

FEC Super-rating
To speed, or not to speed...
(will I get caught?)

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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 resolve this
 - Reduce the MAC effective data rate
 - Increase the PMD data rate
- This presentation lays out the various arguments for and against each alternative

The scale of the issue

- The FEC algorithm has not been selected
- Most proposals have mentioned RS(255,239) as a straw-man code
 - 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

Super-Rating: Pros

- The MAC rate is untouched
 - Everything upstream of the PON need not care that there is FEC going on
 - User gets the full bandwidth as advertised
- Super-rated optics already exist
 - 11.049 Gb/s optics are sold currently
 - In fact, same parts support both rates
- Super-rating is the standard approach in Ethernet – why change now?
 - 1.25 Gb/s is the 8b10b code super-rate for 1G
 - 10.3125 Gb/s is the 64b66b code super-rate for 10G

Super-Rating: 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
 - But then again, said components are not PON-capable, and may not work anyway
- Who needs a full 10G, anyway?

Sensitivity versus Speed (FEC)

$$\frac{\langle s^2 \rangle}{\langle n^2 \rangle} = \frac{(m_s \mathfrak{R} M P_s)^2}{(2e \mathfrak{R} M^2 F_A P_s + 4k T F_N / R) B_2} = \frac{(m_s \mathfrak{R} M P_s)^2}{(2e \mathfrak{R} M^2 F_A P_s + 16k T C B_1 F_N / A) B_2}$$

- For a normal receiver, $B_1=B_2=B$
- We can see that $\text{SNR}=f(P/B)$ for a receiver with an optimized pre-amp
- So, a 0.3 dB increase in speed will require a 0.3 dB increase in received power for a constant SNR

Additional comments

- 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.
- Similarly (but not of practical concern), if the receiver has excess bandwidth, then the penalty will be < 0.3 dB

Sub-Rating: Pros

- Line Rate remains same as 10GbE
 - Reuse of PMA and PMD components
- Support of FEC optionality
 - Probably not important for 10G PON
- MAC sub-rating was the approach for 1GbE – why change now?
- Could result in simpler 62.5 MHz clock generation (for 10/1 system)
 - Probably a small issue

Sub-Rating: Cons

- MAC rate is decreased from standard 10GbE
- IPG stretching mechanism must be used
 - Minor complexity issue
 - There are several options for this
- PMD reuse is doubtful, since PON loss budget is so different from P2P 10GbE budgets

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

Additional thoughts (1)

- It is hard to estimate the cost premium at present, because we don't know how much margin the practical receivers will have
- In the long run, the cost premium of the small bit rate increase will probably be negligible

Additional thoughts (2)

- 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

The final answer

- The group will answer this the way it always does: People will consider all the issues, and then vote on it, each with their own judgment
- Previous straw-polls have indicated a strong preference for sub-rating
 - Evidently, people believe the cost advantage outweighs the revenue loss
 - Evidently, people believe the pragmatic approach is best
- We can continue to take polls, both in .3av and in the larger 802.3 group, to confirm this stance