

802.1AS Amendment to support 10BASE-T1S -- PAR/CSD Discussion --

Don Pannell, Fellow
Automotive Ethernet Networking, NXP Semiconductor

IEEE 802.1 TSN – Aug 2021



SECURE CONNECTIONS
FOR A SMARTER WORLD

PUBLIC



Introduction

- July 2021 meeting proposed to amend 802.1AS to support 802.3cg 10BASE-T1S media
 - The motion was approved to work on PAR in the Sept 2021 meeting
 - This session is intended to get as much of the PAR's text aligned to reduce the work time needed in Sept

- As proposed, it is important to limit the scope of the amendment PAR to the intended task
 - A focused PAR will allow this work to get done so that it can be referenced in IEEE 802.1DG without delaying DG (the TSN Automotive Profile)
 - The changes need to be minimal for faster time to standardization and for smallest code footprint and ease of code implementation
 - Many devices (Bridges and End Stations) that need to support gPTP on 10BASE-T1S links also need to support gPTP on point-to-point links (using today's AS-2020)
 - The more the algorithms & state machines stay the same, the faster this amendment will progress, and supports less work in the future when more features are added to 802.1AS

History / Problem Statement

- IEEE 802.1AS-2011 gPTP specifically prohibited Ethernet shared media (CSMA-CD) as that media could not support the initial AVB plug-n-play use cases
- In 2019 IEEE 802.3cg standardized a short-reach, single pair, 10Mb/s shared media (multi-drop) PHY (10BASE-T1S) that connect to 802.3's CSMA-CD MAC
- IEEE 802.1AS-2020 gPTP continued the shared media restriction
 - Many saw the 10BASE-T1S need coming, but no one wanted to propose a late change to the AS-Rev timeline.
- IEEE 802.3da is currently working on extended reach version of the 10BASE-T1S multi-drop PHY targeted for Industrial applications – it too connects to 802.3's CSMA-CD MAC
- 10BASE-T1S PHYs connect to MACs that are in CSMA-CD half-duplex mode
 - Every node 'sees' every message transmitted by every other node in the shared media use case
 - AS state machines prevent time sync from working on ports that it detects are using shared media
- Support for IEEE 802.3 CSMA-CD media needs to be added to 802.1AS

Broad Market / Need

- Automotive is a main driver for 10BASE-T1S and Automotive needs gPTP for TSN
- In the last year, this group has seen multiple presentations on this topic:
 - <https://www.ieee802.org/1/files/public/docs2020/dg-janker-timesync-in-10BASE-T1S-networks-0920-v02.pdf>
 - <https://www.ieee802.org/1/files/public/docs2020/dg-rentschler-802-1as-MD-multidrop-0920-v01.pdf>
 - <https://www.ieee802.org/1/files/public/docs2021/dg-janker-timesync-in-10BASE-T1S-networks-0521.pdf>
- Industrial will likely need this support too when IEEE 802.3da PHYs become available
 - The problem is the same so the solution will be the same too as IEEE 802.3da connects to the same 10 Mb/s CSMA-CD MAC that has the same shared media behavior as IEEE 802.3cg
 - IEEE 802.1AS-2020 only works when using the 802.3 MAC when that MAC is in full-duplex (non-CSMA-CD, half-duplex) mode
 - This amendment needs to make changes to IEEE 802.1AS so that it can work when using the same 802.3 MAC when that MAC is in CSMA-CD (half-duplex) mode

Feasibility / Need

- 802.1AS implementations running on 10BASE-T1S media already exist in the field
 - This shows that this can work!
 - It also shows that IEEE 802.1AS standardization is needed sooner rather than later, else there will be multiple “industry standards” that will need to be supported
- In Sept of 2017, Craig Gunther presented “802.1 Time-Sensitive Networking (TSN) on 802.3cg [10BASE-T1S] Multidrop networks”
 - <https://www.ieee802.org/1/files/public/docs2017/tsn-cgunther-802-3cg-multidrop-0917-v01.pdf>
 - Craig shows the changes he made to IEEE 802.1AS-2011 to support 10 Mb/s nodes connected to an Ethernet hub (half-duplex repeater) – an 802.3 10 Mb/s CSMA-CD network
 - Craig later created a video showing this gPTP solution working on the network he described in the presentation
- This reference to Craig’s work is not intended to define “the” solution for this work, but it is a clear indication of feasibility – PAR approval 1st, proposed solutions come after that

Proposed PAR Text



SECURE CONNECTIONS
FOR A SMARTER WORLD

PUBLIC



PAR & CSD – Where did this text come from?

- The following slides cover the major sections of the PAR and CSD that need to be created for this project
- The base text was copied from IEEE 802.1ASdm, the hot-standby amendment to gPTP
- The text that is identical to ASdm's PAR & CSD is shown in BLACK.
- Text modifications made for this amendment are shown in GREEN.
- Each slide's text is just an initial proposal which is indicated by the "Dartboard" work in each slide's title
- It is the job of this group to help improve / fix each of the PAR & CSD text items as best we can
- This will be done with real-time editing of each of the following sections with a new version of these slide posted with the results
- Thanks for your contributions to this process!

PAR Scope – Dartboard

5.2.a. Scope of the complete standard: <<This will be what is in IEEE 802.1AS-2020>>

5.2.b. Scope of the project: This amendment specifies protocols, procedures, and managed objects to **add support for IEEE 802.3 CSMA-CD media, including IEEE 802.3cg (10BASE-T1S), by modifying existing mechanisms and state machines.**

The operation and functionality of the base standard for its currently supported media types will not change as well as its compatibility to being a profile of IEEE 1588™-2019.

This amendment also addresses errors and omissions in the description of existing functionality.

5.3 Is the completion of this standard dependent upon the completion of another standard:
No

- **Green** text is new for this PAR. Black text is from IEEE 802.1ASdm's PAR

PAR Purpose – Dartboard

5.4 Purpose: This standard enables systems to meet the respective jitter, wander, and time synchronization requirements for time sensitive applications **using the new, low-cost, IEEE 802.3 PHYs in multi-drop (CSMA-CD / half-duplex / PLCA¹) use cases.**

This includes applications that involve multiple streams delivered to multiple endpoints. To facilitate the widespread use of packet networks for these applications, synchronization information is one of the components needed at each network element where time-sensitive application data are mapped or demapped or a time-sensitive function is performed. ~~This standard leverages the work of the IEEE 1588 Working Group by developing the additional specifications needed to address these requirements.~~

1: PLCA = PHY Level Collision Avoidance, an optional mechanism of IEEE 802.3cg PHYs, where the MAC remains in CSMA-CS / half-duplex mode of operation. This needs to be added to the Additional Explanatory Notes.

- **Green** text is new for this PAR. Black text is from IEEE 802.1ASdm's PAR

PAR Need & Stakeholders – Dartboard

5.5 Need for the Project: **Multi-drop / half-duplex** support is needed in some applications that use time synchronization (e.g., automotive in-vehicle networks and industrial automation networks).

5.6 Stakeholders for the Standard: Developers, manufacturers, distributors, or users of time-sensitive applications, components, and equipment.

- **Green** text is new for this PAR. Black text is from IEEE 802.1ASdm's PAR

Proposed CSD Text



SECURE CONNECTIONS
FOR A SMARTER WORLD

PUBLIC



CSD Managed objects – Dashboard

1.1.1 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.

Item a) is applicable. Additional managed objects may be specified as part of **adding support for IEEE 802.3 CSMA-CD media**.

<<**Green** text is new for this PAR. Black text is from IEEE 802.1ASdm's CSD>>

CSD Coexistence – Dartboard

1.1.2 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? (yes/no)

b) If not, explain why the CA document is not applicable.

Item b) is applicable. This project is not a wireless project; therefore, the CA document is not applicable.

<<Green text is new for this PAR. Black text is from IEEE 802.1ASdm's CSD>>

CSD Broad market potential – Dartboard part 1 of 2

1.2.1 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.

a) This project applies to automotive in-vehicle applications and industrial automation applications.

b) <<is on the next slide>>

<<Green text is new for this PAR. Black text is from IEEE 802.1ASdm's CSD>>

CSD Broad market potential – Dartboard part 2 of 2

b) The need for this project is driven by requirements of **automotive in-vehicle applications**, as part of ongoing work on **IEEE 802.1DG Time-Sensitive Networking Profile for Automotive In-Vehicle Ethernet Communications**. The **IEEE 802.1DG** project applies to multiple **automotive in-vehicle** applications, and multiple **automotive in-vehicle Ethernet applications** vendors and users are participating in its development.

It is anticipated that the support for **IEEE 802.3 CSMA-CD media** will be needed for **industrial automation** applications, as part of ongoing work on **IEC/IEEE 60802 project Time-Sensitive Networking Profile for Industrial Automation** or a future amendment after the competition if **IEEE 802.3da**. The need to support **IEEE 802.3 CSMA-CD media** is not yet specified in the draft of **IEC/IEEE 60802**. As those requirements become clear, it is possible that this amendment will meet them. If not, the work on this amendment can serve as a foundation for a subsequent amendment that meets **industrial** requirements. Therefore, it is anticipated that multiple vendors and users in **industrial automation** applications will participate in the development of this project.

<<**Green** text is new for this PAR. Black text is from IEEE 802.1ASdm's CSD>>

CSD Compatibility – Dartboard

1.2.2 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.

a) Yes, the proposed standard will comply with IEEE Std 802, IEEE Std 802.1AC and IEEE Std 802.1Q.

b) Not applicable.

<<Green text is new for this PAR. Black text is from IEEE 802.1ASdm's CSD>>

CSD Distinct Identity – Dartboard

1.2.3 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.

IEEE Std 802.1AS specifies the transport of synchronized time, however it does not provide for **IEEE 802.3 CSMA-CD media** in the transport. There is no other IEEE standard or project that **defines support for IEEE 802.3 CSMA-CD media** for IEEE Std 802.1AS.

<<**Green** text is new for this PAR. Black text is from IEEE 802.1ASdm's CSD>>

CSD Technical Feasibility – Dartboard

1.2.4 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.

a) Supporting IEEE 802.1AS on IEEE 802.3 CSMA-CD media has been feasibly demonstrated (see <https://www.ieee802.org/1/files/public/docs2017/tsn-cgunther-802-3cg-multidrop-0917-v01.pdf>).

b) The proposed standard will use techniques for which the technology has been proven. IEEE 802.1AS was originally designed to not work on IEEE 802.3 CSMA-CD media as that media did not meet the needs of the original Time-Sensitive Networking (TSN) Audio Video Bridging (AVB) use case needs. This restriction needs to be removed for the expanded use cases of automotive in-vehicle applications and Industrial Automation applications, due to the newer IEEE 802.3cg & IEEE 802.3da PHYs.

<<Green text is new for this PAR. Black text is from IEEE 802.1ASdm's CSD>>

CSD Economic Feasibility – Dartboard part 1 of 2

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.

<<Green text is new for this PAR. Black text is from IEEE 802.1ASdm's CSD>>

CSD Economic Feasibility – Dartboard part 2 of 2

- a) The well-established cost balance between infrastructure and attached stations will not be changed by the proposed standard.
- b) The cost factors are known for the IEEE 802.1AS standard, and will apply to the proposed standard. Specifically, it is expected that **support for IEEE 802.3 CSMA-CD media** can be implemented with small additional costs.
- c) There are small incremental installation costs relative to the IEEE 802.1AS standard that will apply to the proposed standard.
- d) **There are no additional operational costs anticipated.**
- e) No other areas have been identified.

<<**Green** text is new for this PAR. Black text is from IEEE 802.1ASdm's CSD>>

Backup Slides



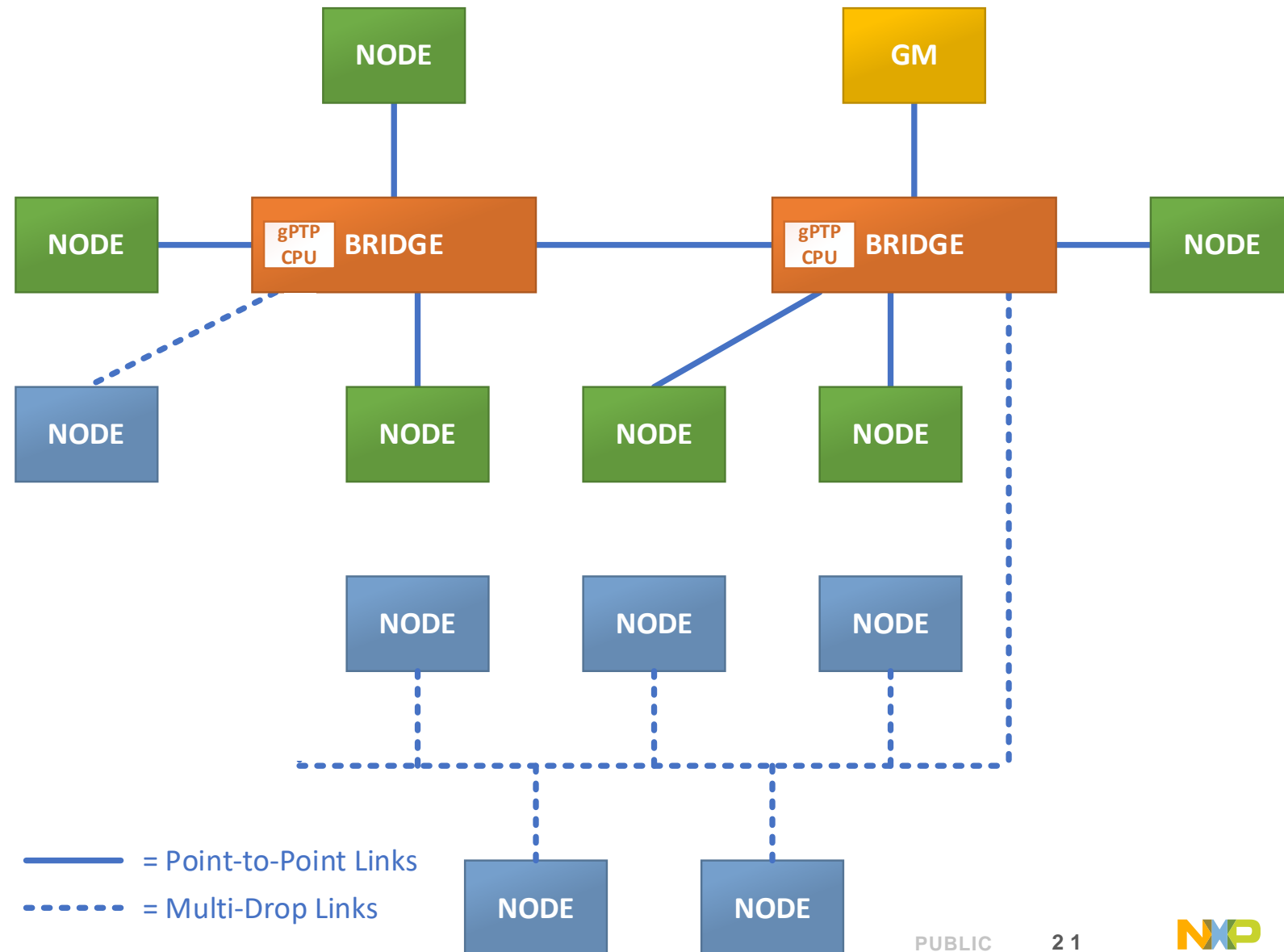
SECURE CONNECTIONS
FOR A SMARTER WORLD

PUBLIC



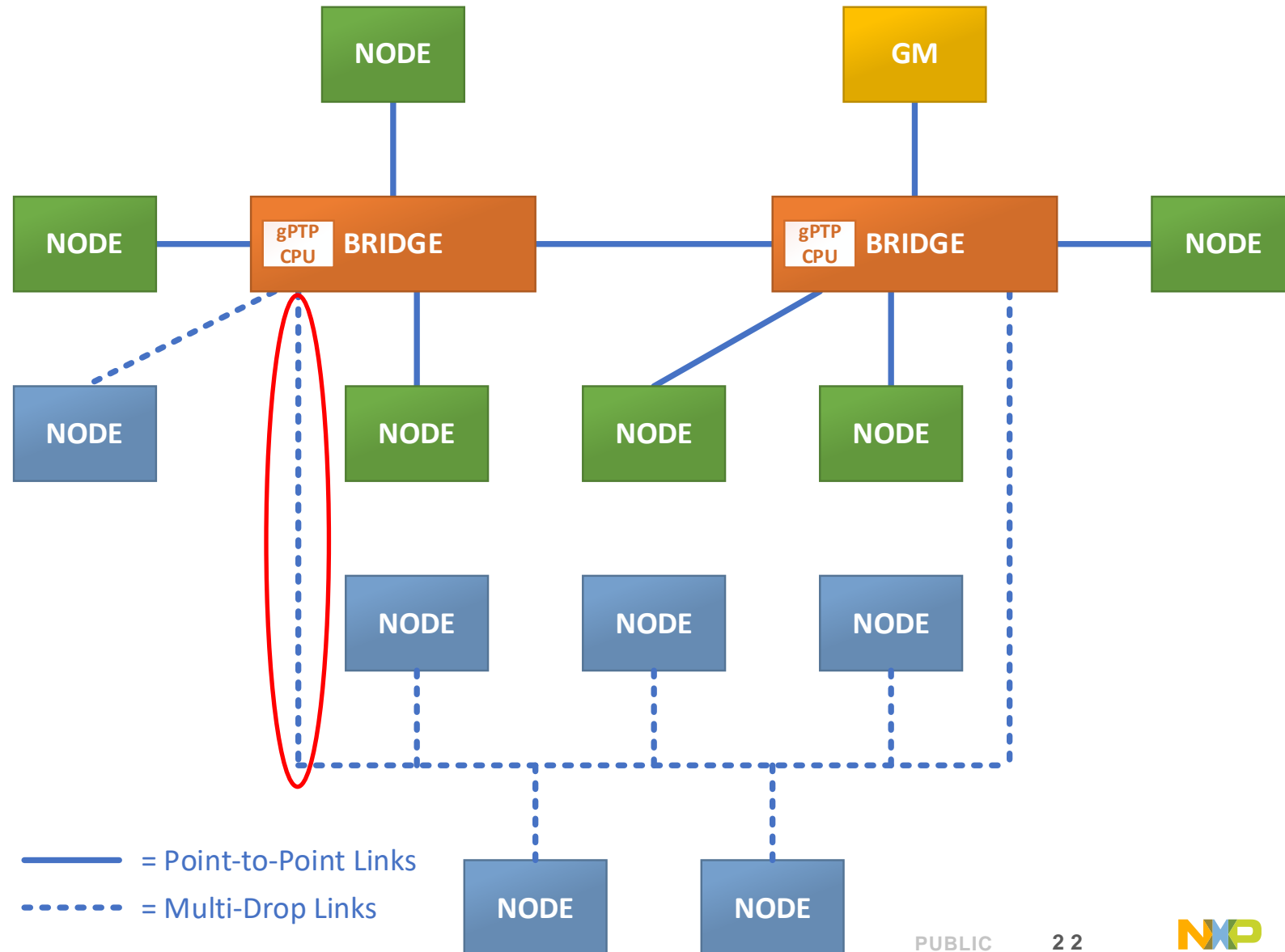
Typical TSN Network with Point-to-Point & Multi-Drop Links

- Bridges will need to support both kinds of links
- Bridges are constrained devices usually with no external code memory
- Their on-die code memory is sized to support gPTP for Point-to-Point links
- Support for Multi-Drop links needs to keep these code changes to a minimum so it can fit!
- AutoSAR's work may also need to be considered



Do we need to support Redundancy (the added red oval)?

- This needs to be decided when work on this project can start (after PAR approval)
- But the more similar the 10BASE-T1S solution is to the current IEEE 802.1AS-2020, the more likely any features AS supports will work on both media – including redundancy
- This is another reason to keep the changes to a minimum!
- And the need to stay consistent w/ IEEE 1588 too!



About IEEE 802.3cg & IEEE 802.3da

- The IEEE 802.3cg project standardized an Ethernet PHY referred to as 10BASE-T1S. It is:
 - A single-pair, 10 Mb/s PHY that can be used in:
 - A point-to-point mode (no IEEE 802.1AS work is needed for this mode)
 - This is referred to as 10BASE-T1L
 - A multi-drop, shared media mode where the 10 Mb/s CSMA-CD MAC is used
 - A multi-drop, shared media mode where the 10 Mb/s CSMA-CD MAC is used & where PLCA (PHY Level Collision Avoidance) is performed in the PHY
 - These last two are referred to as 10BASE-T1S
 - PLCA avoids collisions so the network can be deterministic, but all MACs on the network receive all messages transmitted by other nodes on the same physical multi-drop wire



SECURE CONNECTIONS
FOR A SMARTER WORLD