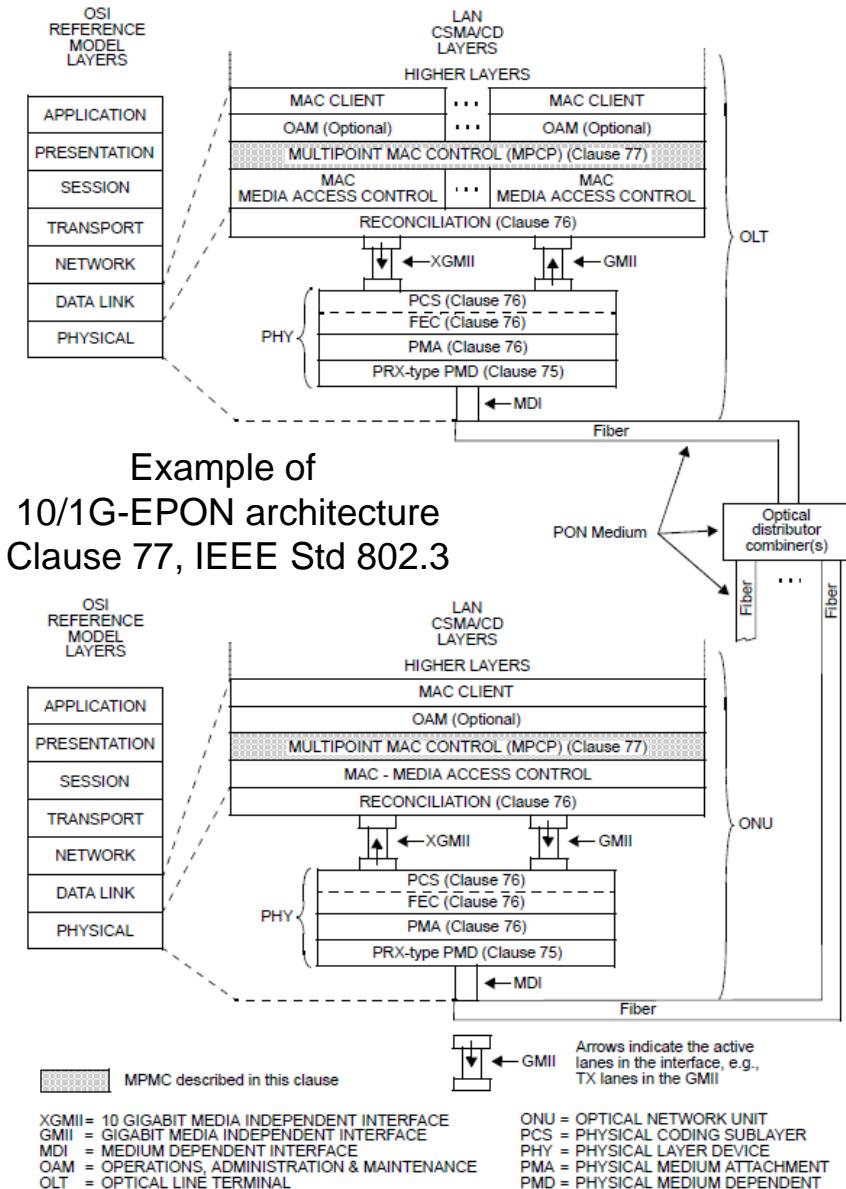# NG-EPON ARCHITECTURE

INITIAL THOUGHTS

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Architecture of EPON (today)

Example of
10/1G-EPON architecture
Clause 77, IEEE Std 802.3

- Multi Point Control Protocol (MPCP) defined in Clause 77 (10G) / 64 (1G)

- Physical Coding Sublayer (PCS) defined in Clause 76 (10G) / 65 (1G)

- Physical Medium Dependent (PMD) defined in Clause 75 (10G) / 60 (1G), including MDI and ODN requirements

- Extensions to Reconciliation Sublayer (RS) to support P2MP defined in Clause 76 (10G) / 65 (1G)

- (X)GMII, MAC, OAM, and higher layers defined in other Clauses in 802.3/802.1

- Details on dual-rate OLT receiver architecture in Annex 75A

Architecture of NG-EPON

- The main building blocks for NG-EPON will remain the same:
    - MPCP in control of station discovery, registration, timing, ranging, and bandwidth allocation
    - MAC responsible for serialization / deserialization of data and framing
    - RS responsible for P2P emulation over P2MP medium
    - PCS responsible for coding data from MAC into medium-specific format
    - PMD responsible for delivering encoded data across medium (fiber)

- There will be some changes as well, depending on technical choices taken by the future Task Force:
    - MPCP might need to support multiple wavelengths (wavelength allocation, bandwidth allocation across different lanes, etc.)
    - PCS might need to support data striping across multiple lanes, insert alignment markers, encode data for non-OOK modulation, etc.
    - PMD might need to support multiple data lanes (wavelengths) across a single MDI, etc.

Example of multi-lane architecture

- 802.3ba (40GE/100GE) introduced the concept of multi-lane system, with "extensible architecture"

  - The primary building blocks are the same as in EPON (less MPCP)

  - PCS, PMA, and PMD are designed around the concept of data lanes. The number of data lanes depends on aggregate data rate (40/100G) and data rate per lane (10, 25, 50G)
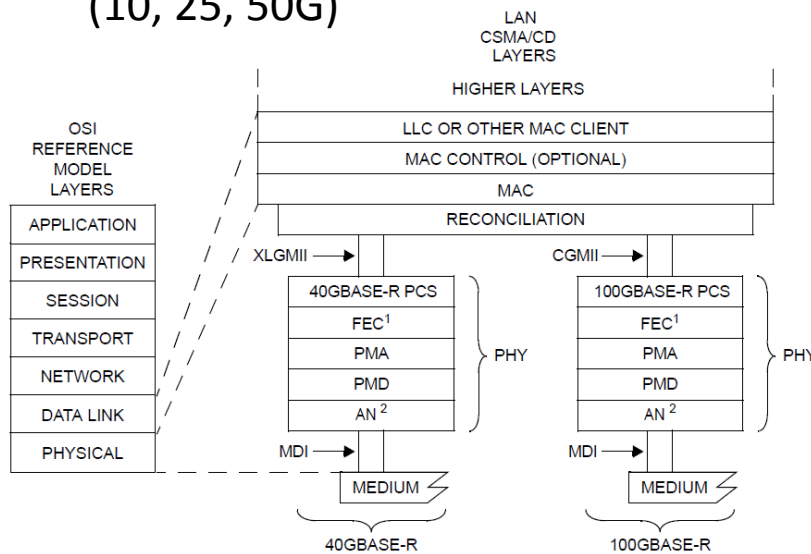

40G/100GBASE-R architecture
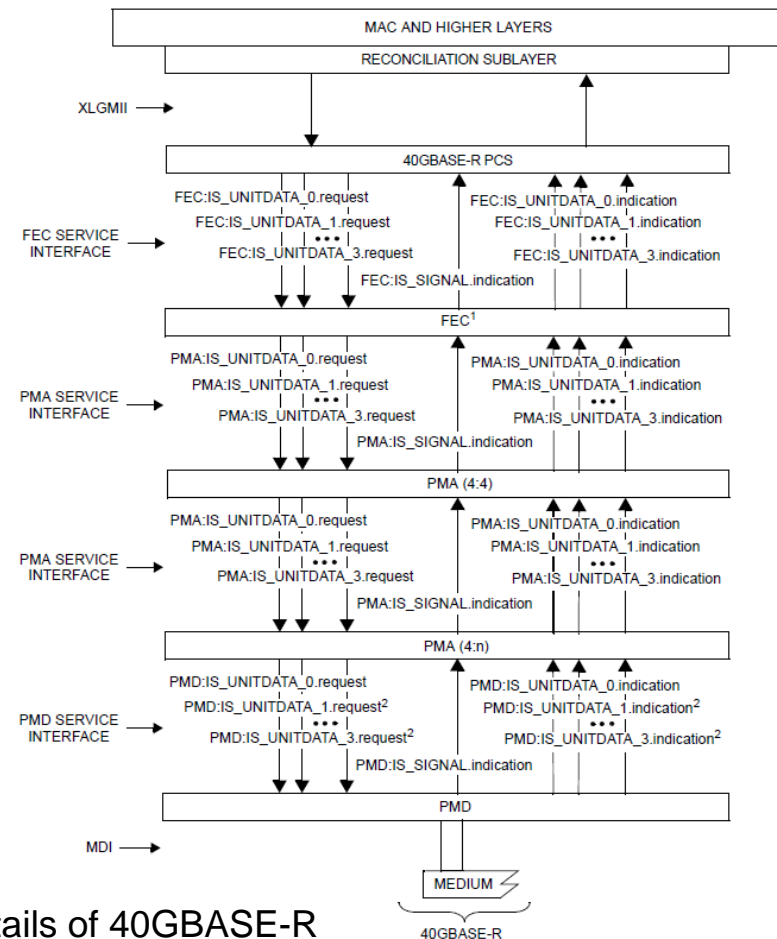
Details of 40GBASE-R with focus on 4x10G lanes

100GBASE-R

- 100GBASE-R supports multiple lane counts: 10x10, 4x25, etc.

  - PCS and FEC sublayers operate on 20x5G parallel data streams

  - PMA-PMA (CAUI) interface performs gearbox of 20x5G to 10x10G streams

  - 10x10G streams are then converted into n×kG streams, where number (n) and data rate (kG) per stream depend on specific PMD

- The same design approach is used for 400GE (P802.3bs), underway today

- Similar architecture could be used in NG-EPON to support data rates up to 100Gbps (or more, if needed)

  - Scalability is limited only by number of parallel lanes used in the architecture and implementation challenges
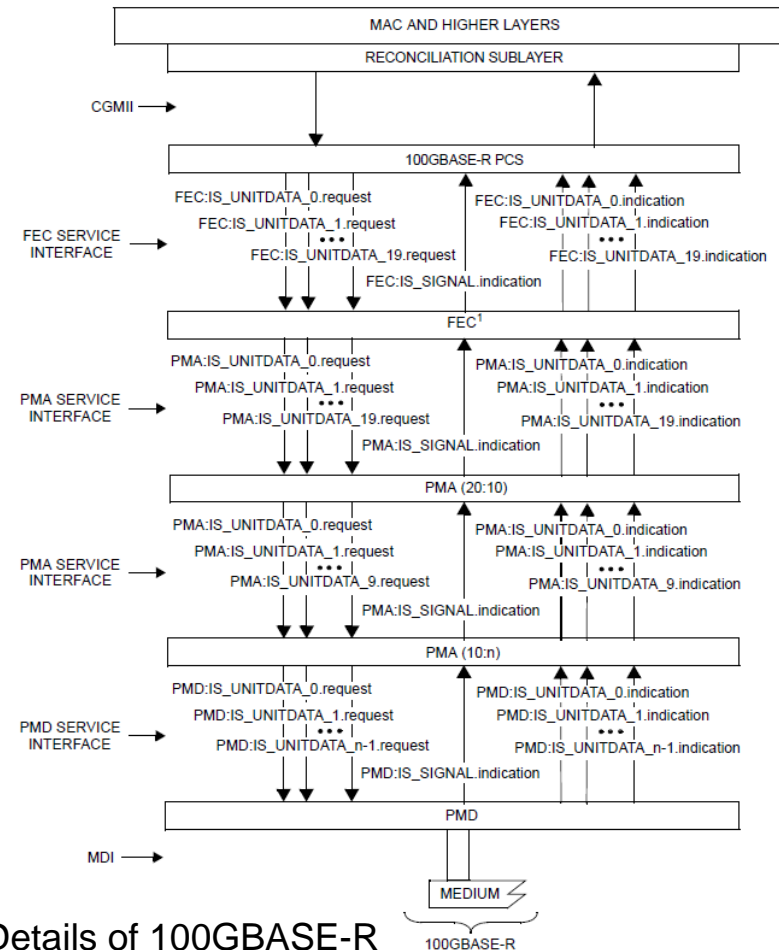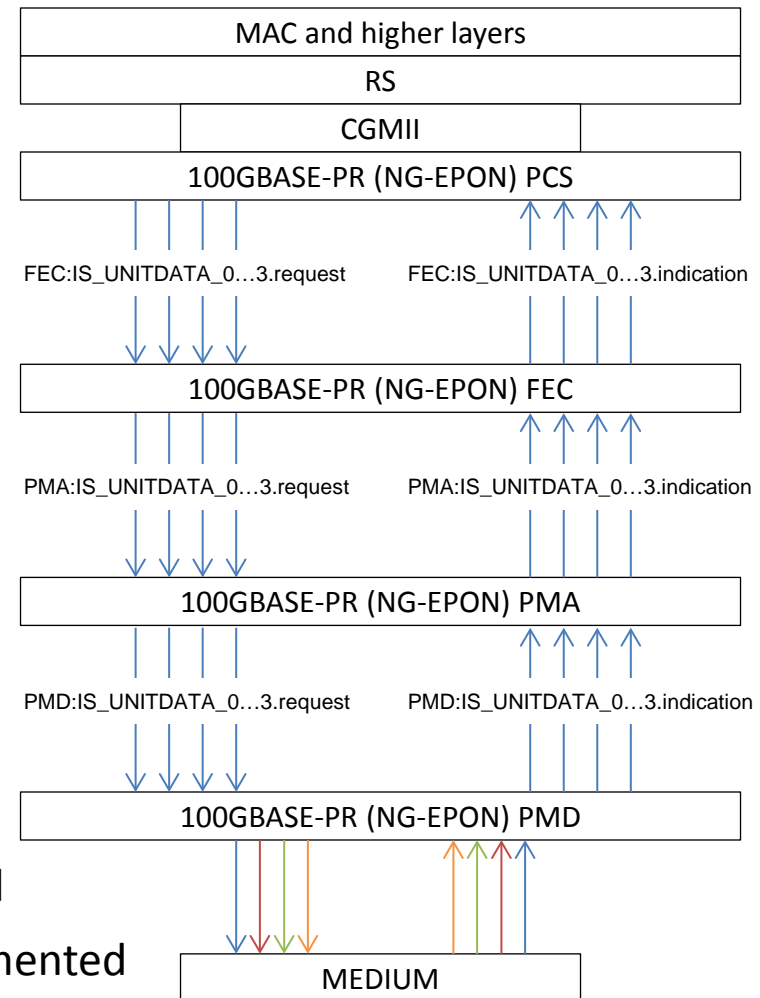

Details of 100GBASE-R with focus on n×kG lanes

100GBASE-PR (NG-EPON)

- Provided that 25GBASE-PR becomes available under NG-EPON project (single lane, operating at 25G)

  - 25GBASE-PR PCS could be extended to use the same approach as in 100GBASE-R

  - Up to 100G of data (in 25G increments) is received from MAC across CGMII

  - PCS encodes received data into 1, 2, 3, or 4 parallel 25G streams (depending on target aggregate data rate)

  - PMA performs any gearboxing needed

  - PMD delivers resulting streams across MDI and onto the medium

- A single architecture could support data rates from 25G to 100G

  - Individual lanes could be disabled, if needed

  - Drawback – the whole PHY has to be implemented **to support the maximum data rate from day 1**

| MAC and higher layers |
| RS |
| CGMII |
| 100GBASE-PR (NG-EPON) PCS |

FEC:IS_UNITDATA_0…3.request   FEC:IS_UNITDATA_0…3.indication

| 100GBASE-PR (NG-EPON) FEC |

PMA:IS_UNITDATA_0…3.request   PMA:IS_UNITDATA_0…3.indication

| 100GBASE-PR (NG-EPON) PMA |

PMD:IS_UNITDATA_0…3.request   PMD:IS_UNITDATA_0…3.indication

| 100GBASE-PR (NG-EPON) PMD |

| MEDIUM |

100GBASE-PR specification

- STEP 1: design 1-lane 25G EPON PHY, including
  - Extensions (as needed) to MPCP, new PCS, PMA, and PMD

- STEP 2: design multi-lane 100GBASE-PR architecture and reuse as much of IEEE Std 802.3ba as possible:
  - CGMII per Clause 81
  - PCS derived from Clause 82 / 76
  - PMA derived from Clause 83 / 76
  - PMD derived from Clause 84 / 75
  - Extend MPCP from STEP 1 to support multi-lane architecture
  - Control for disabling individual lanes
  - Requirements for discovery of ONU capabilities, number of supported data lanes, data striping, etc.

- Work on STEP 1 and STEP 2 could be done in parallel
  - STEP 1 done by 25G PHY group
  - STEP 2 done by 100G Architecture group

PHY: Items for discussion (1)

- Clause 75 will serve as blueprint for NG-EPON PHY design
  - Large portions, including labelling, testing, etc. can be copied into new spec with minimum changes.
  - Tx/Rx specifications will need greatest attention, especially if non-OOK modulation is selected
  - If multi-lane approach is used, additional specifications for multiple transmitters / receivers will be needed (slope, isolation, etc.)

- How many PMD clauses do we need?
  - Do we specify 25G PHY in a separate clause, or use 10G-EPON approach and just do them in subclauses of OLT / ONU Tx/Rx specifications?
  - Do we specify 25G for OLT and ONU, or for the ONU only?

- Testing, testing, testing …
  - All existing 10G-EPON tests assume OOK modulation, 10Gb/s operation. Can we reuse existing tests for NG-EPON?
  - Non-OOK modulation specific tests will be needed as well

PHY: Items for discussion (2)

- Fiber plant
  - Working assumption is that we reuse 10G-EPON ODN, but place upstream / downstream in other locations
  - We need fiber data to identify potential windows of interest assuming we need to coexist with (a) only 10G-EPON, (b) 10G-EPON and 1G-EPON, (c) 10G-EPON, 1G-EPON, and RFoG (bidirectional).
  - Any new fiber types that should be accounted for?

- Channel model will need updates
  - Especially when 4 co-propagating channels are injected into single fiber at high (PR30+ class) power levels
  - For non-OOK modulation, impact of ISI needs to be properly accounted for in the model …

- Bonus discussion topic:
  - We will need names for our PHYs: 25/25GBASE-PR like style naming is acceptable?

PCS: Items for discussion (1)

- Coding scheme
    - Do we continue using 64B/66B or go with something new? 100G/400G systems will use 64B/66B coding schemes, but they do add ~3% overhead

- FEC
    - We need to re-examine FEC code for power-efficient implementation. 802.3av TF did a great comparison for individual proposed FEC codes, we will need something similar for NG-EPON
    - Concepts / assumption from 802.3av times are likely outdated anyway
    - Stream based FEC is likely best candidate (constant overhead)
    - FEC stream per lane, not across all lanes (to allow single lane transmission?)
    - Applicability and efficiency of FEC codes for non-OOK modulation

- Data detector complexity in burst mode
    - How do we detect incoming data burst?
    - How do we figure out if the burst comes across a single lane or multiple lanes?
    - Remember, information on scheduled data bursts from MAC control does not reach into PCS …

PCS: Items for discussion (2)

- Support for multi-lane operation
    - Is there a way to support 1-lane and 4-lane ONUs on the same ODN?
        - If not, all ONUs have to support the same number of lanes to work correctly (lowest common denominator).
        - ONUs could have hardware capability to support more lanes but be able to disable them at request from OLT

- Scrambler
    - Any impact of non-OOK modulation on the use of scrambler?

- Idle Insertion / Idle Deletion
    - Very likely that we will still need them (the model stays the same as in 10G-EPON), but detailed calculations will change

- Idle Lanes
    - What happens with idle data lanes – any data being sent or not?
    - Do we allow asymmetric lane use, i.e., lane is disabled in downstream, but enabled in upstream, or force symmetric use of lanes?

PCS caveats

- The OLT PHY could be complex from day 1, supporting data rates from 25G to 100G, depending on number of enabled lanes

- ONU complexity depends on number of lanes that it needs to support (listen to / transmit on)

- No way to support 1-lane and 4-lane ONUs on the same ODN:
  - all ONUs have to support the same number of lanes to work correctly (lowest common denominator)
  - ONUs can be equipped with fixed number of lanes and need to be replaced every time aggregate data rate is increased per PON **or** support multiple lanes from day 1 and disable some of them.

- No way to selectively stripe data, e.g., one packet is striped on 1 lane, and next packet is striped on 4 lanes.
  - Packet destination information loses relevance once it is passed across CGMII into PCS/PMA/PMD. All packets are treated equal beneath MAC

PCS: Items for discussion (3)

- Control traffic & lanes
    - MAC Control frames are expected to be striped across all lanes, or selected lane?
    - ONUs supporting only one data lane will not be able to understand data striped across all data lanes …

RS/MAC: Items for discussion (1)

- New reserved LLID(s)

  - Likely needed for broadcast to NG-EPON ONUs only / registration & discovery

- Otherwise, no changes to RS / MAC

MPCP: Items for discussion (1)

- General principle of MPCP remains unchanged
  - Time granting, discovery, and registration operate independent of the number of data lanes and PHY details
  - Timing allocation / tolerances might need to be updated, depending on impact of multi-lane PCS encoding and data striping

- Support for device capability (number of lanes) will be needed
  - This will allow for proper identification of the device data rate
  - Mechanism similar to speed capability (see Table 77–3) will need to be added to new GATE MPCPDU

- Interaction with Idle Insertion / Deletion function
  - Formulas will need to be updated, depending on decision on supporting ONU with different number of data lanes

THANK YOU!