10GE WAN PHY Delineation Performance

Bijan Raahemi	Nortel Networks
David W. Martin	Nortel Networks
Iain Verigin	PMC-Sierra
Tom Palkert	AMCC
Pankaj Kumar	Level One/Intel

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http://grouper.ieee.org/groups/802/3/10G_study/public/email_attach/delineation_perf.doc

Agenda

- **Delineation Performance Parameters**
- **10GE WAN PHY Review**
- **10GE WAN PHY Delineation**
  - Framer Performance
  - Pointer Processing Performance
  - Encapsulation Performance
  - Combined Delineation Performance
  - Frame Throughput

Delineation Performance Parameters

- **Delineation performance is calculated using the following statistics:**
  - **Mean Time To Frame (MTTF)**
  - **Probability of Loss of Frame (PLF) & Mean Time To Frame Loss (MTTFL)**
  - **Probability of False Framing (PFF)**
  - **Probability of Rejecting False Frame (PRFF)**

Schemes	Mean Time To frame	Prob. of Frame Loss	Mean Time to Frame Loss	Prob. of False Framing	Prob. of Rejecting False Frame
10GE WAN PHY	254.4 µsec	9.56×10^{-21}	0.7 million years	2.23×10^{-30}	0.9995
10GE 8B/10B	1.2 µsec	2×10^{-11}	4.5 hours	0	Not Applicable

Summary of 10GE WAN PHY and 8B/10B delineation performance

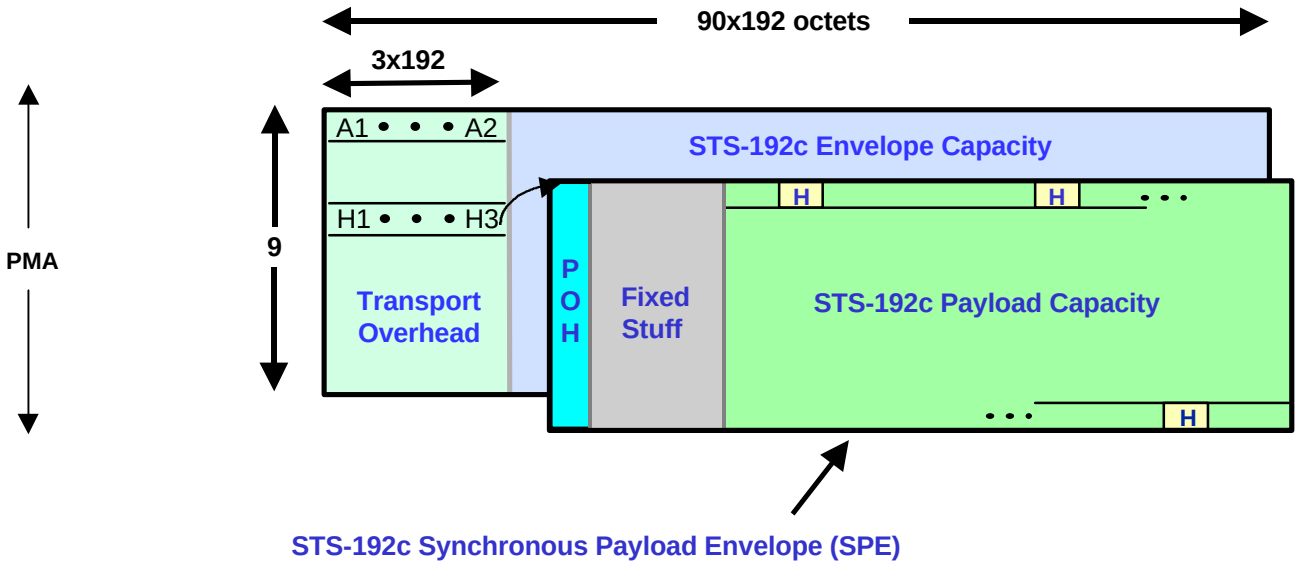
(BER = 10^{-12}, SONET Link Rate = 10 Gbps, 8B/10B Link Rate = 12.5 Gbps, Avg Packet Size = 500 bytes).

10GE WAN PHY Review

Delineation Steps

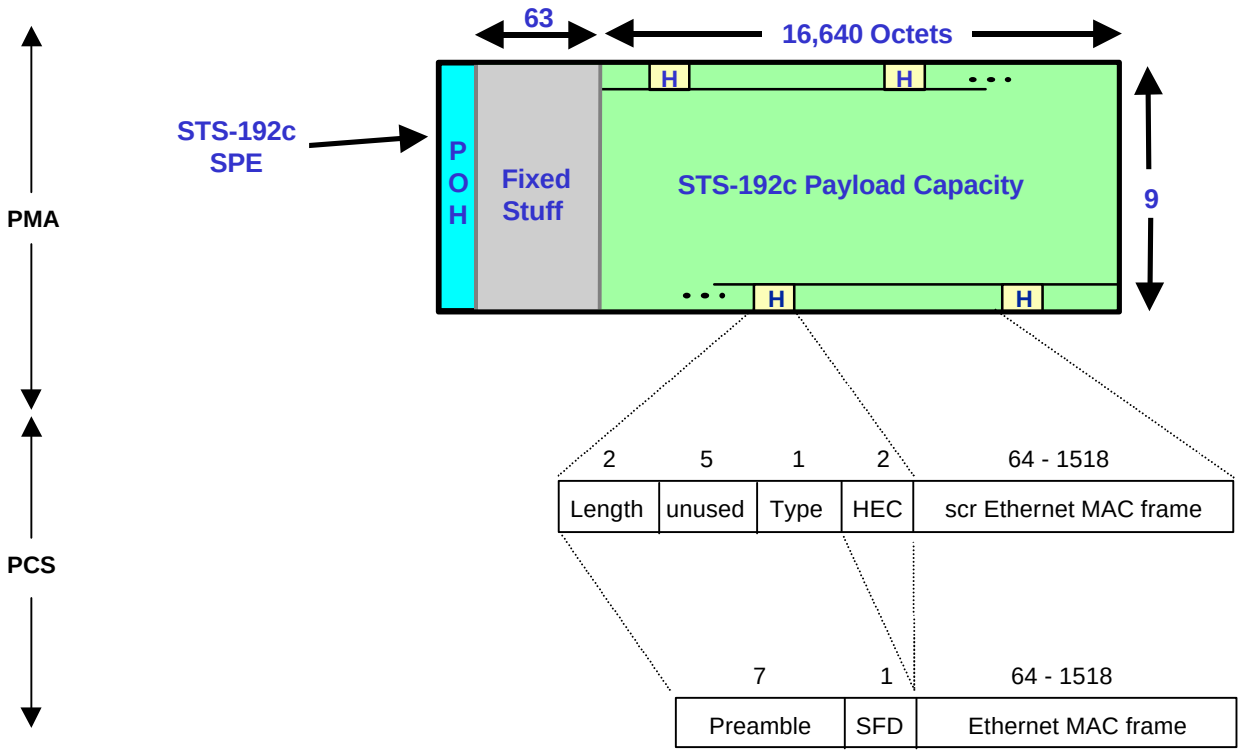
1) Find SONET frame

2) Pointer processing to locate start of payload envelope

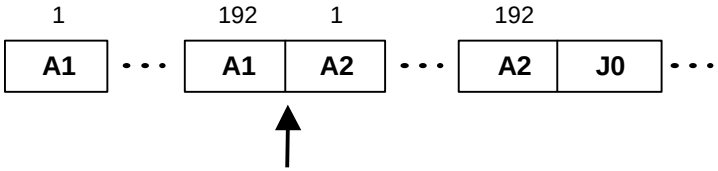


10GE WAN PHY Review (cont'd)

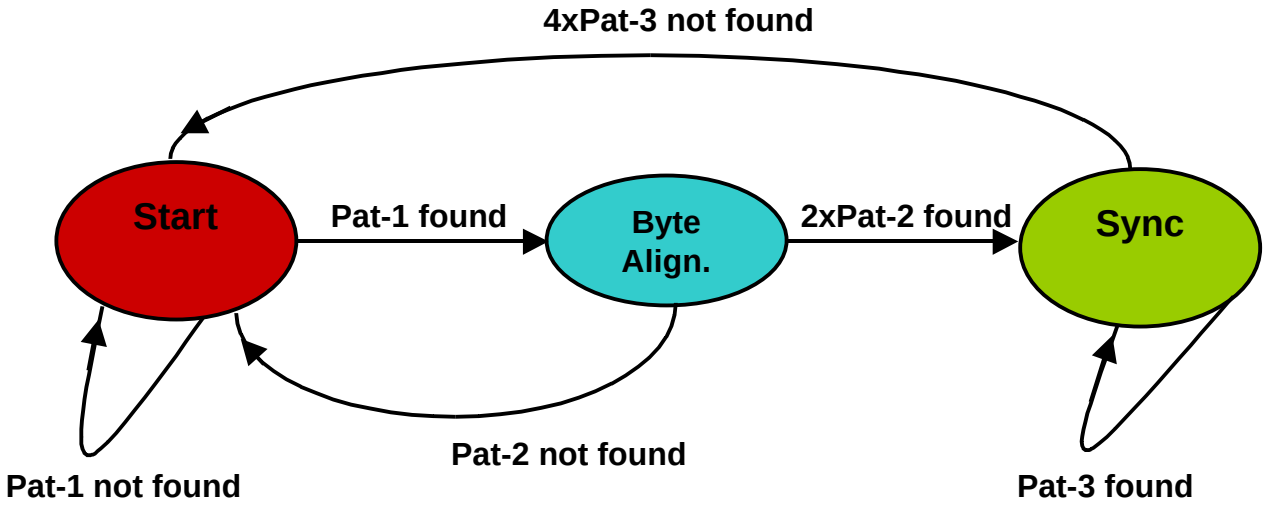
3) Delineation of encapsulated MAC frames



10GE WAN PHY Delineation: SONET Framer



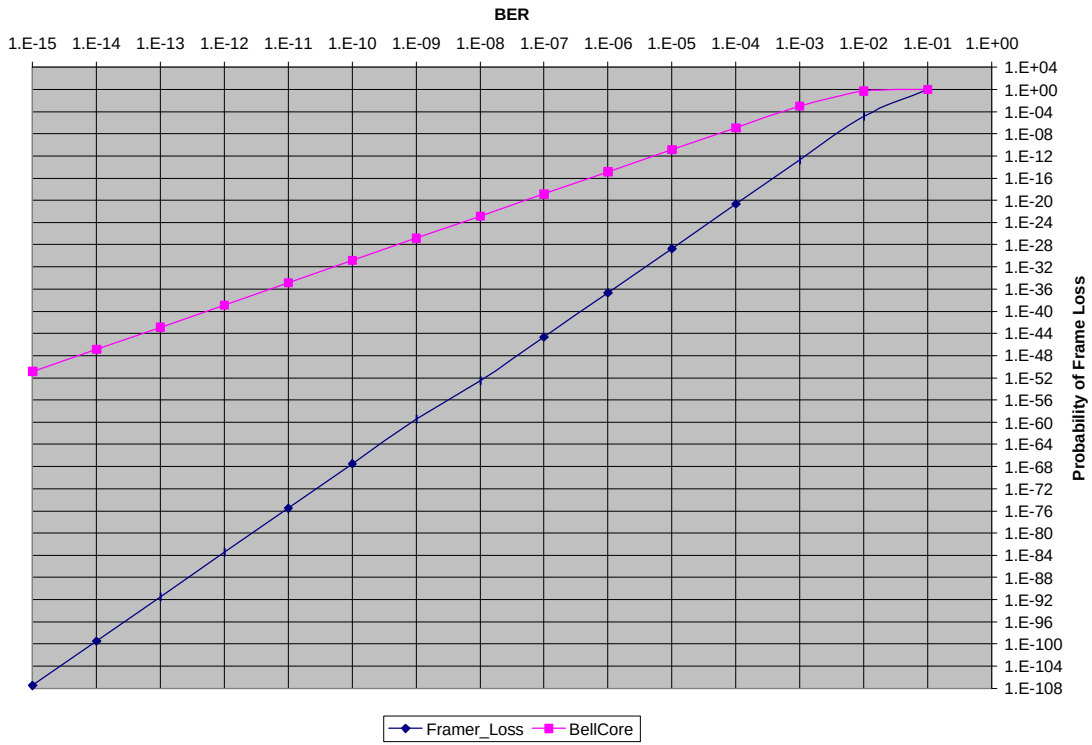
Pat-1: subset of A1s, exact match
Pat-2: A1/A2 transition, exact match
Pat-3: A1/A2 transition, single-bit error tolerant
A1 = F6 (hex)
A2 = 28 (hex)



10GE WAN PHY Delineation: Framer Performance

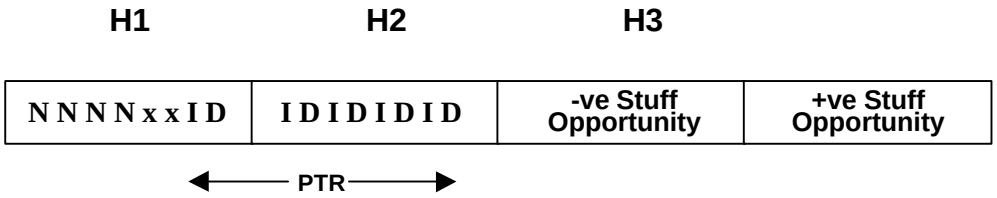
Prob (frame loss due to errors in A1, A2) = $[1 - [(1-BER)^8 + 8 * BER * (1-BER)^7]^{24}]^4$

Prob ≈ $3.26*10^{12} * BER^8$



10GE WAN PHY Delineation: Pointer Processing

- **STS Payload Pointer Coding (H1-3)**



N New Data Flag (nominal value is '0110')

x Unused (nominal value is '00')

I Increment (invert 5-I bits to show Positive Stuff)

D Decrement (invert 5-D bits to show Negative Stuff)

H1-2 = '1001001111111111' indicates concatenation

- **Loss of pointer occurs due to**
  - errors causing a pointer change to be ignored
  - errors emulating a pointer change

10GE WAN PHY: Pointer Processing Performance

Pointer Misdetection

1- Pointer Increment

- **8 of 10 majority vote ⇒ Prob (Inc is misdetected) = 1- Prob(<3 errors in 10 bits)**
- **worst case frequency offset = 100 ppm (Enet) + 20 ppm (SONET) = 120 ppm ⇒ 778 adj/sec**
- **Prob (Inc is misdetected) ≈ 5.84 * BER^3**

2- Pointer Decrement

- **the same as item 1 ⇒ Prob (Dec is misdetected) ≈ 5.84 * BER^3**

3- New Data Flag (NDF)

- **provisioned, happens ≈ once a year (e.g. new payload type) ⇒ Prob(NDF is ignored) ≈ 0**

4- Concatenation Flag is lost if:

- **it is all ones for 3 consecutive frames (i.e. looks like AIS) ⇒ Prob ≈ 0.0001 * BER^{10}**
- **it is anything other than AIS or concatenation flag for 8 consecutive frames ⇒ Prob ≈ 1.5E9 * BER^8**
- **it is a valid pointer value, and remains the same for 3 consecutive frames ⇒ Prob ≈ 1000 * BER^4**

5- New Pointer Value

- **happens ≈ once a year (e.g. protection/restoration) ⇒ Prob(a new pointer value is ignored) ≈ 0**

AIS = Alarm Indication Signal

10GE WAN PHY: Pointer Processing Performance (cont'd)

Pointer Emulation

1- Pointer Increment

- **the 8 of 10 majority vote must be emulated**
- **Prob(Inc emulation) ≈ 10 * BER^3**

2- Pointer Decrement

- **the same as item 1 ⇒ Prob(Dec emulation) ≈ 10 * BER^3**

3- New Data Flag (NDF)

- **need 3 of 4 bits to be in error and the associated pointer value to be a valid number**
- **Prob (NDF emulation) ≈ 3 * BER^3**

4- Concatenation Flag

- **need 3 consecutive matches of the 14-bit concatenation flag (applies to STS-1#1 only)**
- **Prob (Concatenation flag emulation) ≈ 3.7E-9 * BER^9**

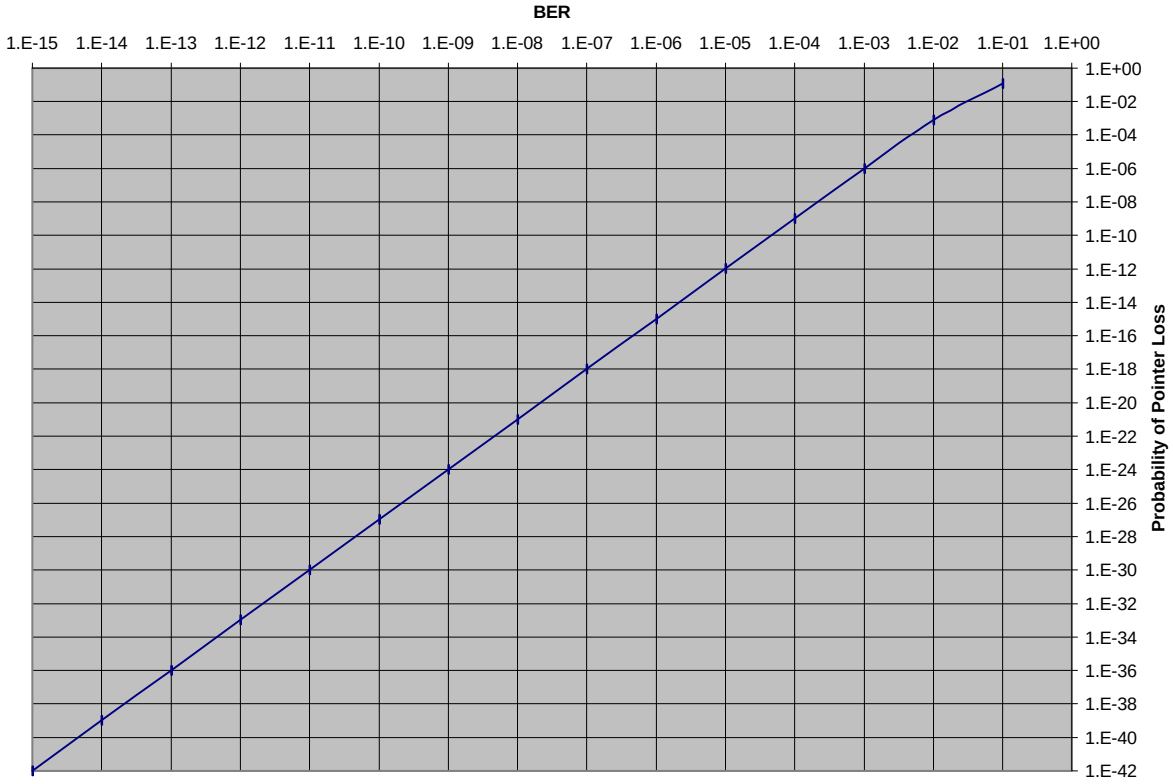
5- New Pointer Value

- **need the pointer value to change and the change to persist for 2 consecutive frames**
- **Prob (New Pointer emulation) ≈ 1E3 * BER^3**

10GE WAN PHY: Pointer Processing Performance (cont'd)

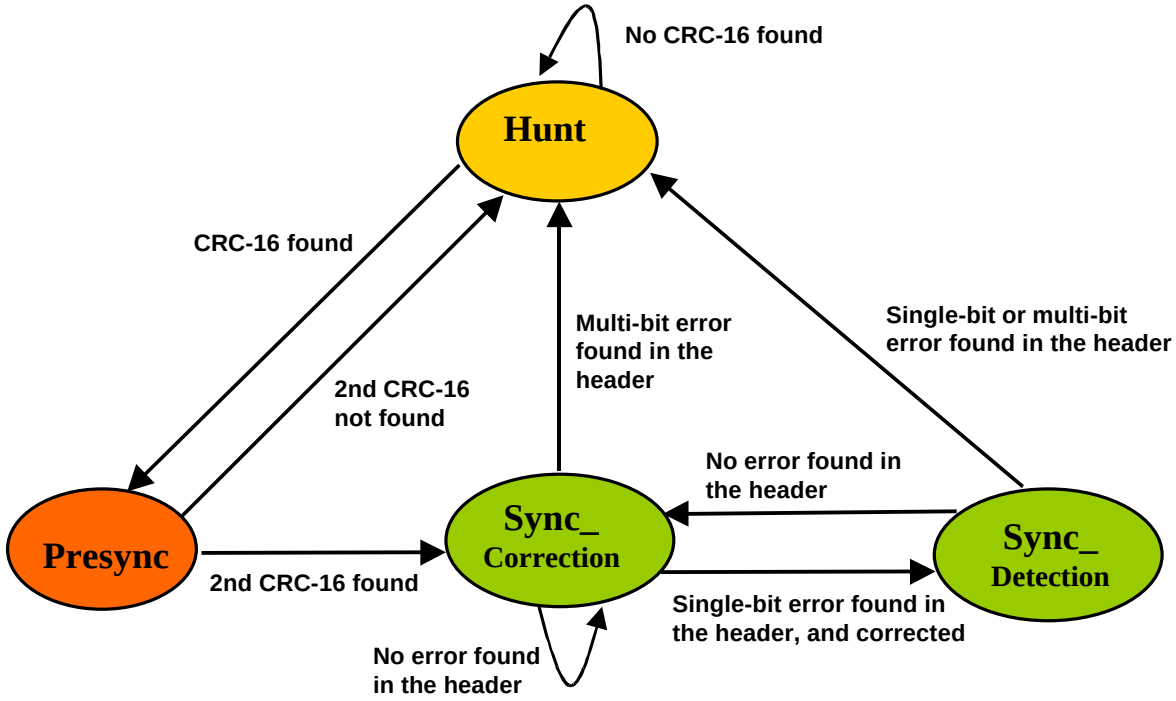
Prob (Pointer Loss) ≈ 5.84 * BER^3 + 5.84 * BER^3 + 0.0001 * BER^{10} + 1.5E9 * BER^8 + 1000 * BER^4 + 10 * BER^3 + 10 * BER^3 + 3 * BER^3 + 3.7E-9 * BER^9 + 1E3 * BER^3

Prob (Pointer Loss) ≈ 1000 * BER^3



10GE WAN PHY Delineation of Encap'd MAC Frames

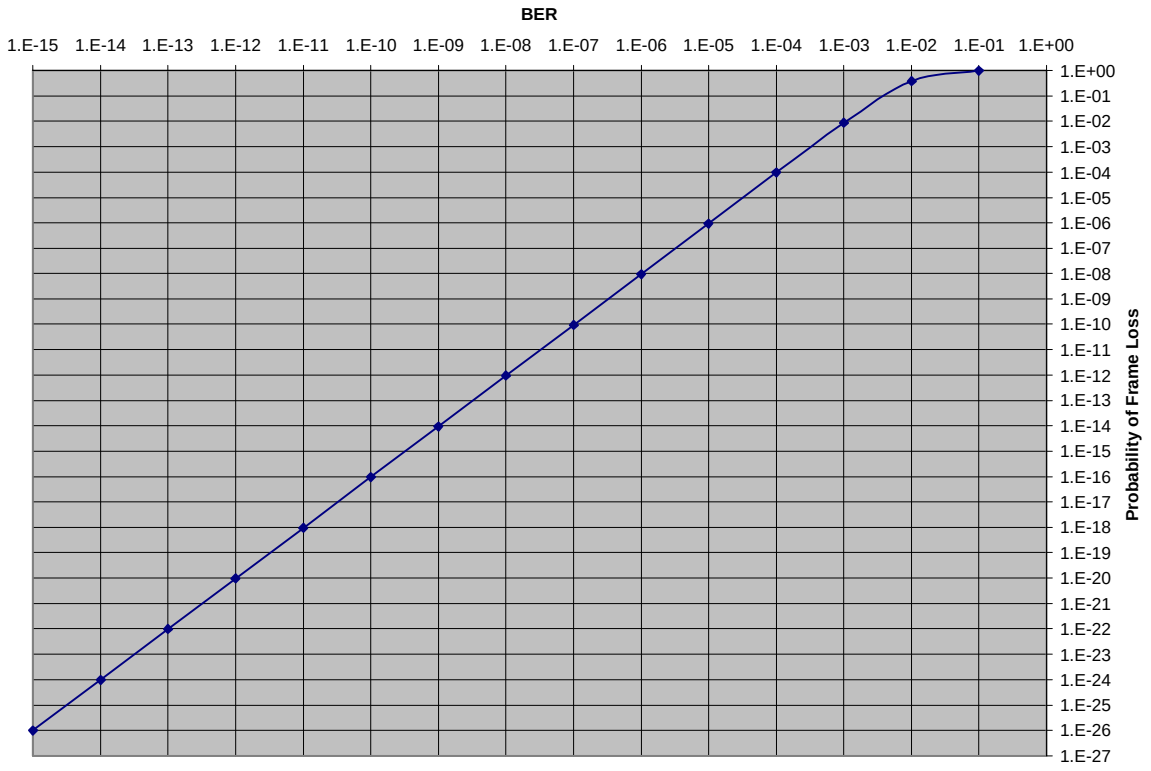
- **Modified version of the Header Error Control (HEC) check algorithm specified in ITU-T I.432.**
- **Two CRC-16 matches are required to move the framer to the Sync_Correction state.**
- **The header length is 10 bytes (CRC-16 is calculated over the first 8 bytes of the header).**
- **Single bit CRC-16 error correction is enabled in the Sync_Correction state.**



Delineation of Encap'd MAC Frames Performance

Prob (frame loss with single bit error correction) = $1 - [(1\text{-BER})^{80} + \binom{80}{1}\text{BER}(1\text{-BER})^{159}]$

Prob ≈ 9560 * BER^2

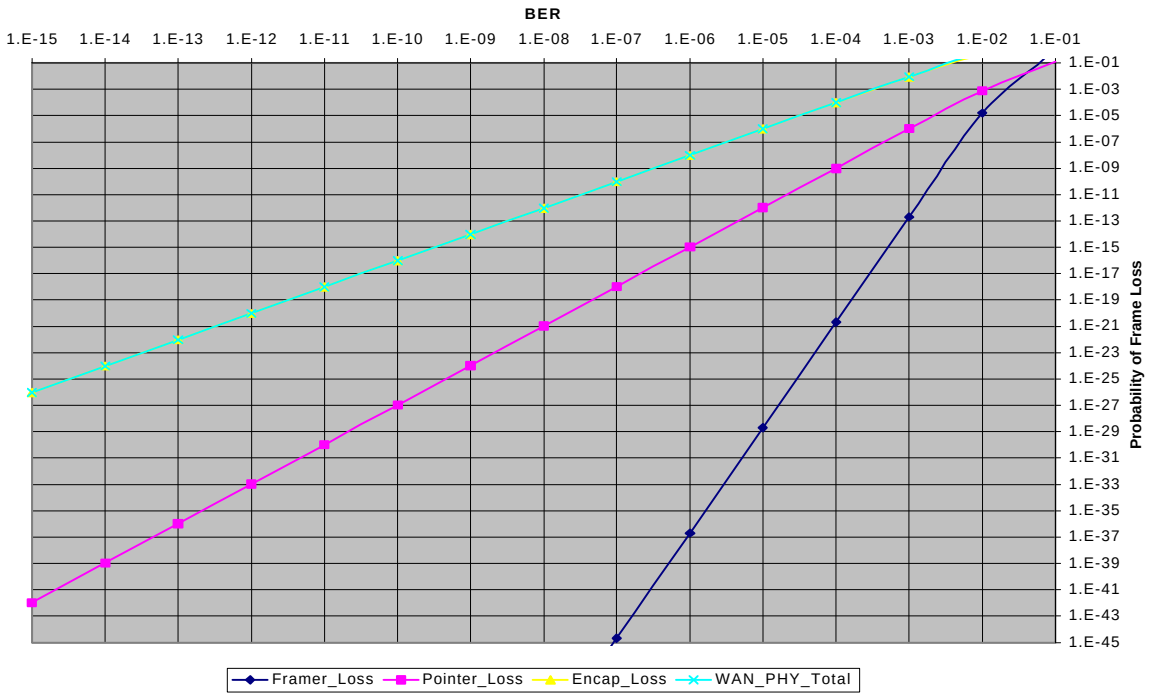


10GE WAN PHY: Combined Delineation Performance

- **Prob (SONET framer loss) ≈ $3.26*10^{12} * BER^8$**
- **Prob (SONET pointer loss) ≈ $1000 * BER^3$**
- **Prob (Encap frame loss) ≈ $9560 * BER^2$**

⇒ Overall performance is dominated by the Encapsulation performance:

$\text{Prob (frame loss)}_{\text{overall}} \approx 9560 * BER^2$



8B/10B Delineation

Special Characters Related To Delineation:

Name	Description	Encoding	10B Code-Word (RD -)	10B Code-Word (RD+)
/I1/	Idle 1	/K28.5/D5.6/	001111 1010 / 101001 0110	110000 0101 / 101001 0110
/I2/	Idle 2	/K28.5/D16.2/	001111 1010 / 011011 0101	110000 0101 / 100100 0101
/R/	Carrier Extended	/K23.7/	111010 1000	000101 0111
/S/	Start of Packet	/K27.7/	110110 1000	001001 0111
/T/	End of Packet	/K29.7/	101110 1000	010001 0111
Preamble	Preamble	/D21.2/	101010 0101	101010 0101
SFD	Start of Frame Delimiter	/D21.6/	101010 0110	101010 0110
Comma	Comma character	/K28.5/	001111 1010	110000 0101

…/I2/I2/I2/S/D21.2/ ……/D21.6/Dx.y/Dx.y/……../R/R/…/R/S/D21.2/ ……/D21.6/Dx.y/Dx.y/……../T/I1/I2

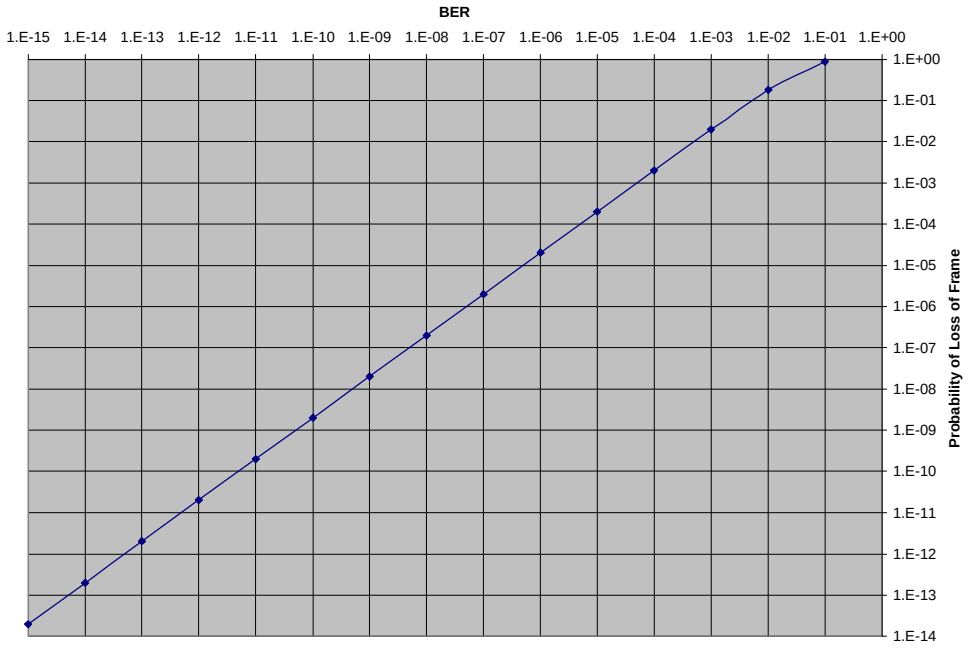
SFD: Start of Frame Delimiter

IFG: Inter Frame Gap

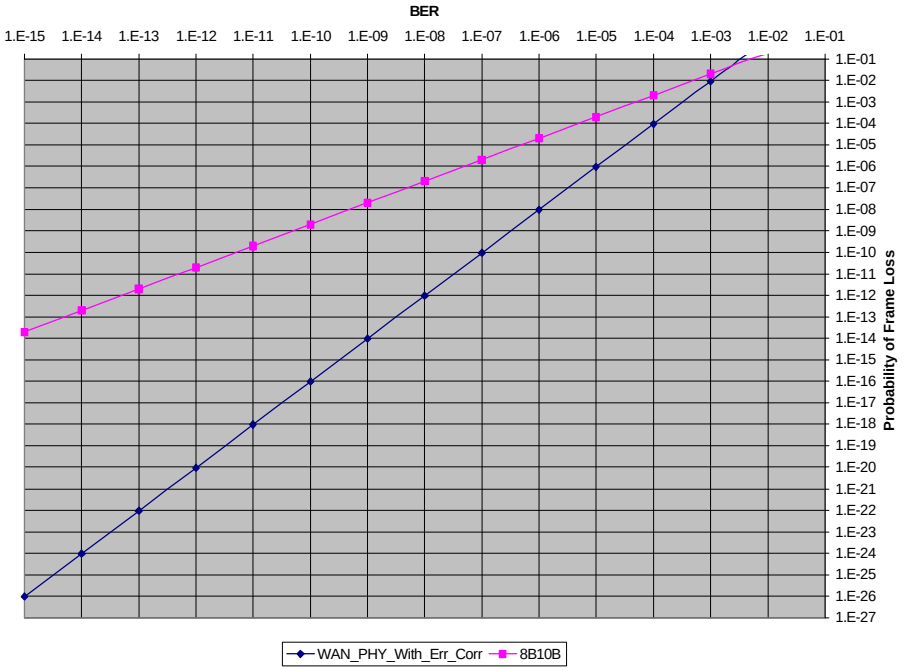
8B/10B Delineation Performance

- **Loss of delineation is due to:**
  - **errors corrupting the delineation characters (/S/, /T/, /R/)**
  - **errors emulating the delineation characters: Single-bit error is detected by the Running Disparity (RD) check, so it can not emulate the delineation flag.**

Prob (frame loss) = 1 – (1-BER)^{20}



10GE WAN PHY vs 8B/10B Delineation Performance



Schemes	Prob. of Frame Loss	Mean Time to Frame Loss
10GE WAN PHY	9.56×10^{-21}	0.7 million years
10GE 8B/10B	2×10^{-11}	4.5 hours

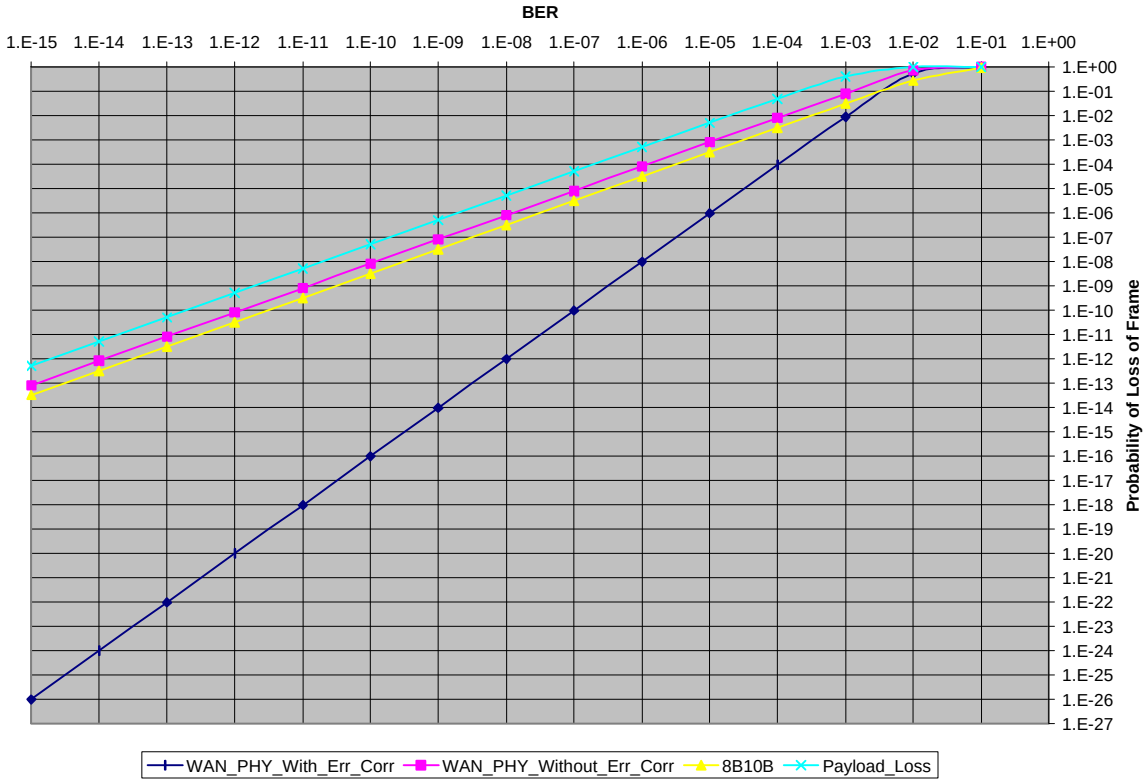
BER=10^{-12}, SONET Link Rate=10Gbps,

8B/10B Link Rate=12.5Gbps, Avg Packet Size=500 bytes

10GE WAN PHY probability of frame loss performance is as robust as 8B/10B

PLF Due To Delineation Error vs Payload Error

- **A frame can be tossed due to a delineation error or a payload error**
- **A well-balanced design should have: PLF (delineation error) < PLF (payload error)**



Frame Throughput

Degradation_In_Thruput = (Number of bits lost) / (Number of bits transmitted)

Degradation_In_Thruput = (K * 1518 * 8) / (MTTFL * BitRate)

K = Number of frames lost from the time delineation is lost until acquired again.

MTTFL = 1 / (PLF * FrameRate)

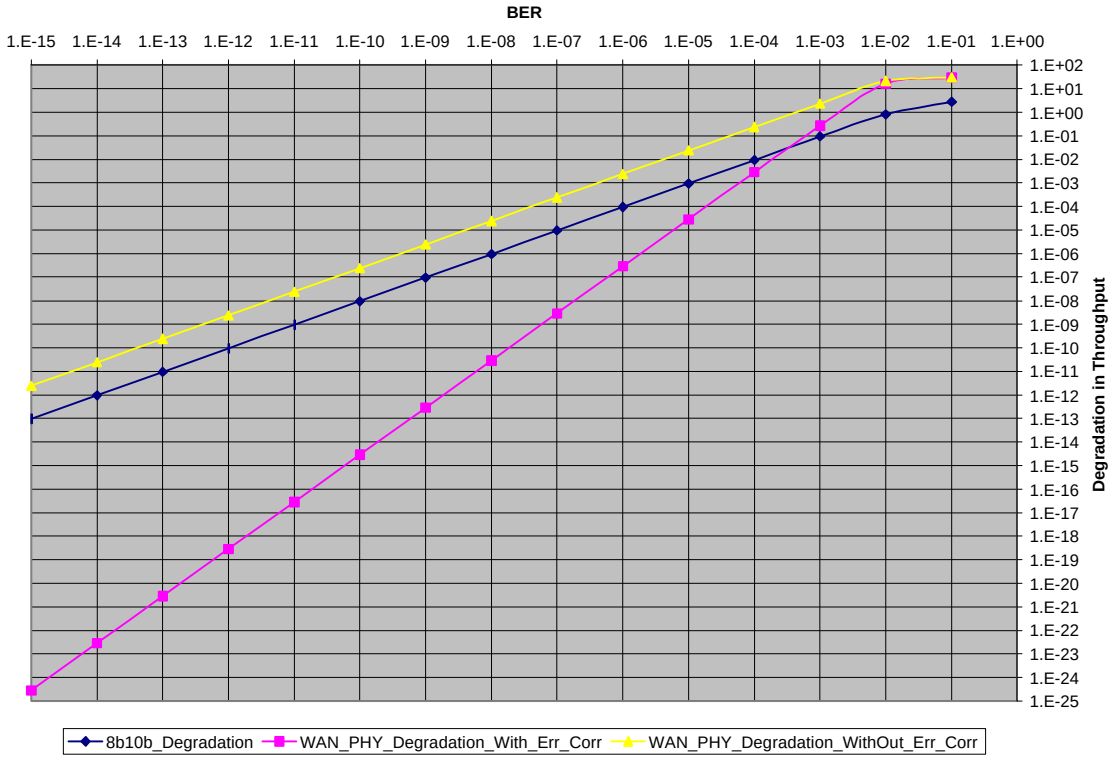
FrameRate = BitRate/AvgFrameLength

Degradation_In_Thruput = (K * 1518 * 8 * PLF) / (AvgFrameLength in bits)

For 10GE WAN PHY $\Rightarrow$ K=5, AvgFrameLength = (500 + 10)/2 = 255 bytes

For 8B/10B $\Rightarrow$ K=1, AveFrameLength = 500 bytes

Frame Throughput (cont'd)



10GE WAN PHY delineation performance with single bit error correction is as good as 8B/10B