IEEE 802 Nov 2022

IEEE 802.3 Ethernet WG
Closing Plenary
17 Nov 2022

IEEE P802.3df
200 Gb/s, 400 Gb/s, 800 Gb/s, and 1.6 Tb/s Force
Closing Report

IEEE P802.3df Task Force Project information

- **Organization**
  - John D'Ambrosia, Chair, IEEE P802.3df Task Force
  - Mark Nowell, Vice-Chair, IEEE P802.3df Task Force, Optics Track Chair
  - Matt Brown, Chief Editor
  - Mark Gustlin, Architecture & Logic Track Chair
  - Kent Lusted, Electrical Track Chair
- **Task force web and reflector information:**
  - Home page: https://www.ieee802.org/3/df/index.html
  - Reflector Info - https://www.ieee802.org/3/df/reflector.html
    - TF Reflector: stds-802-3-b400g@listserv@ieee.org
    - Logic Reflector: stds-802-3-b400g-logic@listserv@ieee.org
    - Optical Reflector: stds-802-3-b400g-optx@listserv@ieee.org
    - Electrical Reflector: stds-802-3-b400g-elec@listserv@ieee.org
- **Project Documentation –**
  - PAR : https://www.ieee802.org/3/df/proj_doc/IEEE_P802.3df_PAR_11122021.pdf
  - CSD: https://mentor.ieee.org/802-ec/dcn/21/ec-21-0306-00-ACSD-p802-3df.pdf
  - Objectives: https://www.ieee802.org/3/df/proj_doc/objectives_P802d3df_220317.pdf
- **P802.3df TF meeting information may be found on:**
  - Public page: https://www.ieee802.org/3/df/public/index.html
  - 802.3 Calendar: https://www.ieee802.org/3/calendar.html
  - Ad hoc Page: https://www.ieee802.org/3/df/public/adhoc/index.html

Activities This Week

- **IEEE P802.3df PAR Modification / IEEE P802.3dj PAR**
  - **Responded to Comments from 802 community**
    - **IEEE P802.3df PAR Modification: IEEE 802.1, 802.11**
    - **IEEE P802.3dj PAR Modification: IEEE 802.1, 802.11, 802.15**
  - **Adopted P802.3df PAR Modification changes, P802.3dj PAR / CSD changes by unanimous consent**
  - **Reaffirmed P802.3df CSD by unanimous consent**
- **31 Technical Presentations**
  - **Motion to adopt RS(544,514,10) as the FEC encoding for the 200G/lane AUIs (C2M and C2C) Passed by unanimous consent**
  - **Motion to to adopt differential PAM4 signaling as the basis for all the 200 Gb/s per lane AUIs (C2M and C2C) 802.3 Voters - Y: 68, N: 3, A: 17**
- **Considered liaison "OIF to IEEE 802.3: 800ZR/800LR IA Project Update"**
  - **Response approved by unanimous consent**

DOCUMENTATION PACKAGES APPROVAL:
IEEE P802.3df PAR MODIFICATION
IEEE P802.3dj PAR

IEEE P802.3df Target PMDs

Ethernet Rate	Assumed Signaling Rate per lane	BP	Cu Cable	MMF 50m	MMF 100m	SMF 500m	SMF 2km	SMF 10km	SMF 40km
200 Gb/s	200 Gb/s		1 pair			1 pair	1 pair		
400 Gb/s	100 Gb/s						4 pairs		
	200 Gb/s		2 pairs			2 pairs			
800 Gb/s	100 Gb/s	8 lanes	8 pairs	8 pairs	8 pairs	8 pairs	8 pairs		
	200 Gb/s		4 pairs			4 pairs	1) 4 pairs 2) 4 λ's		
	TBD							Over single SMF in each direction	Over single SMF in each direction
1.6 Tb/s	100 Gb/s								
	200 Gb/s		8 pairs			8 pairs	8 pairs		

Technology Reuse

Leverage existing or work-in-progress 100 Gb/s per lane (e.g. 3cu, 3ck, 3db) to higher lane counts

Develop 200 Gb/s per lane electrical signaling for 1/2/4/8 lane variants of electrical PMDs

Develop 200 Gb/s per optical fiber for 1/2/4/8 fiber based optical PMDs and per lambda for 4 lambda WDM optical PMD

Potential for either direct detect and / or coherent signaling technology

P802.3df

P802.3dj

Objectives

- **IEEE P802.3df**
  - **See Appendix 1 for modification history**
- **IEEE P802.3dj**
  - **See Appendix 2 for creation history**

Adopted IEEE P802.3df Objectives

- **Non-Rate Specific**
  - Support full-duplex operation only
  - Preserve the Ethernet frame format utilizing the Ethernet MAC
  - Preserve minimum and maximum FrameSize of current IEEE 802.3 standard
  - Support a BER of better than or equal to 10 -13 at the MAC/PLS service interface (or the frame loss ratio equivalent)
  - Provide support to enable mapping over OTN
- **400 Gb/s Related**
  - Support a MAC data rate of 400 Gb/s
  - Define a physical layer specification that supports 400 Gb/s operation:
    - over 4 pairs of SMF with lengths up to at least 2 km
- **800 Gb/s Related**
  - Support a MAC data rate of 800 Gb/s
  - Support optional eight-lane 800 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Define a physical layer specification that supports 800 Gb/s operation:
    - over eight lanes of twin axial copper cables with a reach up to at least 2 meters
    - over eight lanes over electrical backplanes supporting an insertion loss ≤ 28dB at 26.56GHz
    - over 8 pairs of MMF with lengths up to at least 50 m
    - over 8 pairs of MMF with lengths up to at least 100 m
    - over 8 pairs of SMF with lengths up to at least 500 m
    - over 8 pairs of SMF with lengths up to at least 2 km

Adopted IEEE P802.3dj Objectives (1 of 2)

- **Non-Rate Specific**
  - Support full-duplex operation only
  - Preserve the Ethernet frame format utilizing the Ethernet MAC
  - Preserve minimum and maximum FrameSize of current IEEE 802.3 standard
  - Support a BER of better than or equal to 10 -13 at the MAC/PLS service interface (or the frame loss ratio equivalent)
  - Provide support to enable mapping over OTN
- **200 Gb/s Related**
  - Support a MAC data rate of 200 Gb/s
  - Support optional single-lane 200 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Define a physical layer specification that supports 200 Gb/s operation:
    - over 1 pair of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter
    - over 1 pair of SMF with lengths up to at least 500 m
    - over 1 pair of SMF with lengths up to at least 2 km
- **400 Gb/s Related**
  - Support a MAC data rate of 400 Gb/s
  - Support optional two-lane 400 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Define a physical layer specification that supports 400 Gb/s operation:
    - over 2 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter
    - over 2 pairs of SMF with lengths up to at least 500 m

Adopted IEEE P802.3dj Objectives (2 of 2)

- **800 Gb/s Related**
  - Support a MAC data rate of 800 Gb/s
  - Support optional four-lane 800 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Define a physical layer specification that supports 800 Gb/s operation:
    - over 4 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter
    - over 4 pairs of SMF with lengths up to at least 500 m
    - over 4 pairs of SMF with lengths up to at least 2 km
    - over 4 wavelengths over a single SMF in each direction with lengths up to at least 2 km
    - over a single SMF in each direction with lengths up to at least 10 km
    - over a single SMF in each direction with lengths up to at least 40 km
- **1.6 Tb/s Related**
  - Support a MAC data rate of 1.6 Tb/s
  - Support optional sixteen-lane 1.6 Tb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Support optional eight-lane 1.6 Tb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Define a physical layer specification that supports 1.6 Tb/s operation:
    - over 8 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter
    - over 8 pairs of SMF with lengths up to at least 500 m
    - over 8 pairs of SMF with lengths up to at least 2 km

IEEE P802.3df PAR Modification History

- **Proposed PAR Modification Changes**
  - https://www.ieee802.org/3/df/public/22_09/dambrosia_3df_03a_2209.pdf
- **Submitted Task Force PAR –**
  - ec-22-0196-01-00EC-draft-ieee-p802-3df-par-modification.pdf
- **Summary of Changes due to comments at Nov 2022 Plenary**
  - **See Appendix 1, Slides 26-27**
- **Final PAR**
  - ec-22-0196-03-00EC-draft-ieee-p802-3df-par-modification.pdf

IEEE P802.3dj PAR Creation History

- **Proposed PAR (based on IEEE P802.3df approved PAR)**
  - https://www.ieee802.org/3/df/public/22_09/dambrosia_3df_05a_2209.pdf
- **Submitted Task Force PAR –**
  - ec-22-0196-01-00EC-draft-ieee-p802-3df-par-modification.pdf
- **Summary of Changes due to comments at Nov 2022 Plenary**
  - **See Appendix 2, Slides #44**
- **Final PAR**

IEEE P802.3df CSD Modification History

- **Proposed Changes to approved CSD**
  - **https://mentor.ieee.org/802-ec/dcn/22/ec-22-0197-02-00EC-draft-ieee-p802-3df-csd-modification.pdf**
- **Final CSD Responses – See Appendix 1, Slides 30-37**

IEEE P802.3dj CSD Creation History

- **Proposed CSD (based on IEEE P802.3df approved CSD)**
  - https://mentor.ieee.org/802-ec/dcn/22/ec-22-0199-02-00EC-draft-ieee-p802-3dj-csd.pdf
- **Summary of Changes due to comments at Nov 2022 Plenary**
  - **See Appendix 2, Slides #46 - 47**
- **Final CSD Responses – See Appendix 2, #49 - 56**

WG Motion

Move that the IEEE 802.3 Working Group approve:

- **IEEE P802.3df Project Documentation Modification**
  - **Objectives – Page 7 of 2211_3df_close_report**
  - **PAR – https://mentor.ieee.org/802-ec/dcn/22/ec-22-0196-03-00EC-draft-ieee-p802-3df-par-modification.pdf**
    CSD – Pages 30 – 37 of 2211_3df_close_report
- **IEEE P802.3dj Project Documentation**
  - **Objectives – Pages 8 – 9 of 2211_3df_close_report**
  - **PAR - https://mentor.ieee.org/802-ec/dcn/22/ec-22-0198-03-00EC-draft-ieee-p802-3dj-par.pdf**
  - **CSD – Pages 49 – 56 of 2211_3df_close_report**
- **Technical (>=75%)**
- **M: D'Ambrosia**
- **S: Nowell**
- **Results: Y:x N:x A:x**

WG Motion

Move that the IEEE 802.3 Working Group approve

- **IEEE_802d3_to_OIF_3df_2211 with editorial license granted to the Chair (or his appointed agent) as a liaison communication from the IEEE 802.3 Working Group to ITU-T SG15.**

- **Technical (>=75%)**
- **M: D'Ambrosia**
- **S: Lusted**
- **Results: Y:x N:x A:x**

WG Motion

Move that the IEEE 802.3 Working Group grant approval for the P802.3df and P802.3dj Task Forces to take motions during any joint meeting between these task forces only

Technical (>=75%)

- **M: D'Ambrosia**
- **S: Nowell**
- **Results: Y:x N:x A:x**

Next Steps

- Dec 2022 Electronic Session
  - Agenda – Address comments submitted during IEEE P802.3df D1.0 initial Task Force Review
    - 6 Dec, 9am to 1pm, ET
    - 7 Dec, 9am to 1pm, ET
    - 8 Dec, 9am to 1pm, ET
    - 13 Dec, 9am to 1pm, ET
    - 14 Dec, 9am to 1pm, ET
    - 15 Dec, 9am to 1pm, ET
- If PAR "Split" Approved – Setup IEEE P802.3dj Task Force Webpage
- Jan 2023 Interim

Note of Thanks

- The proposed IEEE P802.3df project split was challenging for a number of reasons.

- I would like to personally thank -
  - Mark Nowell
  - Kent Lusted
  - David Law
  - IEEE P802.3df Task Force

THANK YOU!

APPENDIX 1 -
IEEE P802.3df PAR MODIFICATION DOCUMENTATION PACKAGE

Proposed Objectives – Modified P802.3df PAR

IEEE P802.3df Task Force

John D'Ambrosia,
Chair, IEEE P802.3df Task Force
Futurewei, U.S. Subsidiary of Huawei

Mark Nowell
Vice-Chair, IEEE P802.3df Task Force
Cisco

14 Sept 2022

See Page #5 for Revision History

IEEE P802.3 df Objectives

- **Non-Rate Specific**
  - Support full-duplex operation only
  - Preserve the Ethernet frame format utilizing the Ethernet MAC
  - Preserve minimum and maximum FrameSize of current IEEE 802.3 standard
  - Support a BER of better than or equal to 10 -13 at the MAC/PLS service interface (or the frame loss ratio equivalent)
  - Provide support to enable mapping over OTN

- ~~**200 Gb/s Related**~~
  - ~~Support a MAC data rate of 200 Gb/s~~
  - ~~Support optional single-lane 200 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications~~
  - ~~Define a physical layer specification that supports 200 Gb/s operation:~~
    - ~~over 1 pair of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter~~
    - ~~over 1 pair of SMF with lengths up to at least 500 m~~
    - ~~over 1 pair of SMF with lengths up to at least 2 km~~

- **400 Gb/s Related**
  - Support a MAC data rate of 400 Gb/s
  - ~~Support optional two-lane 400 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications~~
  - Define a physical layer specification that supports 400 Gb/s operation:
    - ~~over 2 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter~~
    - ~~over 2 pairs of SMF with lengths up to at least 500 m~~
    - over 4 pairs of SMF with lengths up to at least 2 km

See Page #5 for Revision History

IEEE P802.3 df Objectives

- **800 Gb/s Related**
  - Support a MAC data rate of 800 Gb/s
  - Support optional eight-lane 800 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - ~~Support optional four-lane 800 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications~~
  - Define a physical layer specification that supports 800 Gb/s operation:
    - ~~over 4 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter~~
    - over eight lanes of twin axial copper cables with a reach up to at least 2 meters
    - over eight lanes over electrical backplanes supporting an insertion loss ≤ 28dB at 26.56GHz
    - over 8 pairs of MMF with lengths up to at least 50 m
    - over 8 pairs of MMF with lengths up to at least 100 m
    - over 8 pairs of SMF with lengths up to at least 500 m
    - over 8 pairs of SMF with lengths up to at least 2 km
    - ~~over 4 pairs of SMF with lengths up to at least 500 m~~
    - ~~over 4 pairs of SMF with lengths up to at least 2 km~~
    - ~~over 4 wavelengths over a single SMF in each direction with lengths up to at least 2 km~~
    - ~~over a single SMF in each direction with lengths up to at least 10 km~~
    - ~~over a single SMF in each direction with lengths up to at least 40 km~~

See Page #5 for Revision History

IEEE P802.3 df Objectives

- ~~**1.6 Tb/s Related**~~
  - ~~Support a MAC data rate of 1.6 Tb/s~~
  - ~~Support optional sixteen-lane 1.6 Tb/s attachment unit interfaces for chip-to-module and chip-to-chip applications~~
  - ~~Support optional eight-lane 1.6 Tb/s attachment unit interfaces for chip-to-module and chip-to-chip applications~~
  - ~~Define a physical layer specification that supports 1.6 Tb/s operation:~~
    - ~~over 8 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter~~
    - ~~over 8 pairs of SMF with lengths up to at least 500 m~~
    - ~~over 8 pairs of SMF with lengths up to at least 2 km~~

IEEE P802.3df PAR MODIFICATION CHANGES

PAR Item 5.2.b "Scope of the project" Modification

.3df Proposed Change

Change Current Scope:

Define Ethernet MAC parameters, physical layer specifications, and management parameters for the transfer of Ethernet format frames at 800 Gb/s over copper, multi-mode fiber, and single-mode fiber based on 100 Gb/s signaling technology, and use this work to define physical layer specifications and management parameters for the transfer of Ethernet format frames at 400 Gb/s.

To:

Define Ethernet MAC parameters, physical layer specifications, and management parameters for the transfer of Ethernet format frames at 800 Gb/s over copper, multi-mode fiber, and single-mode fiber physical medium dependent (PMD) sublayers based on 100 Gb/s per lane signaling technology.

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

PAR Item 8.1: "Additional Explanatory Notes" Modification

.3df Proposed Change

Change 8.1:

It became apparent to the IEEE 802.3 Working Group that a portion of the project would leverage existing 100 Gb/s signaling technologies developed for existing standards and projects, while the other portion of the project would leverage new greater than 100 Gb/s signaling technologies. It was also recognized that the development of a standard based on existing technologies would occur on a faster timeline than a standard based on the development of new signaling technologies. As a result, the portion of the project that would leverage new greater than 100 Gb/s signaling technologies has been removed from the IEEE P802.3df amendment PAR and placed in the new IEEE P802.3dj amendment PAR.

To

Items 2.1, 4.2, 4.3, 5.2B, 7.1: It became apparent to the IEEE 802.3 Working Group that a portion of the project would leverage existing 100 Gb/s per lane signaling technologies developed for existing standards and projects, while the other portion of the project would leverage new 200 Gb/s or greater per lane signaling technologies. It was also recognized that the development of a standard based on existing technologies would occur on a faster timeline than a standard based on the development of new signaling technologies. As a result, the portion of the project that would leverage new 200 Gb/s or greater per lane signaling technologies has been removed from the IEEE P802.3df amendment PAR and placed in the new IEEE P802.3dj amendment PAR.

CSD CHANGES FOR IEEE P802.3df PAR MODIFICATION

IEEE P802.3df CSD Modification History

- **Proposed Changes to approved CSD**
  - **https://mentor.ieee.org/802-ec/dcn/22/ec-22-0197-02-00EC-draft-ieee-p802-3df-csd-modification.pdf**
- **Final CSD Responses – See Next Slides**

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 4.5 'Criteria for Standards Development' of the 'IEEE 802.3 Ethernet Working Group Operations Manual'.

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

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. The definition of 800 Gb/s Ethernet will address the growing diverse bandwidth requirements and cost considerations 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.
- 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

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 400 Gb/s and 800 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.

- The proposed amendment will be the first IEEE 802.3 standard defining 800 Gb/s Ethernet, providing an upgrade path for IEEE 802.3 users from lower Ethernet rates, such as 200 Gb/s and 400 Gb/s Ethernet.
- The proposed amendment will define derivative physical layer specifications from those developed for 800 Gb/s Ethernet to address single-mode fiber specifications for 400 Gb/s Ethernet.

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 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 800 Gb/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 on the feasibility of higher speed solutions. Proposals, which leverage existing 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 Ethernet, as well as to address 400 Gb/s Ethernet: pulse-amplitude modulation, parallel transmission techniques and forward error correction.
- 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

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 400 Gb/s and 800 Gb/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 Ethernet standards and derivatives at 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 electrical backplanes, twin-axial copper cables, multi-mode optical fiber cabling, 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 PMD complexity, power, latency, and implementation constraints.

APPENDIX 2 - IEEE P802.3dj PAR DOCUMENTATION PACKAGE

Proposed Objectives – P802.3dj PAR

IEEE P802.3df Task Force

John D'Ambrosia,
Chair, IEEE P802.3df Task Force
Futurewei, U.S. Subsidiary of Huawei

Mark Nowell
Vice-Chair, IEEE P802.3df Task Force
Cisco

14 Sept 2022

See Page #5 for Revision History

IEEE P802.3 df Objectives

- **Non-Rate Specific**
  - Support full-duplex operation only
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  - Support a BER of better than or equal to 10 -13 at the MAC/PLS service interface (or the frame loss ratio equivalent)
  - Provide support to enable mapping over OTN
- **200 Gb/s Related**
  - Support a MAC data rate of 200 Gb/s
  - Support optional single-lane 200 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Define a physical layer specification that supports 200 Gb/s operation:
    - over 1 pair of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter
    - over 1 pair of SMF with lengths up to at least 500 m
    - over 1 pair of SMF with lengths up to at least 2 km
- **400 Gb/s Related**
  - Support a MAC data rate of 400 Gb/s
  - Support optional two-lane 400 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Define a physical layer specification that supports 400 Gb/s operation:
    - over 2 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter
    - over 2 pairs of SMF with lengths up to at least 500 m
    - ~~over 4 pairs of SMF with lengths up to at least 2 km~~

See Page #5 for Revision History

IEEE P802.3 df Objectives

- **800 Gb/s Related**
  - Support a MAC data rate of 800 Gb/s
  - ~~Support optional eight-lane 800 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications~~
  - Support optional four-lane 800 Gb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Define a physical layer specification that supports 800 Gb/s operation:
    - over 4 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter
    - ~~over eight lanes of twin axial copper cables with a reach up to at least 2 meters~~
    - ~~over eight lanes over electrical backplanes supporting an insertion loss ≤ 28dB at 26.56GHz~~
    - ~~over 8 pairs of MMF with lengths up to at least 50 m~~
    - ~~over 8 pairs of MMF with lengths up to at least 100 m~~
    - ~~over 8 pairs of SMF with lengths up to at least 500 m~~
    - ~~over 8 pairs of SMF with lengths up to at least 2 km~~
    - over 4 pairs of SMF with lengths up to at least 500 m
    - over 4 pairs of SMF with lengths up to at least 2 km
    - over 4 wavelengths over a single SMF in each direction with lengths up to at least 2 km
    - over a single SMF in each direction with lengths up to at least 10 km
    - over a single SMF in each direction with lengths up to at least 40 km

See Page #5 for Revision History

IEEE P802.3 df Objectives

- **1.6 Tb/s Related**
  - Support a MAC data rate of 1.6 Tb/s
  - Support optional sixteen-lane 1.6 Tb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Support optional eight-lane 1.6 Tb/s attachment unit interfaces for chip-to-module and chip-to-chip applications
  - Define a physical layer specification that supports 1.6 Tb/s operation:
    - over 8 pairs of copper twin-axial cables in each direction with a reach of up to at least 1.0 meter
    - over 8 pairs of SMF with lengths up to at least 500 m
    - over 8 pairs of SMF with lengths up to at least 2 km

IEEE P802.3dj PAR

PAR Item 5.2.b: "Scope of the project" Modification

.3dj Proposed Change

Change current scope:

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, multi-mode fiber, and single-mode fiber physical medium dependent (PMD) sublayers, based on greater than 100 Gb/s signaling technologies. Use this work to define derivative physical layer specifications and management parameters for the transfer of Ethernet format frames at 200 Gb/s and 400 Gb/s.

To:

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~~, multi-mode fiber,~~ 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.

IEEE P802.3dj CSD

CSD Modifications

.3dj Proposed Change

- **Distinct Identity**
  - **Replace**

    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 greater than 100 Gb/s signaling.

    With

    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.

CSD Modifications

.3dj Proposed Change

- **Technical Feasibility**
  - **Modify 4th Main bullet – 1st sub bullet**

Contributions have been made that presented data at 800 Gb/s and 1.6 Tb/s over copper and single-mode fiber based on greater than 100 Gb/s signaling technologies. Proposals, which either leverage existing technologies or employ new technologies, have been provided.

To

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.

"FINAL" CSD FOR PROPOSED IEEE P802.3dj PAR

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 4.5 'Criteria for Standards Development' of the 'IEEE 802.3 Ethernet Working Group Operations Manual'.

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

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 and 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

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

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 ~~greater than 100 Gb/s~~ 200 Gb/s or greater per lane signaling technologies.

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 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 ~~greater than 100 Gb/s~~ 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

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.