Accommodating FEC overhead: MAC sub-rating vs. PHY super-rating

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Introduction

- All FEC algorithms have a code rate that is less than unity; that is, they use up bits.

- There are two methods to accommodate the added FEC overhead:
  - **PHY super-rating**: Increase the PMD line rate.
  - **MAC sub-rating**: Reduce the MAC effective data rate.

- This presentation lays out the various arguments for and against each alternative.
FEC Overhead Allocation

- XGMII rate is fixed at 156.25 MHz

- PHY super-rating means that FEC overhead is allocated below XGMII (i.e., overhead is added to data)

- MAC sub-rating means that FEC overhead is allocated above XGMII (i.e., overhead displaces data)
The scale of the issue

• The FEC algorithm has not been selected

• Most proposals have mentioned RS(255, 239) as a straw-man choice
  – Super-rated speed would be 1.067×nominal
  – Sub-rated speed would be 0.937×nominal

• FEC algorithms might go to, say, RS(255, 231)
  – Super-rated speed would be 1.104×nominal
  – Sub-rated speed would be 0.906×nominal

• So, we’re talking about a 7~10% factor
  – Not enough to break a technology
  – A ‘small signal’ analysis should be valid
PHY Super-Rating

- Don’t slow down the MAC
- XGMII runs at 156.25 MHz
- FEC inserts extra parity blocks

In RS(255,239) FEC inserts 2 parity blocks per 28 payload blocks

- GearBox input clock = 156.25 MHz × 30/28 = 167.4107142857... MHz
- PMA clock = 167.4107142857... MHz × 66/16 = 690.569196428571... MHz
- PMD rate = 690.569196428571... MHz × 16 = 11.0491071428571... Gb/s
Slowing down MAC means inserting more IDLEs between frames (actual MAC and XGMII rates remain the same).

There exist 3 methods to slow down the MAC:

1. **Inter-frame Stretch** (Clause 4)
2. **Carrier Sense** (Annex 4A enables using carrierSense to extend deference due to congestion in the PHY)
3. **MPCP frame delay** (802.3ah)

Extra IDLE blocks are removed (marked) before the scrambler.

FEC encoder inserts matching number of parity blocks.
PHY Super-Rating

**Pros**

- The MAC rate is untouched
  - Everything upstream of the PON need not care that there is FEC going on
- Super-rated optics already exist
  - 11.049 Gb/s optics are sold currently
  - Same parts support both rates
- Super-rating is the standard approach in Ethernet for line coding – why not use the same method for FEC?
  - 1.25 Gb/s is the 8b10b code super-rate for 1G
  - 10.3125 Gb/s is the 64b66b code super-rate for 10G

**Cons**

- Receiver sensitivity is reduced
  - 6.6% over-rate equals 0.3 dB penalty
  - 10.4% over-rate equals 0.4 dB penalty
- Existing 10.3125 Gb/s devices or equipment can’t interface to new line rate
- Who needs a full 10G, anyway?

One or two respondents mentioned that the sensitivity impact of super-rating is larger than theory, and is ~1 dB. This can be understood if optics are not optimized, and therefore have insufficient bandwidth for the super-rate. The increased penalty arises from ISI.
# MAC Sub-Rating

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<th><strong>Pros</strong></th>
<th><strong>Cons</strong></th>
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| • Line Rate remains same as 10GbE  
  – Reuse of PMA and PMD components  
• Support of FEC optionallity  
  – May be not important for 10G PON  
• MAC sub-rating was the approach for 1G EPON FEC – why change now?  
• Could result in simpler 62.5 MHz clock generation (for asymmetric 10G/1G system) | • MAC data rate is decreased from standard 10GbE  
  – May not be important, as effective user rate has to be reduced anyway due to various other PON overheads  
• IPG stretching mechanism must be used  
  – Minor complexity issue  
  – There are several existing options for this  
• PMD reuse is doubtful, since PON loss budget is so different from P2P 10GbE budgets |
Additional Thoughts

- A hybrid solution could be considered
  - Super-rating in the downstream, where link budget is more forgiving (perhaps)
  - Sub-rating in the upstream, where the link budget is more stringent
Reaching a Decision

• There are several ways to decide
• On the basis of cost:
  – Which is worse? The Cost premium of super-rated optics, or the Lost revenue due to MAC sub-rating?
• On the basis of ‘Style’
  – Architecturally clean, with added cost
  – Pragmatically economic, with complications
Straw Poll

• A preferred method for accommodating FEC overhead is

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• PHY super-rating: _7_ _7_

• MAC sub-rating: _40_ _23_

• No opinion/Don’t care: _32_ _23_