Food for thought on active copper cables

Adee Ran, Cisco

P802.3dj copper cable objectives

(https://www.ieee802.org/3/dj/projdoc/objectives_P802d3dj_230316.pdf)

- “Define a physical layer specification that supports 200 Gb/s operation over 1 pair of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter”
- “Define a physical layer specification that supports 400 Gb/s operation over 2 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter”
- “Define a physical layer specification that supports 800 Gb/s operation over 4 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter”
- “Define a physical layer specification that supports 1.6 Tb/s operation over 8 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter”

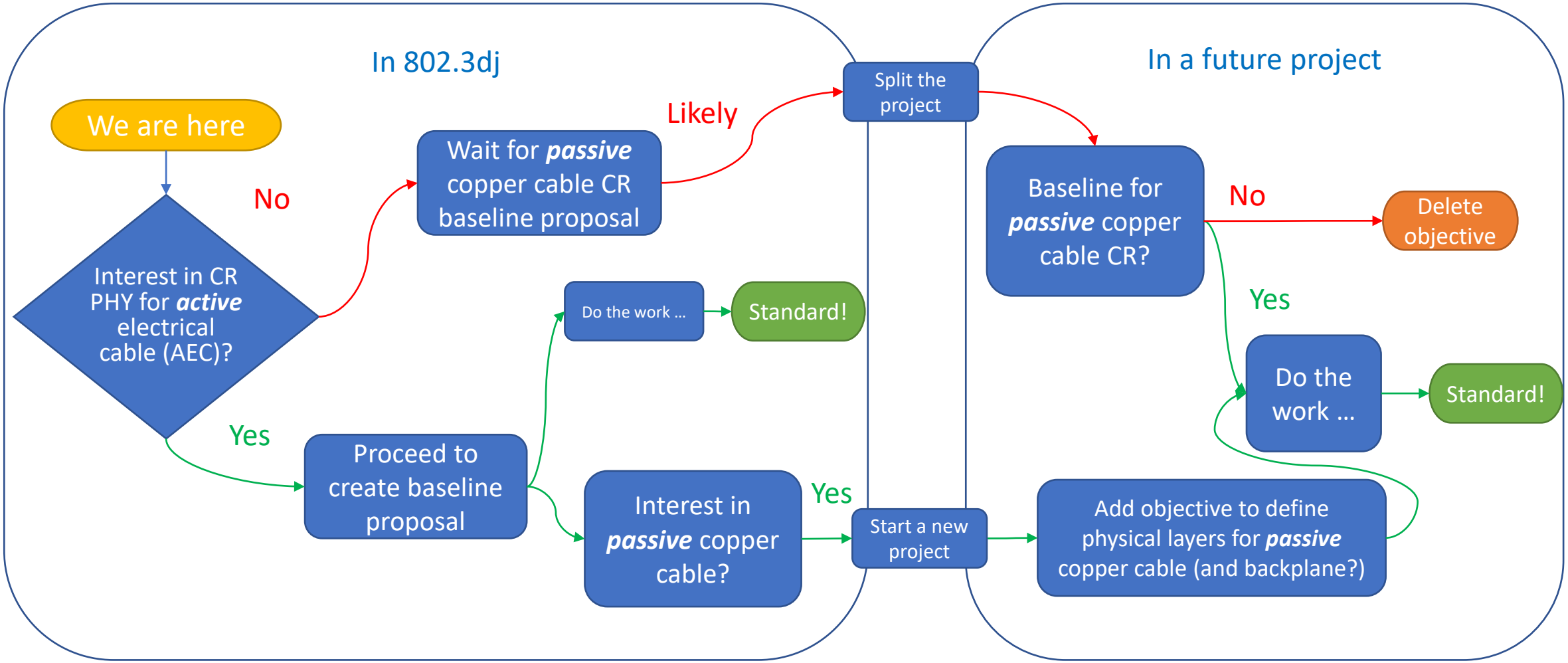
“CR” specifications

- In previous projects we defined PHYs for operation over **passive** copper cables from 10G/lane to 100G/lane
  - With ports that also support pluggable optics (as AUI-C2M)
  - Intended to enable use of same IPs for backplane PHY
  - Specifications for the passive cables too
- There may be interest in continuing this trend in 802.3dj for 200G/lane, but there has been little progress in this direction
  - As highlighted in the recent “State of IEEE P802.3dj and Future Schedule” presentation
- 200G/lane poses technical challenges (e.g., Host PCB/package loss budget)
  - There may be solutions, but it can take time and effort
  - We may end up with no cable solution in 802.3dj (and for a considerable time)

Active copper cable?

- The objectives could be satisfied with definitions of physical layer specifications for **active** copper cable
- Several kinds of active copper cables at 100G/lane exist in the market
  - Lower power than optical modules, longer reach and less bulky than passive copper cables
  - Some are implicitly compatible with AUI-C2M (but there is no Ethernet port type and no compliance requirements)
- In this presentation I focus on **fully retimed cables** (aka active electrical cable, AEC)
  - It is the lowest hanging fruit – but still complex enough that it requires specification!
  - Closely tied with the AUI-C2M definitions
- **Having AEC specifications does not preclude future work on PHYs for passive cables and backplanes**
  - Possibly with more strict definitions (e.g. lower host loss)
  - Possibly with different solutions enabling higher loss (e.g. different modulation or FEC)

Possible paths forward



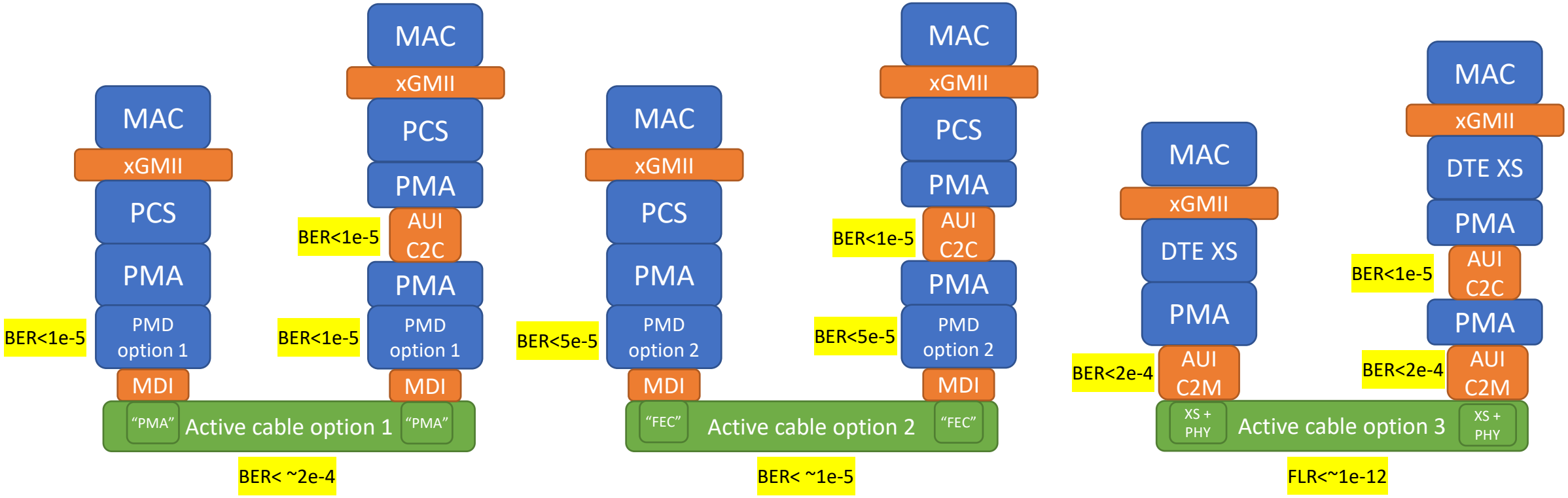
What AEC specs can look like

- CR PHY
  - PCS and PMA – the same ones we have for other PHYs
  - PMD electrical specifications – same as AUI-C2M host
    - With an internal BER allocation!
    - If we have more than one AUI-C2M we may choose which one is used for the CR PHY, or have several CR sub-types
  - May use AUI-C2C internally
- CR cable
  - Electrical specifications – same as AUI-C2M module on either end
  - **Cable-specific requirements: end-to-end BER specifications and test methodology (interference/jitter tolerance, stress calibration…)**
- MDI specifications as in previous generations (with pin-out and test fixture annexes)
- See backup slide for some further thoughts…

What should an active cable include?

- Depending on the PMD's BER allocation – there could be different cable types with different BER specifications
- Cables could include:
  - Bidirectional retimers (equivalent of a PMA) on both ends
  - Inner FEC codec (equivalent to the FEC_I sublayer in optical modules) on both ends
  - PHY XS on either or both ends
- Cable only needs to meet the specified BER in ITT/JTT conditions!
  - **Specification should allow various implementations**

Possible BER budgeting with active cable



These are the same options we have in optical modules; with "PMD" replacing AUI-C2M

The BER values are for random error events (for analysis purposes) and do not represent measured BER (for compliance purposes).

Summary

- Once we have BER allocations for AUIs – it is a natural step to define active CR PHYs and media
  - Active cable specifications should include BER test (new methodology, setup) to ensure interoperability with the PHYs
- It is easier to specify (and meet the objective) than passive
  - And will satisfy a market demand
- It does not preclude future specification of passive copper cable PHYs and media (likely in a future project)

Discussion?

Thank you

Backup

Thank you

Architectural considerations

- In the existing 802.3 architecture, an active cable that does not terminate the RS-FEC is a medium, just like a passive cable
  - But it has different specifications than what we are used to: module-like specifications for each end, and a new BER requirement (or something similar).
  - It does not have electrical end-to-end specs like s-parameters or COM.
  - It is connected to two PHYs, which coincide with AUIs.
- An AEC that terminates the RS-FEC at both ends is architecturally a bundle of two PHYs and a medium connecting them.
  - This makes the hosts function as xMII extenders, as depicted in option 3.
  - It may be of interest in many use cases.