FEC Summary

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FEC Summary

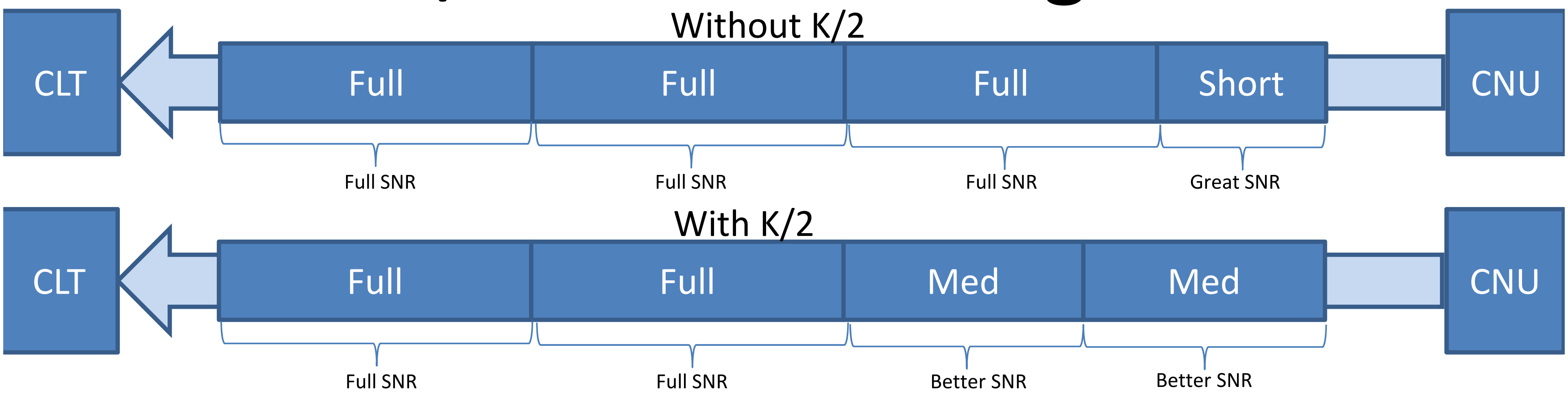
	Encoder Delay	Decoder Delay	Overall Efficiency*	Complexity
Medium Only	0	Med	80.5%	Easy
Long-Short	Long	Long	86.3%	Medium
Long-Short Parity at End	0	Long	86.3%	Medium
Long-Med-Short	Long	Long	86.3%	Difficult
L-M-S Parity at End	0	Long	86.3%	Difficult
L-M-S + K/2	Long + Short/2	Long + Short/2	86.3%	Most Difficult

*Victoria Presentation – 128 Users at 1Gbps upstream

FEC Summary

K/2

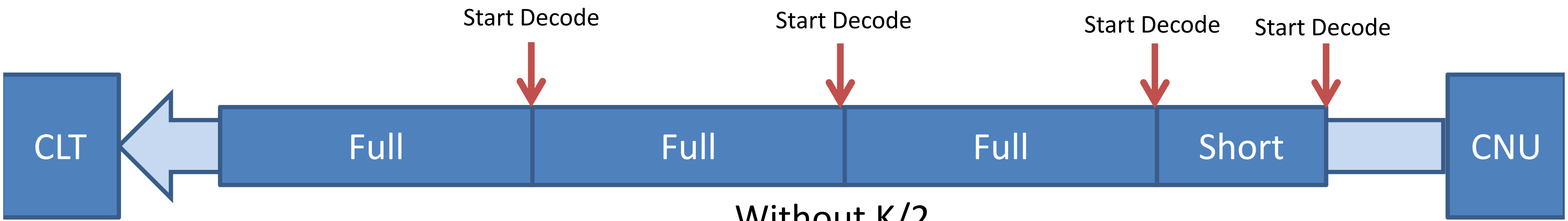
K/2 SNR Advantage?



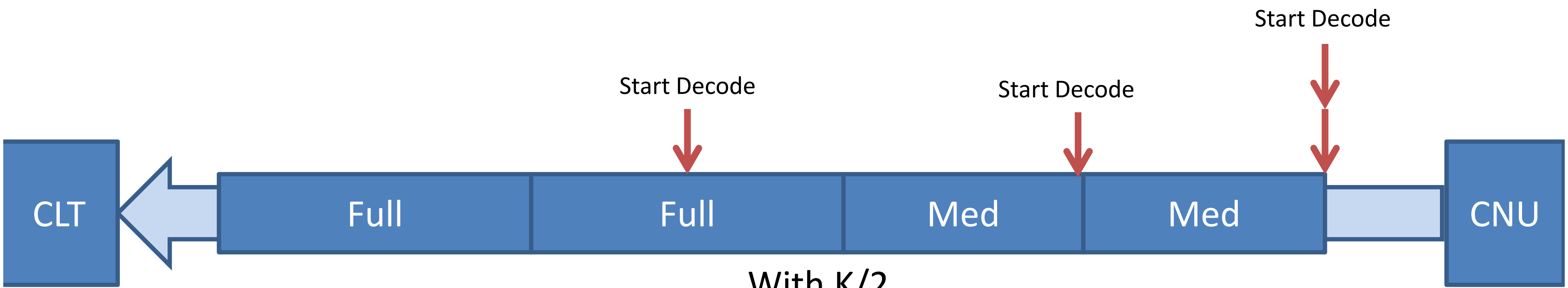
- Without K/2, Final Short codeword has much better SNR than Full blocks.
- With K/2, last 2 blocks have better SNR.
- Overall SNR is still limited by Full Block size SNR since improvement only on last block on certain block sizes.

K/2 Does not improve overall SNR

K/2 Decode Delay



Without K/2

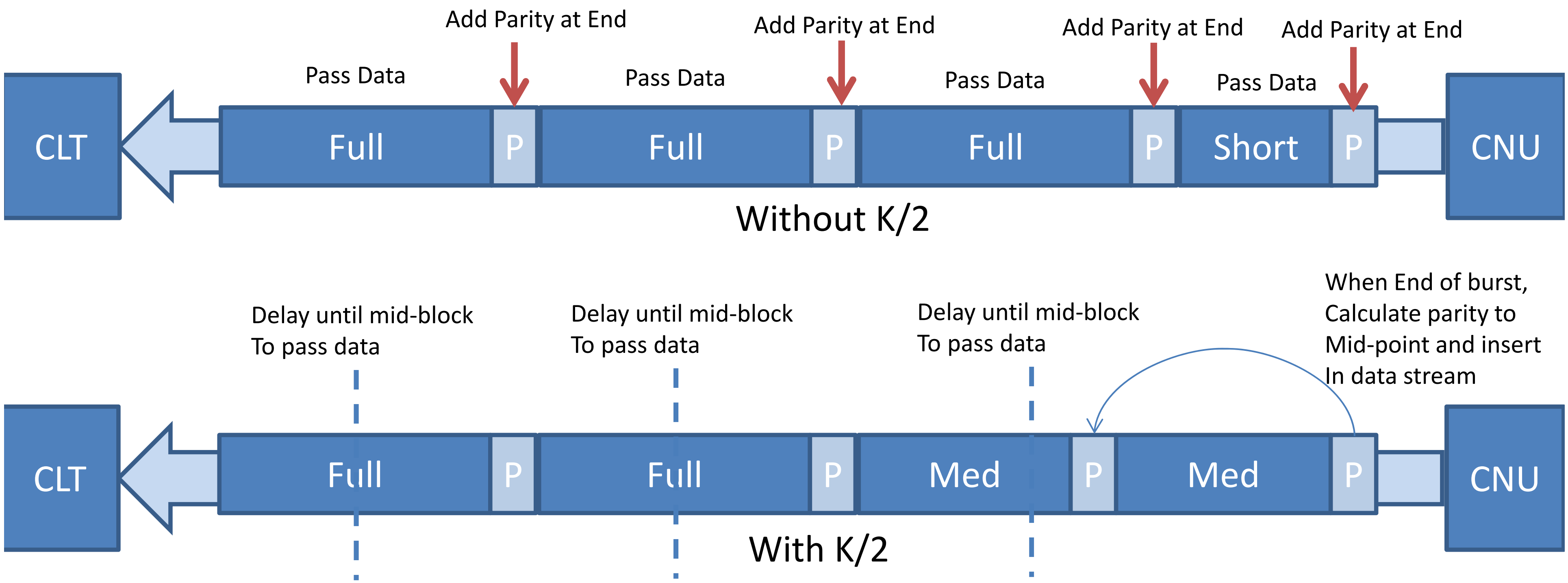


With K/2

- Without K/2, decoding starts after full codeword of data or End of burst marker.
- With K/2, decoding is delayed until half of next codeword or end of burst marker.
- With K/2, decoding the final 2 blocks starts at last code word.

K/2 Increases Decoder Delay

K/2 Encode Delay



- Without K/2, transmit data is not delayed and parity is always after data.
- With K/2, transmitter must delay data until mid-point of next block to determine where parity will be inserted.
- With K/2, parity calculation can't start until end of burst for last 2 blocks and must be inserted in non-end location.

K/2 Increases Encoder Delay and Complexity

FEC Summary

MULTIPLE CODE WORD SIZES

Multiple Code words (L-M-S)

- The tail of a burst can use 1 or more smaller code words to shorten the parity required.
- The code word sizes can be determined by the number of bits in the block.
- The Look up table below shows the most efficient code words sizes and required parity for any block size.

Min Bits	Max Bits	Long	Medium	Short	Parity Bits
1	840	0	0	1	280
841	1680	0	0	2	560
1681	2520	0	0	3	840
2521	5040	0	1	0	900
5041	5880	0	1	1	1180
5881	6720	0	1	2	1460
6721	7560	0	1	3	1740
7561	14400	1	0	0	1800

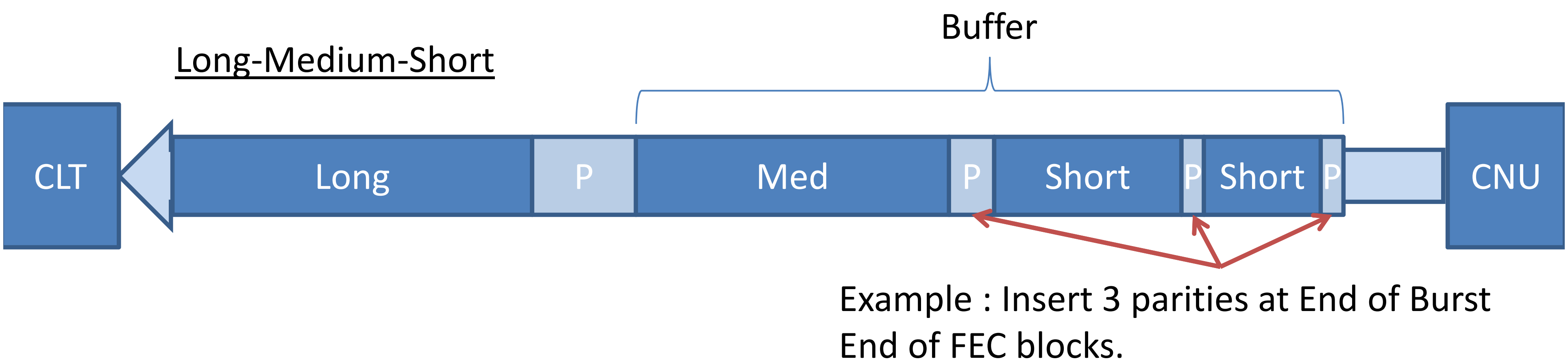
Multiple Code words (L-S)

- If the Medium code word size is not used, the following look up table could be used to select the parity.

Min Bits	Max Bits	Long	Short	Parity Bits
1	840	0	1	280
841	1680	0	2	560
1681	2520	0	3	840
2521	3360	0	4	1120
3361	4200	0	5	1400
4201	5040	0	6	1680
5041	14400	1	0	1800

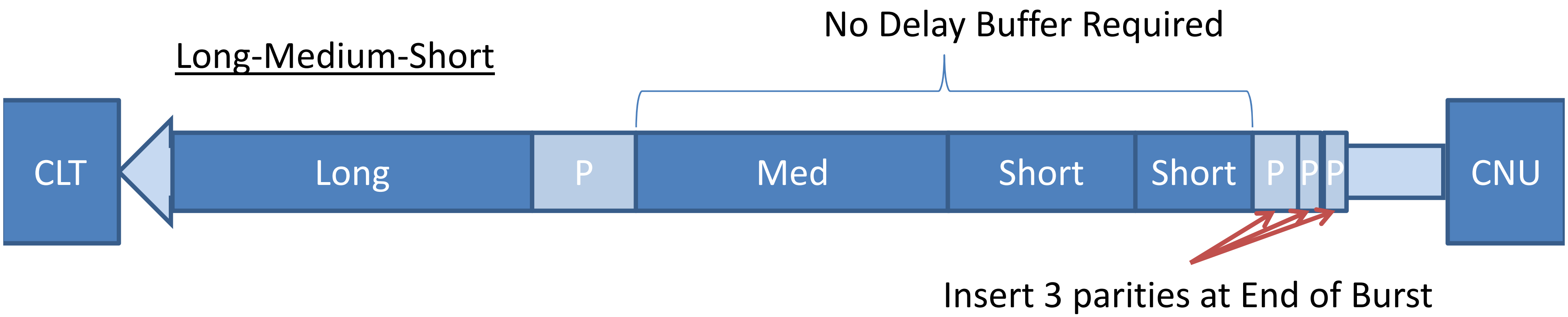
Multiple Code Word Complexity

Medium Only



- Medium only has no transmit buffering delay and parity only inserted at the end.
- LMS requires that transmitter buffer data so it can insert the parity between multiple different size blocks of data.
- K/2 not considered.

Parity at the End

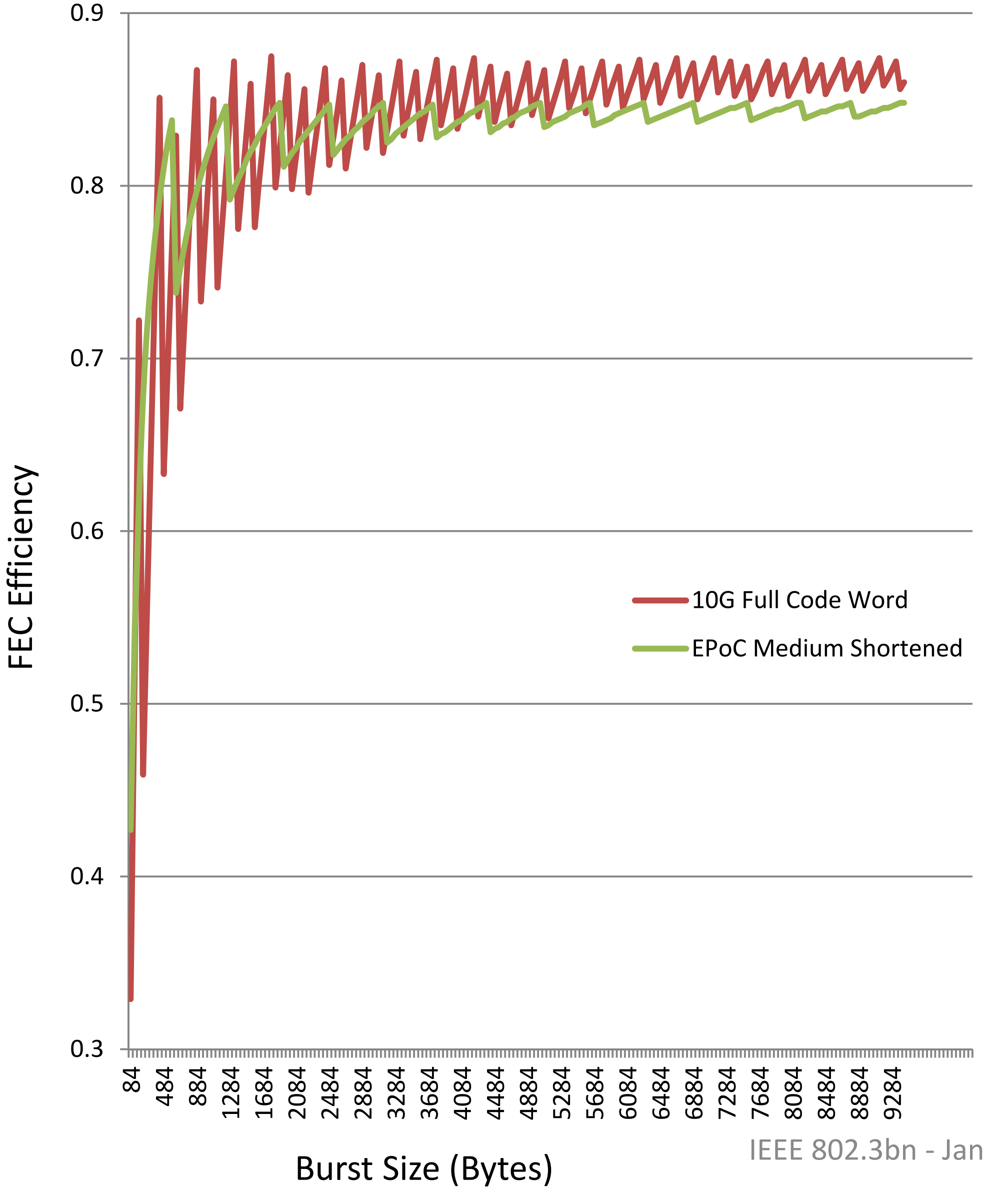


- If parity for 1 or more blocks is always transmitted at the end, transmit data doesn't need to be delayed.
- Multiple Sized Encoders need to calculate parity on multiple data block sizes at the end of the burst.
- K/2 not considered in this slide.

FEC Summary

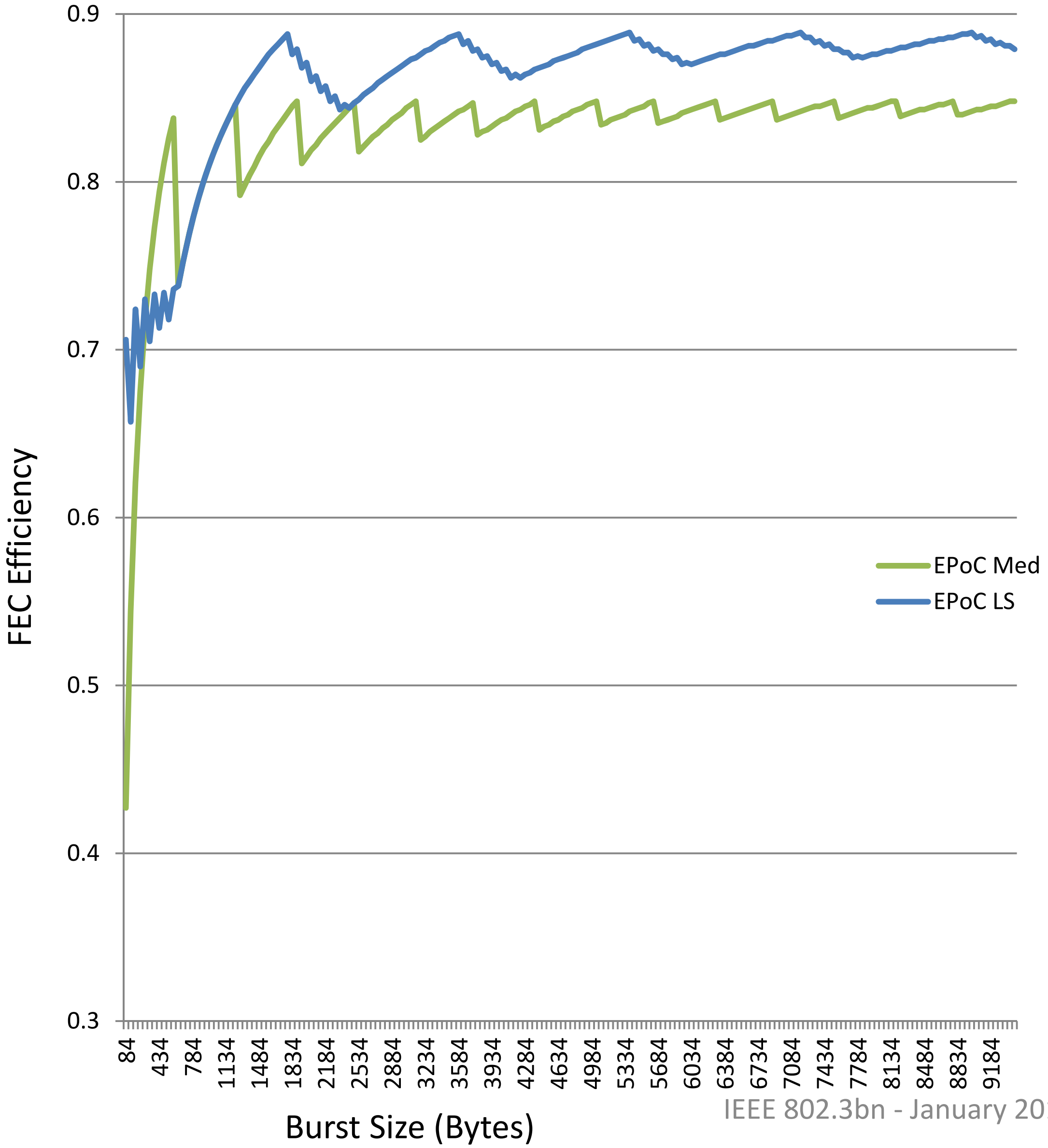
BURST PERFORMANCE

EPON 10G vs EPoC Medium



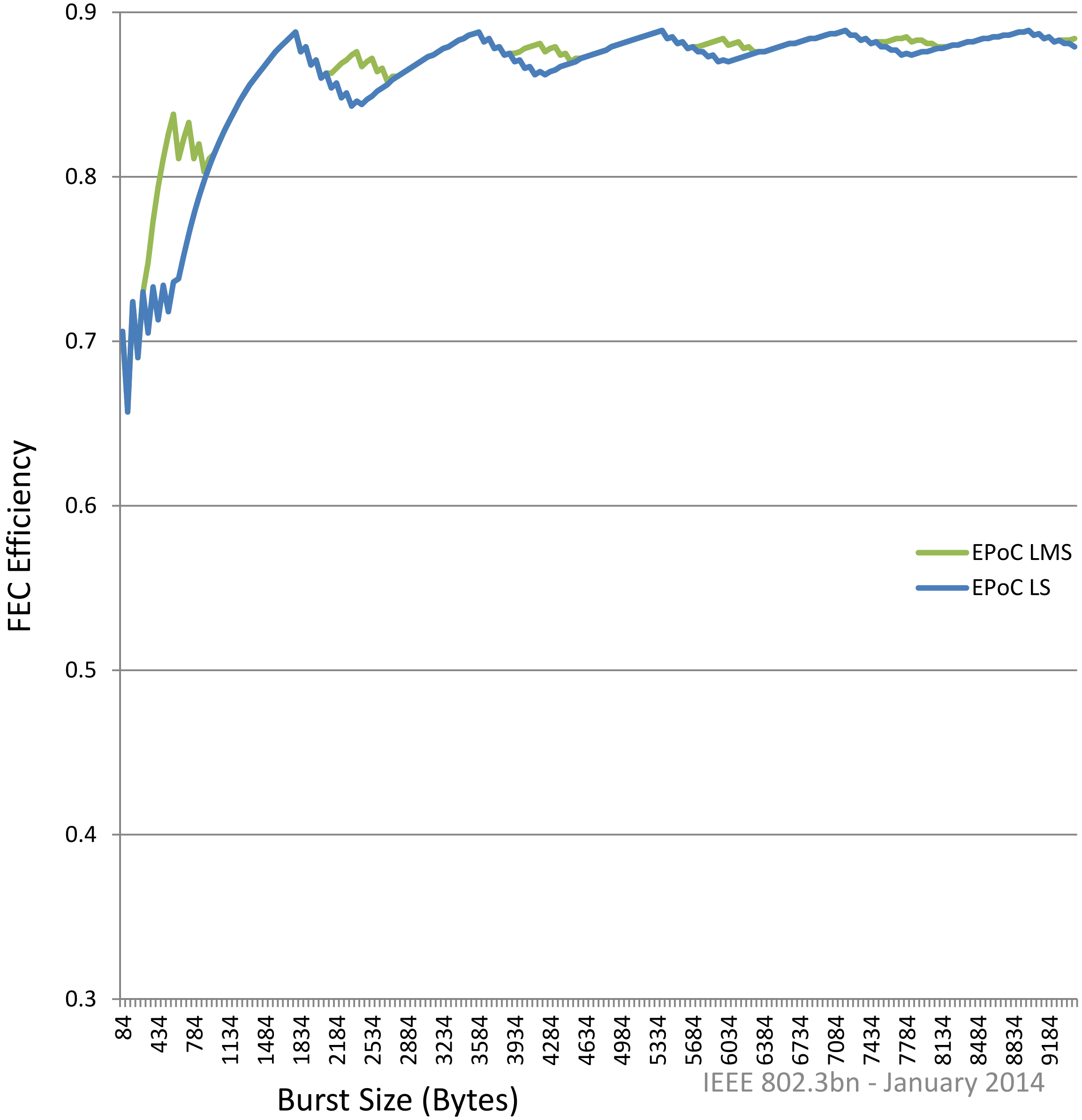
- EPoC Medium Code Word with shortening is more Efficient than 10G-EPON FEC on small bursts.
- 10G EPON is more Efficient on long bursts. (Code rate difference).
- Does EPoC needs to improve efficiency over 10G-EPON?
- How can we compare these graphs and get the overall system efficiency?

EPoC Medium vs EPoC LS



- EPoC with a mixture of Long and Short code words improves performance on short and long bursts.
- Is it enough to justify complexity?

EPoC LS vs EPoC LMS



- EPoC with Long, Medium, and Short Code words increases the efficiency of burst sizes in the range of 400 Bytes to780 Bytes.
- Bursts will normally be smaller than 400 Bytes for ACKs, polling, etcs.
- Data Bursts on a loaded system will be larger than 780 Bytes.
- Overall, Little or no performance improvement for LMS over LS.

FEC Summary

SYSTEM EFFICIENCY

Burst vs System Efficiency

- Burst Efficiency does not give a realistic worst-case system efficiency.
  - It is impossible to only have small bursts.
    - If all CNUs are transmitting small bursts and aren’t getting enough bandwidth, they will start sending large bursts.
  - It is impossible to only have large bursts.
    - Some CNUs will only have ACKs or polling to send.
- Worst Case System Efficiency
  - Upstream rate and number of CNUs are inputs.
  - Assume that all CNUs except 1 are transmitting the smallest least efficient burst.
  - One CNU is transmitting a large burst to fill in the rest of the data in a 2ms cycle time.

System Efficiency

	64 @ 500Mbps	64 @ 1Gbps	128 @ 500Mbps	128 @ 1Gbps
Medium	80.6%	82.7%	76.3%	80.6%
LS	86.3%	87.6%	83.7%	86.3%
LMS	86.3%	87.6%	83.7%	86.3%

- Medium is about 5-7% less efficient than Long & Short.
  - Is it worth the additional complexity?
- LMS has not advantage over LS
  - Small and Long bursts set efficiency.
  - 400-800 Byte burst advantage for LMS doesn't show up.
  - No need for LMS.

*From Victoria Presentation boyd_3bn_05_0513.pdf

FEC Summary

CONCLUSION

Conclusions

- Medium efficiency is simplest solution
  - Efficiency is close to 10G EPON FEC
- Long & Short improves efficiency
  - 5-7% system efficiency improvement
  - Parity should be at end to avoid transmit delay.
  - Is it worth the complexity?
- Long & Medium & Short
  - Performance improvement is not worth complexity added over LS.
- K/2
  - Adds delay and complexity with no clear benefit