

T e c h n o l o g y t o t h e C o r e

10GBASE-T: How much capacity is enough?

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Problem Statement

- Is 10G bit/sec over CAT5/CAT6 feasible ?
- Suppose that capacity calculation of CAT5 cable yield C bit/sec/Hz
 - If $C < 10G \rightarrow$ not feasible
 - A question that arise naturally: For what value of C will people feel that it is feasible
 - In this presentation a method for evaluating this is provided

Capacity Limit Line

- Denote by:
 - W the one sided bandwidth
 - $N_0/2$ the noise spectral density (double sided)

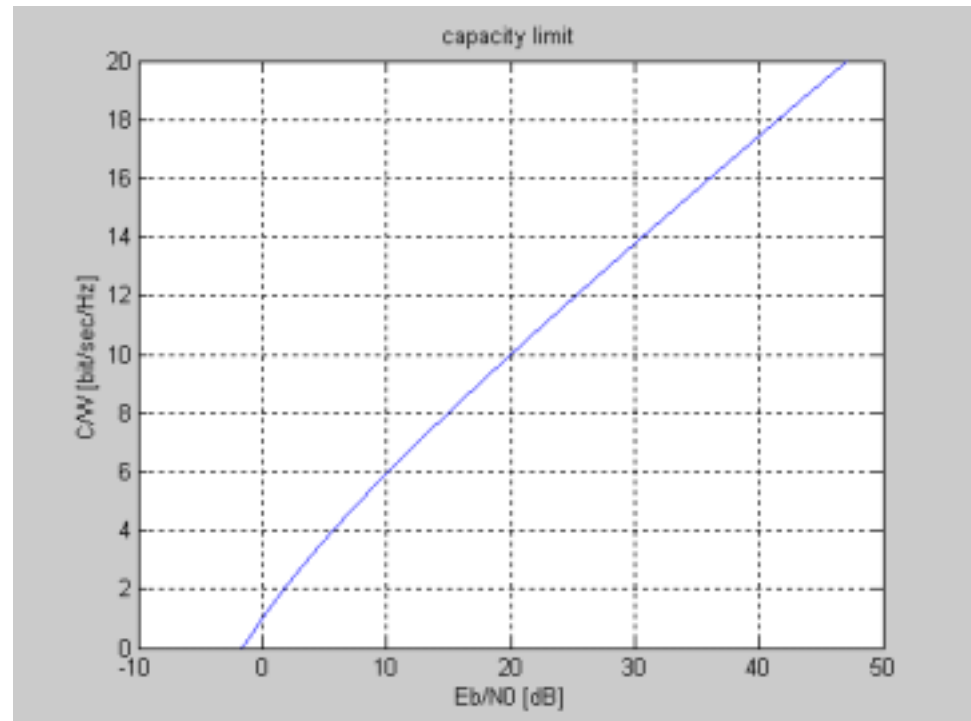
- Capacity:

$$C = W \log_2 \left(1 + \frac{S}{N} \right)$$

$$\frac{S}{N} = \frac{E_b \cdot C}{N_0 \cdot W} = \frac{E_b}{N_0} \frac{C}{W}$$

$$\frac{C}{W} = \log_2 \left(1 + \frac{E_b}{N_0} \frac{C}{W} \right)$$

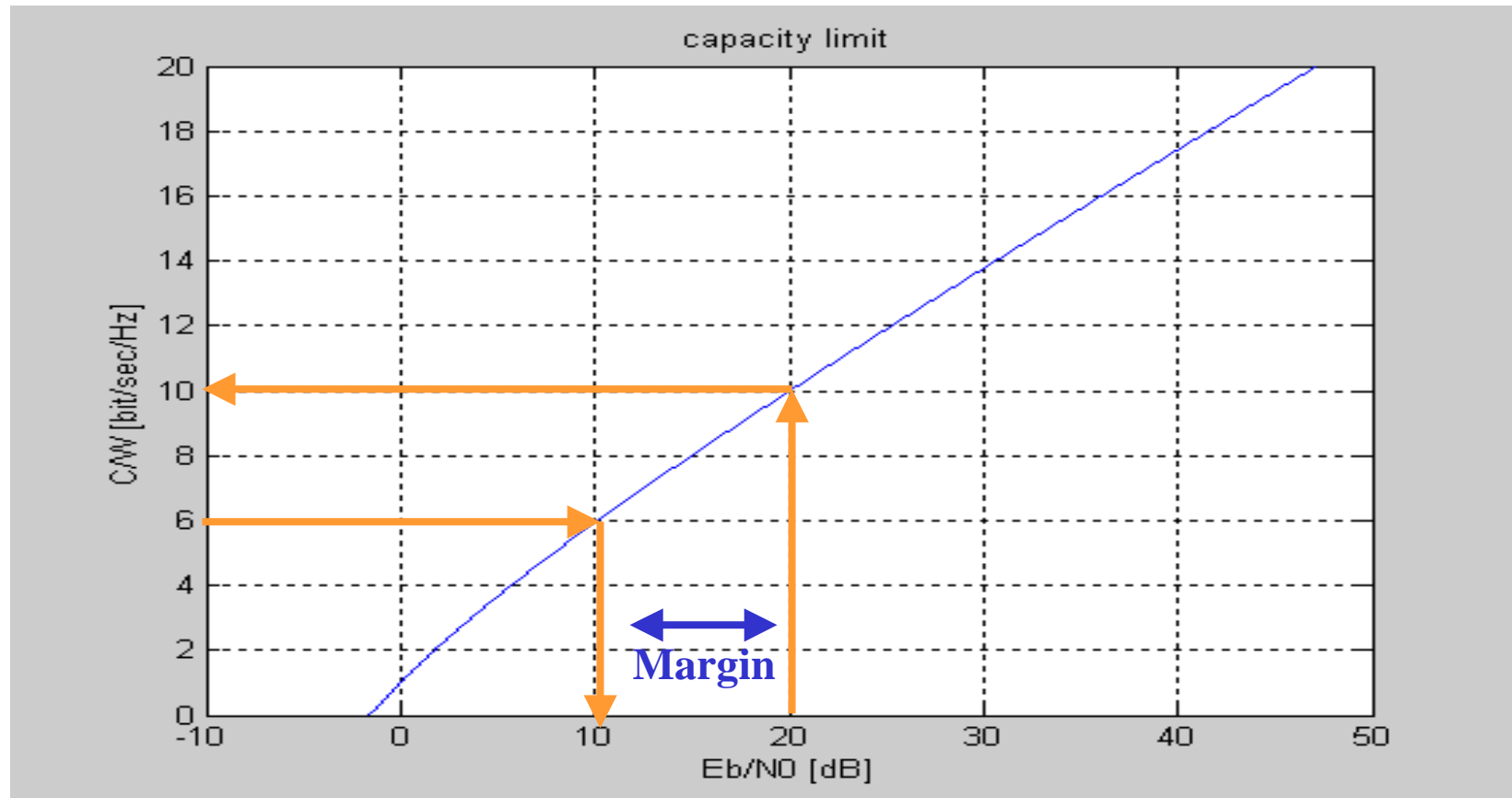
$$\Rightarrow \frac{E_b}{N_0} = \frac{2^{\left(\frac{C}{W}\right)} - 1}{\left(\frac{C}{W}\right)}$$



10GBASE-T Operating Point

- 10Gbit/sec rate
- 4*416MHz bandwidth
- →6 bit/sec/Hz

Adding Margin



Example for Computing Target Capacity

- The required E_b/N_0 for 6bit/sec/Hz is : 10dB
- Assume Margin: 10dB
- →Target 10bit/sec/Hz
- →Target Capacity : $10G * 10/6 = \mathbf{16.6Gbit/sec}$

Why 15dB Margin

- Using good code (Turbo code): 2dB
 - Delay probably unacceptable
- No shaping done : 1.5 dB
- Non-perfect equalization : 3dB
- Jitter 5dB (guess)
- Analog impairments: 3dB
- Total=14.5dB → **15dB**
- **Subjective**

Target Capacity for Various Margins

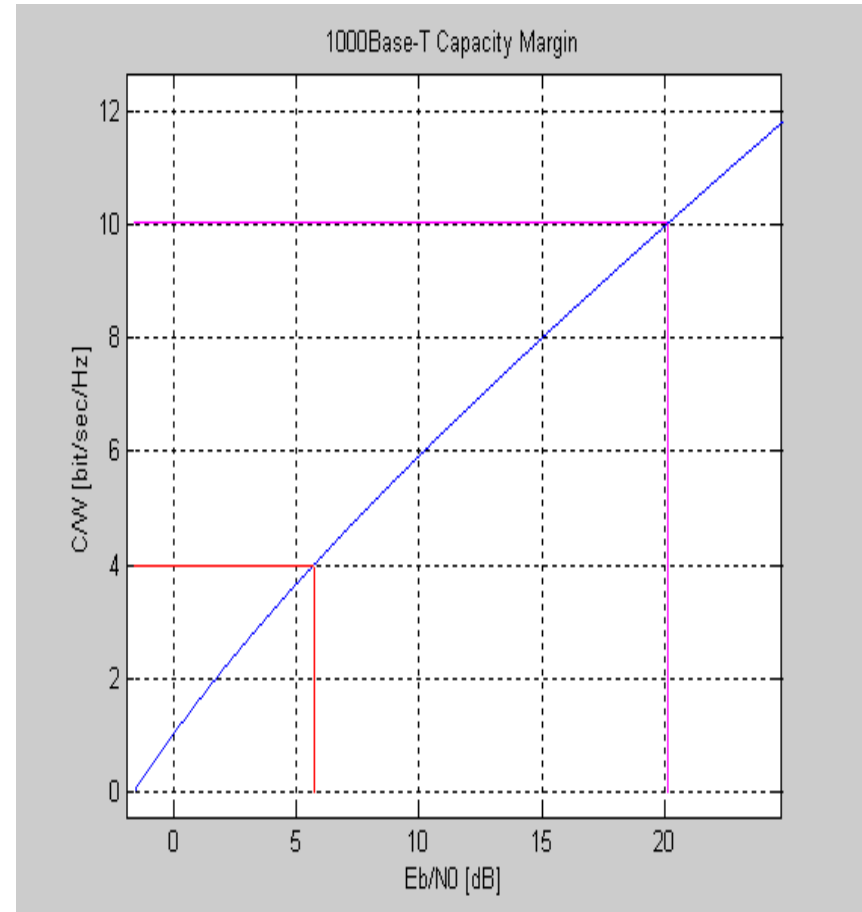
Margin [dB]	Capacity factor	Target Capacity [bit/sec]
6	1.41	14.1
9	1.61	16.1
10	1.65	16.5
12	1.80	18.0
15	1.96	19.6
20	2.30	23.0

How does this fit on 1000Base-T ?

- Assumptions
 - Echo canceling –35 dB
 - Next canceling – 20 dB
 - Fext canceling – none
 - AWGN - -140dBm/Hz
 - Launch power – 10dBm
- Resulting Capacity = 2.5 Gbit/sec

How does this fit on 1000Base-T ? – Cont'd

- Target Rate – 1Gbit/sec
 - 4bit/sec/Hz
- Capacity for CAT5
 - 2.5Gbit/sec
 - 10bit/sec/Hz
- Margin = 14.4dB



Summary & Conclusions

- A method to introduce margin into the capacity requirements was shown
- Reasonable estimate for margin was provided
- The amount of margin is a value judgment
- From 1000Base-T it seems that a 15dB margin is not unreasonable
- Capacity goal that should be targeted: [18-20] Gbit/sec