Consideration of FLR in TSN for Fronthaul

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FLR vs BER in IEEE 802.3

- Frame loss ratio is related to frame size and BER.
- 802.3 standard defines BER objective and ensures realistic FLR is better than $6.2x10^{-x}$, x is according to specific Clause of “IEEE Standard for Ethernet”. When link quality is poorer than expected, Ethernet can disconnect by loss of sync.
  - For 64-Octet frames with minimum inter packet gap
  - FLR is slightly different over 10/25/50/100/200GbE and 400GbE

	BER Objective	FLR Guarantee (64 Octet)	FLR Guarantee (1000 Octet)
10/25/50/100/200GbE	1E-12	6.2E-10	6.6E-8
400GbE	1E-13	6.2E-11	6.6E-9

Burst Error Impacts to BER/FLR

- From physical link perspective, burst errors are inevitable and already counted in overall BER objective of 802.3 standard.
- High speed Ethernet, e.g. 25/50/100/ 200/ 400GbE, has mandatory Reed Solomon FEC to resist burst errors.
- 802.1CM does not have to worry about burst errors in particular physical link.

Comment in D0.4 of FLR Measure Time

- There were discussion of FLR measurement in D0.4 comments.

Cl **5** *SC* **5.1.2.2** *P* **8** *L* **3** # 45

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Comment Type **TR** *Comment Status* **X**

Over what time interval is FLR measured (i.e., what is the measurement interval)? The same comment applies to 5.1.3, line 10.

SuggestedRemedy

Indicate what the measurement interval is or, if it cannot be sated right now, say that it is TBD (for now, with the intent of filling it in later).

Proposed Response *Response Status* **W**

DISCUSS on a P802.1CM call

- Refer to Equation 9-11 from ITU-T G.Sup39 for required number of error free bits in test with a corresponding confidence level.

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

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})

- To verify BER of 1E-12@100GbE, test time is at least 30 seconds; and for BER of 1E-13@400GbE, need to test at least 75 seconds.
- No need to define measure time in 802.1CM document.

Comment in D0.4 of Target FLR

Cl 5 SC 5.1.2.2 P 8 L 3 # 46

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Comment Type **TR** *Comment Status* **A**

The FLR requirement given here is 10^(-7), and in 5.1.3 is 10^(-6). In Annex B, The relation between BER and FLR is described; it is indicate that for BER of 10^(-12), FLR is 1.6e-9 for 200 octet frame size and 8e-9 for 1000 octet frame size. With this methodology, FLR would be 1.2e-8 for 1500 octet frame size (i.e., (1e-12)(1500)(8)) for a single Ethernet hop. However, it is indicated in 7.3.1.4 (Meeting FLR targets for Profile A) and 7.3.2.5 (Meeting FLR for Profile B) that the network has to be configured and operated such that frame loss from fronthaul traffic never occurs due to congestion, and that fronthaul packets are never dropped by REC or RE due to late arrival. It is implied that frame loss occurs only due to BER. In this case, assuming the the bit errors on successive hops are independent, the FLR of 10^(-7) is consistent with an average of 8.33 hops assuming 1500 octet frames, and the FLR of 10^(-6) is consistent with an average of 83.3 hops assuming 1500 octet frames. However, the FLR requirements in 5.1.2.2 and 5.1.3 are not consistent with each other. In any case, the overall consistency of the BER in Annex B (which seems to be taken from CPRI specification 7.0) and the FLR requirements of 5.1.2.2 and 5.1.3 needs more discussion.

SuggestedRemedy

Provide more discussion of the overall consistency of the FLR values in .5.1.1.2, 5.1.3, and Annex B. This discussion could go in Annex B (which is informative). The discussion should include a list of assumptions (i.e., underlying BER, HRM (i.e., number of hops/bridges), the fact that is is assumed frames are not lost due to congestion and that fronthaul packets are not lost at RE or REC due to late arrival, etc.) It also should be explained why the FLRs in 5.1.1.2 and 5.1.3 are different (it seems that, given the current assumptions, the FLR should be the same for IQ and C&M frames

Response *Response Status* C

ACCEPT IN PRINCIPLE.
Delete Annex B.

DISCUSS on a P802.1CM call
The difference between FLRs in 5.1.1.2 and 5.1.3.

FLR will be impacted by

- BER of physical link
- Congestion
- Re-transmission

It is assumed that in fronthaul network in D0.4, no frame is lost due to congestion and late delivery.

- But how to ensure no congestion in fronthaul network?

Impact to FLR from Bridged Network

- Congestion
  - Use buffering to avoid frame loss, at expense of latency as in Annex C.1
  - 802.1CM project allows background flow conflicting and corresponding delay to CPRI, but provides no specification on its priority and behavior. Need more study and analysis on the influence of background traffic.
- Re-Transmission
  - 802.3 Ethernet will corrupt/drop data if too many errors happen in transmission, this protection behavior may cause more bandwidth cost in retransmission from application level;
  - No re-transmission in Bridged Network for CPRI application, so we think this is not in scope of 802.1CM

End-to-End FLR

Refer to FLR analysis in *cm-varga-CPRI-packetloss-considerations-0116-v02*,

- Optical transport (dark fiber or lambda):
  - Errors: bit errors
  - Characterized by BER
- Switched Ethernet transport
  - Errors:
    - loss of frames — caused by congestion, failures, etc.
note: late delivery also causes loss for CPRI
    - out-of-order delivery — caused by multiple paths, rerouting, etc.;
note: can be also treated as loss if no re-ordering function at receiver
  - Characterized by FLR

- Factors affecting End-to-End FLR (over Bridged Ethernet Network)
  - What is the typical packet length? 1000 bytes or 1500 byte? Or in a range?
  - What is the FLR over multi-hop PTP-link?
    - Sum of FLR on each PTP links which is characterized by BER from physical link
    - What is the estimation of number of hops：N=6~8？ Or in a range?
  - What is the behavior in network device?
    - Congestion: Assumed no congestion in 802.1cm D0.4. But how ensure that in bridged network?
    - Out of order in multi-path scenario： Assumed no multi-path scenario in 802.1cm, options? Shall we clearly state it in draft?

Suggestions

- End-to-End FLR requirement from CPRI TWG are different to the definition of single-link 802.3 Ethernet FLR capability, and we think Bridge Ethernet Network can satisfy the demand in general, but some issues exist and need clarify.
- Decouple FLR in 802.1CM from CPRI TWG requirement can avoid the risk of changes from CPRI TWG for future scenarios or emerging technologies. So we suggest to define FLR in 802.1CM according the FLR capability of Ethernet physical link and bridged network.
- Based on analysis, FLR equation will be as follows, with the assumptions of ideal network.

BER packet_length * number_of_hops*

//use up_limit for pkt_length and hop_number

Further Questions

- Then the questions leads to the assumptions, how to ensure them in Bridged Ethernet Network in reliable solutions.
- Figure out how to prevent frame loss from traffic congestion.
  - By use light traffic load and enough queue buffering? How to quantify ?
  - How to provide specific guidance to implementation based on 802.1CM?
- Figure out the effect of multi-path and fast re-routing on FLR, will this affect FLR? Or we can clearly state that no multi-path in TSN for Fronthual.

Thank You

Reference

- http://www.ieee802.org/3/400GSG/public/13_09/anslow_400_01_0913.pdf