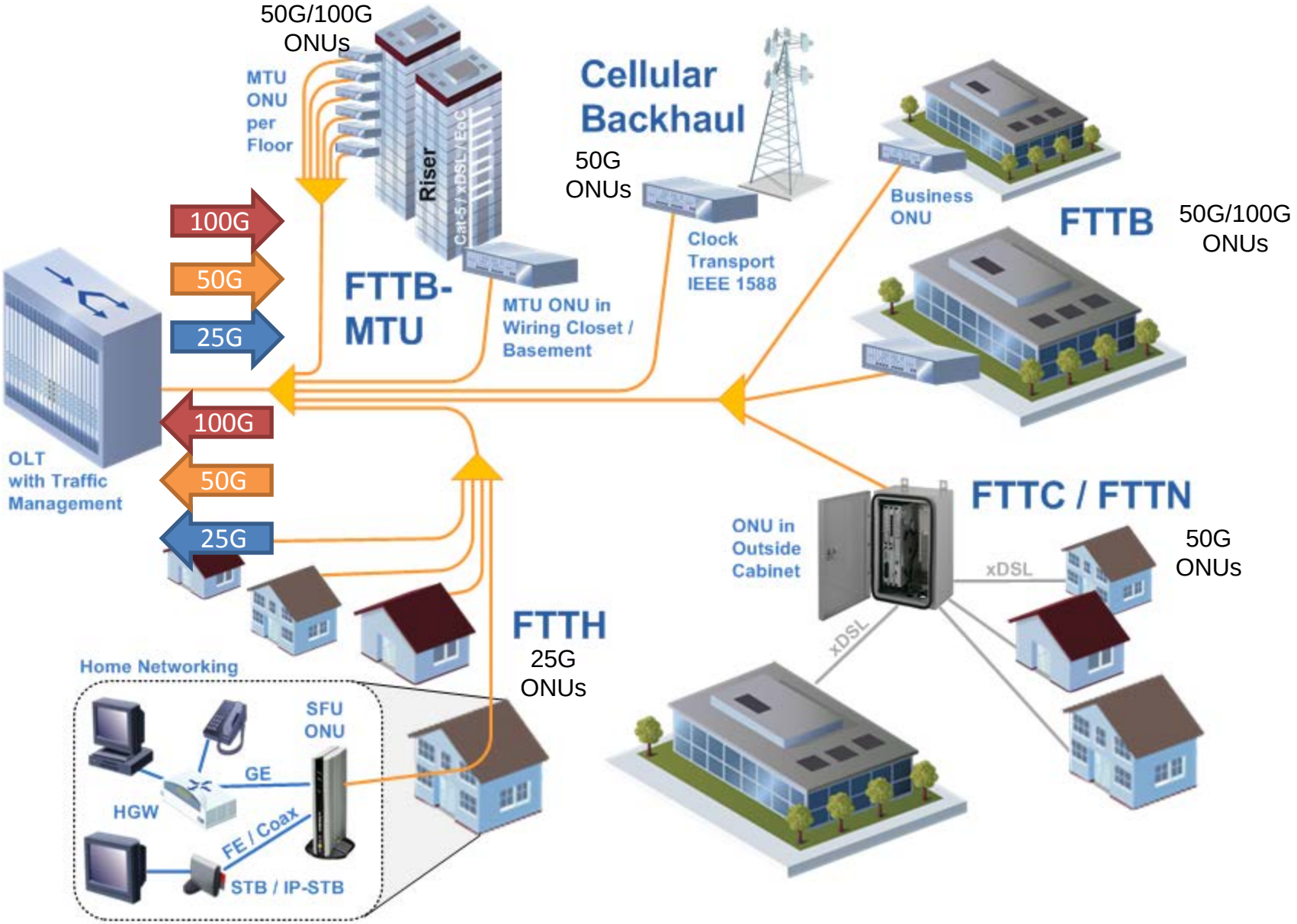
NG-EPON ARCHITECTURE

CONTACT:
MAREK HAJDUCZENIA
NETWORK ARCHITECT, PRINCIPAL ENGINEER
EMAIL: MAREK.HAJDUCZENIA@MYBRIGHTHOUSE.COM

Multi-rate ONUs in NG-EPON

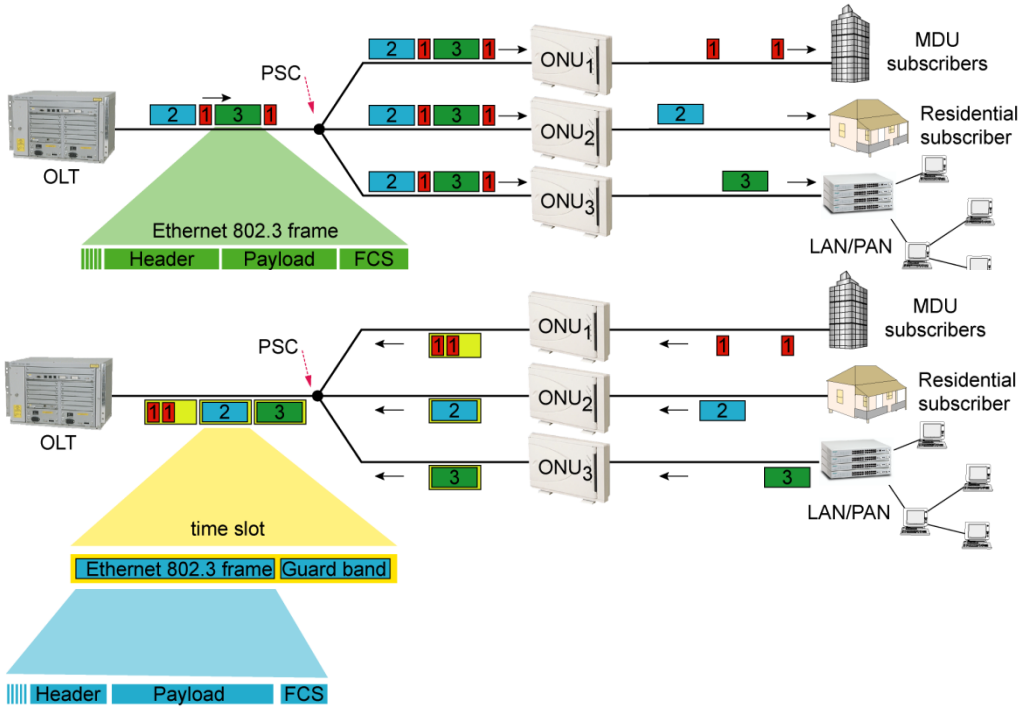
- NG-EPON objectives (with proposed updates per conference calls) include support for 25/50/100G data rates
- Operators would love to be able to support 25/50/100G ONUs on the same ODN (connected to one OLT port)
  - This would allow for cost-effective mix of residential-class (25G) and business class (50G+) ONUs on the same ODN → OLT as converged platform
- Transmission efficiency in DS / US directions are of primary interest
  - Efficient use of scarce fiber resource is critical *everywhere* (cost / mileage varies, depending on type of area)
-

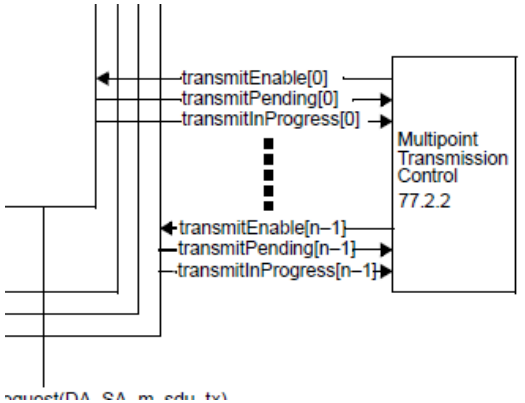
Multi-rate ONUs in NG-EPON



1G/10G-EPON scheduling

- Existing TDM-PON OLTs schedule transmissions in upstream from individual ONUs in time domain only
  - Each ONU is granted specific amount of time to burst queued packets
  - With proper ONU ranging and smart pipelined scheduling, burst-mode upstream can operate with very high efficiency
  - Only one MAC transmits in upstream / downstream. Multipoint MAC Control function in OLT makes sure that only one MAC is enabled to transmit at any time.

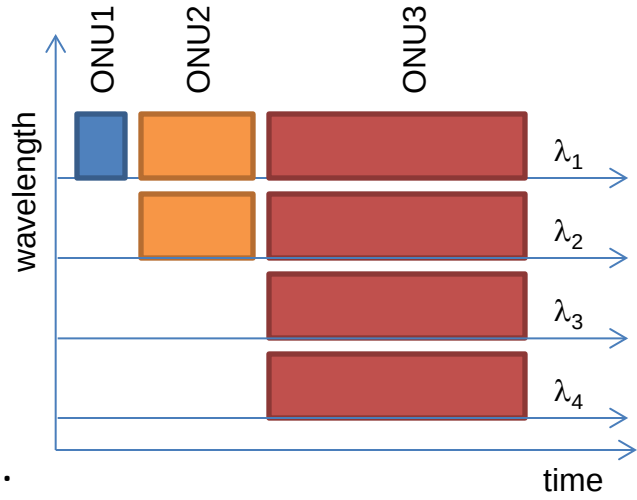




Excerpt from Figure 77–4—Multipoint MAC Control functional block diagram

TDMA in NG-EPON

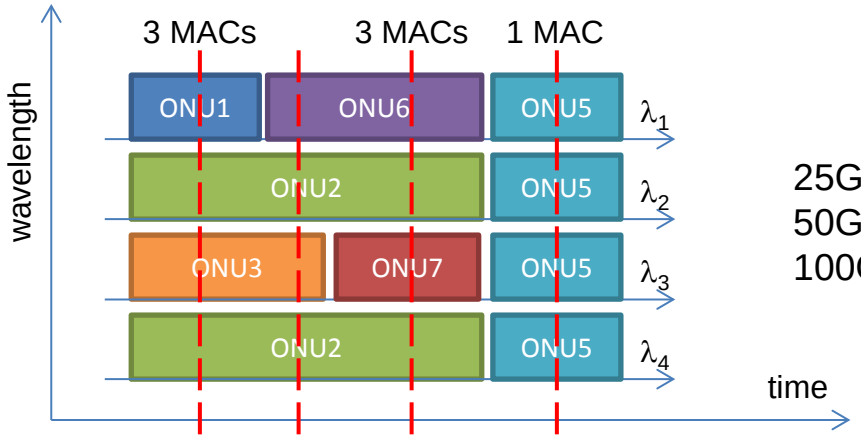
- Existing transmission scheduling scheme (one MAC at a time) can be extended to NG-EPON and multi-lane systems
  - Each ONU is granted specific period of time, during which ONU can transmit on all available data lanes.
  - ONU1 supporting 25G transmits on only 1 data lane.
  - ONU2 supporting 50G transmits on 2 data lanes
  - Only ONU3 supporting 100G transmits on 4 data lanes.



  - For ONU1, three (3) available data lanes remain idle during allocated time slot. For ONU2, two (2) available data lanes remain idle during allocated time slot. Only ONU3 uses all data lanes in an optimum fashion.
  - With a single MAC allowed to transmit at any time, lower speed ONUs will underutilize upstream (and downstream) link capacity, leaving large share of available bandwidth unused.
- Solution: **allow more than one MAC transmit at a time!**

Time/Lane scheduling in NG-EPON

- Improved efficiency can be achieved when multiple MACs are allowed to transmit at a time



25G ONUs: ONU1, ONU3, ONU6, ONU7
50G ONUs: ONU2
100G ONUs: ONU5

  - Certain assumptions about wavelength allocation need to be made, e.g.,:
    - 25G (single lane) ONU transmits only on L1, or L3,
    - 50G (two-lane) ONU transmits on L2 and L4, and
    - 100G ONU transmits on all lanes (L1 … L4)
  - 50G and 100G ONUs can easily utilize fixed optics for lower cost.
  - 25G ONUs could use tunable optics to move between L1 and L3, as needed. Fixed optics could be also used with statistical distribution of TRx assignment to L1/L3.

Multi-lane PHYs in 802.3

- There are a number of multi-lane PHYs specified in 802.3 today
  - These PHYs stripe data units (typically, FEC encoded data block) across individual lanes
  - Data striping is done typically in a round-robin fashion
  - Additional data is being inserted (alignment markers) to de-skew signal at the receive side
- There is no notion of data frames at this PCS level
  - all data is treated as units (blocks)
- Similar approach in NG-EPON will limit support for multi-rate ONUs

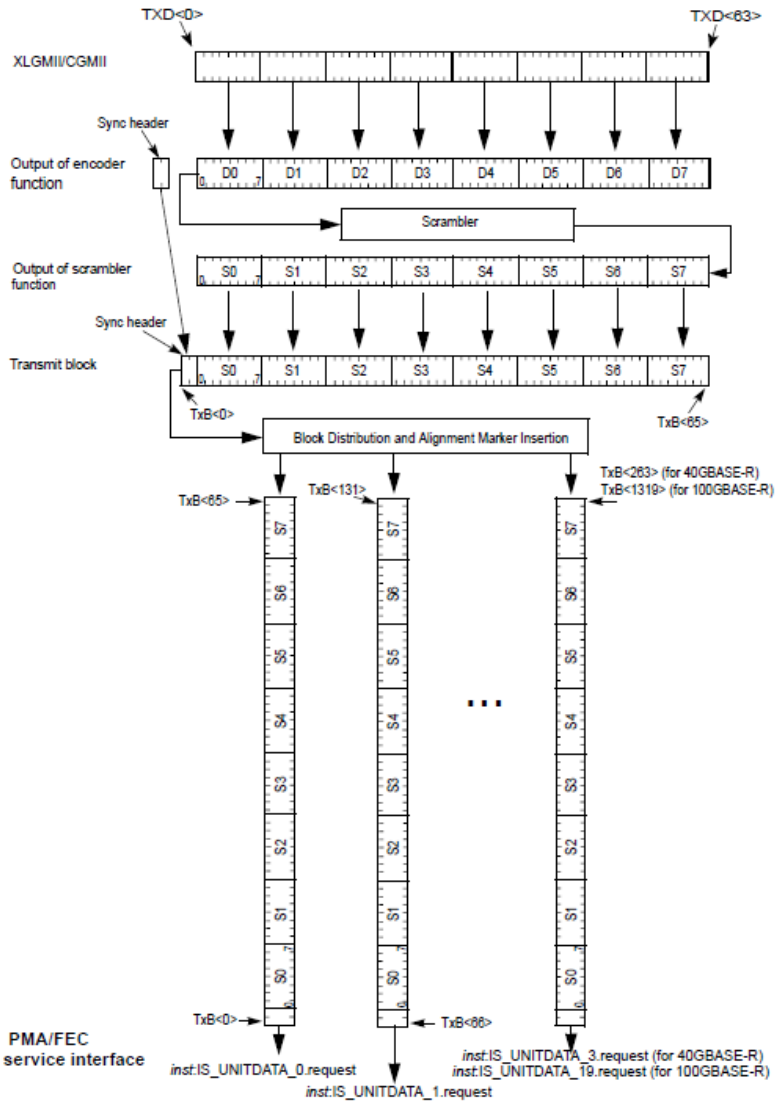
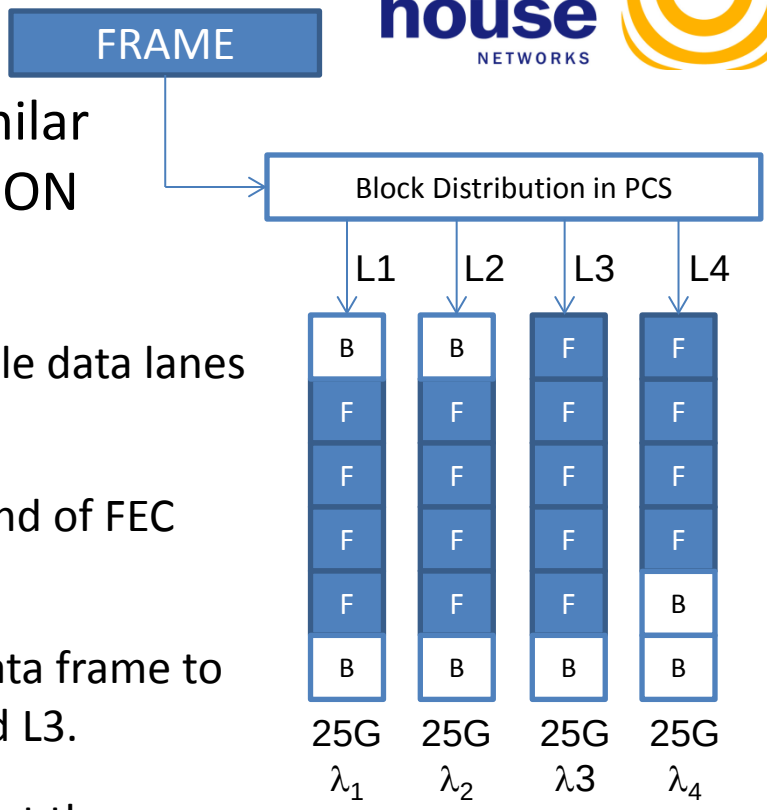
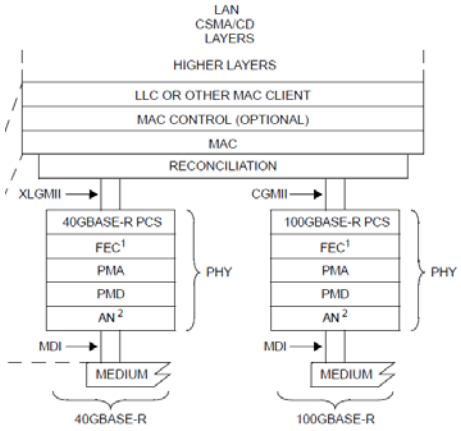


Figure 82–3—PCS Transmit bit ordering

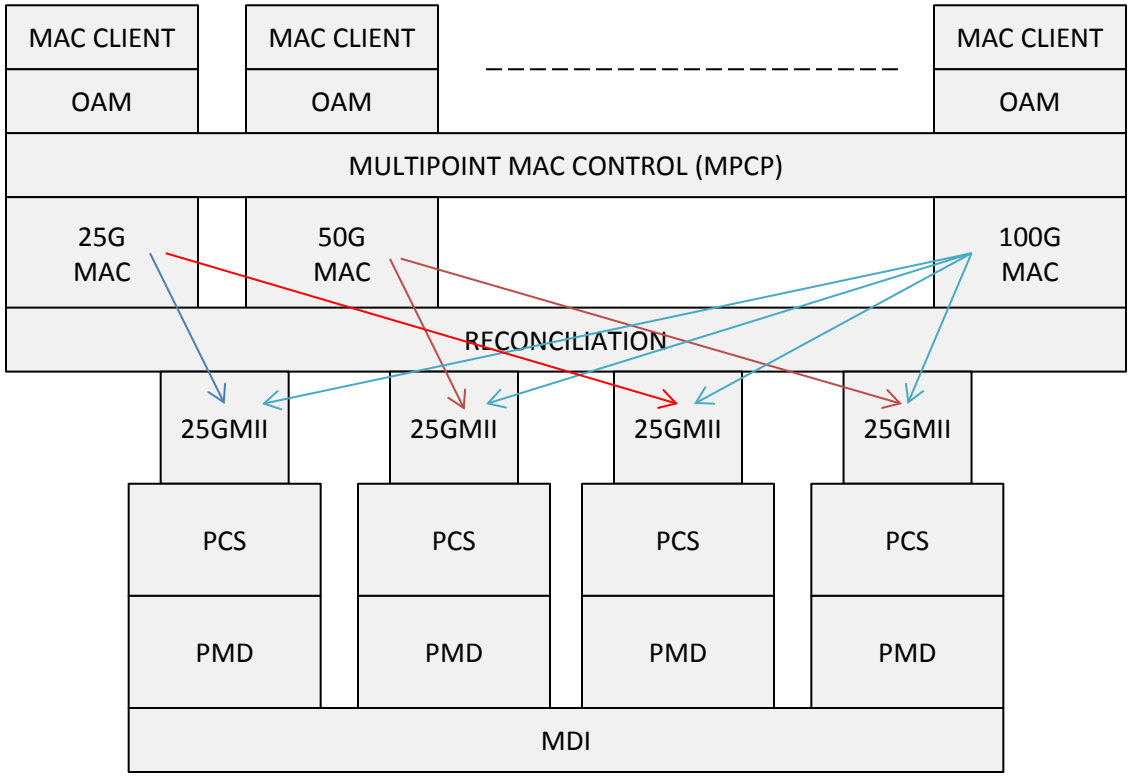
Data striping in NG-EPON

- Using block distribution mechanisms similar to existing P2P multi-lane PHYs in NG-EPON means that:
  - A single encoded frame is striped into available data lanes based on its position in data stream.
  - Frame start / end is not aligned with start / end of FEC codewords (if stream-based FEC is used)
  - Not possible to constrain transmission of a data frame to only one data lane, e.g., just lane L1 or L1 and L3.
  - All ONUs connected to the OLT have to support the same number of data lanes to work correctly, i.e., not possible to support 25/50/100G ONUs on same ODN
- A destination-aware data distribution mechanism is needed for NG-EPON to support 25/50/100G ONU on the same ODN





NG-EPON OLT architecture



- 25/50/100G MAC are combined by a single RS sublayer
- RS maps data stream from individual MACs into specific 25GMIIs depending on MAC speed / instance
- MPCP enables specific MACs for transmission, as individual 25GMII instances become available

- Each 25GMII is connected to an independent PCS/PMD, with independent stream-based FEC, and wavelength-specific PMD
- Data is striped into specific 25GMII instances on per-frame basis. The given 25GMII instance becomes occupied with a frame until it transmits all data in the frame. Other 25GMII instances can be transmitting other frames at the same time.

Issues for technical discussion in TF

- Potential frame reordering
  - A large frame followed by several short frames - smaller frames will arrive at Rx before the large one. A frame reordering mechanism is needed on Rx side.
- Lane skew
  - Seems to be irrelevant in frame-based striping approach – each data lane is independent and does not need to be synchronized to other data lanes.
- Broadcast / multicast traffic delivery
  - Support for 25/50/100G ONUs on the same ODN requires replication of broadcast traffic to multiple lanes to be received by all ONUs.
  - Approach similar to existing 1G/10G-EPON can be adopted, i.e., broadcast MAC instance per ONU speed + a dedicated broadcast LLID per speed.
- MPCP discovery, registration, and scheduling
  - MPCP Discovery Windows need to be opened on multiple lanes for different ONUs.
  - Each ONU can announce their capabilities using fields already present in Discovery GATE.
  - GATE / REPORT does not need to carry information on data lane assignment – this is implicit by ONU speed capability information provided in Discovery GATE.

THANK YOU!