

MAC link latency considerations

Matt Brown, Huawei

802.3dj joint optics/logic ad hoc meeting

Contributors

- Thanks for inputs, discussion, and review from the following individuals:
 - Kent Lusted, Intel
 - Adee Ran, Cisco
 - Gary Nicholl, Cisco
 - Xiang He, Huawei
 - Mike Dudek, Marvell
 - Arash Farhood, Marvell
 - Upen Reddy Kareti, Cisco

Introduction

- Choice of FEC architecture affects end to end latency.
- Need to consider the latency implications as one of the trade offs.
- MAC-link (MAC to MAC) latency is provided for a set of potential permutations.
- Latency assumptions are intended to represent a well designed but not necessarily fully optimized implementation.

PCS/XS (RS-FEC) Latency

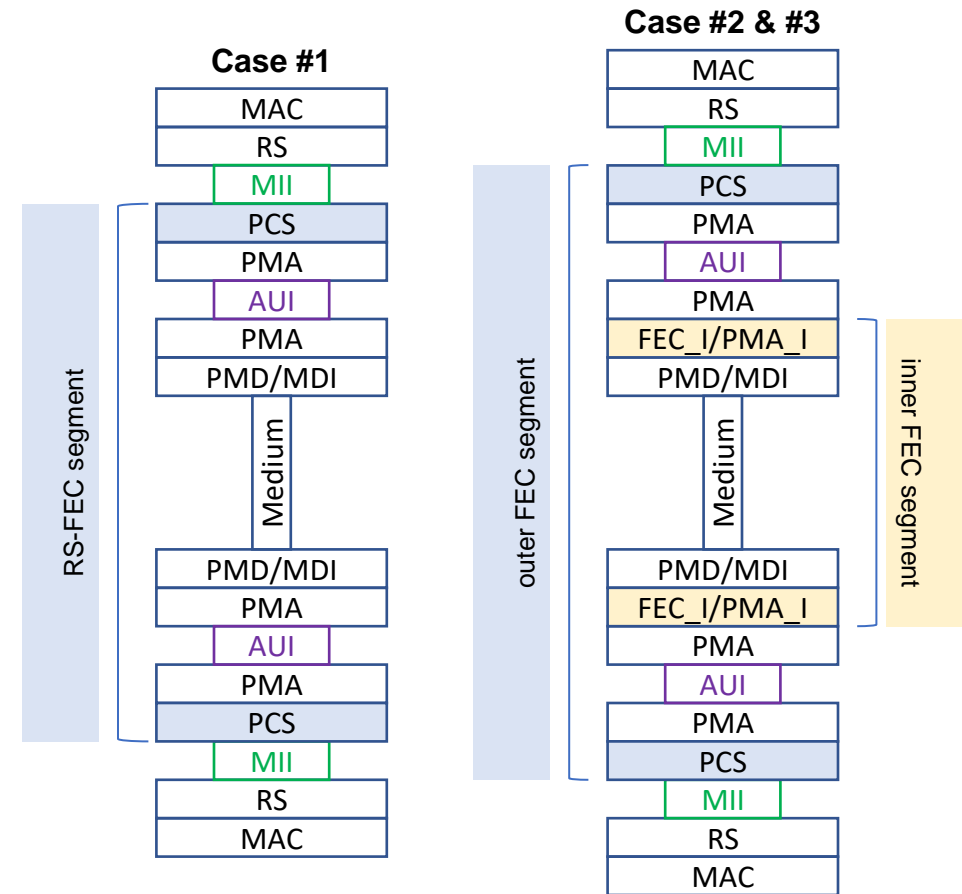
- Assumptions
 - Core clock 1 GHz
 - 3 clock cycles for encoder (3 ns)
 - 3 clock cycles for decoder miscellaneous (3 ns)
 - codewords are corrected in parallel
 - 31 clocks cycles for correction (31 ns)
 - 4 x 5440 bit-times for 800G (25.6 ns) and 1.6T (12.8 ns) for codeword storage
 - 2 x 5440 bit-times for 200G (51.2 ns) and 400G (25.6 ns) for codeword storage
- Total:
 - 200GE: $3 + 3 + 31 + 51.2 = 88.2$ ns
 - 400GE: $3 + 3 + 31 + 25.6 = 62.6$ ns
 - 800GE: $3 + 3 + 31 + 25.6 = 62.6$ ns
 - 1.6TE: $3 + 3 + 31 + 12.8 = 49.8$ ns

FEC_I (Inner FEC) Latency

- Assumptions
 - 1 GHz core clock
 - BCH Encoder/Decoder
 - 2 clock cycles for encoder (2 ns)
 - 2 clock cycles for decoder miscellaneous (2 ns)
 - 128 * 8 bit-times for the decoder BCH codeword de-interleaver (4.52 ns)
 - 15 clock cycles for decoder error correction (15 ns)
 - Total for encoder/decoder without pre-encoder interleaver:
 - $2 + 2 + 15 + 4.52 = 23.5$ ns
 - Pre-encoder interleaver (e.g., convolutional interleaver)
 - Case 1: 4 CW total (extra 2 CW for 200G/400G only)
 - 200GE (51.2 ns), 400GE (25.6 ns), 800GE (0 ns), 1.6TE (0 ns)
 - Case 2: 12 CW total (extra 8 CW for 800G/1.6T, 10 CW for 200G/400G)
 - 200GE (256 ns), 400GE (128 ns), 800 GE (51.2 ns), 1.6TE (25.6 ns)

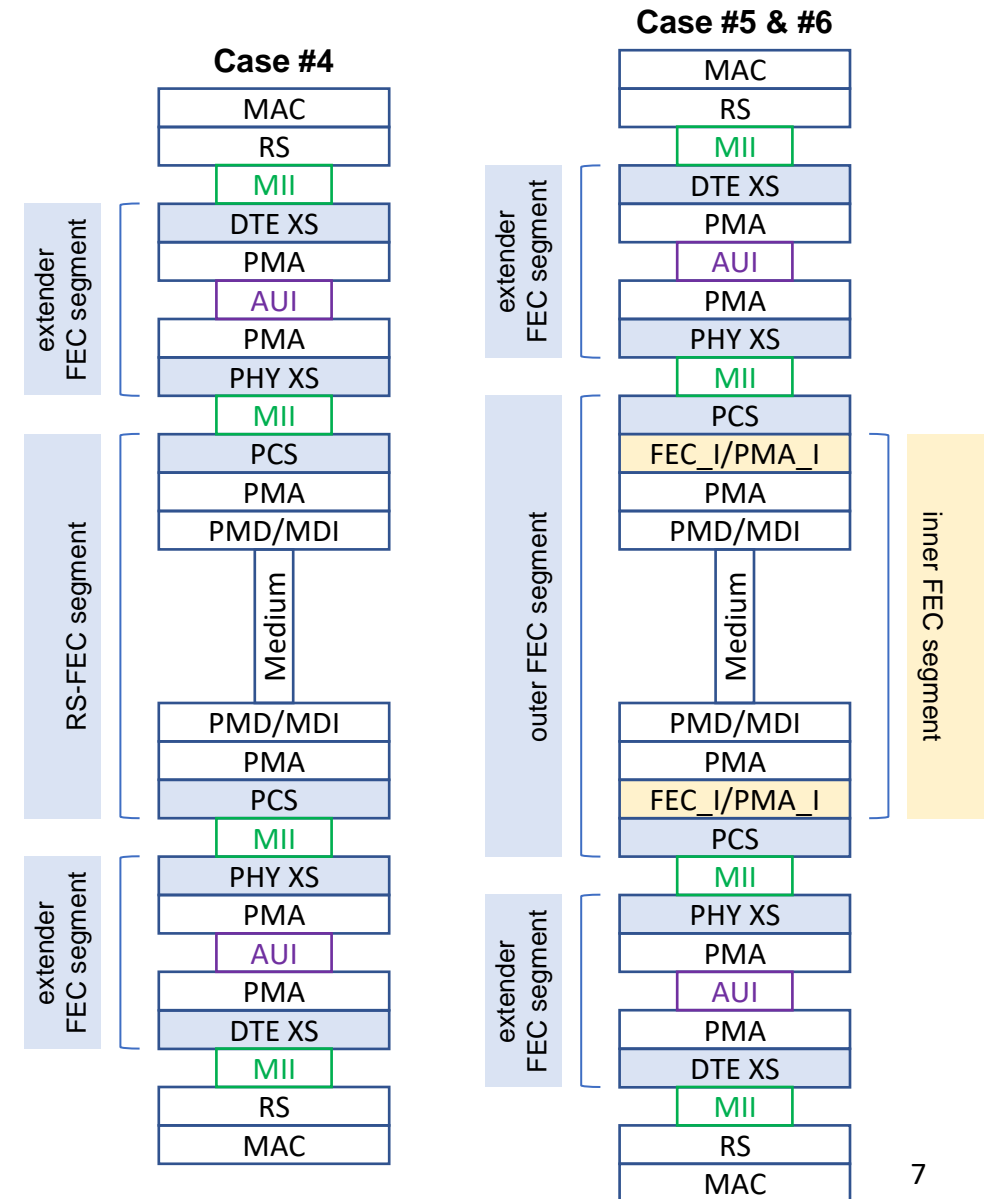
MAC-link Latency, no extenders

Case #1: Type 1, no extenders	1.6T	800G	400G	200G
PCS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
Total (ns)	49.8	62.6	62.6	88.2
Case #2: Type 2, 4 CW interleaving, no extenders				
PCS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
FEC_I: interleaver/deinterleaver	0.0	0.0	25.6	51.2
FEC_I: encoder/decoder	23.5	23.5	23.5	23.5
Total (ns)	73.3	86.1	111.7	162.9
Case #3: Type 2, 12 CW interleaving, no extenders				
PCS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
FEC_I: interleaver/deinterleaver	25.6	51.2	128	256
FEC_I: encoder/decoder	23.5	23.5	23.5	23.5
Total (ns)	98.9	137.3	214.1	367.7



MAC-link latency, with extenders

Case #4: Type 1, extender at each end	1.6T	800G	400G	200G
XS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
PCS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
XS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
Total	149.4	187.8	187.7	264.6
Case #5: Type 2, 4 CW interleaving, extender at each end	1.6T	800G	400G	200G
XS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
PCS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
FEC_I: interleaver/deinterleaver	0.0	0.0	25.6	51.2
FEC_I: encoder/decoder	23.5	23.5	23.5	23.5
XS: RS FEC encoder/decoder	49.8	62.6	88.2	139.4
Total	172.9	211.3	262.5	390.5
Case #6: Type 2, 12 CW interleaving, extender at each end	1.6T	800G	400G	200G
XS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
PCS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
FEC_I: interleaver/deinterleaver	25.6	51.2	128	256
FEC_I: encoder/decoder	23.5	23.5	23.5	23.5
XS: RS FEC encoder/decoder	49.8	62.6	62.6	88.2
Total	198.5	262.5	339.3	544.1



MAC-link latency, summary and observations

Case	Latency (ns)			
	1.6T	800G	400G	200G
Case #1: Type 1, 4 CW interleaving, no extenders	49.8	62.6	62.6	88.2
Case #2: Type 2, 4 CW interleaving, no extenders	73.3	86.1	111.7	162.9
Case #3: Type 2, 12CW interleaving, no extenders	98.9	137.3	214.1	367.7
Case #4: Type 1, 4 CW interleaving, extender at each end	149.4	187.8	187.8	264.6
Case #5: Type 2, 4 CW interleaving, extender at each end	172.9	211.3	262.5	390.5
Case #6: Type 2, 12 CW interleaving, extender at each end	198.5	262.5	339.3	544.1
Legend Blue: < 100 ns Green: 100 ns to 200 ns Yellow: 200 ns to 300 ns Red: > 300 ns				

1. Case #1 provides a minimum latency baseline for comparison.
2. Small relative latency increment from Type 1 (#1) to Type 2 (#2) if interleaving limited to 4 RS CWs.
3. Latency, esp. for 200GE and 400GE, is getting out of hand for Type 2 with 12 CW interleaving (#3) or when using extenders (#4, #5, #6).

Summary

- MAC link latency is “reasonable” for either
 - Type 1 PHY
 - Type 2 PHY with 4 RS codeword interleaving.
- MAC link latency becomes rather large, esp. for 200GE and 400GE, for either:
 - Type 2 PHY with 12 codeword interleaving
 - Type 1 or Type 2 PHY with extenders at each end
- Keep this in mind when considering features for each PHY baseline.

Thanks