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Shannon capacity targets: Effects of coding loss and margin

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Motivation

- Several target Shannon capacity values have been discussed so far
  - As low as 14.5Gbps and as high as 20Gbps
- Multiple coded modulation signaling architectures have been discussed so far
  - Modulation: 8PAM, 10PAM, 12PAM, etc.
  - Coding: TCM, LDPC, RS+TCM, etc.
- This presentation compares the effects of coding and margin on the target Shannon capacity while normalizing other factors out.

Shannon Capacity

- A good transceiver design will convert the 10GBT channel into an (approx) AWGN channel.
  - Total noise includes residual ISI, residual Xtalk, thermal noise, quantization noise, jitter, etc.
- Shannon capacity for an ideal 4D AWGN channel
  - $C = 2*F_s*\log_2(1+S_{eq}/N_{tot})$ bits per second,
    - S_{eq} is the equivalent signal
    - N_{tot} is the total noise
    - F_s is the sampling or baud rate

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Data rate with Coding Loss

- Shannon's capacity expression applies to an optimal coded modulation scheme with optimal decoding.
  - All practical coded modulation schemes and decoders have "coding loss" relative to Shannon capacity
  - The term "coding gain" is relative to the uncoded modulation
- Practical data rate with coding loss
  - Rate = $2 * F_s * \log_2(1+S_{eq}/(N_{tot} * L_{BER}))$
  - L(BER) is the Loss relative to capacity and depends on the coded modulation scheme and on the target BER.
  - For uncoded PAM and BER=1e-12, L_{BER}~12dB
  - LDPC 8/12PAM, L_{BER}~4dB, TCM 10PAM, L_{BER}~8dB
- The ratio S_{eq}/N_{tot} must be increased by L_{BER} to account for coding loss

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Data Rate w/ Coding Loss and Margin

- Not all transceiver impairments are included in (most) current 10GBT capacity estimates
- To account for additional impairments we include margin
  - $N_{tot} = N_{incl} + N_{other} = N_{incl}$*Margin
  - The term N_{other} can include residual ISI, Xtalk, quantization, jitter, etc.
  - The required Margin depends on how many impairment terms are included in N_{incl}
  - Margin values of 3dB to 9dB have been considered
- Practical data rate with margin and coding loss
  - $\text{Rate} = 2 * F_s * \log_2(1+S_{eq}/(N_{incl} * \text{Margin} * L_{BER}))$
- The ratio S_{eq}/N_{incl} must be increased by Margin*L_{BER} to account for margin and coding loss

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Shannon Capacity Target

- Target Shannon Capacity (high SNR approx)
  - $TSC = 10G + 2 * F_s * [\log_2(Margin) + \log_2(L_{BER})]$
- For Fs = 900MHz we can use the following rules of thumb:
  - For each 1dB of margin required, the Shannon capacity target increases by 0.6Gbps
  - For each 1dB improvement of the FEC the Shannon capacity target drops by 0.6Gbps
- Rao’s LDPC proposal requires 2.4Gbps lower Shannon capacity target than the 4D-8 state TCM proposal (for the same margin).

Target Shannon Capacity

- The required Margin depends on how many impairment terms are included in N_{incl}
- Assuming 900MHz baud rate and 6dB margin
  - Rao's LDPC proposal requires about 16Gbps
  - 4D-8state TCM proposal requires about 18.5Gbps
- For other values of margin see the table below

			Margin (dB)			
			0.0	3.0	6.0	9.0
Coding Loss (dB)	Shannon	0.0	10.0	11.8	13.6	15.4
	LDPC	3.8	12.3	14.1	15.9	17.7
	TCM	8.0	14.8	16.6	18.4	20.2