

How NPO May Fit in IEEE 400GPL

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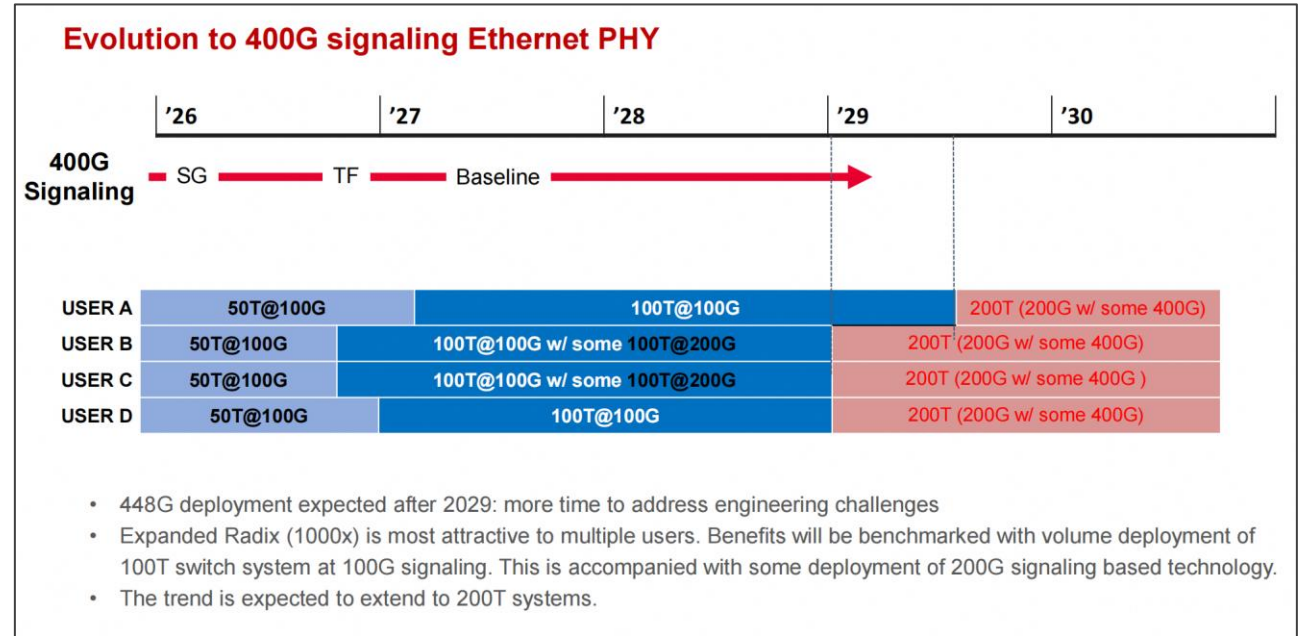
Motivation

- **Scaling challenges in 400GPL Ethernet systems**
 - Increasing port density (800GE → 1.6TE → 3.2TE per port)
 - Power and bandwidth constraints of long-reach electrical interfaces
 - System-level complexity and cost
- **Emerging architectures supporting 400GPL:**
 - Fully-retimed pluggable optics → power & reach overdesigned
 - Linear pluggable optics → facing significant challenges on host loss
 - Co-packaged optics (CPO) → limited serviceability
 - Near-Packaged Optics (NPO) emerging as practical compromise!

Supporters

Broad Market Potential

- E4AI contribution [mi_e4ai_01_260219](#) gathered input from End-users on expectations for 400G per lane Ethernet interfaces:
Strong mutual interest in NPO



End-user Perspective 1

- Time for adopt 400Gb/s per lane Ethernet PHY is expected to be after 2029
- Adopted linear optics technology at 100G signaling, and expect to stay on the track of linear optics at 400G.
- Expect to use optical interconnect more extensively throughout the network, such as scale-up and intra-rack
- NPO/CPO to relax the tension on signal integrity at high signaling rate, need standard to guarantee interoperability and accelerate eco-system growth
- FR4 types of WDM optics is used in the 2nd layer network spanning across the data center, due to considerations on fiber cabling. Full 2km transmission is required, 3km is preferred for 100% coverage. Accept new fiber technologies like MCF/HCF to stay on the track of single pair IMDD fiber link as signaling rate grows beyond 200Gb/s.



End user perspective 2

- Currently planning deployment of 200G signaling rate
- Committed R&D and deployment of NPO system, start with 100G and 200G signaling, with roadmap extending to 400G signaling
- FPP optics is still a good option, provided that competence in supply chain, power consumption and system-level performance is satisfactory.
- Optics for even shorter reach is expected as early as 224G
- Motivated to be more actively involved in the Ethernet standardization of 400G signaling rate

End user perspective 3

- Electrical Interconnect
 - 200G signaling is pushing the limit of PCB.
 - Transition to full cable solution for 400G signaling is mandatory.
 - CPC/NPC is essential to stretch the lifetime of copper interconnect.
- Optical Interconnect is to take over some conventionally copper use cases, at a sizable portion.
- Though NPO/CPO still need to prove its reliability and cultivate the eco-system, these linear types of optics will be the focus in the time of 400G signaling.

Background – Industry Activities

- **OIF EEI (Energy Efficient Interfaces):**
 - Focusing on short-reach, high-speed electrical interfaces, targeting chip-to-optics connectivity in advanced packaging scenarios
- **OIF HDC (High-Density Connector):**
 - Defines high-density electrical connector solutions, enabling short-reach, high-bandwidth module interconnects
- **Other Ecosystem Efforts:** Various MSAs and industry groups exploring:
 - Co-packaged optics (CPO)
 - Near-packaged optics (NPO): Open CPX MSA
 - Alternative pluggable form factors, e.g. XPO
- Strong activity exists in electrical interfaces and mechanical/form factor, but gap remains: No IEEE-defined interoperable electrical interface for NPO systems
- 400GPL is the perfect time to include support of NPO in IEEE 802.3.

Current IEEE 802.3 Coverage (and Gap)

- Interoperable interface classes supported by current IEEE 802.3 standards

Interface	Scope	Standardized?	Domain
AUI	Chip-to-module and chip-to-chip interfaces	YES	Electrical
PMD	Optical links	YES	Optical
CPO internal	Host to optical engine	NO, no need to define	Electrical
CPO external	Optical links	YES, rely on DR/FR specs.	Optical
NPO internal	Host to optical engine	NO, should be defined	Electrical
NPO external	Optical links	YES, rely on DR/FR specs.	Optical

How NPO is Different

- **IEEE philosophy:**
 - If two independently built things might connect → standardize the interface.
- **For CPO:**
 - There is no exposed interoperable electrical interface
 - Optics are tightly coupled to ASIC (no “plug boundary”)
 - No need to standardize in IEEE.
- **For NPO, there is a replaceable module:**
 - There is a short-reach electrical interface
 - Vendors will mix – vendor A’s host can be connected with vendor B’s module.
 - NPO naturally fits IEEE’s interoperability scope, unlike CPO.

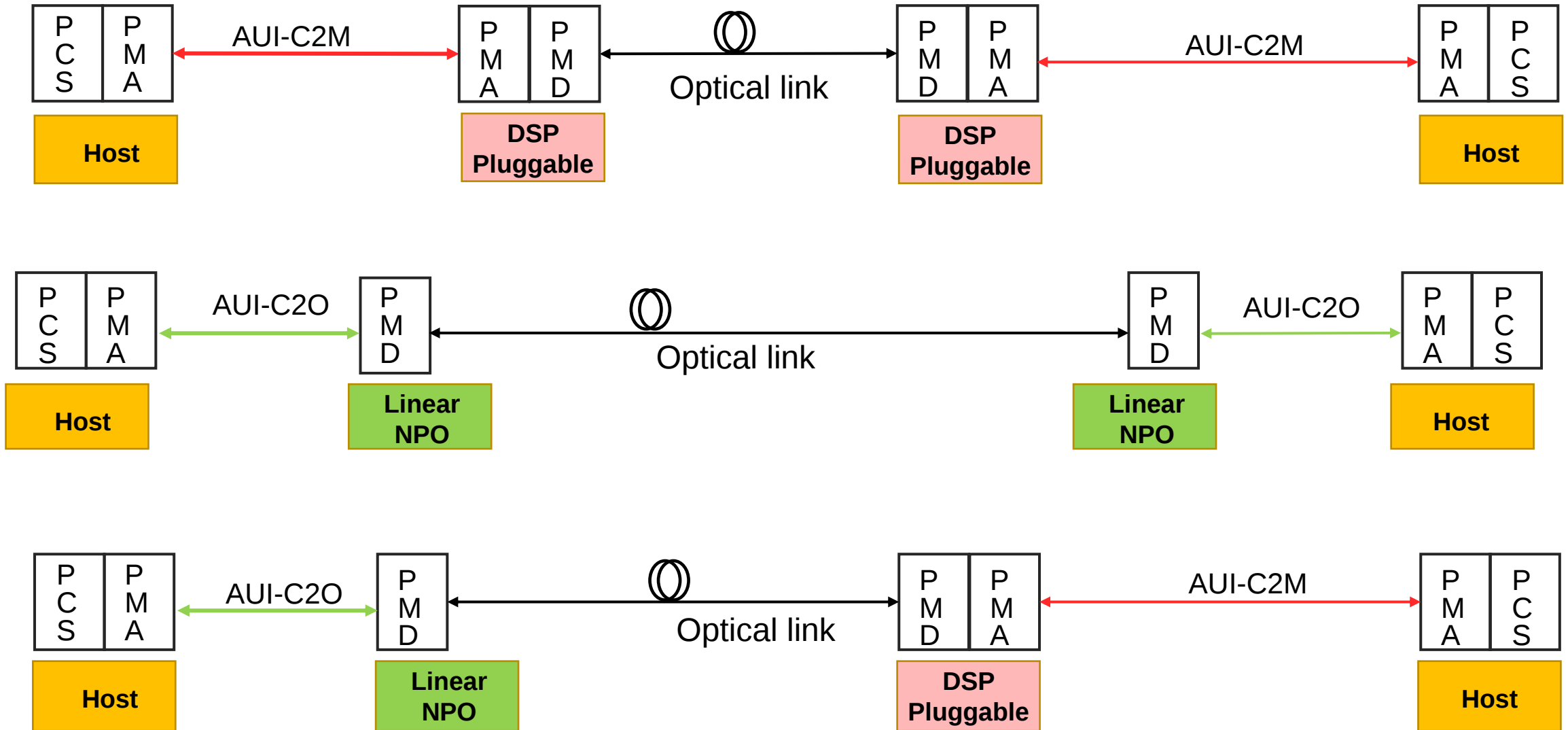
Near-Packaged Optics (NPO) Objectives – Nothing special needed!

- **The optical side should follow optical PMDs**
- **The electrical side requires a new class of AUI, a shorter reach electrical interface.**
 - Option A: a new name (C2O?) – preferred
 - Option B: Include in the C2M objectives – a sub-type of C2M (e.g. C2M-NPO).

Future work for the Task Force:

- Define a short-reach electrical interface between host devices and NPO modules supporting interoperable multi-vendor implementations.
- Specify electrical characteristics for it
- Define channel characteristics for it
- Define compliance and test points enabling interoperability between host devices and near-packaged optical modules.

The New “C2O” Interface Completes the Ethernet Interface Stack



* AUI-C2C instantiation was not illustrated, for simplicity

Summary

- For the first time, NPO introduces a **pluggable** yet ultra-short electrical interface that requires interoperability, something neither CPO nor traditional FPP pluggables address today.
- We propose to add a separate AUI type to include NPO for the 400 Gb/s per lane generation.
Proposed objectives:
 - Support optional single-lane 400 Gb/s attachment unit interfaces for near-package optics applications
 - Support optional two-lane 400 Gb/s attachment unit interfaces for near-package optics applications
 - Support optional four-lane 400 Gb/s attachment unit interfaces for near-package optics applications

Thank you!