Proposed content for Annex 174A
(comments #190, #191, #192, #205, #206)

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Subclause 174A.1

Current text:

This annex provides common frame loss ratio and bit error ratio requirements for:

— a complete physical layer

— an xMII extender

— a PHY with 200 Gb/s per lane

— a PHY with 200 Gb/s per lane, including Inner FEC defined in Clause 177

Issues

- This is currently a mini "table of contents" of the clause. This isn't required.
- Instead, an introduction to the annex would be helpful for readers.
  - It should provide the relationship between bit error ratio as defined in the project's objective and the frame loss ratio, as well as the purpose of defining error requirements for internal interfaces within the physical layer.

Subclauses 174A.2-174A.7

- Currently all subclauses are empty.
  - All titles refer to either FLR or BER
  - Since this annex defines several performance metrics, it seems preferable that the titles of specific subclauses be just the sub-link in question.
  - The specific requirement (FLR, BER, etc.) should preferably be in the subclause text.
- Specifically, the title of 174A.3 is “Frame loss ratio for a Physical Layer implementation”…
  - "Physical Layer implementation" seems to mean the path between the RS and the MDI.
  - It is unclear how frame loss ratio can be defined for this path, because the two interfaces are not equivalent; frames are defined only at the RS, and cannot be identified, checked for errors, or counted on the MDI.
  - Similarly, the signals on the MDI cannot be compared to the data stream on the RS.
  - No other "error metric" seems to be adequate for this path. There can be no single specification for a PHY – this subclause should be discarded.
- Text and updated titles for each subclause is proposed in the next slides.

Approach for defining data reliability Extenders vs. PHY-to-PHY

- FLR is additive across separate FEC domains
  - Errors occurring independently on each domain is a reasonable assumption
- Allocate the FLR
  - 6×10^{-11} for the “main link” (between PCSs)
  - 10^{-12} for each extender
  - Total of 6.2e-11
- FEC codeword error ratios can be derived from these FLRs

Approaches for defining data reliability in segments within a PCS-to-PCS link (with RS-FEC)

- Two directions are proposed:

A. Allocate the 15 correctable RS-FEC symbols between the segments

- Assuming error events in different segments are independent – the probability of having more than 15 would be the product of the probabilities.
- This product can be a smaller value than the maximum allowed codeword error ratio – creating some guard band.
- Example: 12 symbol errors for the main link with some probability, 3 symbol errors for an AUI with some probability; with low enough probabilities such that having 4 or more in two AUIs is negligible.
- Specific numbers and measurement methods can be discussed and refined in future contributions.

B. Specify the codeword error ratio for each segment with additional uncorrelated errors from other segments.

- Allocation can be based on the established “random BER” budget of 2.4e-4 for PMDs and 1e-5 for each AUI.
- Specific numbers and measurement methods can be discussed and refined in future contributions.

Proposed content for 174A.1

174A.1 Introduction

Ethernet Physical Layers at 200 Gb/s, 400 Gb/s, 800 Gb/s and 1.6 Tb/s are specified to enable a frame loss ratio (FLR) lower than 6.2×10^{-11} for 64-octet frames with minimum interpacket gap. This FLR is considered equivalent to the FLR that would result from uncorrelated random bit errors on the MAC/PLS service interface with bit error ratio (BER) of 10^{-13}. This is defined as the minimal data reliability for these physical layers.

The presence of forward error correction (FEC) as part of the physical layer enables higher bit error ratios in intermediate points within the physical layer, such as the PCS and the PMD/PMA service interfaces. The error ratio that can be acceptable varies between interfaces and depends on the data encoding as well as the distribution of errors over time.

This annex defines the error requirements at each interface that are expected to enable the minimal data reliability of the physical layer.

Proposed content for 174A.2

174A.2 RS-to-RS link

Data reliability of the link between two Ethernet DTEs is defined in terms of the FLR between the Reconciliation sublayer (RS) of the transmitting DTE and the RS of the receiving DTE.

The FLR for 64-octet frames with minimum interpacket gap is expected to be lower than 6.2×10^{-11}.

NOTE—The FLR is affected by multiple components within the link and is not a normative requirement of a specific component.

Proposed content for 174A.3 (currently 174A.4)

174A.3 xMII Extender

Data reliability of the xMII Extender defined in terms of the FLR between the transmitting XS (DTE or PHY) and the receiving XS (PHY or DTE, respectively).

The FLR for 64-octet frames with minimum interpacket gap is expected to be lower than 10^{-12}.

This requirement is equivalent to a FEC codeword error ratio lower than 2.4×10^{-13}.

NOTE—The FLR is affected by multiple components within the xMII Extender and is not a normative requirement of a specific component.

FLR in different FEC segments is additive.

Allocating FLR of 1e-12 for the xMII in both sides of the link would enable keeping 6e-11 for the PHY link, for a total of 6.2e-11.

See next slide for FEC codeword error ratio.

Proposed content for 174A.4 (currently 174A.5)

174A.3 PHY-to-PHY link

Data reliability of the PHY-to-PHY link is defined in terms of the FLR between the service interfaces of the transmitting PCS and the receiving PCS.

The FLR for 64-octet frames with minimum interpacket gap is expected to be lower than 6×10^{-11}.

NOTE—The FLR is affected by multiple components within the PHYs and by the media, and is not a normative requirement of a specific component.

174A.3.1 200GBASE-R, 400GBASE-R, 800GBASE-R, and 1.6TBASE-R

For PHYs using the 200GBASE-R, 400GBASE-R, 800GBASE-R, or 1.6TBASE-R PCS, the required data reliability is equivalent to a FEC codeword error ratio lower than 1.45×10^{-11}.

174A.3.2 800GBASE-ER1

For PHYs using the 800GBASE-ER1 PCS, the required data reliability is equivalent to a FEC codeword error ratio lower than TBD.

"FLR with 64-octet frames" is not directly measurable in the PCS because the traffic is typically different.

FEC codeword error ratio is measurable in the PCS, so it is a more useful metric. It can also be predicted from FEC counters.

Proposed content for 174A.5 (currently 174A.6)

174A.5 200 Gb/s per lane PMDs with no inner FEC sublayer

For PMD types defined in clauses (…), which are used without an inner FEC sublayer, data reliability is specified between two PMDs as defined in this subclause.

<Option A>

Define a requirement based on the probability of having k or more FEC symbol errors in a codeword-size block of data. This can be tested with either a FEC encoded data stream and a FEC decoder, or with a known pattern such as PRBS31Q.

A possible value of k is 12. A possible probability is 1e-8.

Based on 12+4 symbol errors having a probability of 1e-8*1e-8=1e-16 with a single AUI; for 4 AUIs the probability will be higher but still less than 1.45e-11

<Option B>

Define a requirement based on the probability of having 16 or more FEC symbol errors in a codeword-size block of data, with additional errors added by a random process at a BER of B, uncorrelated with the data pattern (e.g. using the state of an LFSR implementing a PRBS23). This can be tested with either a FEC encoded data stream and a FEC decoder, or with a known pattern such as PRBS31Q.

A possible value of B is 4e-5. A possible probability is 1.45e-11.

Based on 2.4e-4 + 4e-5 = 2.8e-4 which is the random BER maximum for the FLR

Proposed content for 174A.6 (currently 174A.7)

174A.6 200 Gb/s per lane PMDs with inner FEC sublayer

For PMD types defined in clauses (…), which are used with an inner FEC sublayer, data reliability is specified between the two inner FEC sublayers as defined in this subclause.

<Option A>

Define a requirement based on the probability of having k or more FEC symbol errors in a codeword-size block of data. This can be tested with either a FEC encoded data stream and a FEC decoder, or with a known pattern such as PRBS31Q.

A possible value of k is 12. A possible probability is 1e-8.

Based on 12+4 symbol errors having a probability of 1e-8*1e-8=1e-16 with a single AUI; for 4 AUIs the probability will be higher but still less than 1.45e-11

<Option B>

Define a requirement based on the probability of having 16 or more FEC symbol errors in a codeword-size block of data, with additional errors added by a random process at a BER of B, uncorrelated with the data pattern (e.g. using the state of an LFSR implementing a PRBS23). This can be tested with either a FEC encoded data stream and a FEC decoder, or with a known pattern such as PRBS31Q.

A possible value of B is 4e-5. A possible probability is 1.45e-11.

Based on 2.4e-4 + 4e-5 = 2.8e-4 which is the random BER maximum for the FLR

Proposed content for 174A.7 (new)

174A.6 200 Gb/s per lane AUIs within a PHY

For the 200 Gb/s per lane AUIs defined in Annex 176D and Annex 176E, data reliability is specified between two C2C components or between two C2M components as defined in this subclause.

<Option A>

Define a requirement based on the probability of having k or more FEC symbol errors in a codeword-size block of data. This can be tested with either a FEC encoded data stream and a FEC decoder, or with a known pattern such as PRBS31Q.

A possible value of k is 3. A possible probability is 1e-8.

Based on 12+4 symbol errors having a probability of 1e-8*1e-8=1e-16 with a single AUI; for 4 AUIs the probability will be higher but still less than 1.45e-11

<Option B>

Define a requirement based on the probability of having 16 or more FEC symbol errors in a codeword-size block of data, with additional errors added by a random process at a BER of B, uncorrelated with the data pattern (e.g. using the state of an LFSR implementing a PRBS23). This can be tested with either a FEC encoded data stream and a FEC decoder, or with a known pattern such as PRBS31Q.

A possible value of B is 2.7e-4. A possible probability is 1.45e-11.

Based on 1e-5 + 2.7e-4 = 2.8e-4 which is the random BER maximum for the FLR

Summary

- Specific content for some of the subclauses of Annex 174A is proposed.
- For the allocation of errors between segments within a single FEC domain (e.g., medium and AUIs), two general directions are proposed
  A. Specify maximum probability for specific FEC bins.
  B. Specify maximum FEC codeword error ratio with additional random errors from other interfaces.
- Decision on one of these directions would enable the editors to write the specific text.
  - Specific values can be adopted separately.