

IEEE 802.3
Beyond 10km Optical PHYs Study Group
Closing Report

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San Diego, CA, USA
July 12, 2018

IEEE 802.3 Beyond 10km Optical PHYs Study Group Project information

Study Group Organization

John D'Ambrosia, Chair, IEEE 802.3 Beyond 10km Optical PHYs SG

Task force web and reflector information

- Reflector: <http://www.ieee802.org/3/B10K/reflector.html>
- Home page: <http://www.ieee802.org/3/B10K/index.html>

Project Documentation – none approved by 802.3 WG

- PAR <https://mentor.ieee.org/802-ec/dcn/18/ec-18-0145-00-00EC-ieee-p802-3cn-standard-for-ethernet-amendment-physical-layers-and-management-parameters-for-50-gb-s-100-gb-s-200-gb-s-and-400-gb-s-operation-over-single-mode-fiber-and-dwdm-dense-wavelength-division-multiplexing-systems.pdf>
- CSD <https://mentor.ieee.org/802-ec/dcn/18/ec-18-0146-00-00EC-ieee-p802-3cn-draft-csd.pdf>
- Objectives http://www.ieee802.org/3/B10K/project_docs/objectives_180521.pdf
- Timeline N/A

Ad Hoc page <http://www.ieee802.org/3/B10K/public/adhoc/index.shtml>

Private Area None Yet

This Week's Accomplishments

- 1 technical presentation
 - “400GBASE -LR8 Measurement Data for Reaches > 10km”
- Reviewed comments submitted against project documentation.
 - Summary / Response –
http://www.ieee802.org/3/B10K/public/18_07/dambrosia_b10k_03_0718.pdf
- Adopted updated PAR / CSD (Approved 34/0/0)
- Liaisons
 - ITU-T SG15 to IEEE 802.3 regarding progress on G.698.2
 - OIF – 400ZR Implementation Agreement (B10k SG Progress)
- Request extension of Study Group

IEEE P802.3cn PROJECT DOCUMENTATION

Adopted Objectives

* - Adopted by SG Jan 2018 Interim. Not approved by IEEE 802.3 WG.
** - Adopted by SG Mar 2018 Plenary. Not approved by IEEE 802.3 WG.
*** - Adopted by SG May 2018 Interim. Not approved by IEEE 802.3WG.

- Support full-duplex operation only*
- Preserve the Ethernet frame format utilizing the Ethernet MAC*
- Preserve minimum and maximum FrameSize of current Ethernet standard*
- Provide appropriate support for OTN*

50 Gb/s Ethernet

- Support a MAC data rate of 50 Gb/s*
- Support a BER of better than or equal to 10^{-12} at the MAC/PLS service interface (or the frame loss ratio equivalent) for 50 Gb/s*
- Provide a physical layer specification which supports 50 Gb/s operation over at least 40 km of SMF*

100 Gb/s Ethernet

- Support a MAC data rate of 100 Gb/s **
- Support a BER of better than or equal to 10^{-12} at the MAC/PLS service interface (or the frame loss ratio equivalent) for 100 Gb/s **
- Provide a physical layer specification supporting 100 Gb/s operation on a single wavelength capable of at least 80 km over a DWDM system. **

200 Gb/s Ethernet

- Support a MAC data rate of 200 Gb/s **
- Support a BER of better than or equal to 10^{-13} at the MAC/PLS service interface (or the frame loss ratio equivalent) for 200 Gb/s **
- Provide a physical layer specification supporting 200 Gb/s operation over four wavelengths capable of at least 40 km of SMF**

400 Gb/s Ethernet

- Support a MAC data rate of 400 Gb/s ***
- Support a BER of better than or equal to 10^{-13} at the MAC/PLS service interface (or the frame loss ratio equivalent) for 400 Gb/s ***
- Provide a physical layer specification supporting 400 Gb/s operation over eight wavelengths capable of at least 40 km of SMF***
- Provide a physical layer specification supporting 400 Gb/s operation on a single wavelength capable of at least 80 km over a DWDM system.***

WG Motion #1

Move that the IEEE 802.3 Working Group approve the IEEE P802.3cn B10K objectives, as per slide 5 of 0718_b10k_close_report.pdf

M: John D'Ambrosia

S: Mark Nowell

(Technical \geq 75%)

Results approved by voice without opposition

IEEE P802.3cn PAR (1 of 3)

<https://mentor.ieee.org/802-ec/dcn/18/ec-18-0145-00-00EC-ieee-p802-3cn-standard-for-ethernet-amendment-physical-layers-and-management-parameters-for-50-gb-s-100-gb-s-200-gb-s-and-400-gb-s-operation-over-single-mode-fiber-and-dwdm-dense-wavelength-division-multiplexing-systems.pdf>

2.1 Title: Standard for Ethernet: Amendment: Physical Layers and Management Parameters for 50 Gb/s, 100 Gb/s, 200 Gb/s, and 400 Gb/s Operation over Single-Mode Fiber and DWDM (dense wavelength division multiplexing) systems

5.2.b. Scope of the project: Define physical layer specifications and management parameters for the transfer of Ethernet format frames at 50 Gb/s, 100 Gb/s, 200 Gb/s, and 400 Gb/s at reaches greater than 10 km over single-mode fiber and DWDM systems. Make TDECQ (Transmitter and dispersion eye closure for PAM4) related changes to existing 200 Gb/s and 400 Gb/s physical medium dependent sublayers over single-mode fiber.

5.5 Need for the Project: Optical solutions targeting greater than 10 km over single-mode fiber will address the bandwidth requirements of mobile backhaul networks fueled by consumer video. Optical solutions targeting greater than 10 km over a DWDM system will address the bandwidth growth and reach requirements of Cable/MSO (multiple system operator) distribution networks, mobile backhaul networks, and interconnect for distributed data centers where reaches greater than 10 km are required, or where fiber availability drives the need for multiple instances of Ethernet over a DWDM system.

5.6 Stakeholders for the Standard: Users and producers of systems and components for mobile backhaul networks, cable/multi-service operator (MSO) distribution networks, data center interconnect networks, and any other networks needing reaches in excess of 10 km over single-mode fiber or DWDM systems.

IEEE P802.3cn PAR (2 of 3)

<https://mentor.ieee.org/802-ec/dcn/18/ec-18-0145-00-00EC-ieee-p802-3cn-standard-for-ethernet-amendment-physical-layers-and-management-parameters-for-50-gb-s-100-gb-s-200-gb-s-and-400-gb-s-operation-over-single-mode-fiber-and-dwdm-dense-wavelength-division-multiplexing-systems.pdf>

7.1 Are there other standards or projects with a similar scope?: Yes

If Yes please explain: While there are no other IEEE standards or projects with a similar scope, the IEEE 802.3 Working Group has received liaisons from two organizations indicating that the respective groups have related efforts underway. ITU-T Study Group 15 has communicated that it is revising Recommendation ITU-T G.698.2 to include multi-vendor interoperable 100 Gb/s single channel optical interfaces that operate over a DWDM system for approximately 80 km distances. The Optical Internetworking Forum (OIF) has communicated that it is developing the 400ZR Implementation Agreement (IA), which is targeted at (passive) single channel and (amplified) short-reach DWDM (dense wavelength division multiplexing) / DCI (data center interconnect) pluggable modules with distances supported from 80-120 km. The effort will support 400 Gb/s Ethernet via the 400GAUI-8 interface that is defined by IEEE 802.3. Stakeholders have expressed the desire for this project, as it will define physical layer specifications and Protocol Implementation Conformance Statements (PICS) for 100 Gb/s and 400 Gb/s Ethernet operation over DWDM systems that are consistent and completely integrated with existing IEEE 802.3 Ethernet specifications.

and answer the following

Sponsor Organization: ITU-T SG15 and OIF

Project/Standard Number: Recommendation ITU-T G.698.2 and OIF 400ZR Implementation Agreement

Project/Standard Date:

Project/Standard Title: Recommendation ITU-T G.698.2 Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces and OIF 400ZR Implementation Agreement

IEEE P802.3cn PAR (3 of 3)

<https://mentor.ieee.org/802-ec/dcn/18/ec-18-0145-00-00EC-ieee-p802-3cn-standard-for-ethernet-amendment-physical-layers-and-management-parameters-for-50-gb-s-100-gb-s-200-gb-s-and-400-gb-s-operation-over-single-mode-fiber-and-dwdm-dense-wavelength-division-multiplexing-systems.pdf>

8.1 Additional Explanatory Notes: Item 5.2b: PAM4 expands to 4-level pulse amplitude modulation

Item 7.1 Project/Standard date: Recommendation ITU-T G.698.2 anticipated 'consent' date of 19th Oct 2018

Item 7.1 Project/Standard date: OIF 400ZR Implementation Agreement project start date 3rd Nov 2016

PAR Changes Summary

Item 7.1 - Change the proposed response to the following (changes indicated in red)-

While there are no other IEEE standards or projects with a similar scope, the IEEE 802.3 Working Group has received liaisons from two organizations indicating that the respective groups have related efforts underway. ITU-T Study Group 15 has communicated that it is revising Recommendation ITU-T G.698.2 to include multi-vendor interoperable 100 Gb/s single channel optical interfaces ~~that operate over a DWDM system, which specifically includes the rate for 100 Gb/s Ethernet signals, and will include an application code for 100G appropriate for approximately 80 km distances, not precluding 120 km, and without OADMs (optical add drop multiplexers).~~ The Optical Internetworking Forum (OIF) has communicated that it is developing the 400ZR Implementation Agreement (IA), which is targeted at (passive) single channel and (amplified) short-reach DWDM (dense wavelength division multiplexing) /DCI (data center interconnect) pluggable modules with distances supported from 80-120 km. The effort will support 400 Gb/s Ethernet via the 400GAUI-8 interface that is defined by IEEE 802.3, ~~but other system side formats may also be considered. Stakeholders have expressed a desire to see an IEEE 802.3 standard address 100 Gb/s Ethernet and 400 Gb/s Ethernet over DWDM systems. Where appropriate, existing standards will be referenced, rather than duplicated.~~ Stakeholders have expressed the desire for this project, as it will define physical layer specifications and Protocol Implementation Conformance Statements (PICS) for 100 Gb/s and 400 Gb/s Ethernet operation over DWDM systems that are consistent and completely integrated with existing IEEE 802.3 Ethernet specifications.

Sponsor Organization: ITU-T SG15 and OIF

Project/Standard Number: Recommendation ITU-T G.698.2 and OIF 400ZR Implementation Agreement

Project/Standard Date:

Project/Standard Title: Recommendation ITU-T G.698.2 Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces and OIF 400ZR Implementation Agreement ~~for 400ZR~~

Item 8.1 – added following text –

Item 7.1 Project/Standard date: Recommendation ITU-T G.698.2 anticipated 'consent' date of 19th Oct 2018

Item 7.1 Project/Standard date: OIF 400ZR Implementation Agreement project start date 3rd Nov 2016

WG Motion #2

Move that the IEEE 802.3 Working Group approve the IEEE P802.3cn B10K PAR, in <https://mentor.ieee.org/802-ec/dcn/18/ec-18-0145-00-00EC-ieee-p802-3cn-standard-for-ethernet-amendment-physical-layers-and-management-parameters-for-50-gb-s-100-gb-s-200-gb-s-and-400-gb-s-operation-over-single-mode-fiber-and-dwdm-dense-wavelength-division-multiplexing-systems.pdf>

M: John D'Ambrosia

S: Steve Trowbridge

(Technical $\geq 75\%$)

Results all Y: 92 / N: 0 / A: 0

Motion Passes

IEEE 802.3 Criteria for Standards Development (CSD)

The IEEE 802 Criteria for Standards Development (CSD) are defined in Clause 14 of the IEEE 802 LAN/MAN Standards Committee (LMSC) Operations Manual. The criteria include project process requirements (“Managed Objects”) and 5 Criteria (5C) requirements. The 5C are supplemented by subclause 7.2 ‘Five Criteria’ of the ‘Operating Rules of IEEE Project 802 Working Group 802.3, CSMA/CD LANs’.

The following are the CSD Responses in relation to the IEEE P802.3cn PAR

Items required by the IEEE 802 CSD are shown in Black text and supplementary items required by IEEE 802.3 are shown in blue text.

Managed Objects

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

A WG proposing a wireless project shall demonstrate coexistence through the preparation of a Coexistence Assurance (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?
- b) If not, explain why the CA document is not applicable

- A CA document is not applicable because the proposed project is not a wireless project.

Broad Market Potential

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.

- Ethernet is being adopted in new application areas that require longer transmission distances than currently specified by the IEEE 802.3 Ethernet standard for 50 GbE, 100 GbE, 200 GbE, and 400 GbE. Mobile backhaul, Cable / MSO, and interconnect for distributed data centers are all looking to deploy an optical Ethernet infrastructure based on physical solution ranges of 40 km to 80 km.
 - Optical solutions targeting 40 km over single-mode fiber will address the bandwidth requirements of the access layers of mobile backhaul networks, in particular in China, as forecasted bandwidth data indicates demand fueled by consumer video in excess of other world regions.
 - Optical solutions targeting 80 km over DWDM systems will address the bandwidth growth and reach requirements of Cable/MSO distribution networks, mobile backhaul networks and interconnect for distributed data centers where reaches in excess of 40 km are required or where fiber availability drives the need for multiple instances of Ethernet over a DWDM system.
- This project will provide upgrade paths for existing application areas that need greater bandwidth at the reaches specified. Existing industry solutions that currently do not have an upgrade path are:
 - Applications over 40 km single-mode fiber migrating from 25 GbE to 50 GbE or 100 GbE to 200 GbE / 400 GbE
 - Applications over 80 km over DWDM systems migrating from 10 Gb/s
- Two calls-for-interest for “Beyond 10 km Optical PHYs” (for 50 GbE / 200 GbE / 400 GbE and then separately for 100 GbE) had 103 & 124 participants respectively. In each CFI, approximately 60 individuals affiliated with at least 39 companies indicated that they would support the standardization process. It is anticipated that there will be sufficient participation to effectively complete the standardization process including individuals from end-users, equipment manufacturers and component suppliers.

Compatibility

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**
- e) **Managed object definitions compatible with SNMP**

- 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 50 Gb/s, 100 Gb/s, 200 Gb/s, and 400 Gb/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

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.

- While there are no other IEEE standards or projects with a similar scope, the IEEE 802.3 Working Group has received liaisons from two organizations indicating that the respective groups have related efforts underway. ITU-T Study Group 15 has communicated that it is revising Recommendation ITU-T G.698.2 to include multi-vendor interoperable 100 Gb/s single channel optical interfaces that operate over a DWDM system for approximately 80 km distances. The Optical Internetworking Forum (OIF) has communicated that it is developing the 400ZR Implementation Agreement (IA), which is targeted at (passive) single channel and (amplified) short-reach DWDM (dense wavelength division multiplexing) / DCI (data center interconnect) pluggable modules with distances supported from 80-120 km. The effort will support 400 Gb/s Ethernet via the 400GAUI-8 interface that is defined by IEEE 802.3.

Stakeholders have expressed the desire for this project, as it will define physical layer specifications and Protocol Implementation Conformance Statements (PICS) for 100 Gb/s and 400 Gb/s Ethernet operation over DWDM systems that are consistent and completely integrated with existing IEEE 802.3 Ethernet specifications.

- There is no IEEE 802.3 standard or project developing a standard that supports point-to-point Ethernet over 40 km of single-mode fiber cabling at a data rate of 50 Gb/s, 200 Gb/s, or 400 Gb/s or 80 km over a DWDM system at a data rate of 100 Gb/s or 400 Gb/s.

Technical Feasibility

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 building equipment that supports IEEE 802.3 networks operating up to 400 Gb/s Ethernet rates has been amply demonstrated by a broad set of product offerings.
 - The proposed project will build on the array of Ethernet component and system design experience, and the broad knowledge base of Ethernet network operation.
 - The industry already has experience developing 50 Gb/s per wavelength, direct detect solutions for 50 Gb/s, 200 Gb/s and 400 Gb/s Ethernet and 100 Gb/s and 400 Gb/s coherent detection solutions for metro and long-haul networks. Subcomponents or design experience from these can be leveraged for the proposed Physical Layer specifications.
 - The experience gained in the development and deployment of 25 Gb/s and 100 Gb/s optical solutions targeting 40 km is applicable to the development of specifications for components at 50 Gb/s per wavelength targeting 40 km over single-mode fiber. Feasibility data has been presented.
 - The experience gained from the wide deployment of optical coherent detection solutions at single wavelength 100 Gb/s and higher over DWDM systems with much longer reaches than 80 km provides confidence in feasibility of 80 km solutions over a DWDM system.
 - The reliability of Ethernet components and systems has been established in the target environments with a high degree of confidence.

Economic Feasibility

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) Balanced costs (infrastructure versus attached stations).
 - b) Known cost factors.
 - c) Consideration of installation costs.
 - d) Consideration of operational costs (e.g., energy consumption).
 - e) Other areas, as appropriate.
- The cost factors for Ethernet components and systems are well known.
 - Reasonable cost for the resulting performance will be achieved in this project as established by prior experience in the development of:
 - Ethernet direct detect optical specifications ranging from 50 Gb/s to 400 Gb/s based on the 50 Gb/s per wavelength PMDs
 - Optical coherent detection solutions targeting reaches much longer than 80 km at 100 Gb/s and above that are expected to be cost reduced for 80 km reaches over DWDM systems.
 - In consideration of installation costs, the project is expected to use proven and familiar media consistent with industry deployments.
 - Extended reach optical solutions minimize the need for additional equipment to achieve the target reaches which lowers overall network power consumption.
 - Network design, installation and maintenance costs are minimized by preserving network architecture, management, and software.

WG Motion #3

Move that the IEEE 802.3 Working Group approve the IEEE P802.3cn B10K CSD “Managed Objects”, “Coexistence”, “Broad Market Potential”, “Compatibility”, “Distinct Identity”, “Technical Feasibility”, and “Economic Feasibility” responses, in <https://mentor.ieee.org/802-ec/dcn/18/ec-18-0146-00-00EC-ieee-p802-3cn-draft-csd.pdf>

M: John D’Ambrosia

S: Pete Anslow

(Technical \geq 75%)

Results (all) Y: 95 / N: 0 / A: 1

Motion Passes

Liaisons

- ITU-T SG15 to IEEE 802.3 regarding progress on G.698.2
 - Recommendation – Response from Sept Interim, as ITU-T SG15 meets next in early Oct.
- OIF – 400ZR Implementation Agreement (B10k SG Progress)
 - Proposed Response (Approved by voice vote w/o opposition) - http://www.ieee802.org/3/B10K/public/18_07/IEEE_802d3_to_OIF_B10k_0718_draft.pdf
- Both liaisons have accompanying technical drafts. An ad hoc call is scheduled for August 16, 2018 7am to 9am PT. Individuals interested in discussing the drafts contact chair. If no interest, call will be cancelled.

WG Motion #4

Move that the IEEE 802.3 Working Group approve:

- IEEE_802d3_to_OIF_B10k_0718_draft

with editorial license granted to the Chair (or his appointed agent) as liaison communication from the IEEE 802.3 Working Group to OIF.

Technical ($\geq 75\%$)

M: D'Ambrosia

S: M Nowell

Results: Passed by voice vote without opposition

WG Motion #5

Move:

- The IEEE 802.3 Working Group requests the extension of the Beyond 10 km Optical PHYs Study Group
- The IEEE 802.3 Working Group approve the following rationale for extension: Approval has been sought to forward the IEEE P802.3cn PAR to NesCom which was developed by this Study Group. This request for extension is for two reasons: (a) to be able to address any issues during the approval process for the IEEE P802.3cn PAR; and (b) to allow the Study Group to meet during the IEEE 802.3 September 2018 interim week for further study and consensus building. The IEEE-SA Standards Board won't meet to consider the NesCom recommendation on IEEE P802.3cn PAR until 27th September 2018, after the interim week.

> 50%

M: J. D'Ambrosia

S: M. Nowell

Results All: Y: 89 / N: 0 / A: 1

What's Next

August 16, 2018 (7am to 9am PT) Liaison Ad hoc Teleconference

Discussion of technical drafts provided by ITU-T SG15 and OIF.

Please note - Individuals interested in discussing the drafts should contact chair. If no interest, call will be cancelled.

Sept Interim – Spokane, WA, Week of September 10, 2018

Questions?

Thank you!