Next steps in 802.3 Automotive Ethernet

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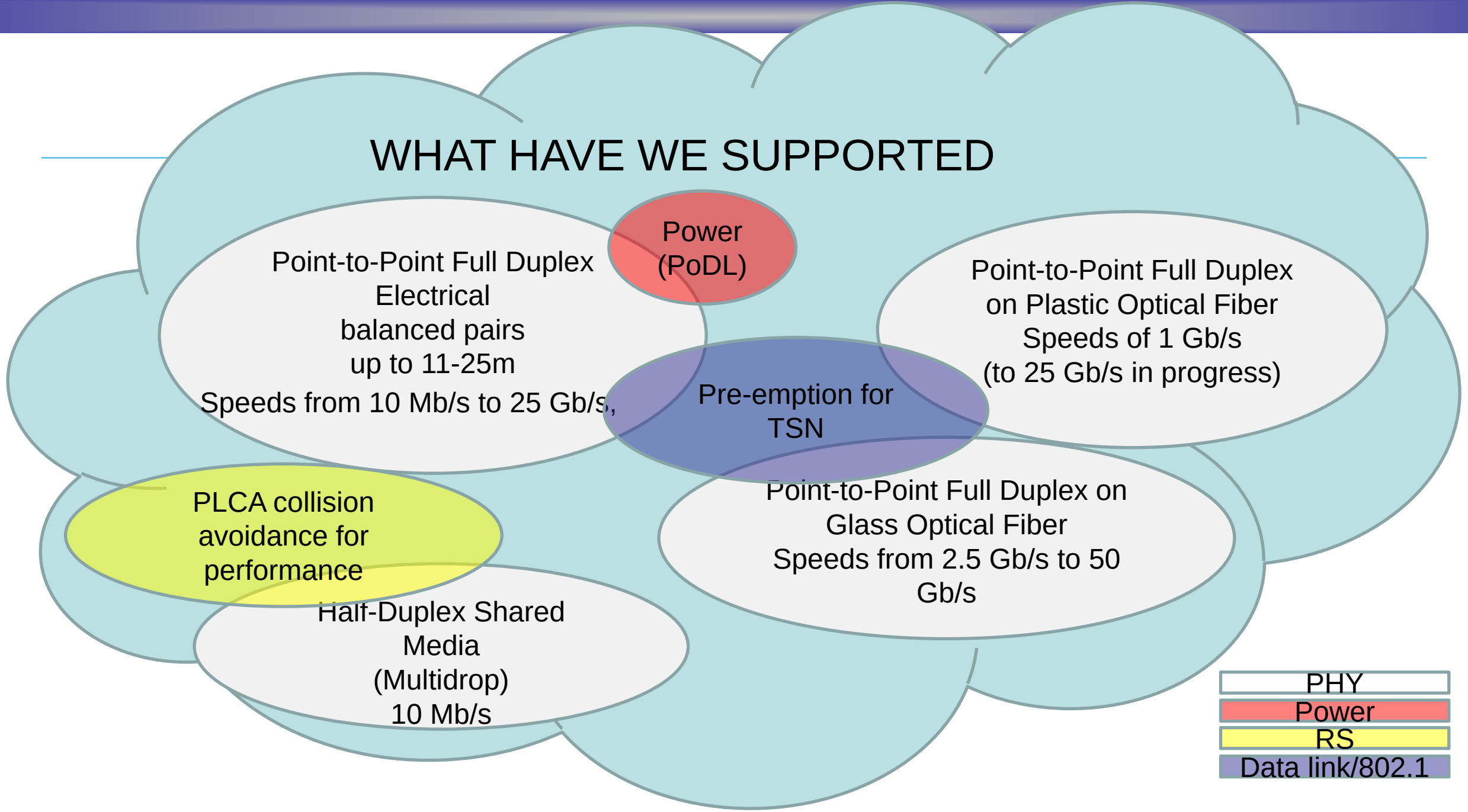
5/16/2023

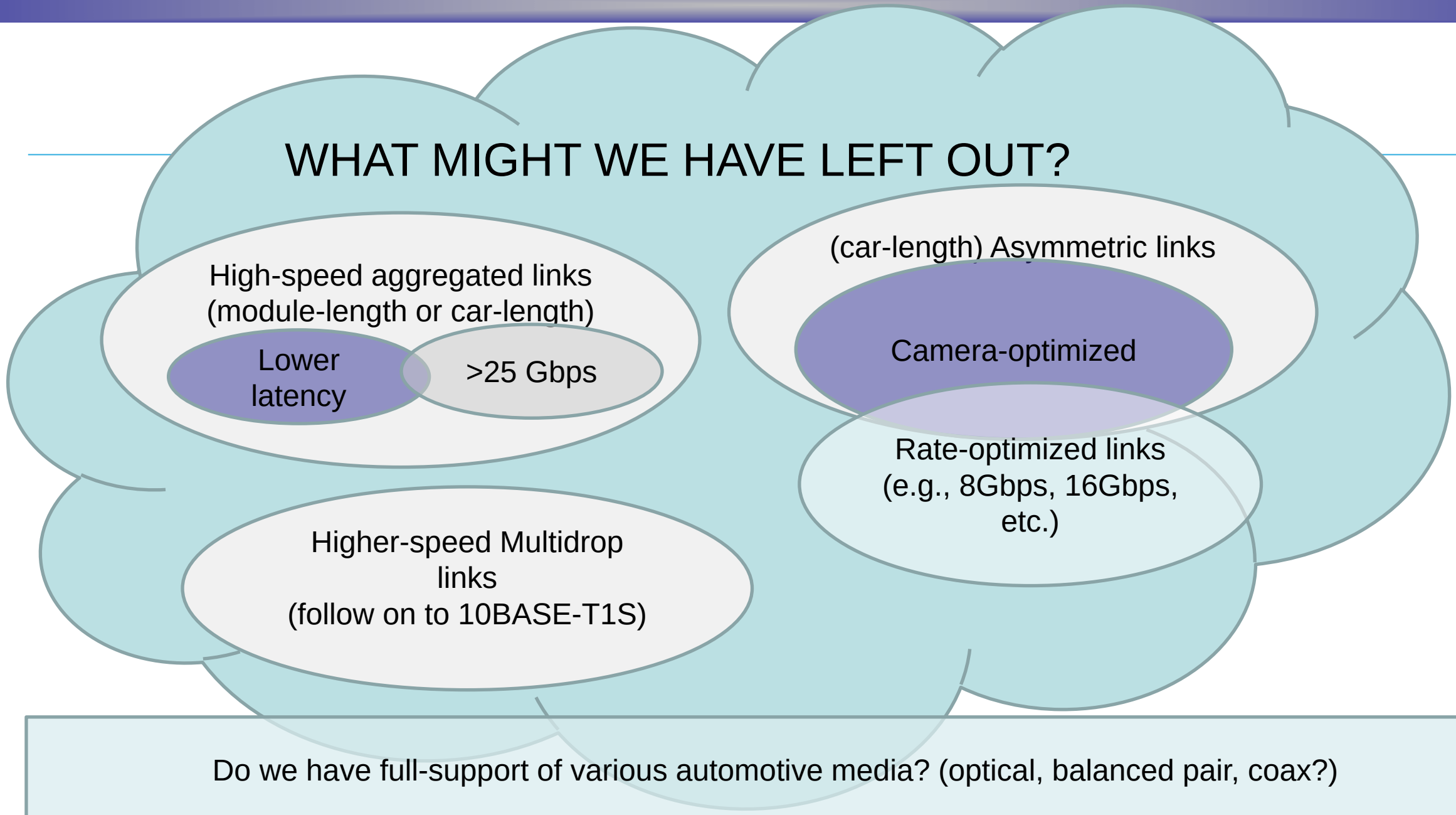
What have we defined in the 802.3 Automotive Space?

- Point-to-point, full duplex speeds from 10 Mb/s to 50 Gb/s
- Shared-medium, half duplex, 10 Mb/s single-pair PHY
- Auto negotiation (single pair electrical)
- Pre-emption (MAC MERGE) to support point-to-point full duplex
- Powering to support 12V, 24V, and 50V (single pair electrical)
- Collision avoidance (PLCA) for half-duplex shared-medium operation

WHAT HAVE WE SUPPORTED



WHAT MIGHT WE HAVE LEFT OUT?



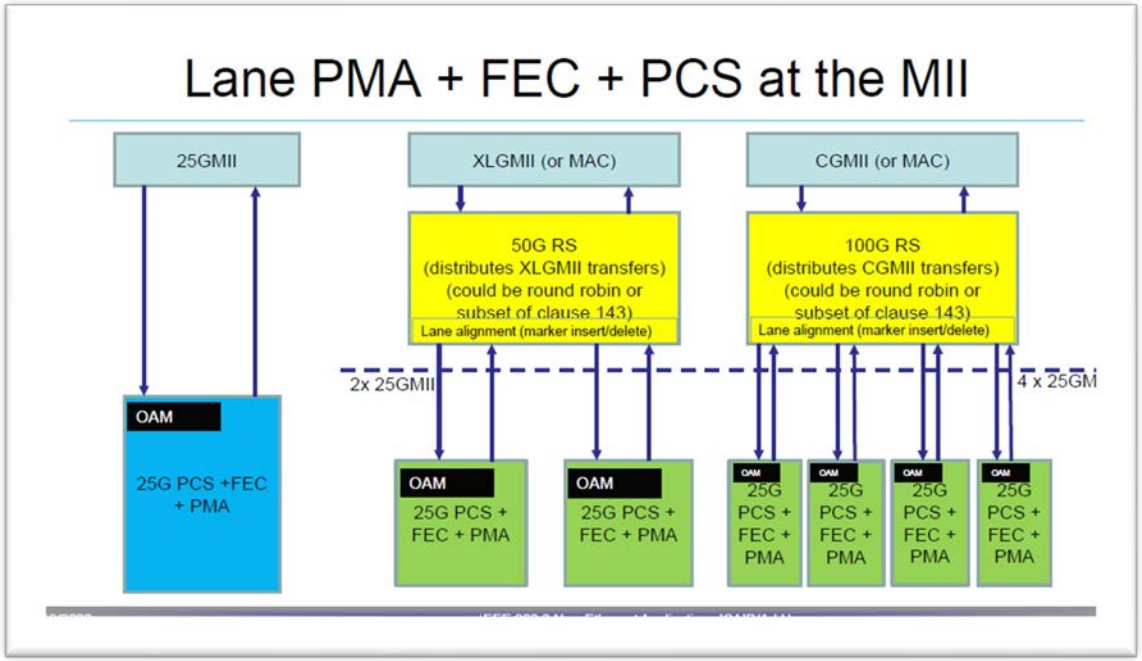
Do we have full-support of various automotive media? (optical, balanced pair, coax?)

More Detail on Media Support

- 10 Mb/s to 25 Gb/s electrical;
  - Latency:
    - Greater than a minimum Ethernet frame for PHY rates of 1 Gb/s or greater (more than a maximum length frame at 5 Gb/s and above)
  - Designed around balanced pair media (data & power)
    - Coax (unbalanced media) is not precluded if interfaced at a balanced MDI (but not optimized)
- 2.5 Gb/s to 50 Gb/s glass optical;
  - Latency greater than a minimum Ethernet frame (approx. equal to maximum length frame), greater than a maximum length frame at 50 Gb/s
- 1 Gb/s to 25 Gb/s PoF
  - Latency: Greater than a minimum Ethernet frame (at 1 Gb/s, higher speeds are still TBD)

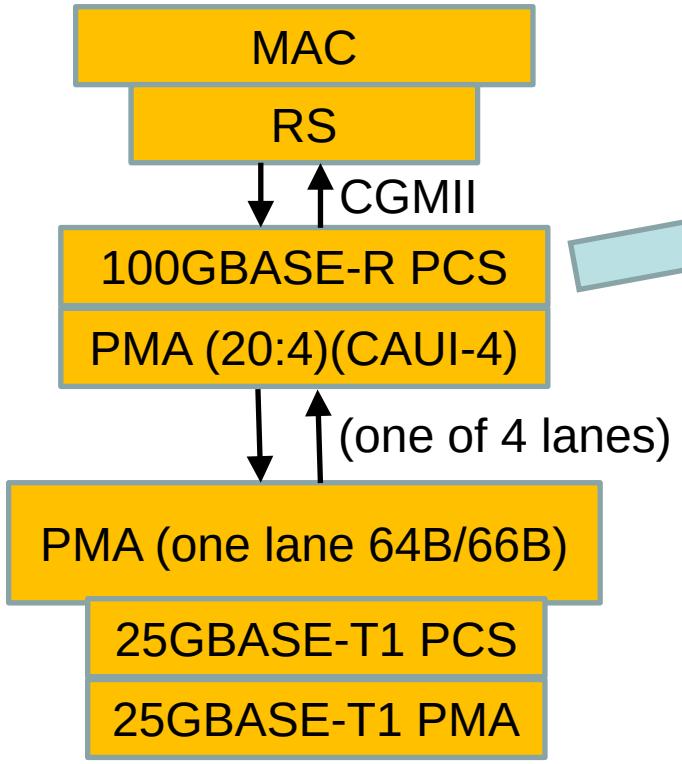
Higher Speed Links by Bonding PHYs

- 802.3cy stopped at 25 Gb/s, aggregated links may need more speed
- zimmerman_jones_3NEA_01b_05_19_2022.pdf suggested bonding multiple 25 GBASE-T1 links, similar to optical breakout modules
  - Techniques based on Clause 143 EPON suggested a follow-on project to define a simplified RS suitable for simple bonding
- Follow on discussions (A. Marris) suggested modeling Optical breakout (CAUI-4 based) might be simpler

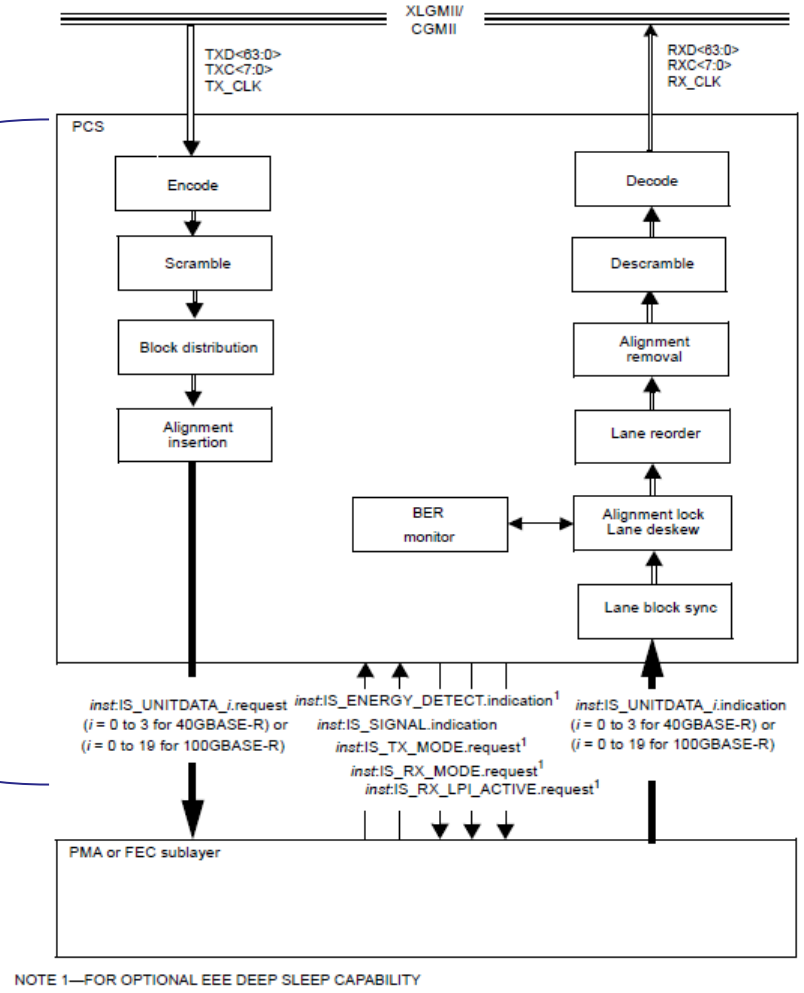


Source: zimmerman_jones_3NEA_01b_05_19_2022.pdf

PHY Bonding - Continued



Alignment markers inserted and removed in 100GBASE-R PCS. 64B/66B Encoded Data passed directly to 25GBASE-T1 PCS for transcoding to 64B/65B



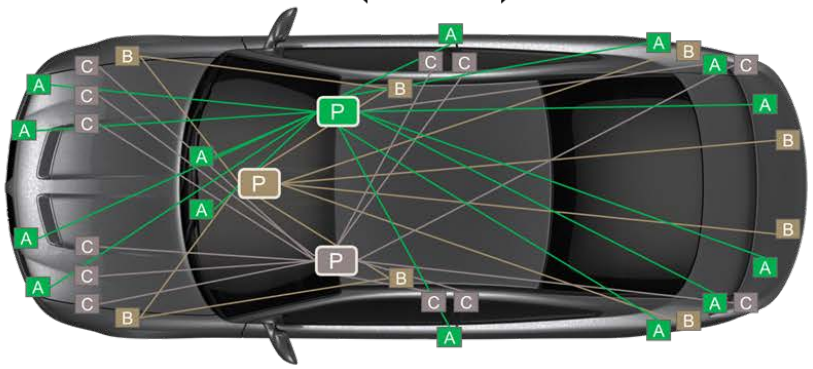
Source: IEEE Std 802.3-2022, Figure 82-2

Could be a subject for an MSA, not a standards project
(or a very short standard project)

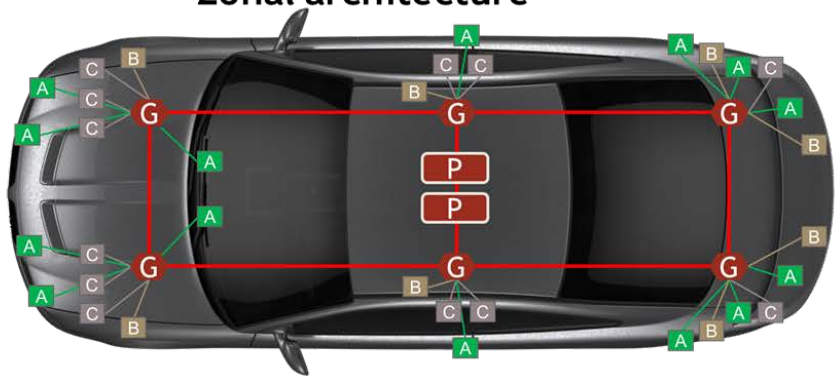
Higher Speed PHYs (single lane)

- Technology advancements take time and market uptake
- Automotive architectures are moving to Zonal, with shorter aggregated high-speed links
- Need to watch for WHEN higher speeds are needed and develop at the right time – probably not now… market is just getting ready for 25Gb/s automotive links
- Suggest we add the automotive segment (and intra-system links) to the next “bandwidth assessment” activity

Conventional (Domain) architecture



Zonal architecture



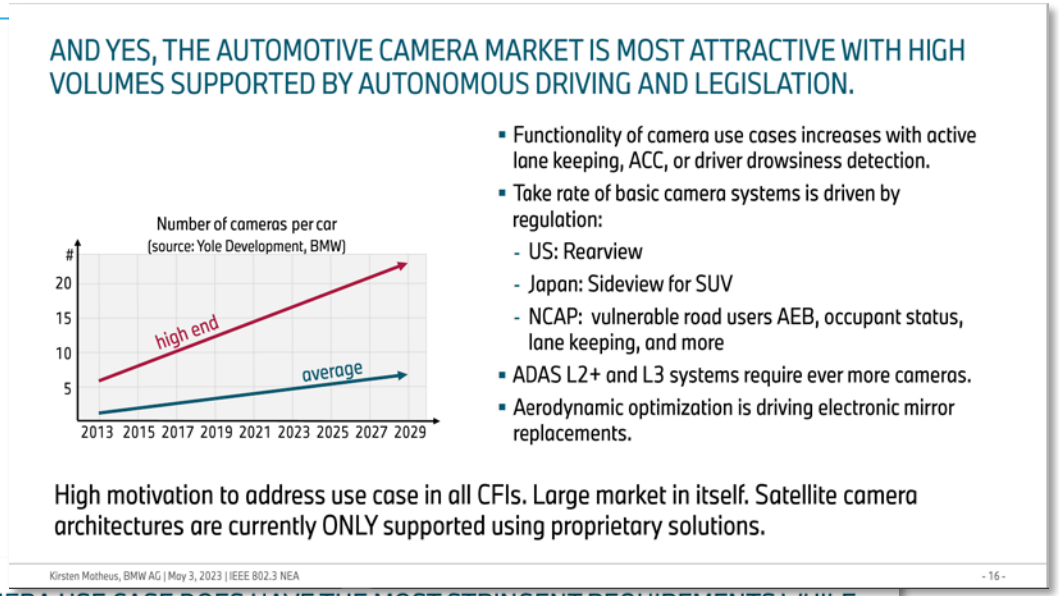
Next Generation Multidrop

- 802.3cg added 10BASE-T1S
- 802.3da is increasing reach, node assignment, and to add power
- OPEN Alliance has been adding PHY features
  - 3-wire transceiver interface
  - Power-down signaling
  - Transponder-based node location
- Is more speed also a need for the next 5 years?

Timing is off – Relevant experts are more than busy in .3da

Camera Links Deserve Attention Now

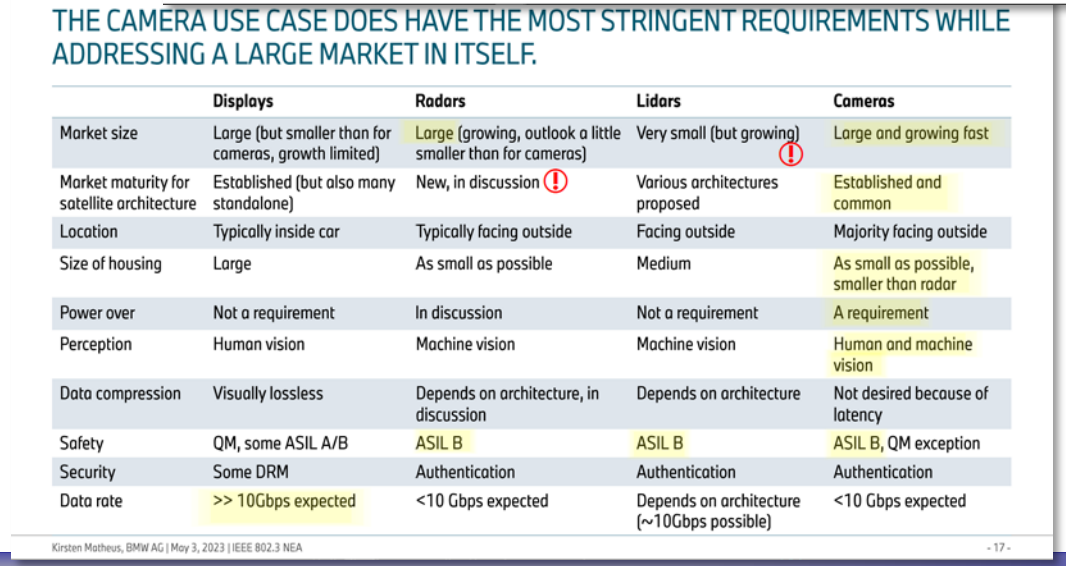
- In matheus_nea_01_230503.pdf, Kirsten Matheus gave compelling reasons for developing a new Ethernet solution intended for automotive camera applications
- There is a large and rapidly growing market for camera connectivity in automotive applications
- There are specific requirements for camera connectivity, which may not be fully addressed by current standards



AND YES, THE AUTOMOTIVE CAMERA MARKET IS MOST ATTRACTIVE WITH HIGH VOLUMES SUPPORTED BY AUTONOMOUS DRIVING AND LEGISLATION.

- Functionality of camera use cases increases with active lane keeping, ACC, or driver drowsiness detection.
- Take rate of basic camera systems is driven by regulation:
  - US: Rearview
  - Japan: Sideview for SUV
  - NCAP: vulnerable road users AEB, occupant status, lane keeping, and more
- ADAS L2+ and L3 systems require ever more cameras.
- Aerodynamic optimization is driving electronic mirror replacements.

High motivation to address use case in all CFIs. Large market in itself. Satellite camera architectures are currently ONLY supported using proprietary solutions.

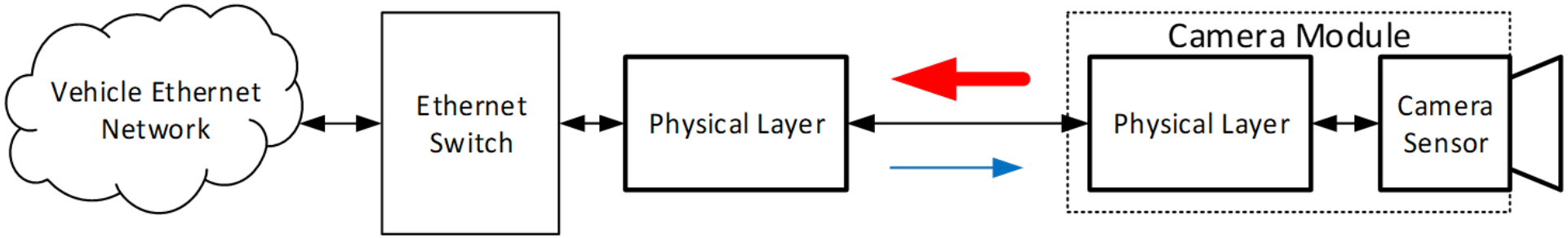


THE CAMERA USE CASE DOES HAVE THE MOST STRINGENT REQUIREMENTS WHILE ADDRESSING A LARGE MARKET IN ITSELF.

	Displays	Radars	Lidars	Cameras
Market size	Large (but smaller than for cameras, growth limited)	Large (growing, outlook a little smaller than for cameras)	Very small (but growing) !	Large and growing fast
Market maturity for satellite architecture	Established (but also many standalone)	New, in discussion !	Various architectures proposed	Established and common
Location	Typically inside car	Typically facing outside	Facing outside	Majority facing outside
Size of housing	Large	As small as possible	Medium	As small as possible, smaller than radar
Power over	Not a requirement	In discussion	Not a requirement	A requirement
Perception	Human vision	Machine vision	Machine vision	Human and machine vision
Data compression	Visually lossless	Depends on architecture, in discussion	Depends on architecture	Not desired because of latency
Safety	QM, some ASIL A/B	ASIL B	ASIL B	ASIL B, QM exception
Security	Some DRM	Authentication	Authentication	Authentication
Data rate	>> 10Gbps expected	<10 Gbps expected	Depends on architecture (~10Gbps possible)	<10 Gbps expected

From https://www.ieee802.org/3/ad_hoc/ngrates/public/calls/23_0503/matheus_nea_01_230503.pdf

Network vs Camera Side



Network Side:

- Transmitting occasionally
- Receiving most of the time
- Less heat constraint
- Power savings desirable
- **Ethernet interoperability is key**

Camera Side:

- Transmitting most of the time
- Receiving occasionally
- Important to control heat in camera module
- Power savings are very important
- **Cost and heat are key**

Camera Link Problem Statement

Key characteristics of the PHY:

1. Efficiently support highly asymmetric data rates:
   - 1Gbps to 10Gbps from camera
   - 10Mbps to 100Mbps towards camera
2. Power constrains in camera module (few hundred mW), to control temperature in the module
3. Power delivery over the data link
4. Very cost sensitive

Seamless integration with the wider Ethernet network in the vehicle (i.e., true Ethernet solution) is a must

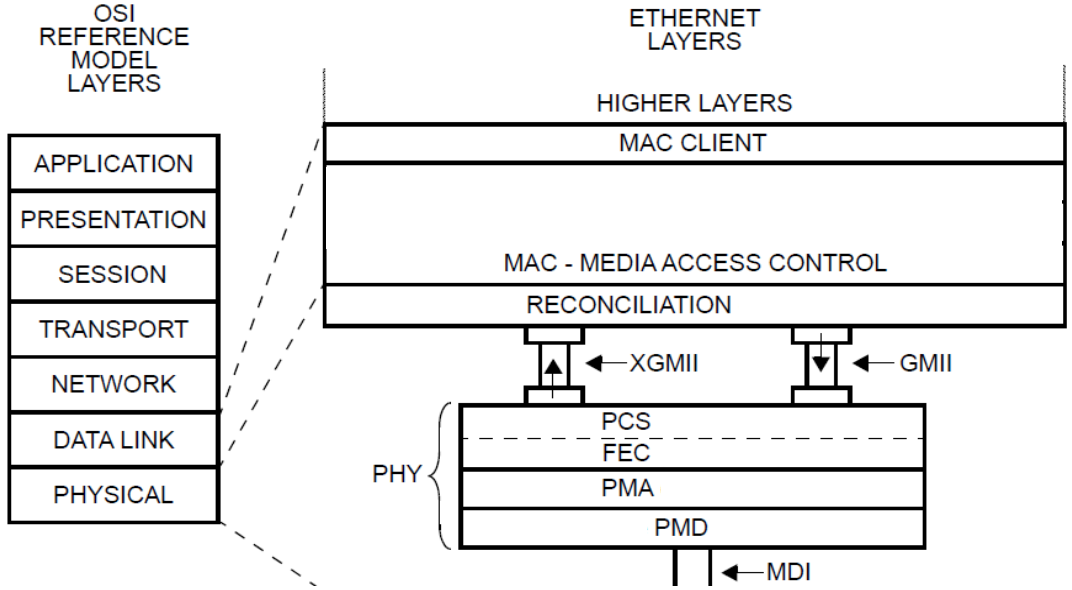
Making asymmetric PHYs fit into Ethernet

- An interoperable specification would work with any MAC
- It's easy to build an engineered, rate-limited system
  - Harder to build an interoperable system where another component is otherwise allowed to burst traffic at you!
- A standard would need to provide a way to limit traffic
  - ***THE MAC CONTROLS ACCESS TO THE MEDIA!***
- Usually this happens in signaling between the MAC and the PHY
  - Rate-specific Reconciliation Sublayers (RS's, e.g., MII, GMII, XGMII)
  - Low power idle request/indications (EEE)
  - Half-duplex carrier sense (not allowed over 1G)
  - Link interruption signaling (fault states)
- All of these are in the details of the MAC & RS

Two Potential RS architectures for Camera Links

Dual-headed RS (ala EPON)

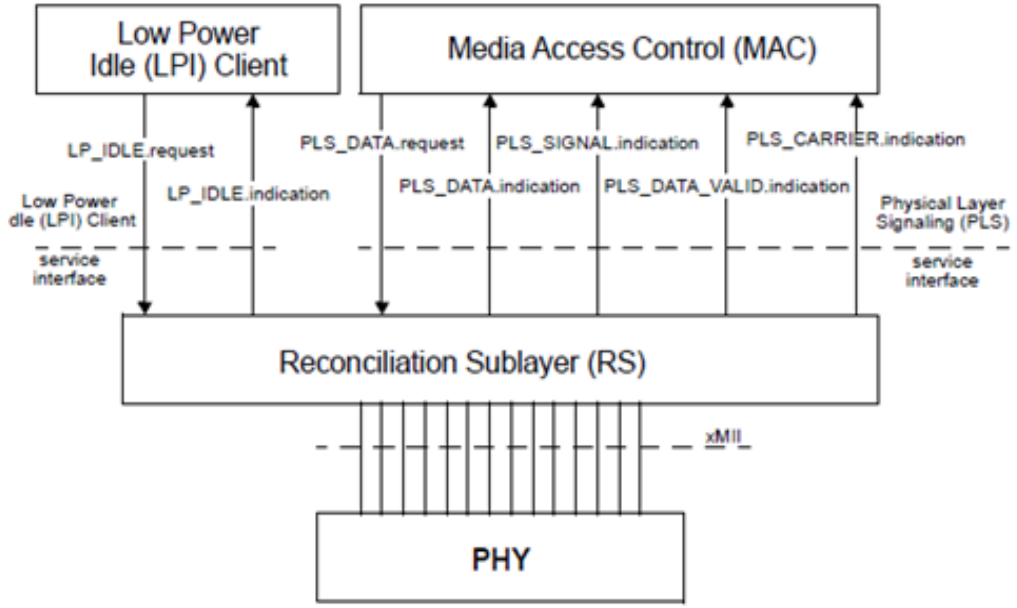
- Needs definition (not just EPON, at least RS)
- Fixes rates in specification



Source: IEEE Std 802.3-2022, Figure 56-5 (modified)

Extensions via a client (like EEE)

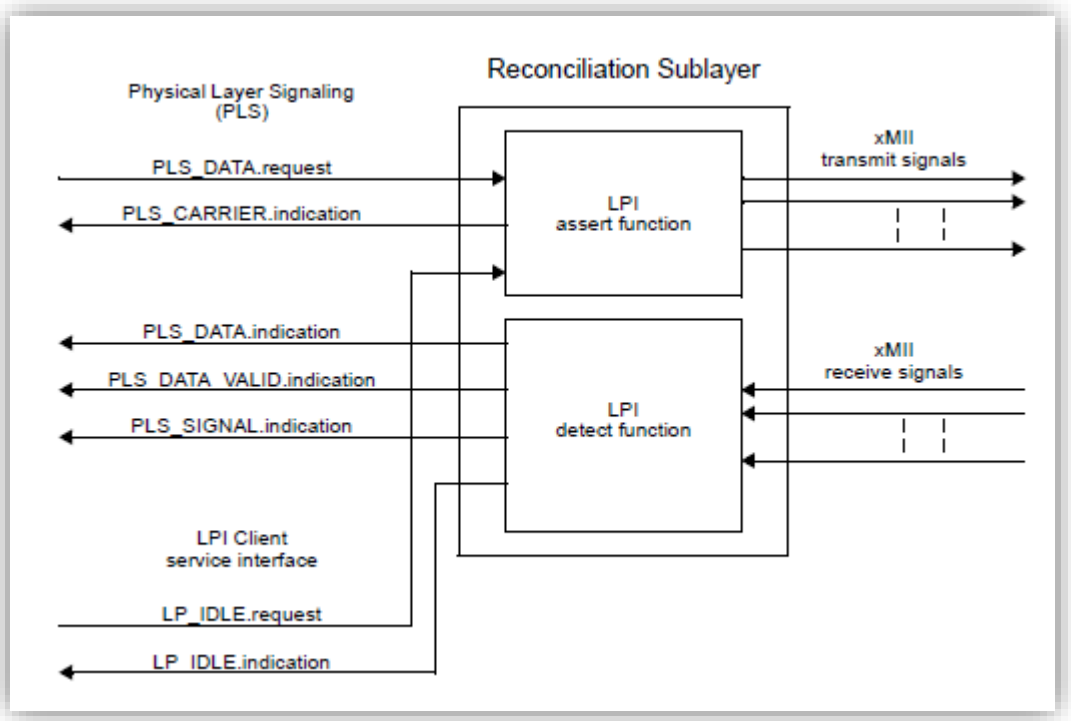
- Needs definition (not just EEE – RS, client)
- Flexible rate based on primitives



Source: IEEE Std 802.3-2022, Figure 78-1

Control via the EEE “LPI Client”

- Transmit Control is from the system down to the PHY
  - From/to the “LPI client”, not specified
- EEE specifies primitives from the LPI client to let it know to shut down or re-enable the link – assuming full symmetric capability
  - RS gives holds off the mac for a fixed wake time
- Limited PHY capabilities require “PHY up” control for pausing data
  - LPI client isn’t specified – only primitives are defined (IDLE request/indication)
  - PHY does not communicate the state of the transmit direction to the client



Source: IEEE Std 802.3-2022, Figure 78-2

Potential for a standards project – needs PHY and RS experts

How might this fit in 802.3?

A potential project might involve:

- Options to existing or new physical layer devices
- Definition of an interface to allow the MAC to control the flow toward the camera/sensor
- Input from camera/sensor experts on important application interfaces
- Input from automotive experts on needs for media, power, and rates

Project likely needs a broad “physical layer” scope	***BUT avoids getting “too broad” in scope!***
Project ideally allows for use beyond automotive cameras	***BUT optimized to serve the high-volume market need!***

Focused on timely solutions

Potential Call for Interest Question

- To develop a PAR, CSD responses, and objectives for a physical layer specification and related functionality of a client for an electrical Ethernet interface optimized for automotive end-node cameras

- Such a question is designed to allow consideration of:
  - Addition of new or modification of existing 802.3 PHYs
  - Addition of new or modification of existing 802.3 RSs
  - Addition of new or modification of existing clients
  - Addition of new or modification of existing media specifications