Extensible Architecture for NG-EPON

Bonding in RS (Option D)

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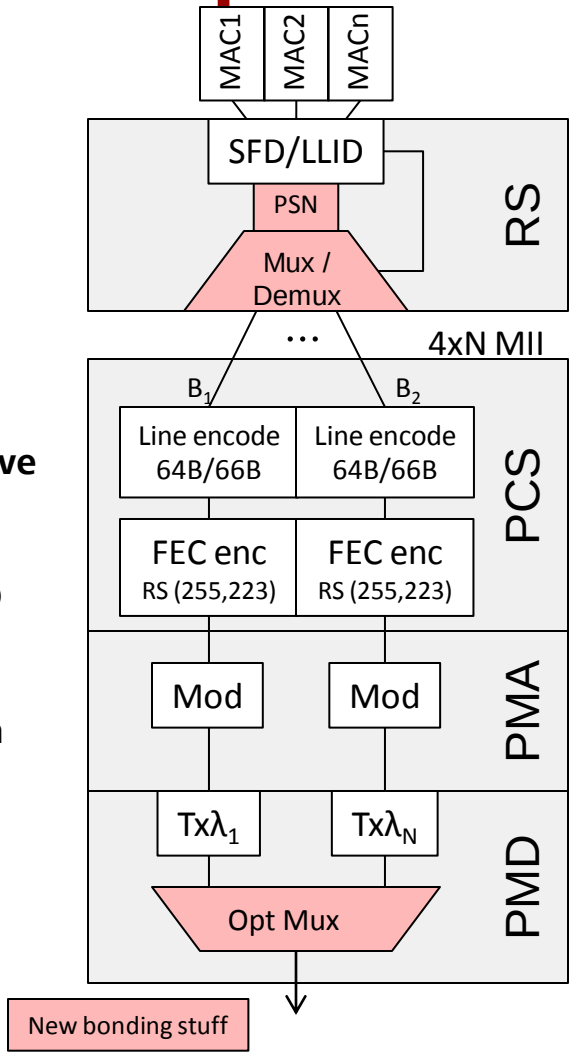
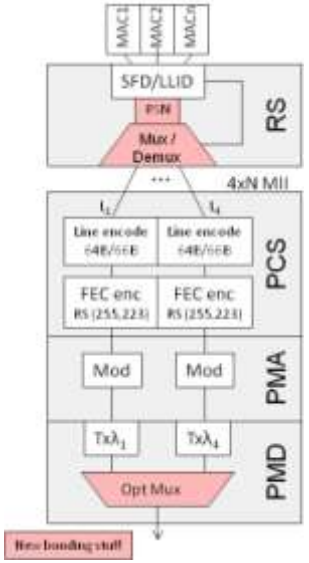
How & Where to bond

Option D

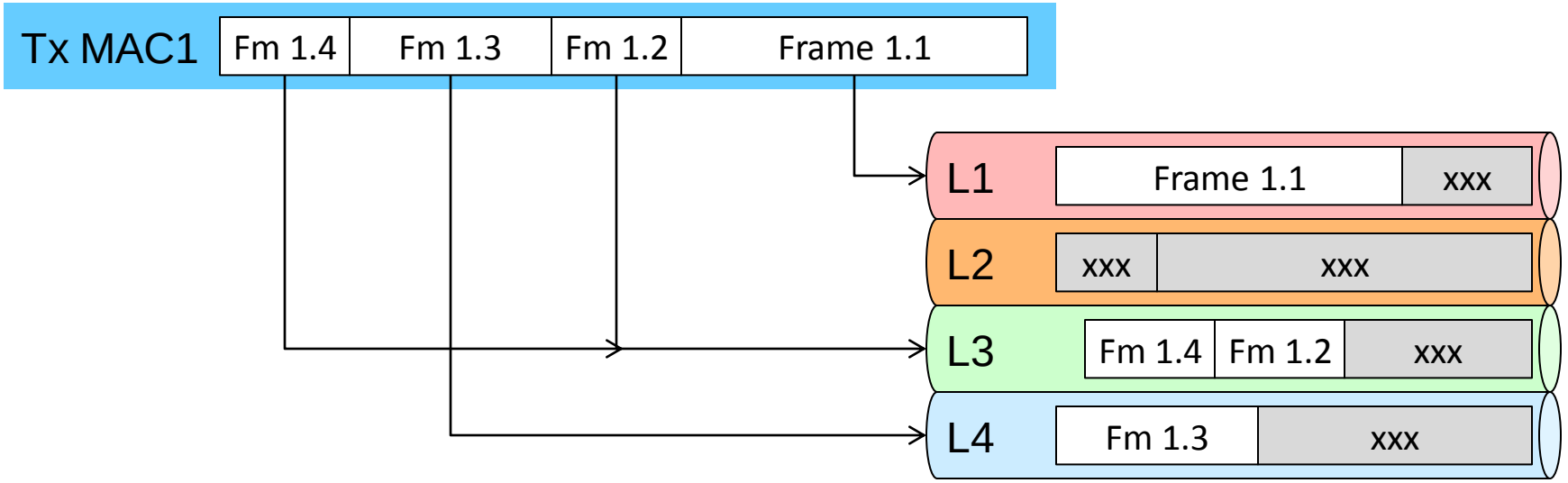
- **Stripe in RS before MII**
  - Send full frame to single lane based on LLID
    - **Some LLIDs need only map to one lane**
    - **Some LLIDs could map to >1 lane**
    - **Frames could arrive out of order – need to resolve**
  - PCS/PMA/PMD relatively unaffected
    - **Could be used with existing 10G PCS/PMA/PMD**
  - Not all ONUs need to support bonding
    - **Bonded and non-bonded ONUs could coexist on the same ODN**
    - **Compatible with existing ONU PHYs**



How & Where to bond Option D

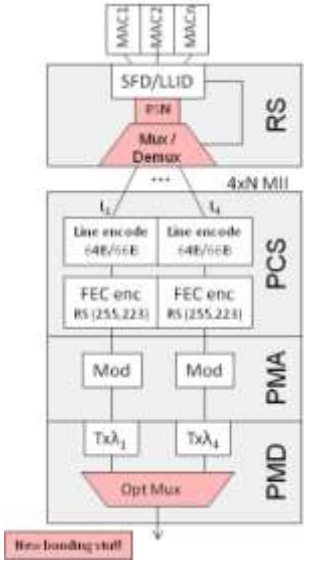


- **Stripe in RS before MII**
  - Mux/Demux by Frames
    - **Each Frame carried in single lane**
    - **Use "first available" lane for any given MAC**

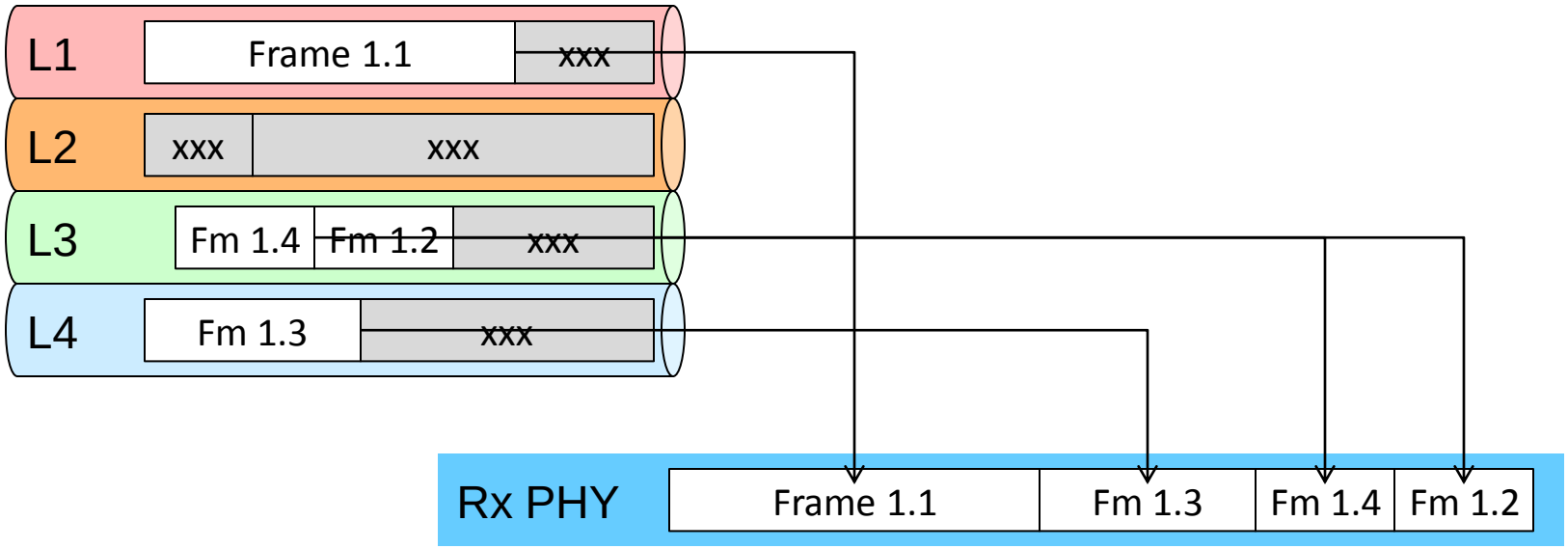


Reordering

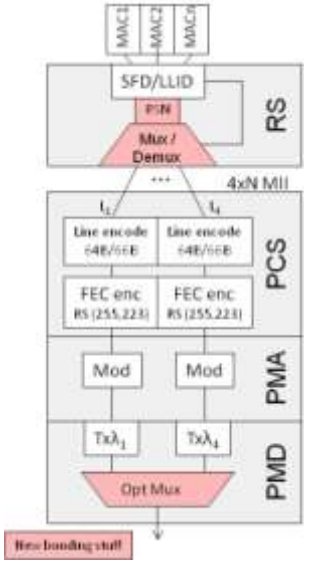
Option D



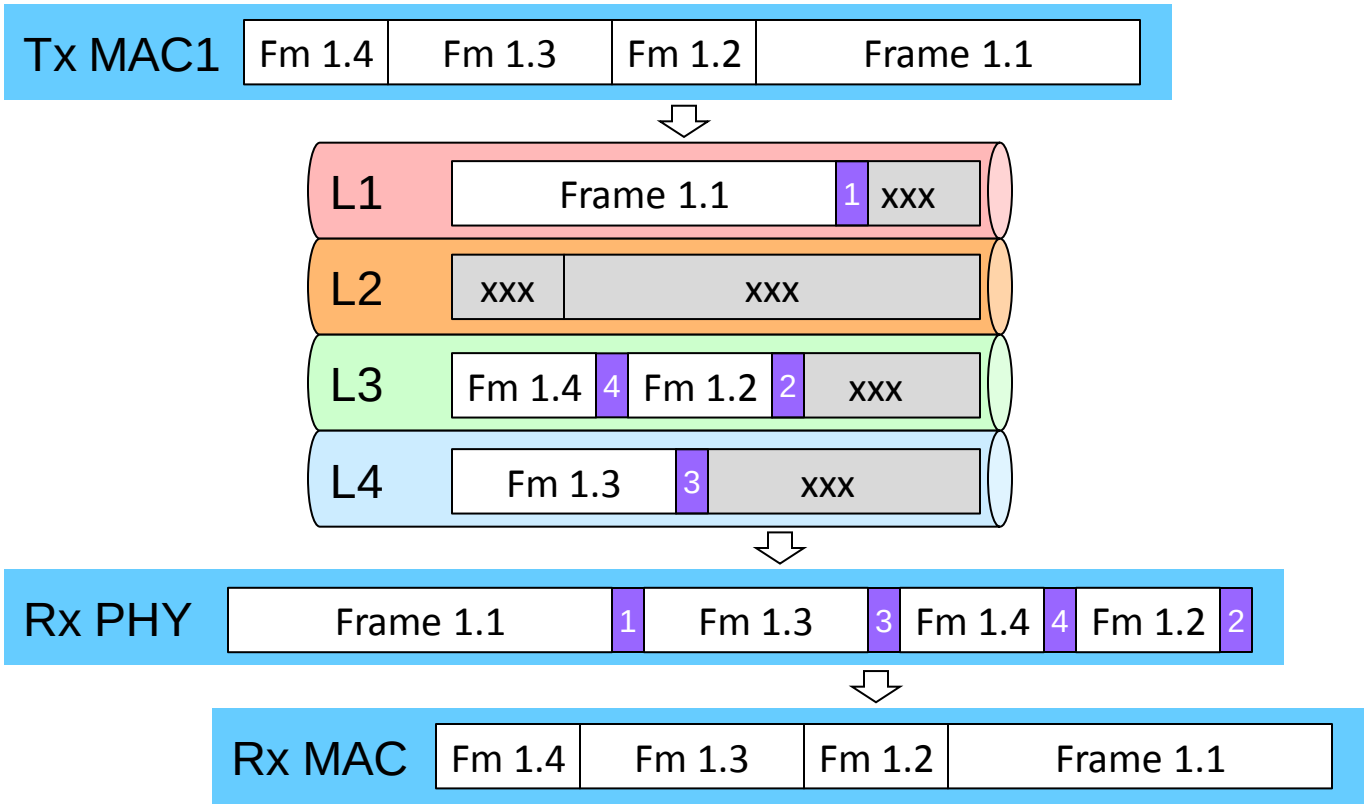
- **Frames can get Reordered!**
  - Bad Bad BAD!
- **Need mitigation technique**



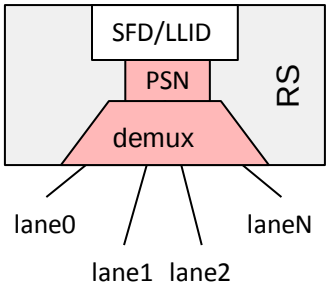
Frame Reordering in Option D



- **Use a Sequence Number to realign frames at receiver**



Packet Sequence Number Option D



- **Where to put the Packet Sequence Number?**
  - There is sufficient room in existing EPON overhead
  - Use XGMII transfer 2 lane 0 (see Table 76-3)
    - **keep 0x55 as reserved value for non-bonded channels**
  - Simple circular counter that tags each frame at Tx and is used to properly order frame handoff on Rx to MAC layer

XGMII Col/La	Field	Pre/SFD	EPON
0.0	---	0x55	0x55
0.1	---	0x55	0x55
0.2	SLD	0x55	0xd5
0.3	---	0x55	0x55
1.0	---	0x55	0x55
1.1	LLID(14:8)	0x55	LLID
1.2	LLID(7:0)	0x55	LLID
1.3	CRC8	0xd5	CRC8

⇨

XGMII Col/La	Field	Pre/SFD	NG-EPON
0.0	---	0x55	0x55
0.1	---	0x55	0x55
0.2	SLD	0x55	0xd5
0.3	---	0x55	0x55
1.0	PSN	0x55	PSN
1.1	LLID(14:8)	0x55	LLID
1.2	LLID(7:0)	0x55	LLID
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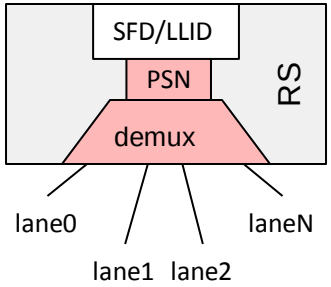
Option D Packet Sequence Number



- **Sizing PSN**
  - Must be large enough to tag all packets that could be sent during the transmission of a single largest sized packet

$$PS_{max} / R_{min} > PSN_{max} * PS_{min} / ((\Sigma R_i)-R_{min})$$

where: **PS = packet size**

R_i = individual channel rate

PSN = packet sequence number (8 bits, 1 reserved value)

Substituting PS_{max} = 2012, PS_{min} = 76 and 254 = PSN_{max} yields:

$$R_{min} / ((\Sigma R_i)-R_{min}) > 0.105$$

8 bits is sufficient for 9 equal channels or 3 x 25G + 3 x 10G

(a 7-bit PSN would allow for 5 equal channels or 1 x 25G + 3 x 10G)

XGMII Col/La	Field	Pre/SFD	EPON
0.0	---	0x55	0x55
0.1	---	0x55	0x55
0.2	SLD	0x55	0xd5
0.3	---	0x55	0x55
1.0	---	0x55	0x55
1.1	LLID(14:8)	0x55	LLID
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Buffering & Delay

- **Reordering frames will require a buffer in the Rx RS**
- **How Big?**
  - All PHYs need to buffer 1 max size frame in order to verify FCS before handoff to MAC
  - Option D bonded solution will require one additional max frame buffer for each additional lane used
- **Delay**
  - Latency will appear to be that of the slowest lane

Pros & Cons

Option	Pros	Cons
A – top of PCS	• ??	• Non-standard • ONUs must be homogeneous • Requires add lane markers
B – after 64B/66B	• Same as 100G (we steal), familiar to WG	• ONUs must be homogeneous • Requires lane markers • Requires add lane markers
C – after FEC	• ??	• Non-standard • ONUs must be homogeneous • Requires add lane markers
D – in RS	• Can mix & match bonded & non-bonded ONUs • Can bond PHYs with unequal rates • Compatible with 10G ONUs • No additional overhead	• Non-standard ~~• Need resolution to Frame reorder issue~~ • Latency looks like that of slowest bonded lane • Required buffering in RS

Technical Feasibility

- **Conclusion**
  - There are several ways that channel bonding could be incorporated in NG-EPON
  - The Task Force will need to choose one and work out the details
- **Items to be considered in selecting a mechanism**
  - Simplicity
  - Efficiency
  - Backwards compatibility & coexistence

Requirement fulfillment

- ☑ **Achieves higher throughput than any single lane**
- ☑ **Pay as you grow – can add lanes as needed**
- ☑ **Supports mixed ONUs types sized to customer need on the same PON**
  - Granma gets one lane
  - MegaCorp gets 4 lanes (and Granma uses space left over)
- ☑ **Possibilities for power saving**
  - active OLT channels could change during operation
  - active ONU channels could change during operation

Thank you

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