Error performance objective for 400GbE

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IEEE 400 Gb/s Ethernet Study Group, Logic Ad Hoc, 7 August 2013

Introduction

The error performance objective adopted for the P802.3ba, P802.3bj and P802.3bm projects was:

"Support a BER better than or equal to 10^{-12} at the MAC/PLS service interface"

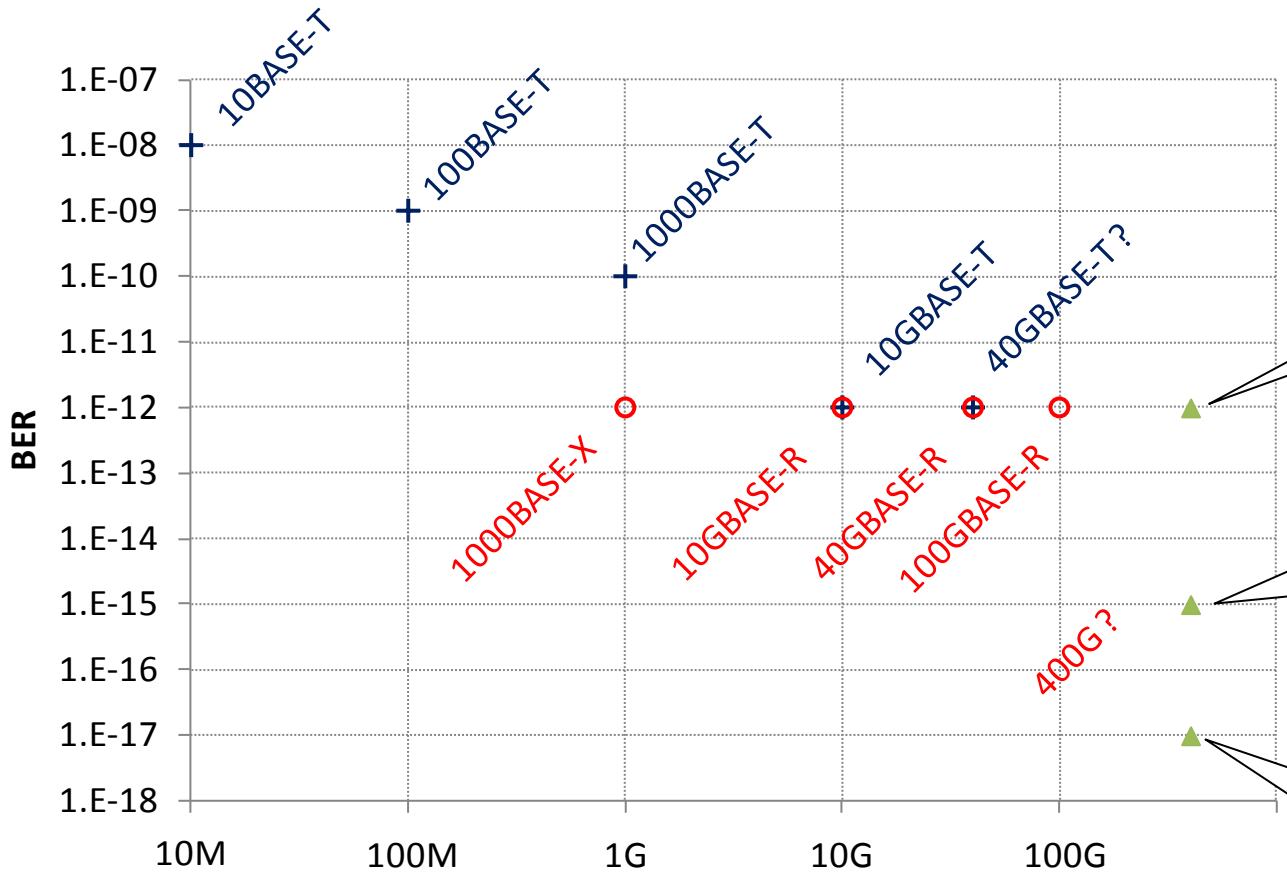
Since it is very likely that at least some 400GbE PHYs will incorporate FEC, anslow_01_0613_logic proposed to set the error performance objective in the form:

"Support a frame loss ratio better than or equal to 6.2 x10^{-x}"

In the Geneva meeting, ofelt_400_01_0713 made proposals for the BER objective with a "minimum" value of 10^{-15} and a "better" value of 10^{-17}. In several other meetings related to 400GbE, views have been expressed that since 400GbE is likely to be made up from many lower rate flows, a BER of 10^{-12} is sufficient.

This contribution discusses the value further and proposes an objective for FEC enabled PMDs in terms of a Frame Loss Ratio (FLR).

Ethernet Bit Error Ratio vs. bit rate

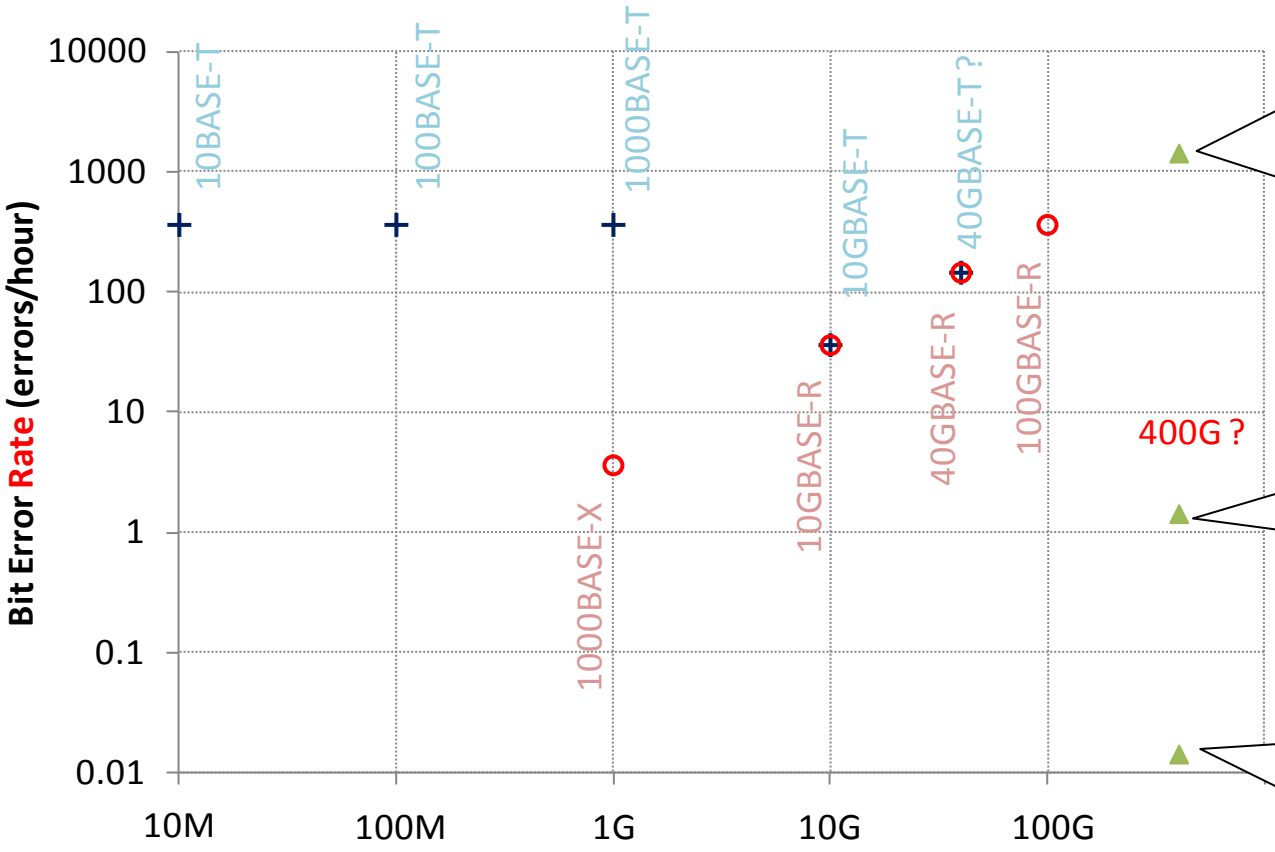


A BER target of 1E-12 has been proposed in discussion.

A BER target of 1E-15 was proposed in ofelt_400_01_0713 as a "minimum".

A BER target of 1E-17 was proposed in ofelt_400_01_0713 as "better".

Ethernet Bit Error Rate vs. bit rate



Some view this is the appropriate BER target since 400GbE will contain many lower rate flows.
Others view keeping the BER target at 1E-12 (one error every 2.5 seconds or 1440 per hour) as unrealistic.

A BER target of 1E-15 (one error every 42 minutes or 1.4 per hour) seems the lowest reasonable value.

A BER target of 1E-17 (one error every 2.9 days) is way below any error rate specified previously. What is the justification for this?

BER verification

PMDs with FEC

For routine measurement of modules that don't contain the FEC decoder, obtaining the pre-FEC BER should be ok. However this would have to be backed up with at least occasional verification that the error statistics are such that the post FEC BER is met. The easiest way to do this is apply the FEC decoder and count errors or lost frames.

PMDs without FEC

Here extrapolation from measurements at 1E-12 and above could be used to indicate the expected performance to lower BER, but this would also have to be backed up with at least occasional measurement down to the BER target.

BER measurement times

To obtain a reasonable estimate of the BER when the PHY is making some errors it is necessary to measure at least 10 errors. The time taken to do this at 400 Gb/s is:

BER	Time
1E-12	25 seconds
1E-15	7 hours
1E-17	29 days

If the PHY does not make any errors then using Equation 9-11 from ITU-T G.Sup39:

$$n = \frac{\log(1-C)}{\log(1-P_E)}$$

Where:

- n is the required number of error free bits
- C is the confidence level (e.g., 0.95 for 95% confidence)
- P_E is the BER requirement (e.g., 10^{-12})

Then the time taken for 95% confidence that the BER is below the requirement is:

BER	Time
1E-12	7.5 seconds
1E-15	2 hours
1E-17	9 days

One performance objective or two?

Even for the more reasonable BER target of 1E-15 measuring the BER down to the target value is a very time consuming process which some customers may insist on for non FEC based PHYs to ensure that there isn't a hidden error floor.

This may mean that the project needs two performance objectives – one for PHYs that use FEC and another for PHYs that don't.

Looking at the points on slide 4, it seems reasonable to set the BER target for 400GbE PHYs without FEC to be lower than 1E-12 (or 1440 errors per hour).

Setting the BER target to be 1E13 would be 144 errors an hour which is the same rate as 40GbE. This would make the time taken to count 10 errors 4.2 minutes as opposed to the 7 hours required for a BER of 1E-15

FLR from BER

The BERs discussed previously can be translated using the analysis given in anslow_01_0613_logic to the equivalent Frame Loss Ratios for 64-octet frames with minimum interpacket gap - according to the definition being introduced by P802.3bj and being used by P802.3bm:

1.4.210a frame loss ratio: The number of transmitted frames not received as valid by the MAC divided by the total number of transmitted frames.

This gives:

BER	FLR
10^{-12}	6.2×10^{-10}
10^{-15}	6.2×10^{-13}
10^{-17}	6.2×10^{-15}

Since the relationship between BER and FLR depends on the frame size and the definition in 1.4.210a is not frame size specific, a performance target given in terms of FLR should include the size:

Support a frame loss ratio for 64-octet frames of better than or equal to 6.2×10^{-x}

Conclusion

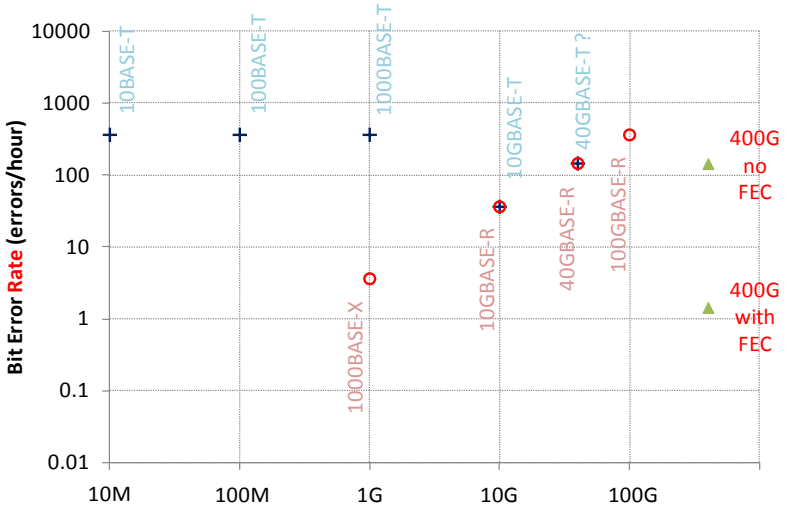
If it is expected that all 400GbE PHYs will incorporate FEC, it seems reasonable to set the error performance objective as the equivalent of 1E-15:

Support a frame loss ratio for 64-octet frames of better than or equal to 6.2 x10^{-13}

If it is expected that there will be some PHYs that use FEC and some PHYs that do not then a reasonable starting point is to set the error performance objective as:

For PHYs that utilise FEC, support a frame loss ratio for 64-octet frames of better than or equal to 6.2 x10^{-13}

For PHYs that do not utilise FEC, support BER better than or equal to 10^{-13} at the MAC/PLS service interface



Thanks!