

# PHY/FEC architecture considerations

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# Introduction

- Consideration of PHY/FEC schemes from IEEE architecture perspective.
- Exploration of impact of different FEC concatenation and segmentation choices.

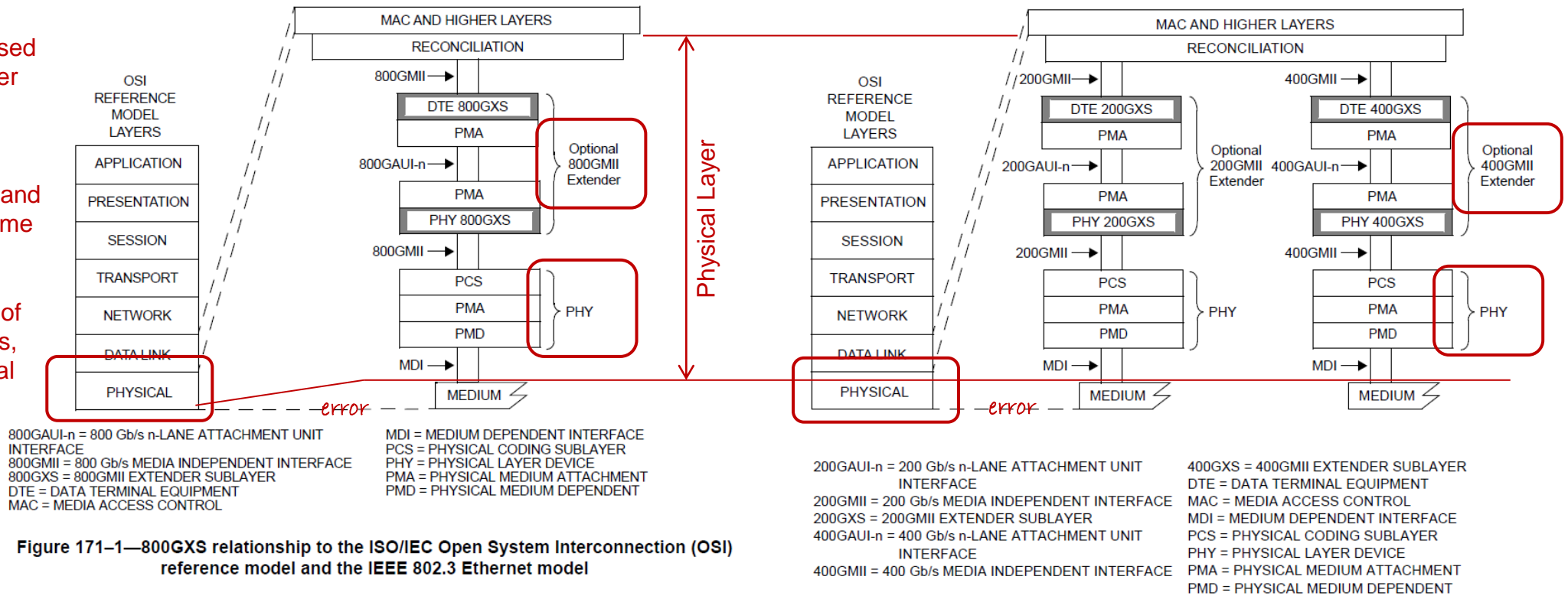
# IEEE architecture terms

**1.4.467 Physical Layer device (PHY):** Within IEEE 802.3, the portion of the Physical Layer between the Medium Dependent Interface (MDI) and the media independent interface specific to the data rate (e.g., MII, GMII, XGMII). The PHY contains the functions that transmit, receive, and manage the encoded signals that are impressed on and recovered from the physical medium.

The physical layer is composed of the Reconciliation Sublayer (RS), optional MII Extender, PHY, and MDI.

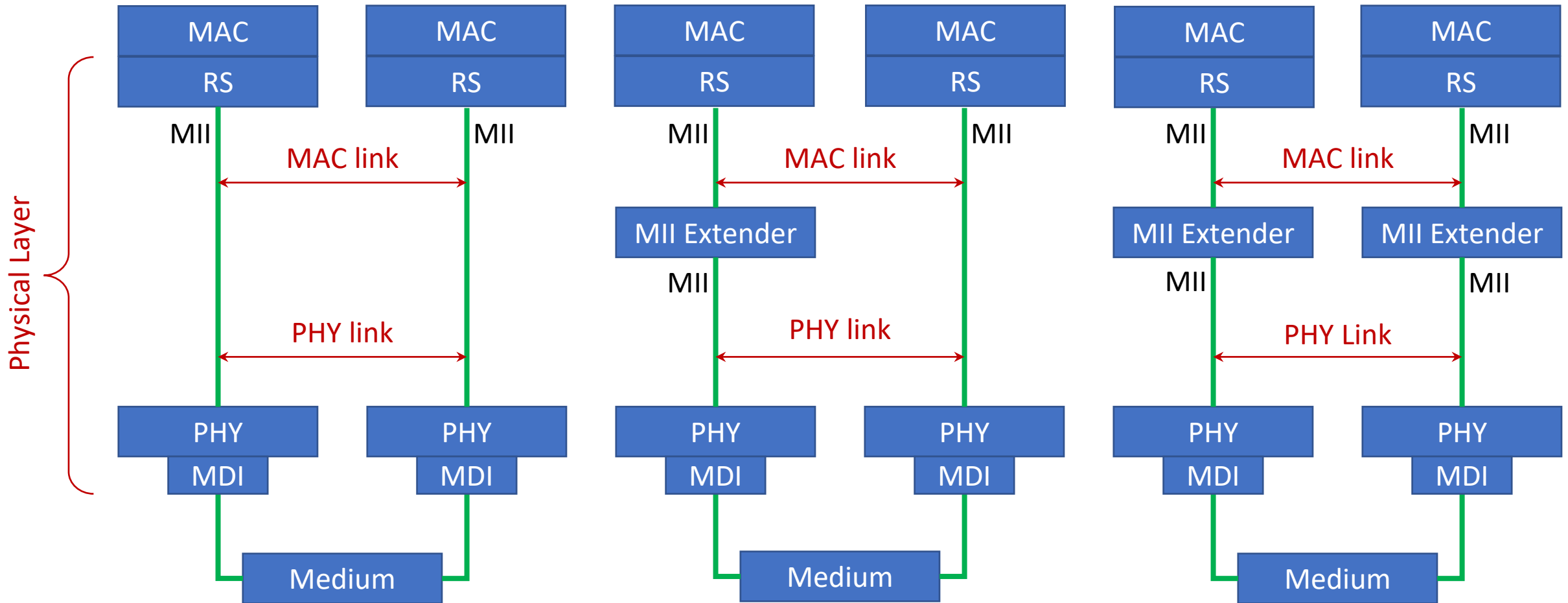
PHY (physical layer device) and physical layer are not the same thing.

The MII extender is not part of the PHY. As its name implies, the MII Extender is a physical extension of the MAC/RS.



# Ethernet Physical Layer View

RS here means "Reconciliation Sublayer", not "Reed-Solomon".

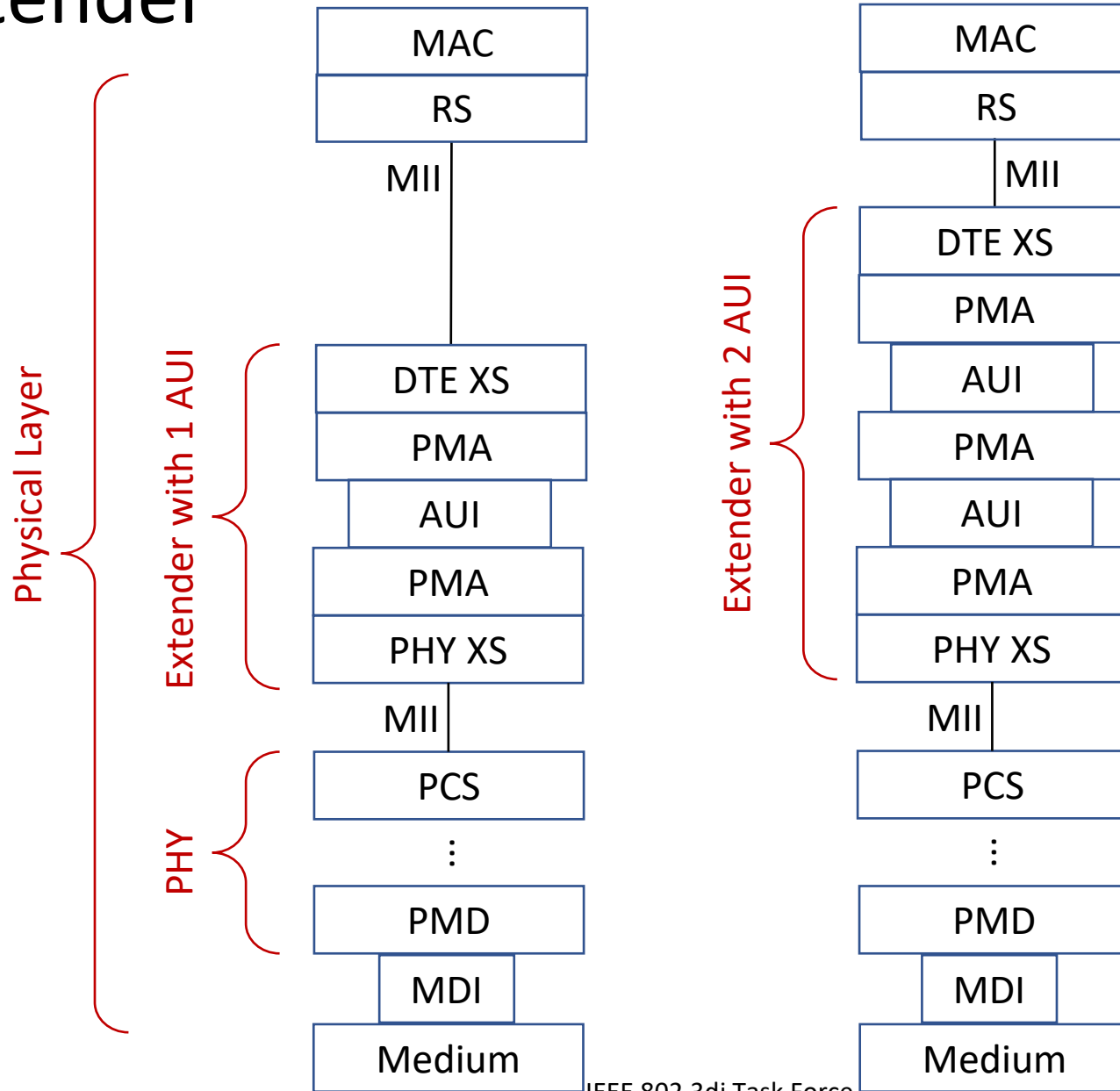


MAC link = path from MII below one MAC/RS to the MII below the other MAC/RS (i.e., MAC to MAC) – not IEEE term

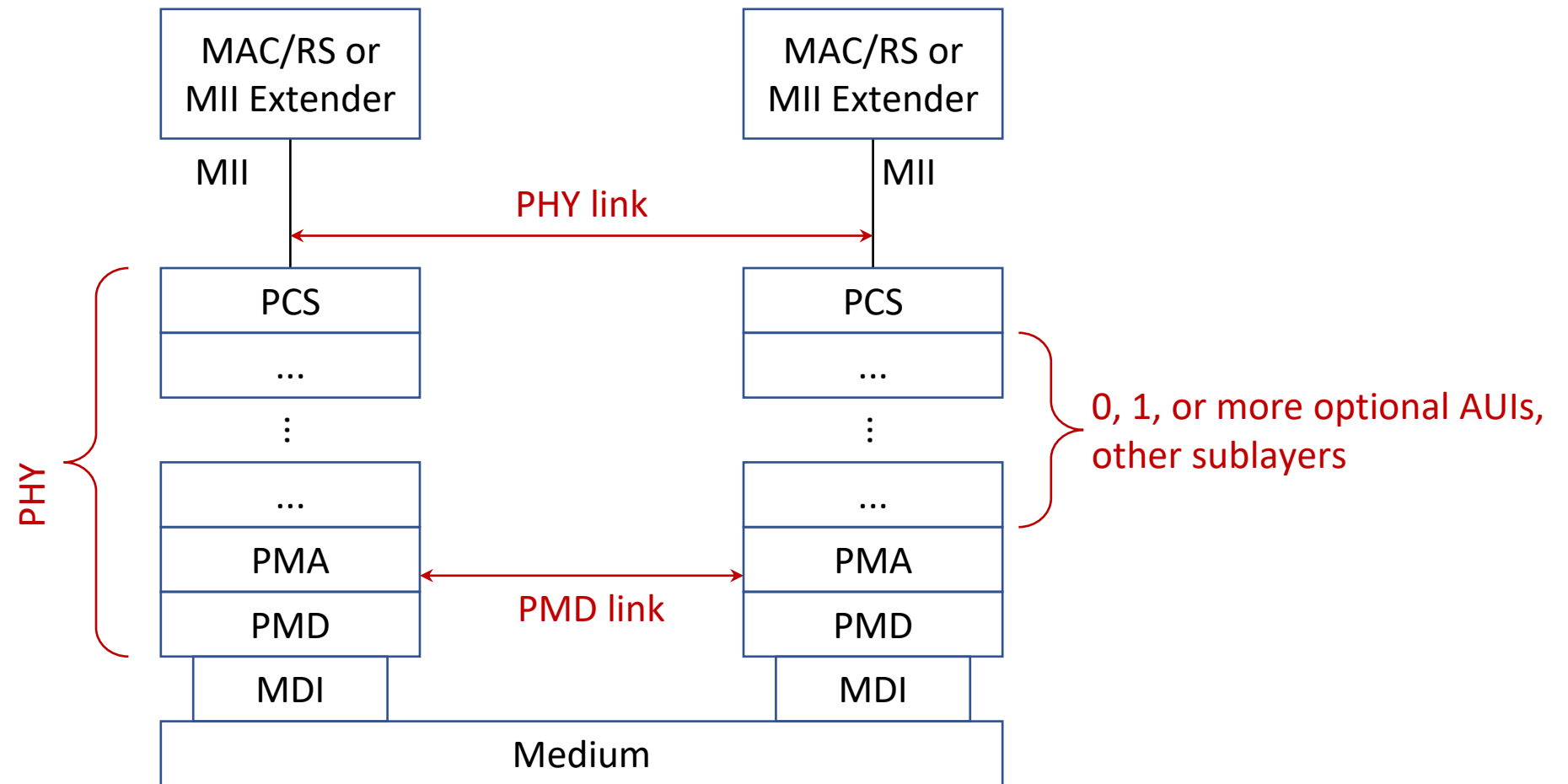
PHY link = path from MII above one PHY to the MII above the other PHY – not IEEE term

If there are no MII Extenders then MAC link = PHY link (far left)

# MII Extender



# Ethernet PHY view

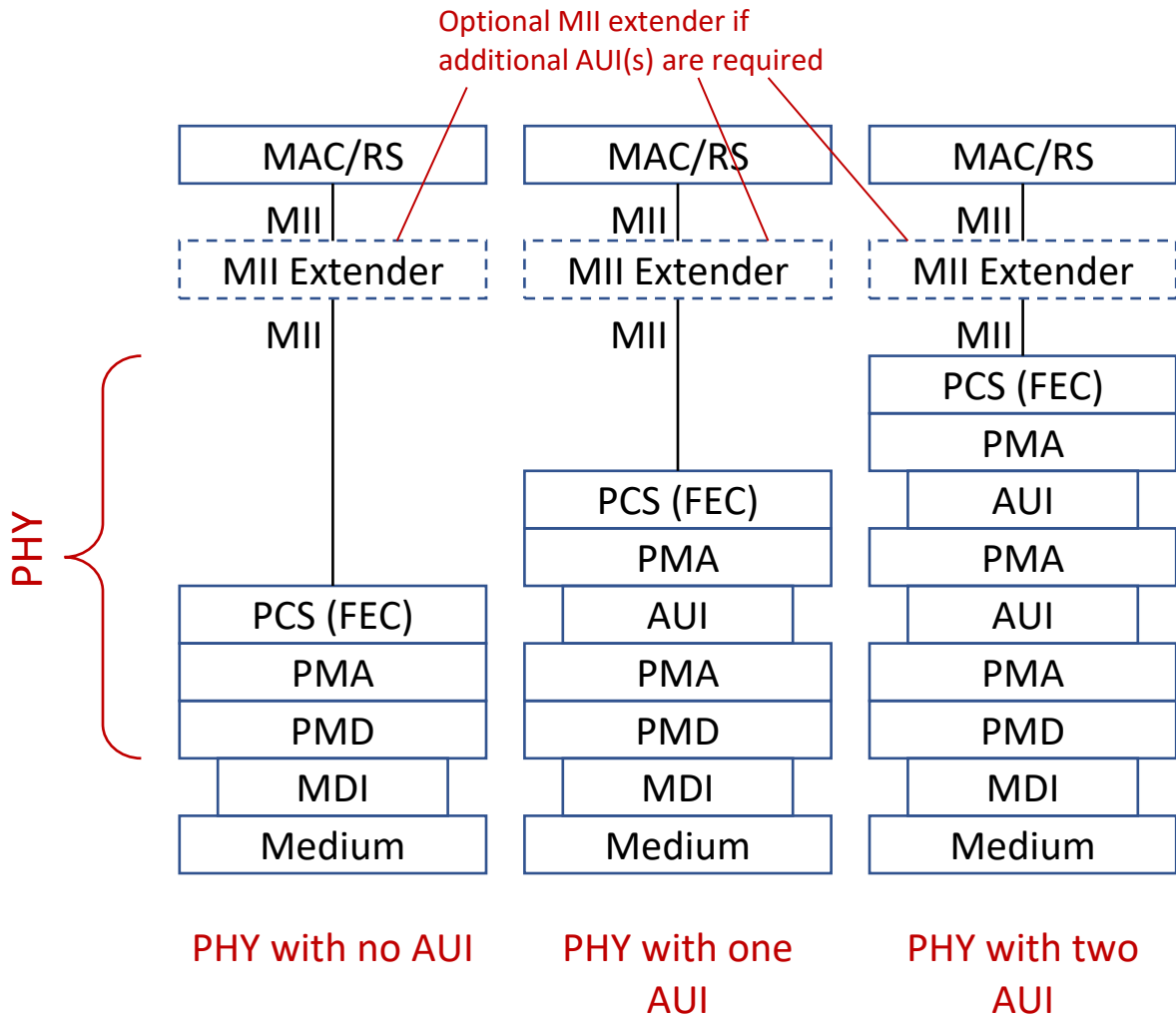


PMD link = path from PMD at one end to PMD at the other end (i.e., no AUIs) – not IEEE term

# PHY/FEC types

- Three PHY/FEC types are explored
- Type 1: single FEC spans multiple AUIs and the PMD link
  - sometimes referred to as “end-to-end FEC”
- Type 2: outer FEC spans multiple AUIs and PMD link (like Type 1), additional inner FEC spans PMD link
  - sometimes referred to as “concatenated FEC”
- Type 3: FEC is dedicated to PMD link
  - sometimes referred to as “segmented FEC”

# Type 1 PHY/FEC scheme



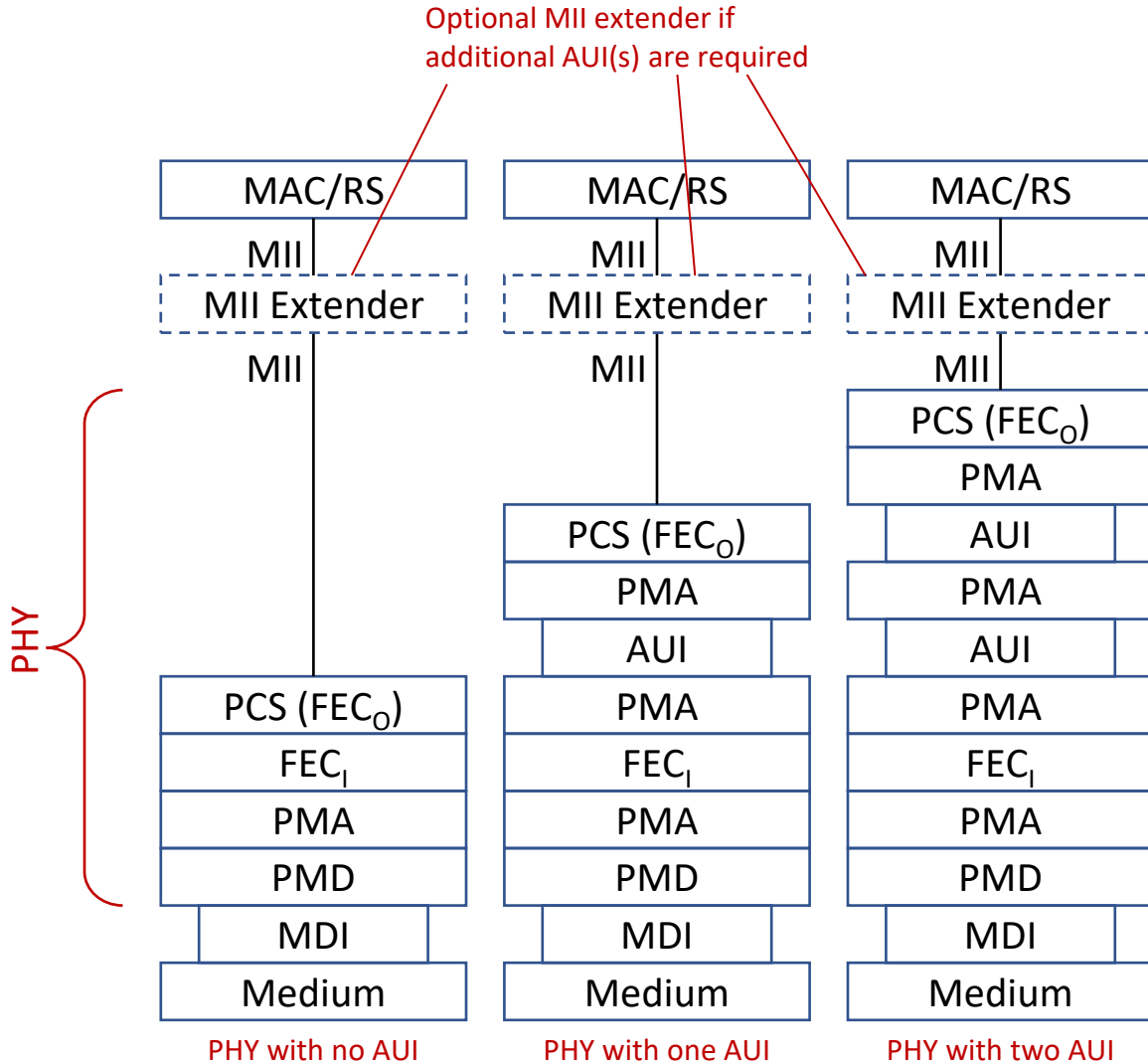
- A single FEC spans the PHY link (PCS to PCS) which may include up to four AUIs.
- FEC corrects errors that are contributed by the PMD link and the AUIs.
- PMD and Medium characteristics are defined with AUI errors in mind.
- BER trade off between the AUIs and the PMD link.
- More AUIs may be added above the PHY using the optional MII Extender without affecting PHY performance.
- The following PHYs use this PHY/FEC scheme:
  - all 200GBASE-R in 802.3, 802.3ck, 802.3db
  - all 400GBASE-R in 802.3, 802.3ck, 802.3db
  - all 800GBASE-R in 802.3df



# Type 1 PHY/FEC scheme

- This intent of this scheme is to provide minimum net latency, power, and complexity (gate count) due to FEC processing in the PHY link.
- Pro:
  - Latency limited to a single FEC encode-decode pair.
- Con:
  - PMD specifications must be tightened up to allow for errors introduced by AUI(s).

# Type 2 PHY/FEC scheme

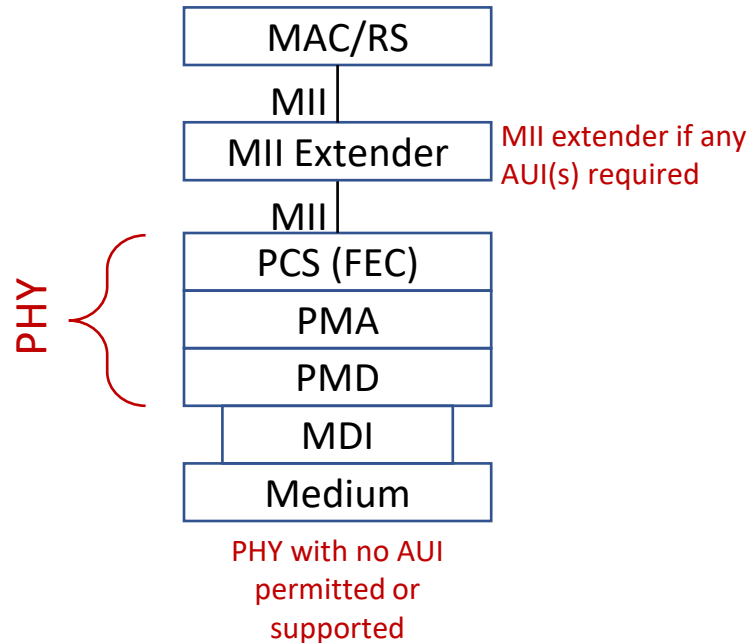


- An outer FEC (FEC<sub>0</sub>) spans the PHY link (PCS to PCS) including up to four optional AUIs (like Type 1)
- An inner FEC (FEC<sub>1</sub>) spans only the PMD link (PMD to PMD)
- FEC<sub>1</sub> corrects “most” errors contributed by the PMD link
- FEC<sub>0</sub> corrects errors not corrected by FEC<sub>1</sub> and error contributed by the AUIs
- The combined effect of FEC<sub>1</sub> and FEC<sub>0</sub> results in the target frame loss ratio (FLR) for the PHY.
- FEC<sub>1</sub> and FEC<sub>0</sub> defined in conjunction with each other.
- PMD and Medium characteristics defined with AUI errors in mind.
- BER trade off between the AUIs and the PMD link.
- More AUIs may be added above the PHY using the MII Extender without affecting PHY performance.
- This PHY/FEC scheme is new for 802.3.

# Type 2 PHY/FEC scheme

- This intent of this scheme is to provide a compromise with better performance than Type 1 and lower net latency, power, and complexity (gate count) than Type 3 for the PHY Link.
- Pros:
  - Provides extra FEC processing (allows for higher pre-FEC BER) for the PMD Link compared with smaller increment in latency, power, and complexity compared with Type 3.
  - Can permit higher AUI BER than Type 1.
  - Higher signaling rate due to enhanced FEC limited to just the PMD link and does not affect the AUI links.
  - Allows inner code to be collocated with the PMA/PMD so that soft decoding is an option.
- Cons:
  - For the same FEC encoding, PMD specifications must be tighter (compared to Type 3) to allow for errors introduced by AUI(s).
  - Careful consideration of combined effect of inner and outer FECs is required.

# Type 3 PHY/FEC scheme



- An FEC spans the PHY link (PCS to PCS) with no AUIs in either PHY.
- If one or more AUIs are required at either end, then an MII Extender is required.
- The FEC corrects errors contributed ONLY by the PMD link.
- The FEC may take many forms, e.g., RS only, RS + Hamming/BCH (like Type 2), oFEC, etc.
- FEC may be defined independently of other encoding sublayers.
- PMD and Medium characteristics defined independent of AUI characteristics.
- No trade off between the AUIs and the PMD link is required.
- The following PHY uses this PHY/FEC scheme:  
400GBASE-ZR in 802.3cw

# Type 3 PHY/FEC scheme

- This intent of this scheme is that the PMD FEC is optimized for and dedicated to the PMD link.
- Pros:
  - Errors created by AUI(s) are isolated from PMD link.
  - No interaction with other encoding sublayers.
  - A higher signaling rate (if needed) of enhanced FEC limited to just the PMD link and does not affect the AUI links.
- Cons:
  - Extra latency, power, complexity (gates) due to FEC processing (compared to Type 1 and Type 2) due to 3 FEC segments (3 encoders/decoders) to support AUIs at both ends.

# Conclusion

- Three unique PHY/FEC schemes are explored.
- Each scheme has a set of advantages and disadvantages and uniquely impacts how the PMD and medium are specified.
- Use of terms like “end-to-end” and “segmented” to describe these schemes are ambiguous.

# Thanks