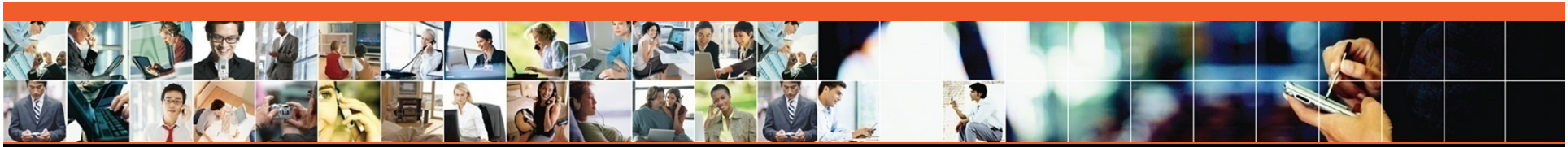

Analysis of Link Budget for 3m Cable Objective

IEEE 802.by Task Force – Jan 2015

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Objective

- Quantify BER targets to meet MTTFPA and FER objectives in the presence of DFE error propagation
- Analyze the total Insertion Loss budget for the 3m cable objective with no FEC, CL-74 FEC, and CL-91 FEC
- Translate FEC coding gain to delta in Insertion Loss

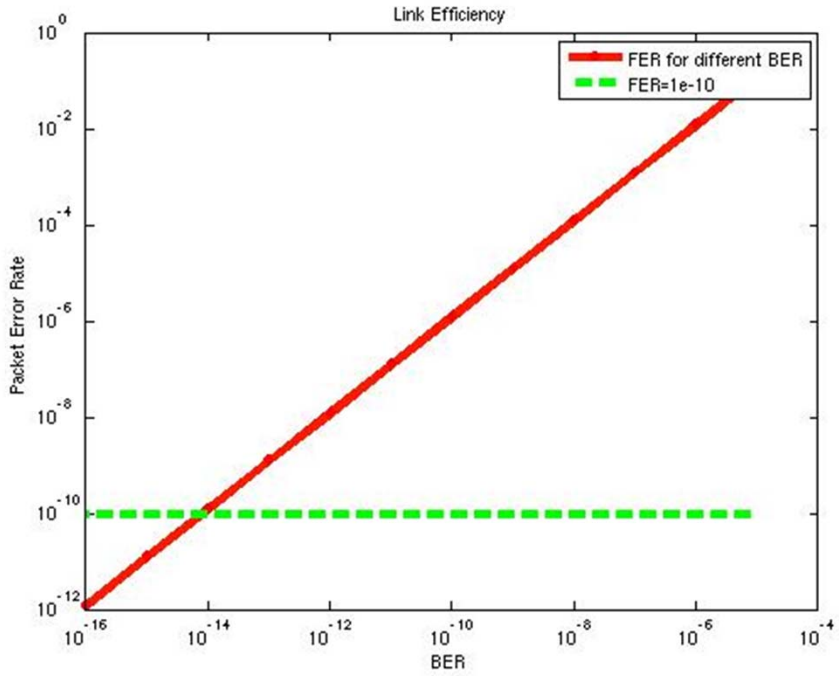
Impact of error propagation

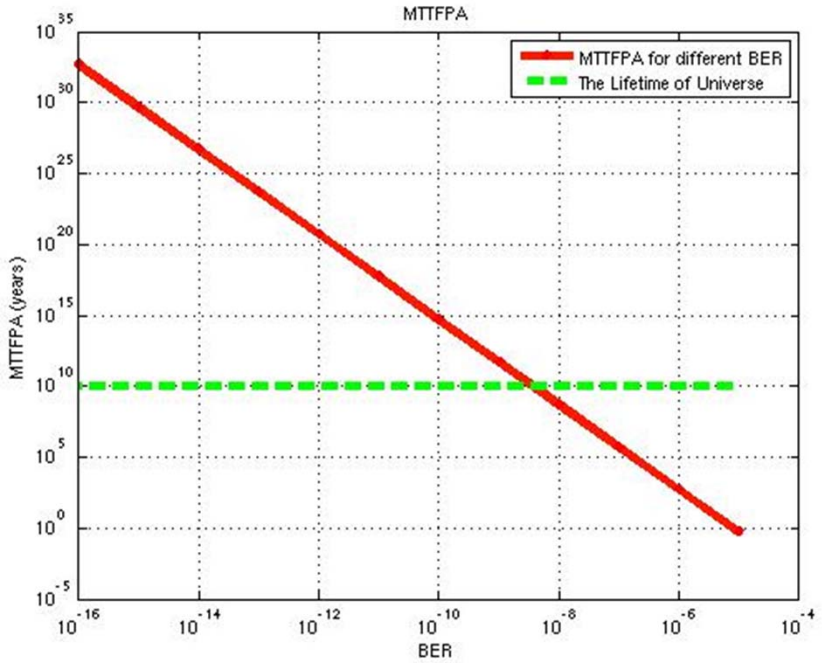
- BER required to meet specific MTTFPA and FER targets impacted by DFE error propagation
- FEC coding gain reduced due to DFE error propagation
  - Reduction in gain varies for different FEC types
- DFE error propagation computed assuming a channel insertion loss of 25dB
  - Higher insertion loss channels will require larger DFE tap values, resulting in lower BER requirements to meet MTTFPA and FER targets

Capabilities of CRC32, CL-74 FEC and CL-91 FEC

- **IEEE 802.3 CRC32 has hamming distance of 4, and can detect following errors in a packet**
  - Three random errors
  - Two 8-bit burst
  - One 32 bit burst
  - PRBS58 scrambling does not affect CRC32 error detection capability
- **CL-74 KR FEC: (2112,2080) Binary burst error correction code**
  - Corrects a single burst up to 11 bits
- **CL-91 KR4 FEC: RS(528,514) over GF(2^{10})**
  - Corrects up to seven 10-bit symbols
  - Mode A: Performs both error correction and decode failure check
  - Mode C: Does only error correction without decode failure check for lower latency

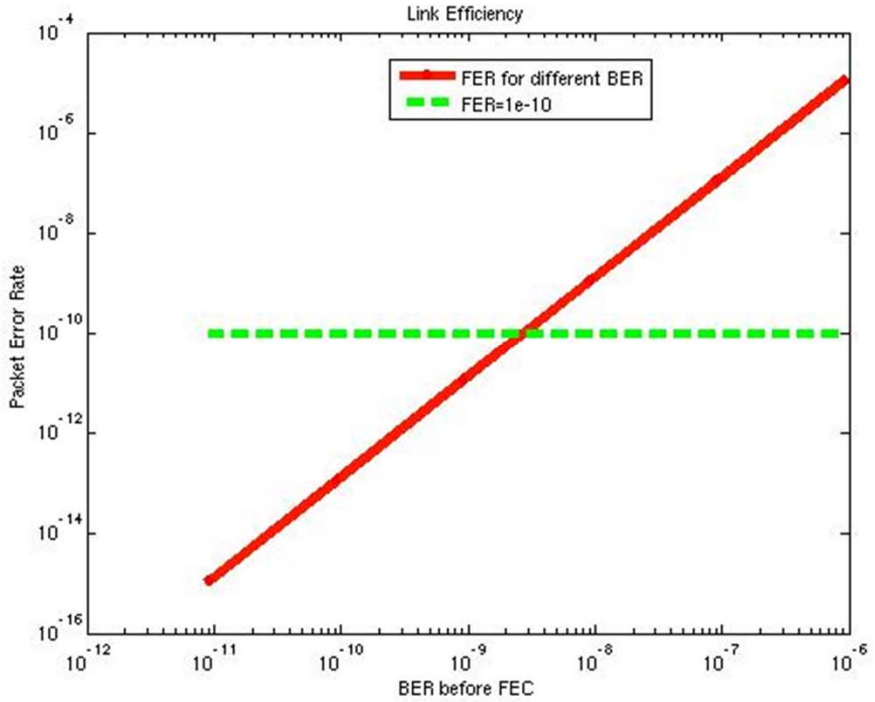
FER and MTTFPA without FEC

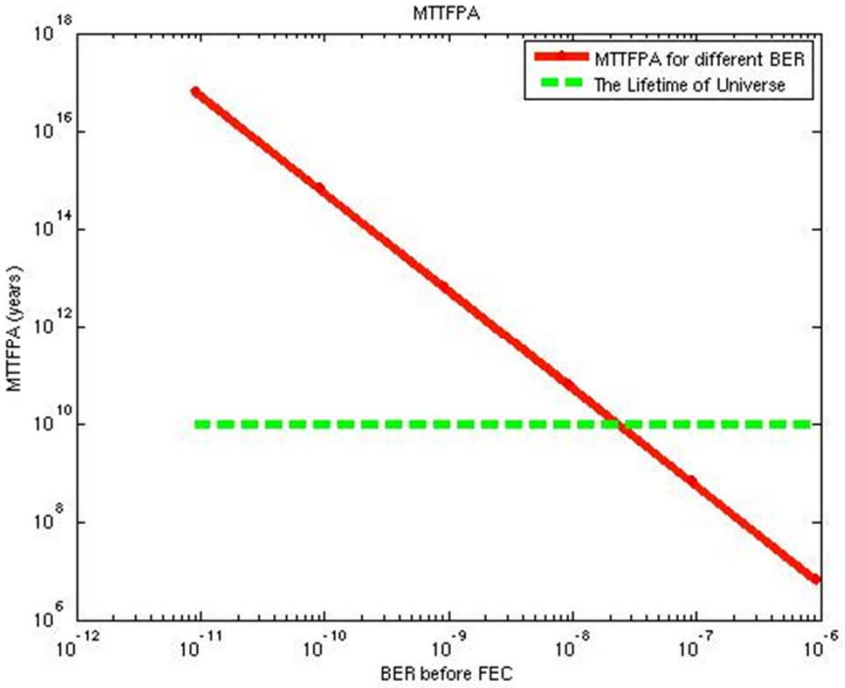




- **BER needs to be 1E-14 to achieve MTTFPA=1.3E10 years and FER=1E-10**
- **BER needs to be 1E-16 to achieve MTTFPA=1.3E10 years and FER=1E-12**

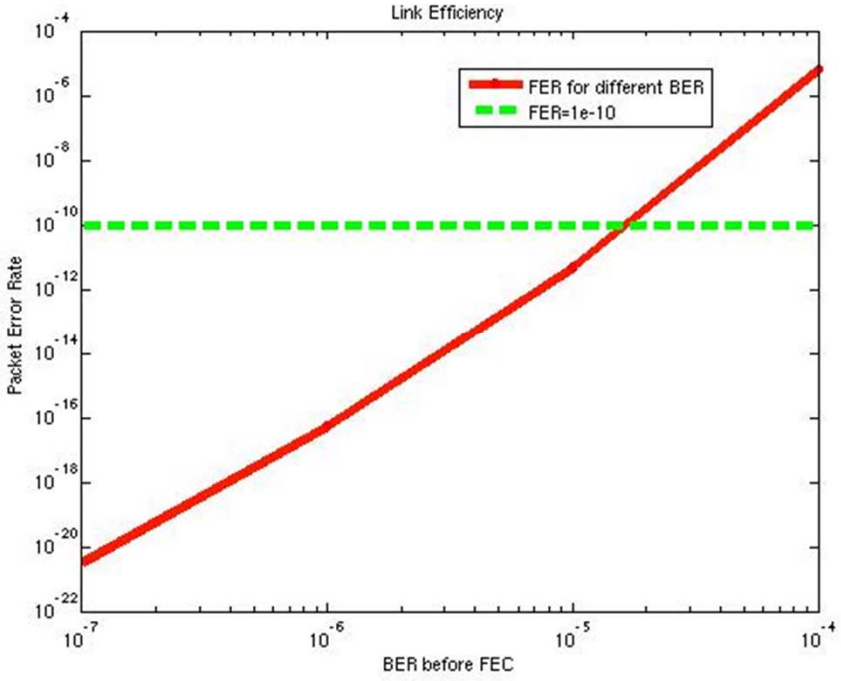
FER and MTTFPA with CL-74 FEC

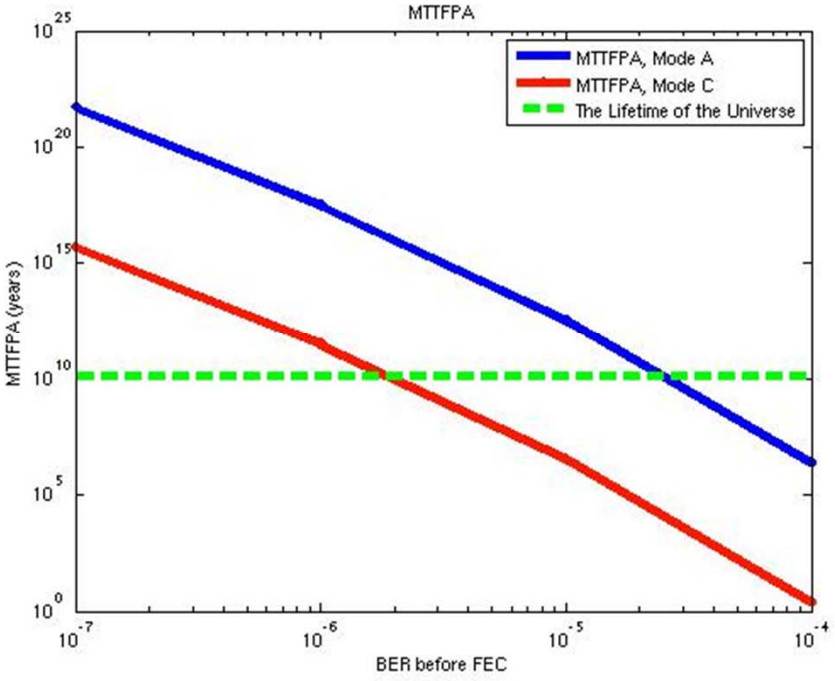




- **BER before FEC needs to be 2E-9 to achieve MTTFPA=1.3E10 years and FER=1E-10**
- **BER before FEC needs to be 2E-10 to achieve MTTFPA=1.3E10 years and FER=1E-12**

FER and MTTFPA with CL-91 FEC





- **BER needs to be 1E-5 for Mode A and 2E-6 for Mode C to meet MTTFPA=1.3E10 years and FER=1E-10**
- **BER needs to be 7E-6 for Mode A and 2E-6 for Mode C to meet MTTFPA=1.3E10 years and FER=1E-12**

Summary of BER requirements to meet FER and MTTFPA targets

- **To meet FER of 1E-10 and MTTFPA of 1.3E10 years**

FEC Scheme	No FEC	KR FEC	KR4 FEC (Mode C)	KR4 FEC (Mode A)
BER Requirement	1E-14	2E-9	2E-6	1e-5
SNR Requirement (dB)	17.7	15.4	13.3	12.4

- **To meet FER of 1E-12 and MTTFPA of 1.3E10 years**

FEC Scheme	No FEC	KR FEC	KR4 FEC (Mode C)	KR4 FEC (Mode A)
BER Requirement	1E-16	2E-10	2E-6	7e-6
SNR Requirement (dB)	18.3	15.9	13.3	12.8

Analysis of Link Budget for 3m cable objective

- **Find the total fitted insertion loss for a 3m cable assembly[1] for the different FEC options, using the COM model**
  - **Case 1: No FEC, in the presence of moderate error propagation**
  - **Case 2: CL-74 FEC, in the presence of moderate error propagation**
  - **Case 3: CL-91 FEC, in the presence of moderate error propagation**
- **Translate removal of FEC coding gain to loss in Insertion Loss**
- **Identify host loss budget for a 3m cable assembly**

1. Amphenol 3m QSFP to Quad SFP cable data provided by Erdem Matoglu used for the analysis

Amphenol 3m, P1RX1

Amphenol, 3m, P1RX1 (4 NEXT, 1 FEXT)					
DER	**Z_p (TX & RX)**	**Z_bp (TX)**	**Z_bp (RX)**	**Fitted IL at Nyquist (dB) (TP0 to TP5)**	**COM (dB)**
1E-14 (No FEC)	12mm (0.93dB)	125mm (5.2dB)	125mm (5.2dB)	25.3	3.1
2E-9 (CL-74 FEC)	12mm (0.93dB)	210mm (8.6dB)	210mm (8.6dB)	32.2	3.1
1E-5 (CL-91 FEC)	12mm (0.93dB)	293mm (11.9dB)	293mm (11.9dB)	38.7	3.1

- **Coding gain of CL-91 FEC corresponds to IL difference of 13.4dB compared to no-FEC**
- **Coding gain of CL-74 FEC corresponds to IL difference of 6.9dB compared to no-FEC**
- **Without FEC, host loss budget limited to 5.2dB**

Amphenol 3m, P1RX2

Amphenol, 3m, P1RX2 (4 NEXT, 1 FEXT)					
DER	**Z_p (TX & RX)**	**Z_bp (TX)**	**Z_bp (RX)**	**Fitted IL at Nyquist (dB) (TP0 to TP5)**	**COM (dB)**
1E-14 (No FEC)	12mm (0.93dB)	149mm (6.2dB)	149mm (6.2dB)	27.4	3.1
2E-9 (CL-74 FEC)	12mm (0.93dB)	222mm (9.1dB)	222mm (9.1dB)	33.2	3.1
1E-5 (CL-91 FEC)	12mm (0.93dB)	298mm (12.1dB)	298mm (12.1dB)	39.2	3.1

- **Coding gain of CL-91 FEC corresponds to IL difference of 11.8dB compared to no-FEC**
- **Coding gain of CL-74 FEC corresponds to IL difference of 5.8dB compared to no-FEC**
- **Without FEC, host loss budget limited to 6.2dB**

Amphenol 3m, P1RX3

Amphenol, 3m, P1RX3 (4 NEXT, 1 FEXT)					
DER	**Z_p (TX & RX)**	**Z_bp (TX)**	**Z_bp (RX)**	**Fitted IL at Nyquist (dB) (TP0 to TP5)**	**COM (dB)**
1E-14 (No FEC)	12mm (0.93dB)	133mm (5.4dB)	133mm (5.4dB)	25.7	3.1
2E-9 (CL-74 FEC)	12mm (0.93dB)	213mm (8.6dB)	213mm (8.6dB)	32.1	3.1
1E-5 (CL-91 FEC)	12mm (0.93dB)	295mm (11.8dB)	295mm (11.8dB)	38.6	3.1

- **Coding gain of CL-91 FEC corresponds to IL difference of 12.9dB compared to no-FEC**
- **Coding gain of CL-74 FEC corresponds to IL difference of 6.4dB compared to no-FEC**
- **Without FEC, host loss budget limited to 5.4dB**

Amphenol 3m, P1RX4

Amphenol, 3m, P1RX4 (4 NEXT, 1 FEXT)					
DER	**Z_p (TX & RX)**	**Z_bp (TX)**	**Z_bp (RX)**	**Fitted IL at Nyquist (dB) (TP0 to TP5)**	**COM (dB)**
1E-14 (No FEC)	12mm (0.93dB)	140mm (5.7dB)	140mm (5.7dB)	26.4	3.1
2E-9 (KR FEC)	12mm (0.93dB)	220mm (8.9dB)	220mm (8.9dB)	32.7	3.1
1E-5 (KR4 FEC)	12mm (0.93dB)	296mm (11.9dB)	296mm (11.9dB)	38.7	3.1

- **Coding gain of CL-91 FEC corresponds to IL difference of 12.3dB compared to no-FEC**
- **Coding gain of CL-72 FEC corresponds to IL difference of 6.3dB compared to no-FEC**
- **Without FEC, host loss budget limited to 5.7dB**

Summary

- Impact of DFE error propagation on MTTFPA & FER targets must be considered
- Mapping from FEC coding gain to IL budget delta not a one to one mapping
- Host loss budget consistent with 802.3BJ budget of 6.81dB may not be feasible for a 3m cable assembly, without FEC

THANK YOU