Adoption of coherent baselines in P802.3dj

Weiqiang Cheng, China Mobile
Tom Williams, Cisco
Haojie Wang, China Mobile
Or Vidal, Alphawave

Supporters

- Guangcan Mi, Huawei
- Frank Chang, Source Photonics
- Ted Sprague, Infinera
- Arash Farhood, Marvell
- Gary Nicholl, Cisco
- Mike Sluyski, Cisco
- Lijie Zhuang, Hengtong Group
- Bo Zhang, Accelink
- Tao Lin, Accelink
- Atul Srivastava, NTT Innovative Devices
- Kumi Omori, NEC
- Scott Sommers, Molex
- Yongqing Zhu, China Telecom
- Cedric Lam, Google*
- Jeff Maki, Juniper Networks
- Chris Lyons, Amphenol
- Nathan Tracy, TE
- Aihua Liu, ZTE
- Chengbin Wu, ZTE
- Huijun Sha, Viavi
- Xue Wang, H3C
- Guangpeng Ma, Lumentum
- Yanjun Zhu, Hisense
- Zhan Su, Ruijie Networks
- ChiYuan Chen, Spirent
- Chris Cole, Coherent
- Erwan Pincemin, Orange
- Paul Brooks, Viavi
- David Estes, Spirent
- Ken Jackson, Sumitomo
- Matt Brown, Alphawave
- Ted Schmidt, Effect Photonics
- Werner Weiershaousen, Deutsche Telecom
- Tomoo Takahara, Fujitsu
- Ernest Muhigana, Lumentum
- Haim Ben Amran, Retym
- Aharon Roni El-Bahar, Retym
- Gert Sarlet, Coherent
- Jack Jian Xu, Coherent
- Vasu Parthasarathy, Broadcom
- Chongjin Xie, Alibaba
- Xueshun Wang, CICT
- Fangchang Li, Tencent
- Tianle Yang, China Broadnet
- Wenyu Zhao, CAICT
- Han Li, China Mobile
- Wendell Liu, AT&T
- Sunil Khatana, Effect Photonics
- Ali Ghiasi, Ghiasi Quantum

*Supports O-band 800G-LR1 proposal, no position on ER1 objectives

Topics

- Market demand for coherent interfaces
- What’s proposed, what’s missing
- New objective
- CSD/PAR review
- Proposal

800G Coherent market & P802.3dj status

The P802.3dj (and formerly P802.3df) Task Force has had numerous contributions to satisfy various use cases for coherent interfaces for 800 GbE.

- Intra-datacenter up to 10 km – optimized for latency and power
- Telecom (access, mobile) 10 & 40 km – interop between reaches and maximizing investment leverage are important

Current disagreement in IEEE revolves around satisfying both these market demands

- BCH FEC for 10km selected. (latency and power considerations)
- Choice of O-band (lowest dispersion) or C-band (40 km interop) for 10km – not yet selected
- No clear path to support traditional interoperability between reaches for telecom use cases

Deciding on baselines for existing 802.3dj objectives has the following conflicts:

- 10km C-band would not be optimal for intra-datacenter
- 40km O-band would not be optimal for telecom applications

Telecom Application Perspective

- 40km interfaces are an important building block for the network and require higher performance and amplification
  - Availability of lower cost implementations to achieve shorter reach objectives provide value to the network operator
- In IEEE802.3 history, 10km and 40km **interoperation** can be beneficial by driving industrial scale, which can lower manufacturers' cost
  - Cost of optical/electrical components is heavily impacted by volume
- Interoperation of 800G 10km and 40km is needed to support existing applications, like 5G backhaul and metro networking applicaiton
  - Some nodes in metro or 5G backhaul are directly connected within 40km
  - 40km module maybe used in 10km reach, and interoperate with 10km module
- However, proposed 10km and 40km coherent specifications can not support interoperation due to preferred choices of FEC and optical wavelengths

IEEE 802.3dj recent history

- July ’23: Early attempted compromise proposal (kota_3dj_02a_2307)
  - 800GBASE-LR1: O-band, BCH FEC
  - 800GBASE-ER1: C-band, oFEC
  - Note: this proposal would break interop between 10 & 40km and nothing was adopted
- July ’23: Adopted BCH FEC (per kota_3dj_01a_2307) as part of 800GBASE-LR1 baseline
- July ‘23: 800GBASE-LR1/ER1 opt. baseline proposal based on BCH FEC (maniloff_3dj_01_2307)
- July ’23: 800GBASE-ER1 logic baseline proposal (nicholl_3dj_02_2307)
- July ‘23: 800GBASE-ER1 opt. baseline proposal (williams_3dj_01a_2305 pgs 7-10)
- July ‘23: Straw poll on O-band for LR1. Y:44, N: 12, NMI: 30, Abs: 30
- Nov ’23: 800GBASE-LR1 O-band opt. baseline proposal (kota_3dj_01a_2311)
- Nov ‘23: 800GBASE-LR1/ER1 C-Band opt. baseline proposal (maniloff_3dj_01_2311)
- Nov ‘23: Straw poll on O vs C-band for LR1. O:34, C: 20, NMI: 22, Abs: 33

Compromise Outline

- Two technical approaches have received significant support, but not sufficient for adoption to date
- O-band, BCH FEC is a very good solution for 800GBASE-LR1 (10km)
  - Laser focused (no pun intended) on the needs of new AI/ML application space
  - Lowest latency and lowest power
  - Not hindered by legacy / technology reuse / interop considerations. “Do something new !”
- C-band, oFEC is a very good solution for 800GBASE-ER1 (40km)
  - Focus is on telecom requirements of higher performance/ longer reach / older fiber applications
  - Latency and power (although a consideration) are not the overriding factors
  - Leverages industry investments in more mature FEC technology widely deployed in ZR applications
- These two solutions do not address the telecom market need for a cost optimized solution supporting interop with 40km (and future 80km)
  - Propose to add a new 20km objective that would be interoperable with 800GBASE-ER1

New Objective for 800G coherent

- 800 Gb/s operation over 1 wavelength over one-pair SMF with lengths up to at least **20 km**
- Support telecom application of more than 10 km or older fiber links with a higher loss, like metro direct-connection and 5G backhaul scenerios
- In these scenerios, while the fiber links between different core nodes are geographiclly distributed around 10km, the required actual link margin is above 10km due to the higher loss caused by dusty fiber end face, poor fiber connectors or extra patch panels
- Support interoperation requirement with 40km
- 10km coherent (LR1) still should be supported for optical interconnection of the ever-increasing hyperscale datacenter in AI/ML era

Technical feasibility assumptions

A 20km solution: compared with 40km ER, relaxed specs and reduced testing requirements, different technologies may be explored

- wavelength: C band, avoids excessive loss and nonlinear penalties, interoperates with 40km solution
- FEC: oFEC, offers higher sensitivity (more margin) to reach the objective
- Enables implementation without an optical amplifier – lower power/cost
  - ER1 baseline assumes implementation with an internal amplifier
- Breadth of optical components technologies possible: InP, SiPh or LNOI
- Fixed λ, no laser tunability – lower power/cost

New proposed objective language

Define a physical layer specification that supports 800 Gb/s operation over a single SMF in each direction with lengths up to at least 20 km

CSD & PAR

Do we need to modify the Criteria for Standards Development (CSD) or PAR to support the addition of a new objective?

- Current PAR: https://www.ieee802.org/3/dj/projdoc/P802d3dj_PAR.pdf
- Current CSD: https://mentor.ieee.org/802-ec/dcn/22/ec-22-0256-00-ACSD-p802-3dj.pdf
- Current Objectives: https://www.ieee802.org/3/dj/projdoc/objectives_P802d3dj_231116.pdf

General conclusion – current CSD and PAR remain appropriate and inclusive of the proposal. (see backup to review)

Bringing it all together

- Solutions to multiple market applications have shown to be addressable with coherent technology
  - The markets are evolving beyond the traditional telecom applications in this space
- The optimal coherent technology solution differs for each market
- For IEEE 802.3dj to appropriately address all of these, it is proposed we jointly adopt baselines/objectives to provide clarity on the path forward:
  - Intra-datacenter applications
  - Interoperable telecom applications

The complete 10km+ solution set at 800G

- 800GBASE-LR4 (10 km IMDD)
  - Optimized for cost
  - High volume data center use cases
- 800GBASE-LR1 (10km Coherent)
  - Optimized for high volume and low power/latency coherent
  - Fully optimized for AI/ML use cases
- (new) 800GBASE-ER1-20* (20km Coherent)
  - Addresses traditional 10+ km telecom market
  - Interop with 40 km (and future 80km)
  - Implementation is unamplified – lower power/cost
- 800GBASE-ER1
  - Maximum loss budget
  - Likely requires optical amplification
  - Interop with potential 20 km (and future 80km)
  - Technology reuse an important consideration

*Placeholder name. Nomenclature of 20km PHY needs to be determined if adopted

Joint proposal

Proposal is to adopt:

- O-band based optical baseline for 800GBASE-LR1 (maniloff_3dj_01a_2401)
- Logic baseline for 800GBASE-ER1 logic baseline proposal (nicholl_3dj_02a_2307)
- Optical baseline for 800GBASE-ER1 (williams_3dj_01a_2305 pgs 7-10)
- Add new 20km objective:
  - Define an 800GBASE-ER1-20* physical layer specification that supports 800 Gb/s operation over a single SMF in each direction with lengths up to at least 20 km

*Placeholder name. Nomenclature of 20km PHY needs to be determined if adopted

Backup

Managed Objects

No Change

Describe the plan for developing a definition of managed objects. The plan shall specify one of the following:

a) **The definitions will be part of this project.**
b) **The definitions will be part of a different project and provide the plan for that project or anticipated future project.**
c) **The definitions will not be developed and explain why such definitions are not needed.**

- ❑ The definition of protocol independent managed objects, to be included in Clause 30 of IEEE Std 802.3, will be part of this project.

Coexistence

No Change

A WG proposing a wireless project shall prepare a Coexistence Assessment (CA) document unless it is not applicable.

a) **Will the WG create a CA document as part of the WG balloting process as described in Clause 13? (yes/no)**
b) **If not, explain why the CA document is not applicable.**

- No. A CA document is not applicable because the proposed project is not a wireless project.

Broad Market Potential

No Change

Each proposed IEEE 802 LMSC standard shall have broad market potential. At a minimum, address the following areas:

a) Broad sets of applicability.
b) Multiple vendors and numerous users.

- The principle of building equipment that supports IEEE 802.3 networks operating at different Ethernet rates has been amply demonstrated by a broad set of product offerings.
- Per the IEEE 802.3 2020 Bandwidth Assessment Report, by 2025 the bandwidth requirements of various applications will grow between 2.3 to 55.4 times relative to their 2017 levels. For these key application areas: cloud-scale data centers, internet exchanges, co-location services, content-delivery networks, wireless infrastructure, service provider and operator networks, and video distribution infrastructure:
  - the definition of higher density 800 Gb/s Ethernet will address the cost and power considerations.
  - The definition of 1.6 Tb/s Ethernet will address the growing diverse bandwidth requirements cost considerations.
- Presentations have been submitted to the study group that illustrate the market adoption of Ethernet ports addressing multiple rates and medias for use with duplex and parallel infrastructures.
- Evolving needs of computing applications will be enabled by parallel solutions targeting noted high–bandwidth applications.
- There has been wide attendance and participation in the study group by subject matter experts familiar with the needs of end users, equipment manufacturers and component suppliers. It is anticipated that there will be sufficient participation to effectively complete the standardization process.

Compatibility

No Change

Each proposed IEEE 802 LMSC standard should be in conformance with IEEE Std 802, IEEE 802.1AC, and IEEE 802.1Q. If any variances in conformance emerge, they shall be thoroughly disclosed and reviewed with IEEE 802.1 WG prior to submitting a PAR to the Sponsor.

a) **Will the proposed standard comply with IEEE Std 802, IEEE Std 802.1AC and IEEE Std 802.1Q?**
b) **If the answer to a) is "no", supply the response from the IEEE 802.1 WG.**
c) **Compatibility with IEEE Std 802.3**
d) **Conformance with the IEEE Std 802.3 MAC**

- As an amendment to IEEE Std 802.3 the proposed project shall comply with IEEE Std 802, IEEE Std 802.1AC and IEEE Std 802.1Q.
- As was the case in previous IEEE Std 802.3 amendments, new physical layers will be defined for 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s operation.
- As an amendment to IEEE Std 802.3, the proposed project will conform to the full-duplex operating mode of the IEEE 802.3 MAC.
- By utilizing the existing IEEE Std 802.3 MAC protocol, this proposed amendment will maintain compatibility with the installed base of Ethernet nodes.
- The definition of protocol independent managed objects, to be included in Clause 30 of IEEE Std 802.3, will be part of this project.

Distinct Identity

No Change

Each proposed IEEE 802 LMSC standard shall provide evidence of a distinct identity. Identify standards and standards projects with similar scopes and for each one describe why the proposed project is substantially different.

Substantially different from other IEEE 802.3 specifications/solutions.

- The proposed amendment will be the first IEEE 802.3 standard defining 1.6 Tb/s Ethernet.
- The proposed amendment will be the first IEEE 802.3 standard defining 200 Gb/s, 400 Gb/s, and 800 Gb/s Ethernet physical layer specifications based on 200 Gb/s or greater per lane signaling technologies.

Technical Feasibility

No Change

Each proposed IEEE 802 LMSC standard shall provide evidence that the project is technically feasible within the time frame of the project. At a minimum, address the following items to demonstrate technical feasibility:

a) Demonstrated system feasibility.

b) Proven similar technology via testing, modeling, simulation, etc.

c) Confidence in reliability.

- The principle of scaling the IEEE 802.3 MAC to higher speeds has been well established by previous work within IEEE.
- The principle of building equipment that supports IEEE 802.3 networks operating at different Ethernet rates has been amply demonstrated by a broad set of product offerings.
- Systems with an aggregate bandwidth of greater than or equal to 1.6 Tb/s have been demonstrated and deployed in operational networks.
- The proposed project will build on the array of Ethernet component and system design experience, and the broad knowledge base of Ethernet network operation.
  - Contributions have been made that presented data at 800 Gb/s and 1.6 Tb/s over copper and single-mode fiber based on 200 Gb/s or greater per lane signaling technologies. Proposals, which either leverage existing technologies or employ new technologies, have been provided.
  - The experience gained in the development and deployment of technologies since the start of the development of 40 Gigabit Ethernet and 100 Gigabit Ethernet (IEEE 802.3ba) starting in 2008, is applicable to the development of specifications for components at higher speeds. For example, some combination of the following approaches could be used to address 800 Gb/s and 1.6 Tb/s Ethernet, as well as to address reduced lane count solutions for 200 Gb/s and 400 Gb/s Ethernet: pulse-amplitude modulation, parallel transmission techniques, forward error correction, optical coherent signaling, and wavelength-division multiplexing
- Based on prior experience with developing higher speed solutions, the reliability of Ethernet components and systems is understood and can be projected in the target environments with a high degree of confidence.

Economic Feasibility

No Change

Each proposed IEEE 802 LMSC standard shall provide evidence of economic feasibility. Demonstrate, as far as can reasonably be estimated, the economic feasibility of the proposed project for its intended applications. Among the areas that may be addressed in the cost for performance analysis are the following:

a) Known cost factors.
b) Balanced cost factors.
c) Consideration of installation costs.
d) Consideration of operational costs (e.g., energy consumption).
e) Other areas, as appropriate.

- Prior experience scaling IEEE 802.3 indicates the cost distribution between servers, switches, routers, and the infrastructure will remain acceptably balanced for 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Ethernet.
- The cost factors for Ethernet components and systems are well known. The proposed project may introduce new cost factors which can be quantified.
- The deployment of 800 Gb/s and 1.6 Tb/s Ethernet standards and derivatives at 200 Gb/s and 400 Gb/s will allow economies of scale to reduce cost for all solutions.
- In consideration of installation costs, the project is expected to use proven and familiar media, including twin-axial copper cables~~,~~ and single-mode optical fiber cabling.
- Network design, installation and maintenance costs are minimized by preserving network architecture, management, and software.
- In consideration of operational costs associated with power consumption, the project will examine alternatives that trade off physical medium dependent (PMD) sublayer complexity, power, latency, and implementation constraints.

PAR

No Change recommended

2.1 Project Title: Standard for Ethernet
Amendment: Media Access Control Parameters for 1.6 Tb/s and Physical Layers and Management Parameters for 200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Operation

5.2.b Scope of the project: Define Ethernet MAC parameters for 1.6 Tb/s. Define physical layer specifications, and management parameters for the transfer of Ethernet format frames at 800 Gb/s and 1.6 Tb/s over copper and single-mode fiber physical medium dependent (PMD) sublayers based on 200 Gb/ s or greater per lane signaling technologies.

Using these new definitions for 800 Gb/s and 1.6 Tb/s, define physical layer specifications and management parameters for the transfer of Ethernet format frames at 200 Gb/s and 400 Gb/s, when applicable.

5.5 Need for the Project: The project is necessary to provide higher density solutions to meet the growing bandwidth needs for computing and network interconnect application areas, such as cloud-scale data centers, internet exchanges, co-location services, content delivery networks, wireless infrastructure, service provider and operator networks, and video distribution infrastructure.

5.6 Stakeholders for the Standard: Stakeholders include users and producers of systems and components for high-bandwidth applications, such as cloud-scale data centers, internet exchanges, co- location services, content delivery networks, wireless infrastructure, service provider and operator networks, and video distribution infrastructure.

Thank you!