

Ethernet Network

IP Network

xSP
ONU functions

- Common functions:
  - Traffic segregation
  - Rate limiting
  - Prioritization

- Rate limiting at Gbps speeds is out of the realm of microprocessors

- Switching chips with Gbps interfaces are relatively expensive
  - Prioritization & rate limiting included at no significant add’l cost
  - Most are VLAN-aware
  - Prices will continue to fall
**ONU & layering**

**PON side**

- 1Gbps
  - PHY
  - RS
  - MAC
  - MAC-Control
  - Local Scheduler
  - PON_Tag
  - Filters by LLID
  - Switch/Bridge

**Specialized For EPON**

- Downstream: Strips PON_Tag
  - Upstream: inserts PON_Tag

- Downstream: Terminates MPCP messages
  - Upstream: originates MPCP messages

- EFM stops here!

**Non-EFM**

- MAC
  - RS
  - PHY

**User side**

- 10/100 Mbps
  - Switch/Bridge
  - LAN

- CPE

---

**802.3ah Meetings, Edinburgh**
P2PE and ONUs

802.1D Bridge

Native MAC  vMAC  vMAC  vMAC  vMAC  vMAC  vMAC

PHY

802.3ah Meetings, Edinburgh
Addressing scope

IP scope

VLAN scope

ONU

OLT

PON

S/R

S

R

R

R*

gMACs

LLID scope

MPCP scope

EFM Scope
Scalability

- Another reason why multiple LLIDs per ONU is a bad idea...
- Overhead seriously limits scalability of uniform Cyclic service (e.g., TDM POTS)
- **Downstream GATE overhead** =
  \[
  \frac{(((\text{number of ONUs}) \times (\text{avg # LLIDs per ONU}) / \text{Cycle length}) \times 64 \times 8 \text{ bps})}{1 \text{Gbps}} \times 100\%
  \]
- **Upstream Guardband overhead** =
  \[
  \frac{(\text{number of ONUs}) \times (\text{avg # LLIDs per ONU}) \times \text{Guardband length} / \text{Cycle length}}{100\%}
  \]

**Upstream efficiency is very important – our customers expect BW close to 1Gbps!!**

<table>
<thead>
<tr>
<th>#ONUs</th>
<th># PHY_IDs</th>
<th>1 ms cycle</th>
<th>2 ms cycle</th>
<th>1 usec guard</th>
<th>2 usec</th>
<th>1 usec guard</th>
<th>2 usec</th>
<th>2 usec</th>
<th>3 usec</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>8</td>
<td>6.6</td>
<td>3.3</td>
<td>12.8</td>
<td>25.6</td>
<td>6.4</td>
<td>12.8</td>
<td>19.2</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>8</td>
<td>13.1</td>
<td>6.6</td>
<td>25.6</td>
<td>51.2</td>
<td>12.8</td>
<td>25.6</td>
<td>38.4</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>24</td>
<td>39.3</td>
<td>19.7</td>
<td>76.8</td>
<td>153.6</td>
<td>38.4</td>
<td>76.8</td>
<td>115.2</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>24</td>
<td>78.6</td>
<td>39.3</td>
<td>153.6</td>
<td>307.2</td>
<td>76.8</td>
<td>153.6</td>
<td>230.4</td>
<td></td>
</tr>
</tbody>
</table>
In summary

- Service segregation is not an 802.3 function...
- 802.1Q VLANs can address this in an elegant way today
  - VLANs are visible to L2 and provide an interface to higher layers
  - VLAN-based traffic segregation, prioritization and rate limiting are available in most Gbps Ethernet switching chips
  - VLAN limitations need to be addressed in 802.1Q, not 802.3

- A single LLID per ONU is sufficient for 802.1D compliance & EPON scheduling
  - LLID is only visible within the EPON segment, & below the MAC

- LLIDs are no alternative to VLANs!!

- Multiple LLIDs/ONU introduce serious scalability limitations
  - unnecessarily boost up the cost (requires smaller guard bands)