# Data rate adaptation

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# Supporters

(time-of-arrival order)

- Ed Boyd, Broadcom

# Summary

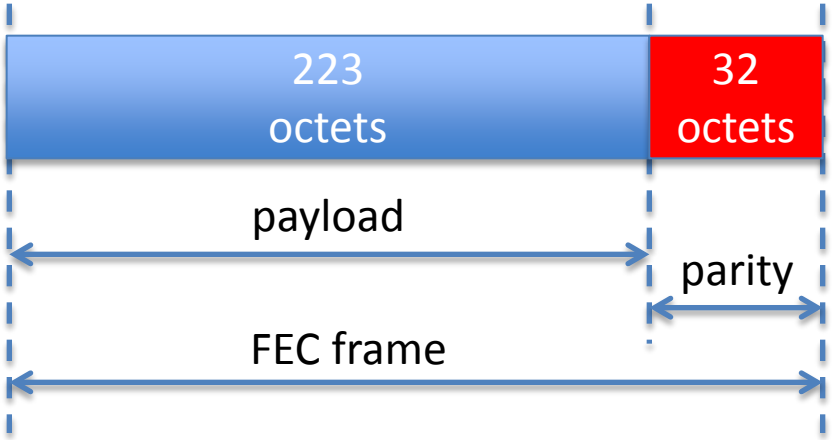
- Data rate adaptation in 10G-EPON: why, how and why not Carrier Sense …
- Data rate adaptation for EPoC: why, how and challenges

# DISCLAIMER

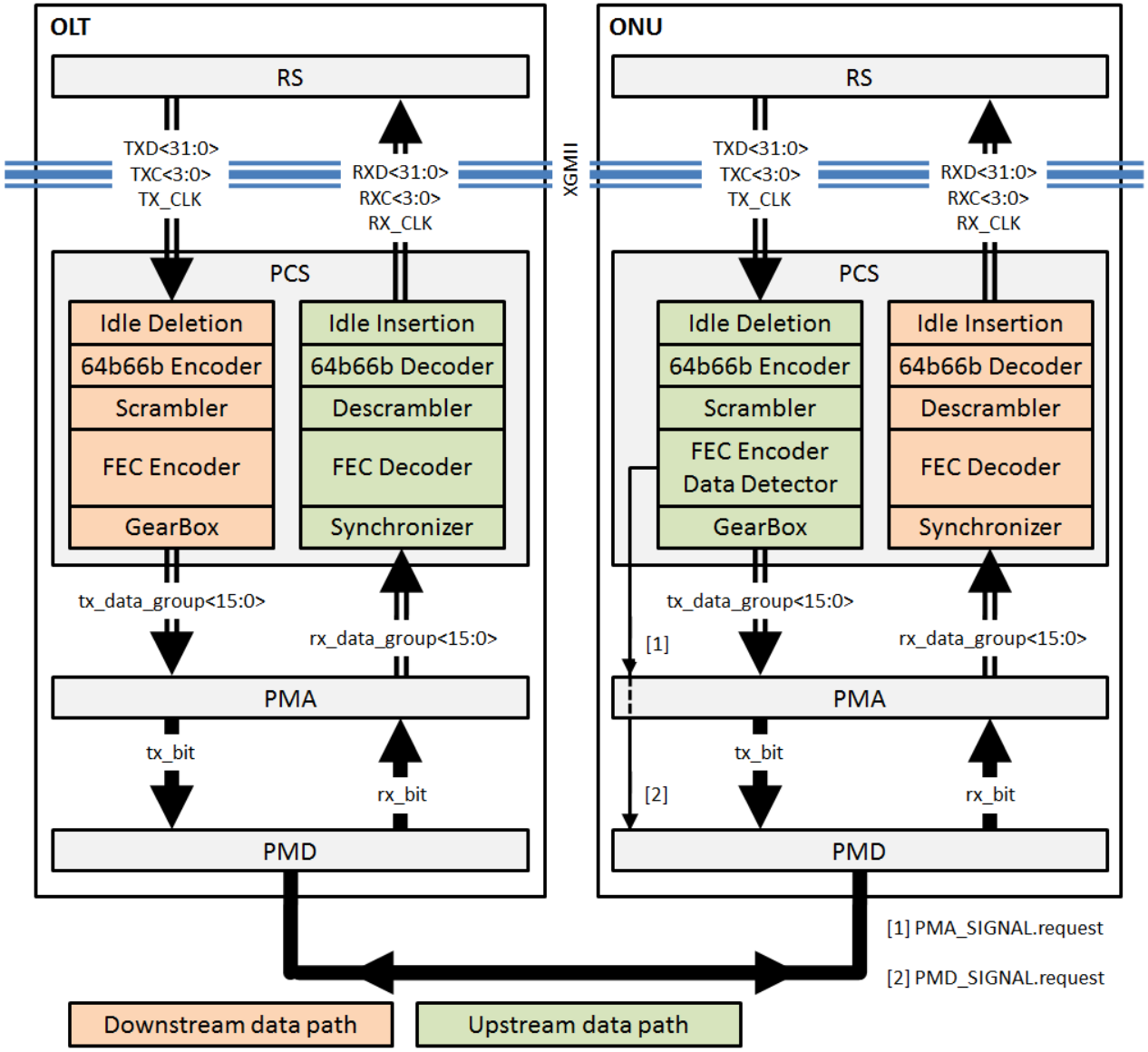
- This contribution assumes that there is some sort of a data filtering mechanism available in downstream, where coax section carries only data destined for the given set of CNUs.
- Details of implementation of such a filtering mechanism are outside the scope of this presentation (and 802.3, most likely).
- This contribution will focus on CLT-CNU link specification details, but the model can be easily adopted into OCU in implementations.

# Why data rate adaptation in 10G-EPON

- 10G-EPON uses mandatory, stream-based RS(255,223) FEC, where every 223 octets of data, 32 octets of parity are added. FEC is added in 10G-EPON to achieve target power budget at the given BER.
- Effective MAC data rate = 10 Gb/s × 223/255 (de-rated when compared to e.g., 10GBASE-T)



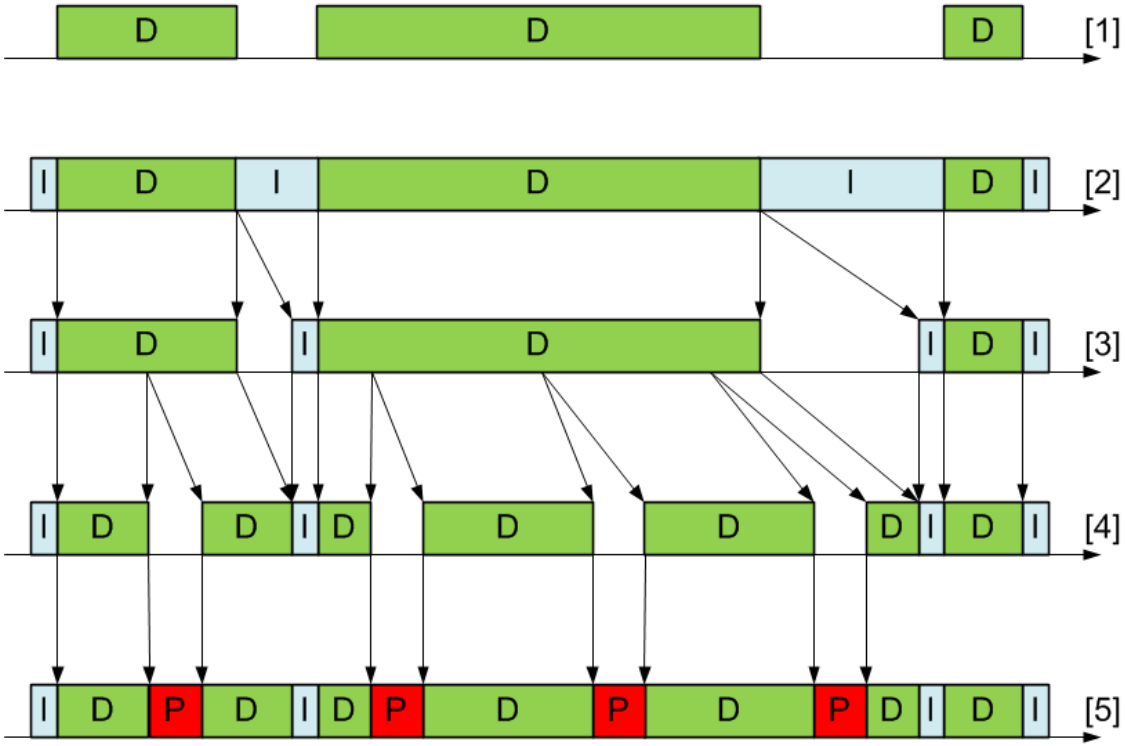
# Frame flow through 10G-EPON

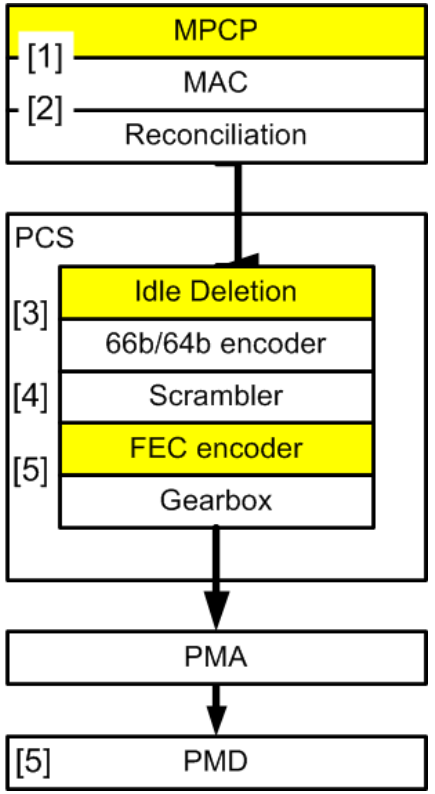



- There are three key functions for de-rating
- **Data Deletion** in Tx path
- **Data Insertion** in Rx Path
- **Data-rate aware MPCP** sublayer, responsible for inserting gaps of sufficient size

# Frame flow in Tx / Rx path

- The example below shows the flow of data across the MPCP, MAC, RS, PCS (with Idle Deletion and FEC encoder) towards PMD and media
- Data flows in reverse in Rx path (not shown)

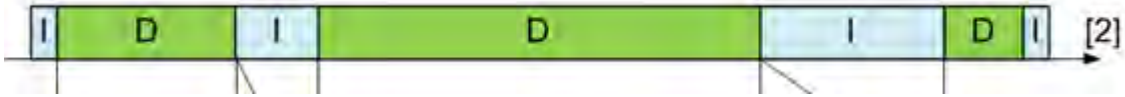


# Frame flow in Tx / Rx path (summary, part 1)

- MAC Control is aware of the effective data rate accepted by PCS/PMD and spaces individual frames accordingly to keep the average data rate on target


- MAC inserts necessary IDLE characters between individual data frames, filling them in to condition data for transmission across XGMII. Data passing through XGMII is continuous (no gaps are allowed on XGMII)

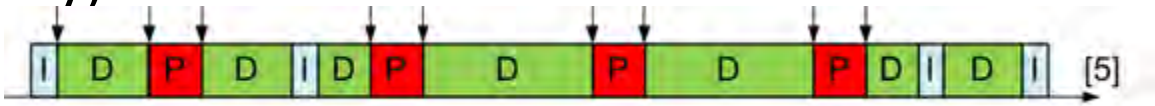



- Idle Deletion function in PCS removes extra Idle characters from incoming data stream, leaving only the necessary Inter Frame Gap (IFG)

# Frame flow in Tx / Rx path (summary, part 2)

- Bursty data stream is 64b/66b encoded and scrambled, increasing the line rate from 10 Gb/s to 10.3125 GBd/s. Useful data rate remains unchanged.


- FEC Encoder accepts bursty data stream (stream based FEC), producing continuous mix of data (FEC payload) and parity (FEC parity)



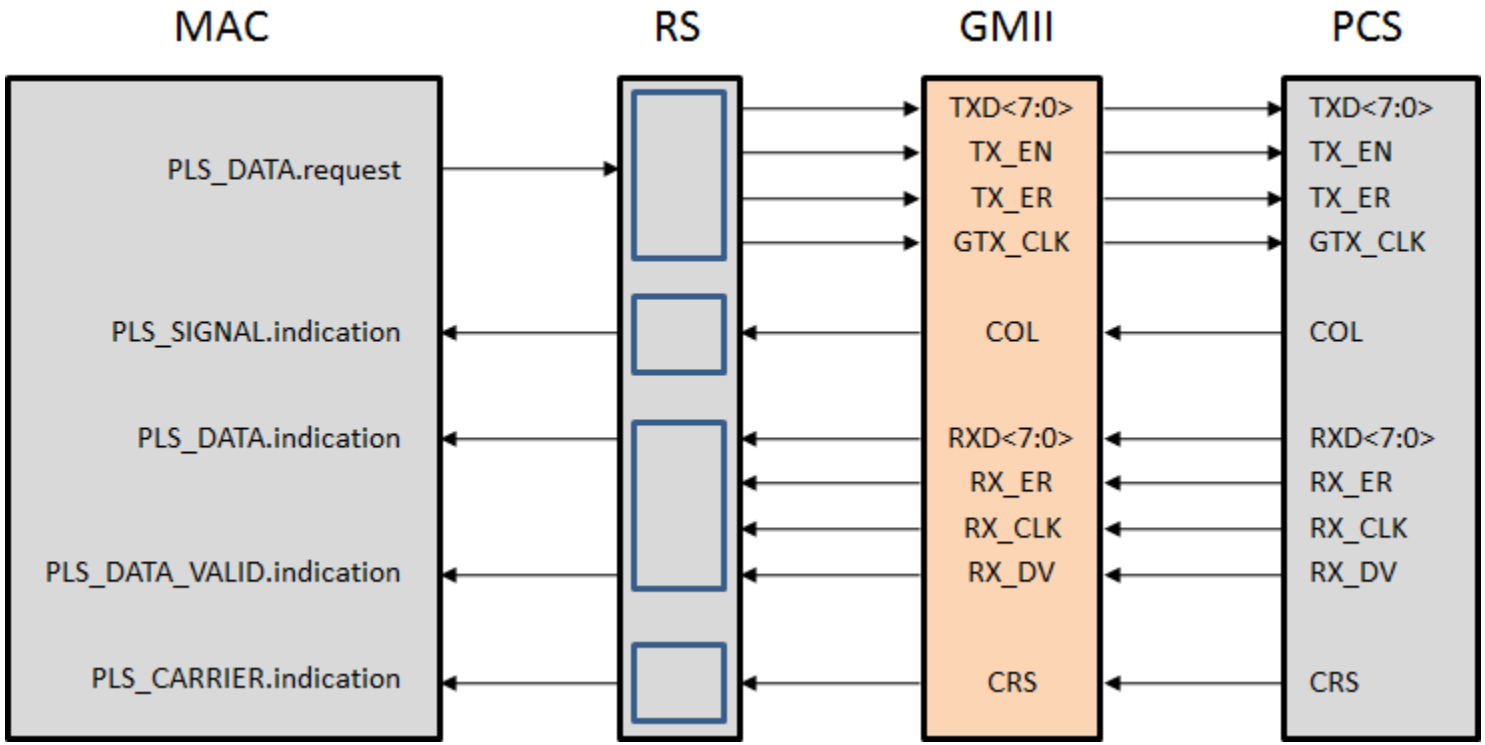

- PMA receives continuous bit stream at 10.3125 GBd/s, unaware of the operations performed by the higher layers in stack
- This process is reversed in the receive direction, where Idle Insertion function fills in the blanks between individual frames with Idle characters before handing off to XGMII.

# Why not Carrier Sense ?

- Carrier Sense is an integral element of CSMA/CD, half duplex MAC and required for proper data transmission.
- Carrier Sense signal is still supported by Annex 4A MAC and could be theoretically used in any full-duplex link;
- However, to work effectively, Carrier Sense (CS) signal should be generated in PCS and delivered to MAC across xMII. MII operating at 10G (XGMII) and above do not transfer CS signal, so this solution is not scalable above 1G (GMII supports CS signal)
- Signaling between PCS and MAC across GMII and XGMII is shown in the following slides

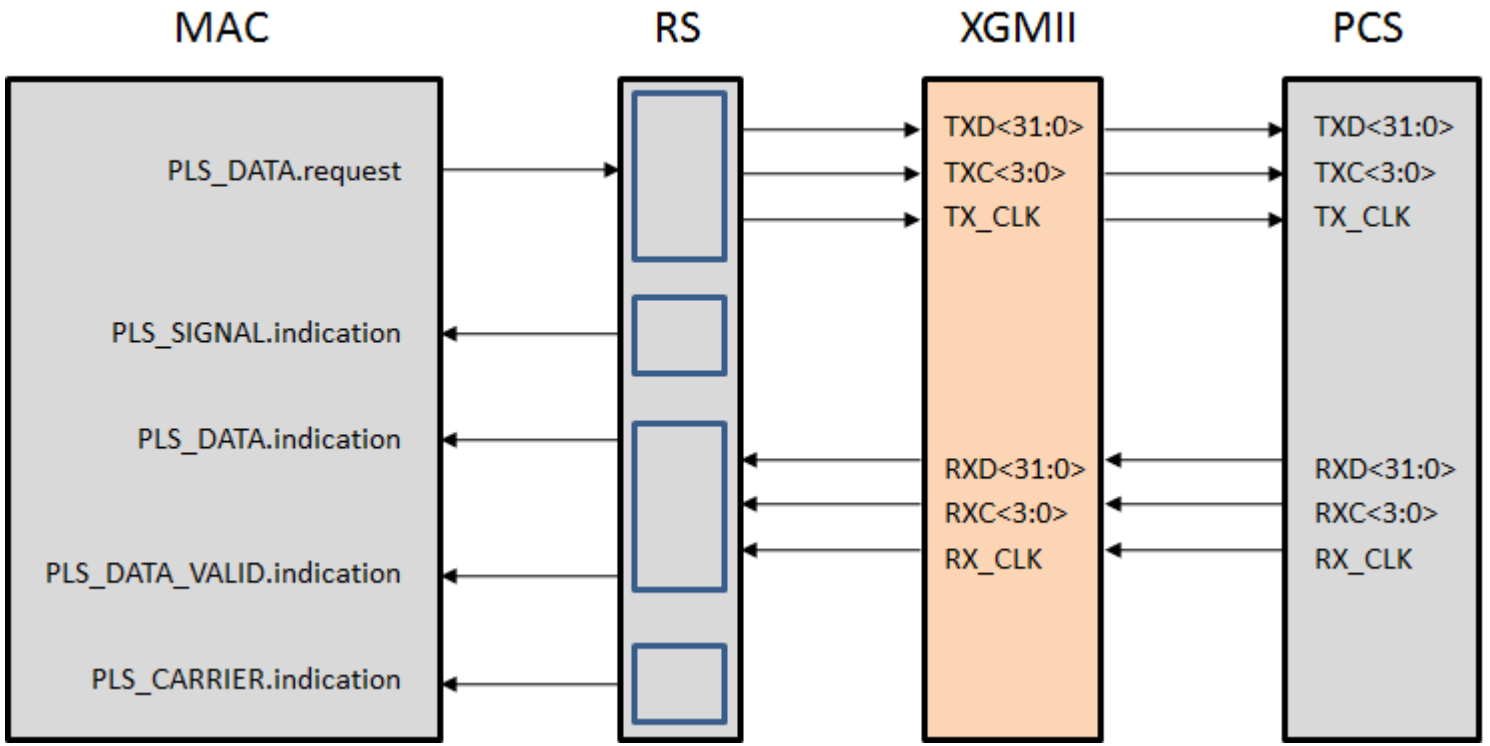
# Signals across GMII

- CS signal is generated within PCS and when goes up, prevents MAC from transmitting user data, effectively lowering down data stream observed at the PCS. Note that GMII has a dedicated data lane for carrying CS signal



# Signals across XGMII

- CS signal in 10G+ systems could be still generated in RS sublayer, but there is no way to carry it across the XGMII and have it generated in PCS.
- This makes data rate adaptation based on CS very hard to implement in 10G+ systems



# Why is it important for EPoC?

- In EPoC, forming consensus has it that MAC rate and PMA data rates might be completely different.
- Data rate adaptation function is needed
- In 10G-EPON, PMA rate was constant.
- In EPoC, it is likely to change over extended period of time (e.g. changes in coax plant conditions, retraining, changes in quantity of allocated spectrum etc.). As a result we could have a 10 Gbit/s MAC transmitting with the effective data rate of 100 Mbit/s.
- A flexible data rate adaptation mechanism is therefore needed, allowing to decouple the MAC rate and the PMA data rate, while reusing existing functional blocks to the largest extent possible.

# Proposal for EPoC (part 1)

- Reuse the data rate adaptation mechanism from 10G-EPON, including the Idle Deletion / Idle Insertion functions, with the following high level characteristics:
  - MAC rate to be equal to 10 Gb/s, effective data rate adapted to coax plant conditions and PMA requirements;
  - PMA rate to be configurable up to 10 Gb/s (without line coding, line code selection is not accounted for in this deck).
    - The minimum data rate should be fixed at some value, e.g., 10 Mbit/s ?
    - The assumption here is that PMA data rate needs to be flexible, something that we might need to discuss and decide upon as soon as possible.
  - MAC Control aware of the effective data rate supported / configured by the PMA at any time (Clause 30 objects / Clause 45 registers read via MDIO)

# Proposal for EPoC

- Reuse … (*continued*):
  - MAC Control adapts spacing between individual data frames to match the average data rate supported at any time by the PMA, accounting for FEC parity (TBD) and line coding (TBD)
  - Idle Deletion function works exactly as specified in 10G-EPON i.e. removes any extra Idle characters from the incoming data stream, adapting it to the PMA
  - In Rx path, the process is reversed, and Idle Insertion function generates Idle characters to fill in gaps between received frames

# Points for further consideration (part 1)

- Can we / should we make the data rate adaptation (de-rating) mechanism generic (like BASE-R FEC – see 802.3, Clause 74) with applicability to a wide range of (current and future) PHYs (e.g. 10G-EPON, EPoC) ?
  - Even though it might be some extra work, this work could be a separate track from PHY design and not slow down the main group

# Points for further consideration (part 2)

- Need to select specific EPoC features, affecting the data rate and de-rating mechanism, including:
  - FEC (code word length, type, etc.);
  - Minimum data rate to be supported by EPoC (do we need it to specify it at all?);
  - Set of supported data rates (via a table) or a more flexible configurable set of data rates (via a formula) – to be defined which approach is more preferable
  - Structure of PCS registers required to control PHY data rate and drive MAC Control frame spacing mechanism;
  - Station discovery mechanism, data rate negotiation to make sure link does not down every time data rate is modified, etc.,