MTTFPA for 100GbE Copper Interface (10GBASE-CR10)

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Agenda

- Background on MTTFPA and CRC error protection
- 100GbE MTTPFA Analysis for the copper interface
- High BER state machine performance
- Summary

MTTFPA and 100GE PCS

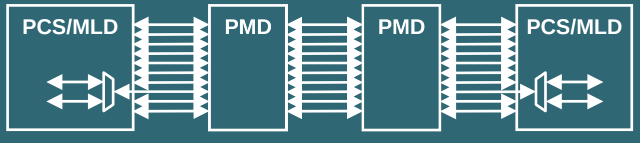
- Ethernet's CRC32 has the following error detection capability
  - All 1, 2 or 3 bit errors are detected
  - All bursts up to 32 bits
  - All double burst errors up to 8 bits
  - The above is true for at least up to 9k frames
- For the 10GBASE-R scrambler, single bit errors become 3 bit errors
- This was shown to not degrade the error detection capability of the IEEE CRC32 for 10GBASE-R
  - No CRC degradation occurs if the CRC and the scrambler polynomial do not share common factors
  - IEEE CRC32 has no common factors with the $X^{\wedge 58}$ scrambler
  - If the original errors can be detected, then the multiplied errors are also detectable
- The PCS/MLD does muxing and scrambling, does that impact MTTFPA?
- For additional background on the CRC32 detection properties see: gustlin_01_0108, gustlin_02_0308

Review of the PCS Processing

- The PCS layer has the following flow of functionality:
  1. Encoding (64B/66B)
  2. Scrambling ($x^{58}+x^{39}+1$)
  3. Striping of the data to multiple lanes from an aggregate stream
  4. De-striping of the data from multiple lanes to an aggregate stream
  5. Descrambling of the data
  6. Decoding (64B/66B)

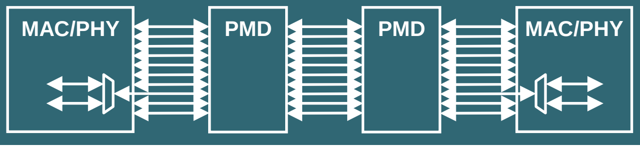
- This is important, since the packet is reconstructed before descrambling, the multiplied errors are right where the scrambler polynomial says they should be. This typically leads to MTTFPA analysis similar to that for 10GBASE-R.

100GE and Burst Errors

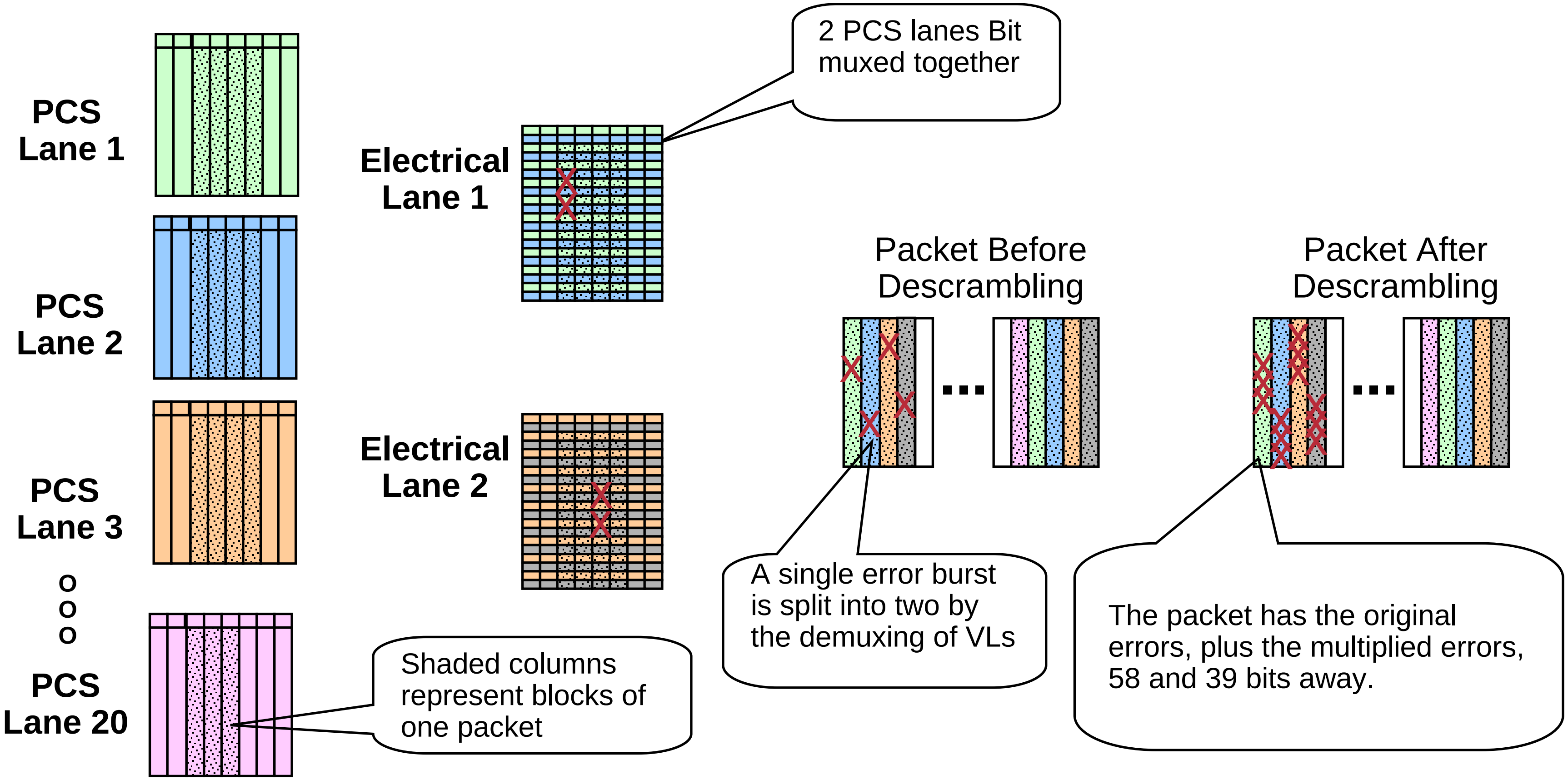


- For 100GE copper interfaces, we do not know if burst errors are likely or not
- The following analysis will assume a very pessimistic case that they are likely, such as they would be if 5 tap DFE is used with a bad channel
  - Leverages previous backplane analysis since we have no other data!
- The analysis shows that the dominant error case that is not 100% detectable is a double error event with each event being extended to 2 bits each (or four errored bits in total)

100GE – Double Error Event

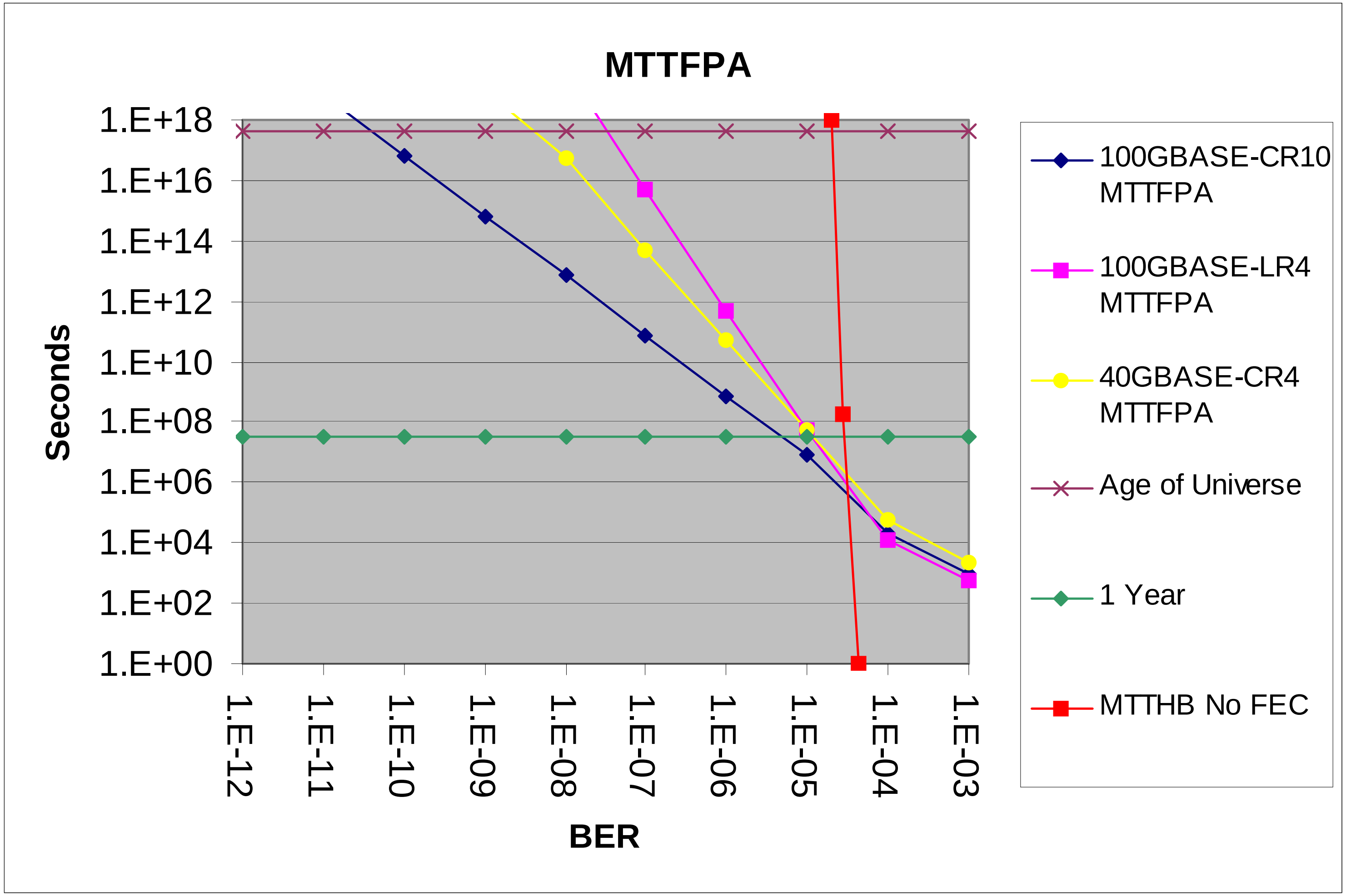


- When the packet is reassembled, the double burst errors get split into two pieces each and therefore we have 4 separate errors
- The IEEE CRC32 can detect these four errors with a probability of $(1-1/2^{32})$
- This equates to an MTTFPA of 2×10^{13} years (age of the universe is 1×10^{10}) at a BER of 10^{-12}



High BER Performance

- High BER takes down the link effectively for CR10 as well as CR4/LR4 etc.



Summary

- For random and independent errors, the error analysis is the same as it was for 10GBASE-R
- This provides for very good MTTFPA, many times the age of the universe
- Even assuming 5 tap DFE, a not very good channel for a 100GbE copper application, and no FEC; the MTTFPA is still very good
  - More than the age of the universe (2×10^{13} years)
- The analysis for 40GbE copper matches the 40GbE backplane analysis
  - See gustlin_02_0308
- The High BER state machine is still effective for CR10
- If this MTTFPA is not acceptable for a user, they can enable the optional FEC to improve it