MLD (CTBI) Updates – MTTFPA for 40G Backplane

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Agenda

- Background on MTTFPA and CRC error protection
- Review of Previous MTTFPA work
- 40GE MTTPFA Analysis for backplanes
- Summary

MTTFPA and MLD

- Ethernet's CRC32 has the following error detection capability
  - All 1, 2 or 3 bit errors are detected
  - All burst up to 32 bits
  - All two bit burst errors up to 8 bits
  - The above is true for at least up to 9k frames
- For the 10GBASER 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 [5], [1], [2]
  - 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

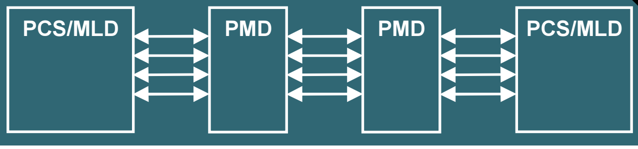
- The PCS/MLD does muxing and scrambling, does that impact MTTFPA?
- For additional background on the CRC32 detection properties see: gustlin_01_0108

Review of the PCS/MLD Processing

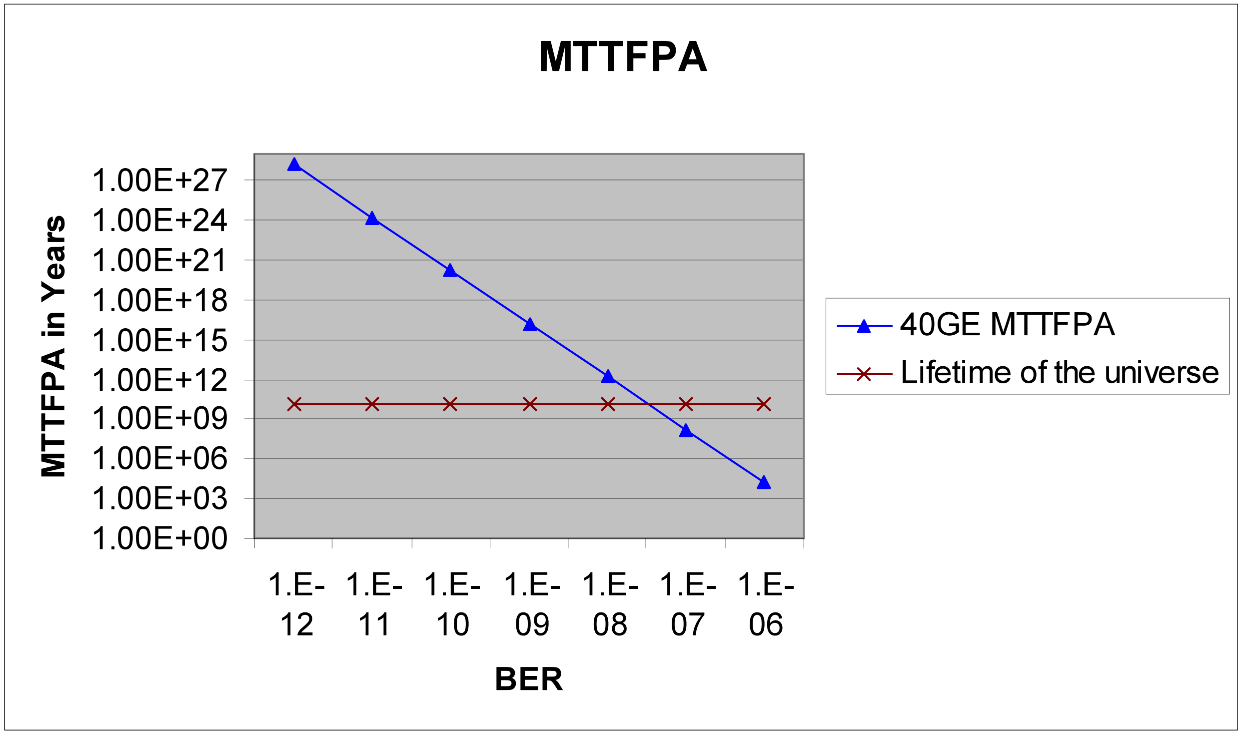
- The PCS/MLD layers have the following flow of functionality:
  1. Encoding (64B/66B)
  2. Scrambling ($x^{58}+x^{39}+1$)
  3. Striping of the data to multiple lanes from an aggregate stream
  4. De-striping of the data from multiple lanes to an aggregate stream
  5. Descrambling of the data
  6. Decoding (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 leads to MTTFPA analysis similar to that for 10GBASE-R.

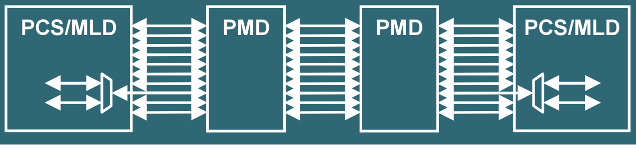
40GE Summary



- Same error detectability as in 10GBASE-R
- No degradation due to the scrambler error multiplication
- Corner cases such as error spill in and spill out are the same as 10GBASE-R so the analysis done for it applies here as well
- The data below assumes random and independent errors



100GE (10:10) Summary



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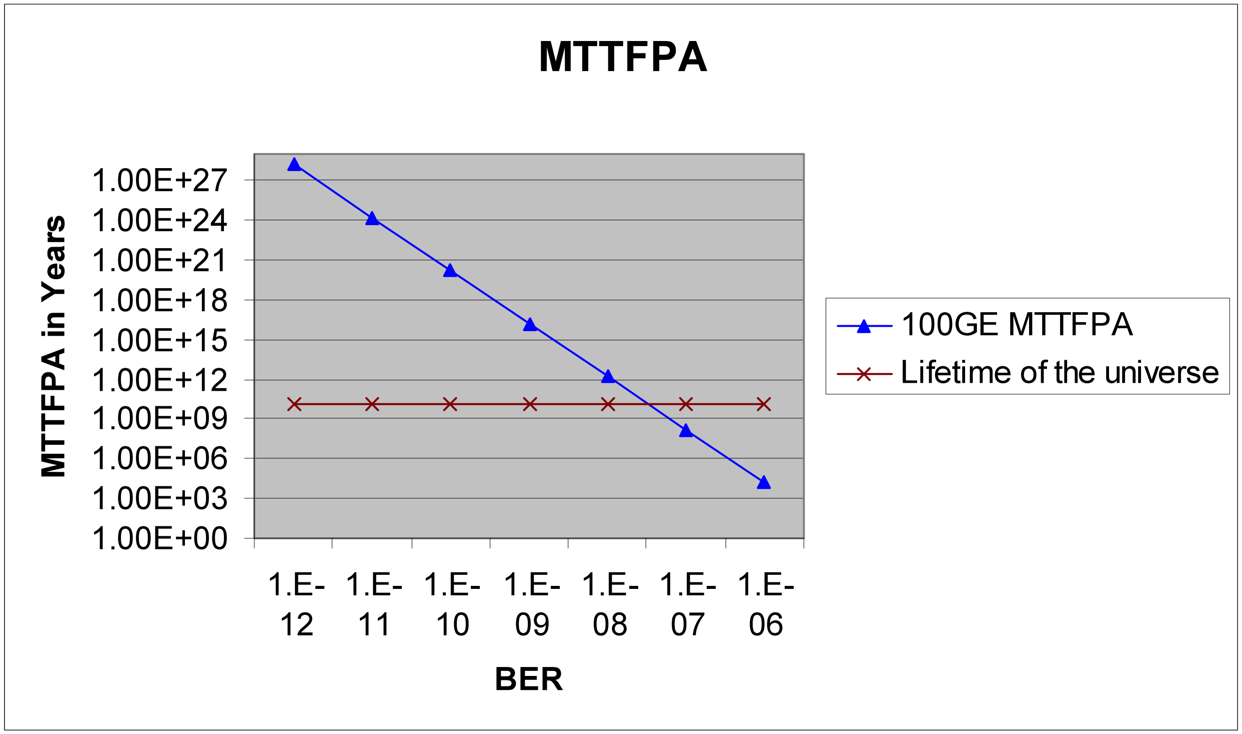
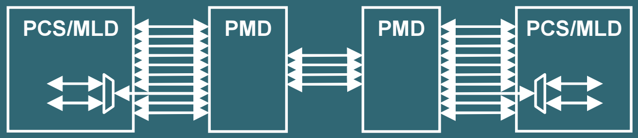


100GE (10:4) Summary



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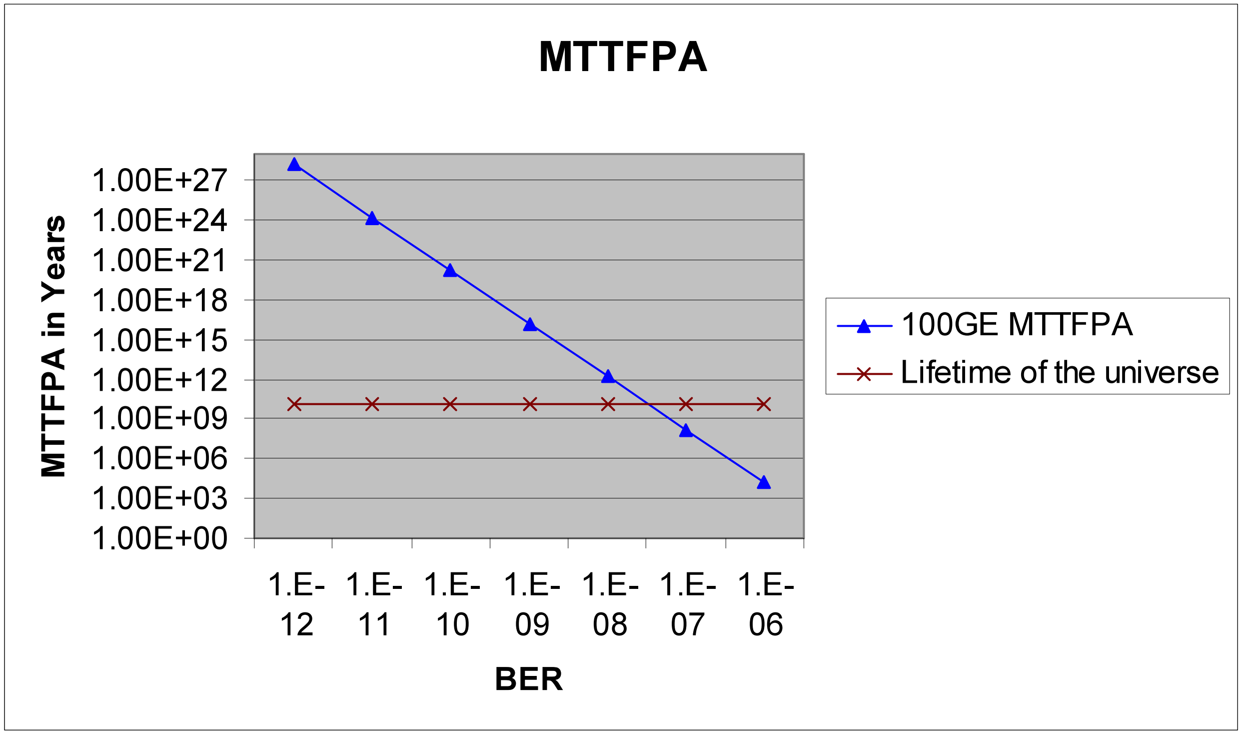
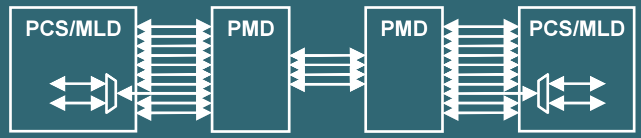
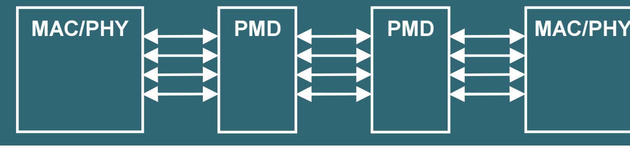


40GE and Burst Errors

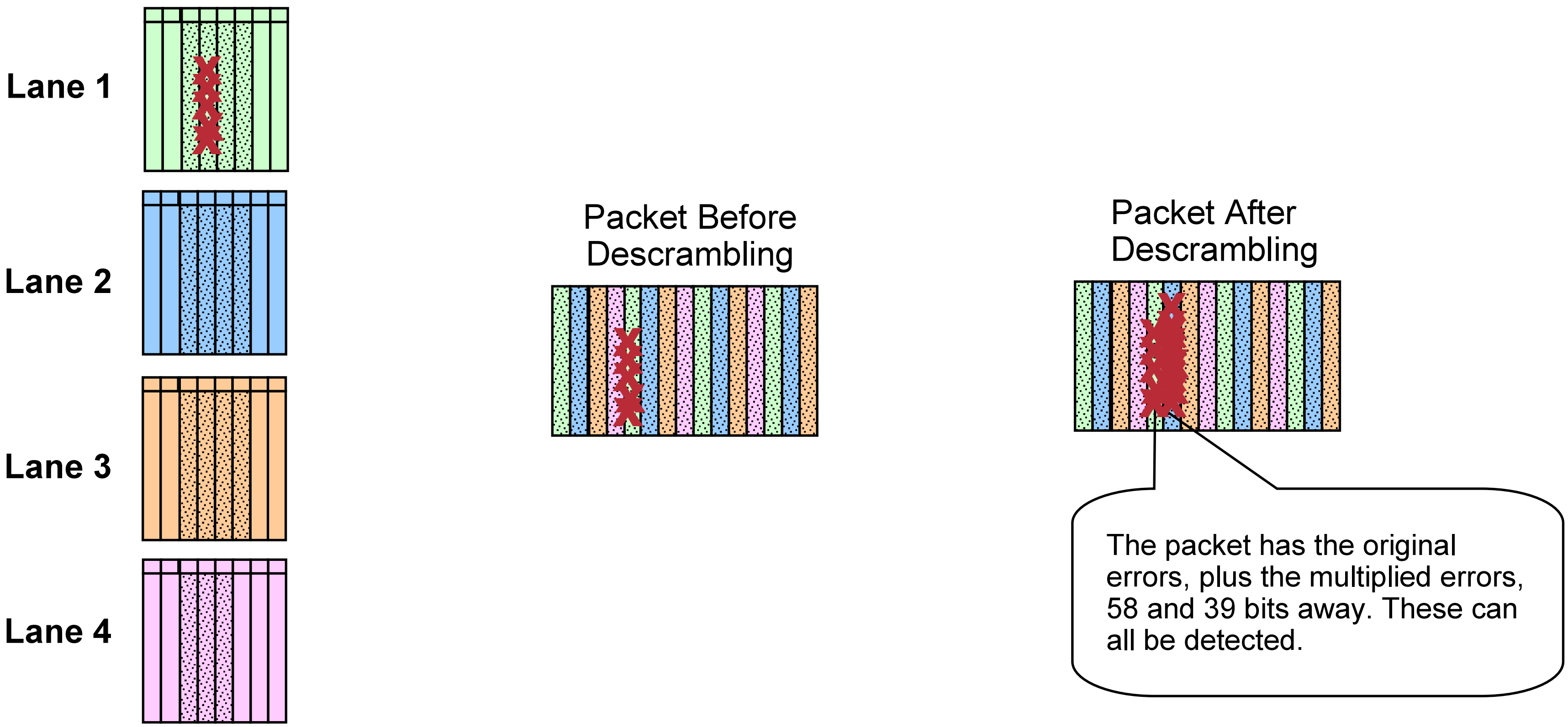


- For 40GE Backplanes, we know that burst errors are likely for some backplane types
- The following analyses the MTTFPA for burst errors for a 40GE backplane application

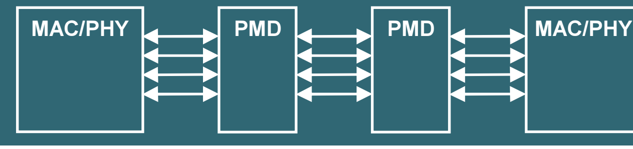
40GE – Burst Error



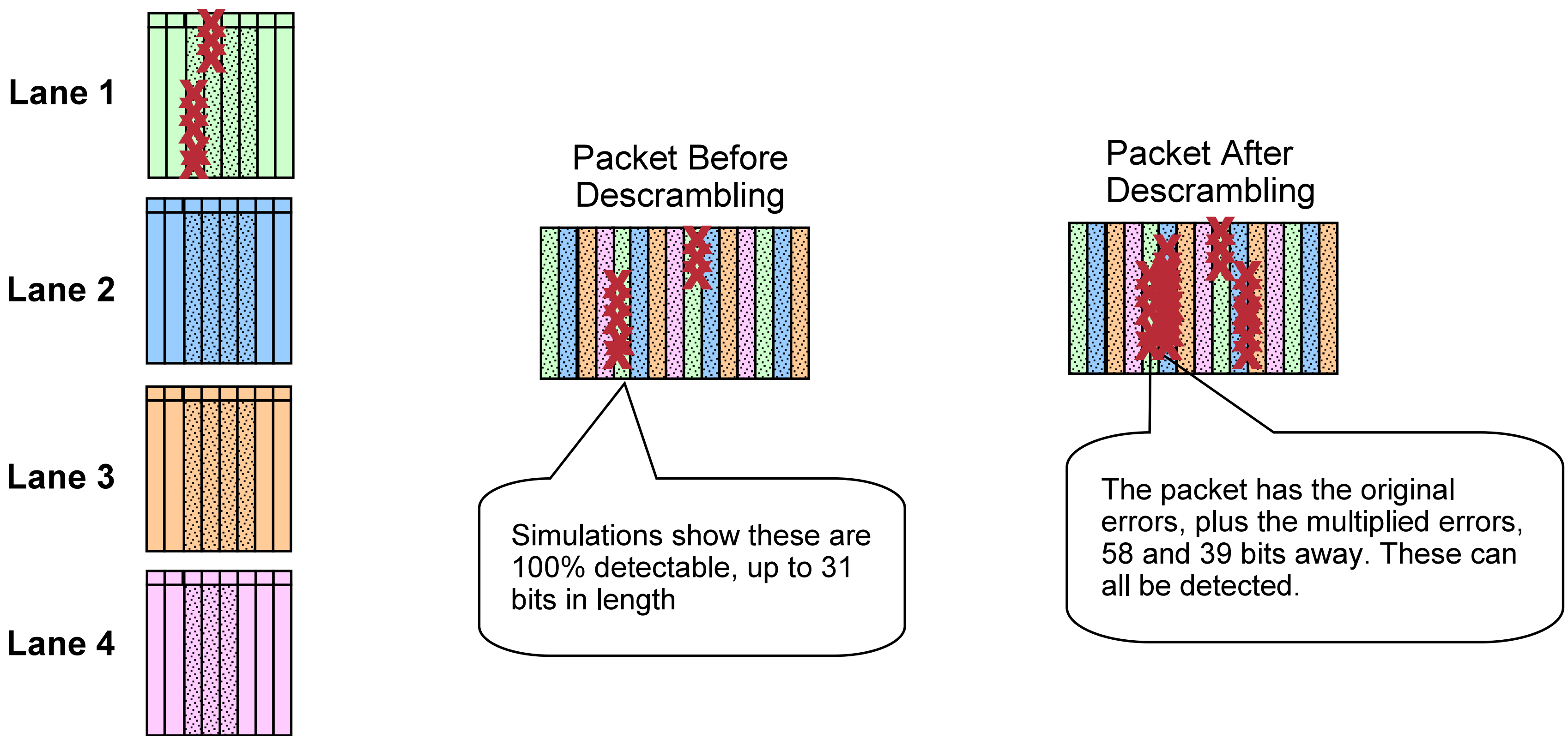
- The original burst error, if ≤ 32 bits and contained in one 64 bit word, is 100% detectable; the multiplied burst error is also 100% detectable
- Same behavior as 10GBASE-R



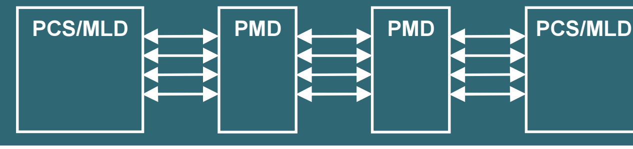
40GE – Burst Error - Split



- This is a special case where the burst error crosses a word boundary
- If the error burst corrupts the sync bits (one or both), that error is 100% detectable due to the inherent packet boundary protection and sync protection that we have with 64/66 encoding
- If it crosses the boundary, but does not corrupt either sync bit then it looks like two error bursts now
- 100% detectable for one burst error at least up to 32 bits, shown by simulations
- If the original error is detectable, then the multiplied errors are detectable



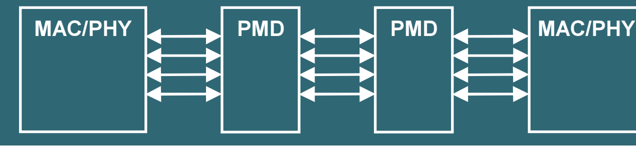
40GE Double Burst Errors



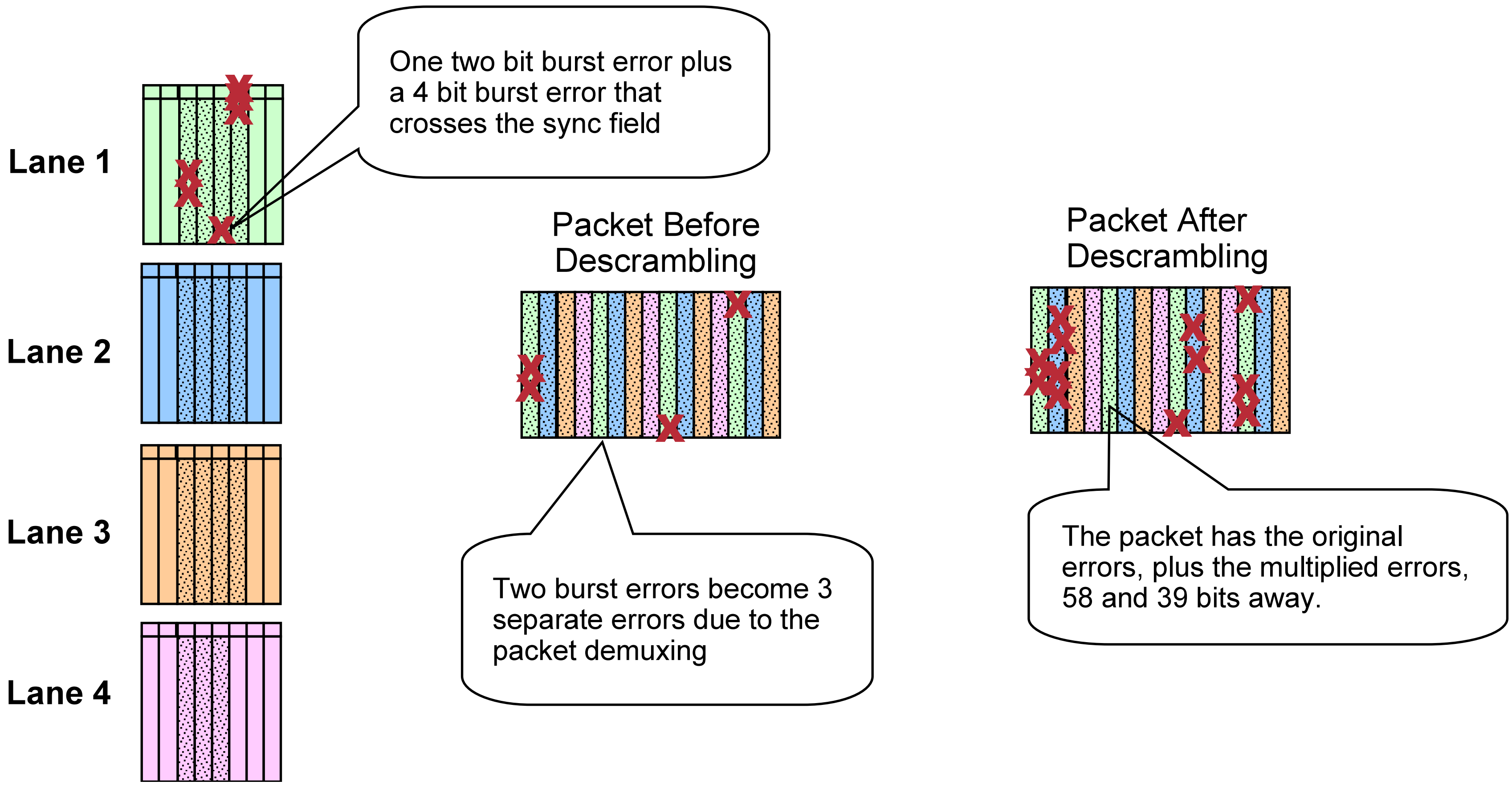
- If DFE or other equalization is used, that can lead to burst errors, and if we get multiple errors that each become burst errors, can we detect them?
- Use for now the Burst error probabilities from liu_01_1105, for the B12 channel (relatively bad channel) with DFE

Probability of 1 bit error propagation	1	8.89E-01
Probability of 2 bit error propagation	2	1.00E-01
Probability of 3 bit error propagation	3	1.00E-02
Probability of 4 bit error propagation	4	1.00E-03
Probability of 5 bit error propagation	5	1.00E-04
Probability of 6 bit error propagation	6	1.00E-05
Probability of 7 bit error propagation	7	1.00E-06
Probability of 8 bit error propagation	8	1.00E-07
Probability of 9 bit error propagation	9	1.00E-08
Probability of 10 bit error propagation	10	1.00E-09
Probability of 11 bit error propagation	11	1.00E-10

40GE – Double Burst Errors



- The minimum double burst errors that is not 100% detectable is a 2bit and a 4bit burst, given that the 4 bit burst crosses the 66b boundary
- This is not 100% detectable only if it does not corrupt the sync bits
  - If it does corrupt the sync field then it is likely detectable due to the 4 bit hamming protection that the PCS encoding has
- If it crosses the boundary, but does not corrupt either sync bit then it looks like three error bursts now



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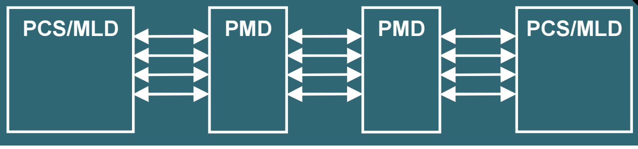

- The minimum double burst errors that is not 100% detectable is a 2bit and a 4bit burst, given that the 4 bit burst crosses the 66b boundary
- With the probability of extending burst errors as given on the previous page, BER = 10^{-12}, and a packet size of 1500B, the probability of this occurring is 8×10^{-21}
- This translates to an MTTFPA of 3.4×10^{17} years (much greater than the lifetime of the universe)
- Other double burst errors scenarios (that are not 100% detectable) are orders of magnitude less likely
- Any triple burst errors that are not 100% detectable are many orders of magnitude less likely than the above two burst scenario
- Therefore, the 2,4 burst error dominates the MTTFPA

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 time the lifetime of the universe
- Even with DFE and not very good channels for a 40GE backplane application, and no FEC, the MTTFPA is very good using MLD
  - Many times the lifetime of the universe