

6 **Draft Standard for**
7 **Local and Metropolitan Area Networks—**
8 **Bridges and Bridged Networks**

9 **Amendment 38:**
10 **Configuration Enhancements for**
11 **Time-Sensitive Networking**

12 Prepared by the Time-Sensitive Networking (TSN) Task Group of IEEE 802.1

13 **Draft for first Working Group Recirculation Ballot**

14 Developed by the
LAN/MAN Standards Committee

16 **This and the following cover pages are not part of the draft.** They provide revision and other information
17 for IEEE 802.1 Working Group members and will be updated as convenient. **New participants: Please read**
18 **these cover pages,** they contain information that should help you contribute effectively to this standards
19 development project. The [Introduction to the current draft](#) should be useful to all readers.

20 The text proper of this draft begins with the [Title page](#).

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1 Participation in 802.1 standards development

2 All participants in IEEE 802.1 activities should be aware of the Working Group Policies and Procedures, and
3 their obligations under the IEEE Patent Policy, the IEEE Standards Association (SA) Copyright Policy, and the
4 IEEE SA Participation Policy. For information on these policies see 1.ieee802.org/rules/ and the slides
5 presented at the beginning of each of our Working Group and Task Group meeting.

6 The IEEE SA [PAR \(Project Authorization Request\)](#) and [CSD](#) (Criteria for Standards Development established
7 by IEEE 802) are summarized in these cover pages and links are provided to the full text of both PAR and
8 CSD. As part of the IEEE 802® process, the text of the PAR and CSD of each project is reviewed regularly to
9 ensure their continued validity. A vote of "Approve" on this draft is also an affirmation that the PAR and CSD
10 for this project are still valid.

11 Comments on this draft are encouraged. NOTE: All issues related to IEEE standards presentation style,
12 formatting, spelling, etc. are routinely handled between the 802.1 Editor and the IEEE Staff Editors prior to
13 publication, after balloting and the process of achieving agreement on the technical content of the standard is
14 complete. Readers are urged to devote their valuable time and energy only to comments that materially affect
15 either the technical content of the document or the clarity of that technical content. Comments should not
16 simply state what is wrong, but also what might be done to fix the problem.

17 Full participation in the work of IEEE 802.1 requires attendance at IEEE 802 meetings. Information on 802.1
18 activities, working papers, and email distribution lists etc. can be found on the 802.1 Website:

19 <http://ieee802.org/1/>

20 Use of the email distribution list is not presently restricted to 802.1 members, and the working group has a
21 policy of considering comments from all who are interested and willing to contribute to the development of the
22 draft. Individuals not attending meetings have helped to identify sources of misunderstanding and ambiguity
23 in past projects. The email lists exist primarily to allow the members of the working group to develop
24 standards, and are not a general forum. All contributors to the work of 802.1 should familiarize themselves
25 with the IEEE patent policy and anyone using the email distribution list will be assumed to have done so.
26 Information can be found at <http://standards.ieee.org/db/patents/>

27 Comments on this draft may be sent to the 802.1 email exploder, to the Editors, or to the Chairs of the 802.1
28 Working Group and Time-Sensitive Networking (TSN) Task Group.

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36 NOTE: Comments whose distribution is restricted in any way cannot be considered, and may not be
37 acknowledged.

38 **All participants in IEEE standards development have responsibilities under the IEEE patent policy and**
39 **should familiarize themselves with that policy, see**
40 <http://standards.ieee.org/about/sasb/patcom/materials.html>

41 As part of our IEEE 802 process, the text of the PAR and CSD (Criteria for Standards Development, formerly
42 referred to as the 5 Criteria or 5C's) is reviewed on a regular basis in order to ensure their continued validity.
43 A vote of "Approve" on this draft is also an affirmation by the balloter that the PAR is still valid.

1 **PAR (Project Authorization Request) and CSD**

2 Extracts from the PAR, as approved by IEEE NesCom:

3 <https://development.standards.ieee.org/myproject-web/public/view.html#pardetail/7088>

4 and the CSD (Criteria for Standards Development):

5 <https://mentor.ieee.org/802-ec/dcn/19/ec-19-0139-00-ACSD-p802-1qdj.pdf>

6 follow.

7 **PAR: Scope of the project**

8 This amendment specifies procedures, interfaces, and managed objects to enhance the three models of
9 'Time-Sensitive Networking (TSN) configuration'. It specifies enhancements to the User/Network Interface
10 (UNI) to include new capabilities to support bridges and end stations in order to extend the configuration
11 capability. This amendment preserves the existing separation between configuration models and protocol
12 specifications. This amendment also addresses errors and omissions in the description of existing
13 functionality.

14 **PAR: Need for the Project**

15 YANG (RFC 7950) is a formalized data modeling language that is widely accepted and can be used to
16 simplify network configuration. The ability to manage the Multiple Spanning Tree Protocol via YANG modules
17 is needed for compatibility with modern network management systems. Industrial automation networks
18 require parameter value ranges that can differ from those currently supported.

19 **PAR: Possible registration activity**

20 The Simple Network Management Protocol (SNMP) MIB will be assigned an Object Identifier (OID) based on
21 the Registration Authority (RA) OID tutorial and IEEE Std 802.

22 The YANG Data Model will be assigned a Uniform Resource Name (URN) based on the RA URN tutorial and
23 IEEE Std 802d.

24 The amendment will use the IEEE 802.1 Organizationally Unique Identifier (OUI) to create a globally unique
25 application identifier as required.

26 The amendment may allow an OUI or Company Identifier (CID) to be used to create code points used in
27 managed objects and protocol fields.

28 **PAR: Additional Explanatory Notes**

29 #5.2.b 'Time-Sensitive Networking (TSN) configuration' is the title of clause 46 of IEEE Std 802.1Qcc-2018.
30 The three existing TSN configuration models are described in subclause 46.1.3 TSN Configuration Models of
31 IEEE Std 802.1Qcc-2018.

32 #5.5 Clause 46 'Time-Sensitive Networking (TSN) configuration' of IEEE Std 802.1Q can be found in IEEE
33 Std 802.1Qcc-2018.

34 #6.1.b While 'YANG' (developed by the Internet Engineering Task Force) appears to be an acronym its
35 expansion 'Yet Another Next Generation' is not meaningful. YANG is a widely-used standard that is relevant
36 to the Registration Authority.

37 IEEE Std 802 IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture

38 IEEE Std 802d IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture
39 Amendment 1: Allocation of Uniform Resource Name (URN) Values in IEEE 802 Standards

40 RA URN tutorial: <http://standards.ieee.org/develop/regauth/tut/ieeeeurn.pdf> RA OID tutorial: <http://standards.ieee.org/develop/regauth/tut/oid.pdf>

1 CSD: Broad market potential [extract]

2 IEEE Std 802.1Qcc-2018 Stream Reservation Protocol (SRP) Enhancements and Performance
3 Improvements specifies configuration models, functionalities, and a User/Network Interface (UNI) to allow
4 configuration of bridged LANs that use Time-Sensitive Networking (TSN) features. These configuration
5 functionalities can be implemented as part of a Software Defined Networking (SDN) Controller, i.e., along the
6 SDN principles, which are supported by IEEE Std 802.1Q. Interest in these features by the industrial and
7 automotive markets has greatly increased during the last years. The large interest and success of IEEE 802.1
8 TSN features has expanded the requirements on the management of these features beyond the capabilities
9 described in the current standard. These additional requirements of the industrial and automotive markets
10 raise the need for enhancements to the configuration models and the UNI.

11 CSD: Distinct identity [extract]

12 No existing IEEE 802 standard or approved project provides a UNI that allows for a configuration workflow
13 from the view of end users satisfying the requirements from the target markets.

14 This amendment differs from existing IEEE 802.1 standards in that it addresses and closes gaps in the
15 configuration workflow that have been identified by users from the target markets.

16 CSD: Technical feasibility [extract]

17 The configuration enhancements are similar in principle to the schemes and interfaces introduced in IEEE Std
18 802.1Qcc-2018 and will build on them to provide additional capabilities.

19 There is a considerable body of experience in supplying interfaces and mechanisms for network
20 management. Mechanisms needed for this project are widely used by other protocols already, e.g.
21 NETCONF/RESTCONF, for specifying management modules.

22 CSD: Economic feasibility [extract]

23 The well-established balance between infrastructure and attached stations will not be changed by the
24 proposed amendment.

25 The amendment will specify management mechanisms and interfaces to enhance already existing
26 management and add no additional hardware costs to bridges and end stations beyond the minimal and
27 firmly bounded resources consumed by additional management modules.

28 The cost factors, including installation and operational costs of bridged LANs are well-known. The proposed
29 amendment will specify enhancements and interfaces that provide more comprehensive configuration of TSN
30 features as well as a standardized interface between the management entities introduced by IEEE Std
31 802.1Qcc-2018 and thus will provide better economic feasibility.

1 Draft development

2 During the early stages of draft development, 802.1 editors have a responsibility to attempt to craft technically
3 coherent drafts from the resolutions of ballot comments and from the other discussions that take place in the
4 working group meetings. Preparation of drafts often exposes inconsistencies in editor's instructions or
5 exposes the need to make choices between approaches that were not fully apparent in the meeting. Choices
6 and requests by the editors' for contributions on specific issues will be found in the editors' [Introduction to the](#)
7 [current draft](#) and at appropriate points in the draft.

8 Any text with a Cyan background (as in this sentence) is temporary, with conditional tag 'Editor comment',
9 inserted by the Editors to solicit comment, suggest a future change, or act simply as an aide memoire. Text
10 can also **highlighted** to be draw it to the readers' attention, using conditional tag 'Editor highlight'. In both
11 these case conditional tagging helps location, and eventual removal, of text or highlighting and can control
12 whether or not it is displayed.

13 The ballot comments received on each draft, and the editors' proposed and final disposition of comments on
14 working group drafts, are part of the audit trail of the development of the standard and are available, along
15 with all the revisions of the draft on the 802.1 website (for address see above).

16 During the early stages of draft development the proposed text can be moved around a great deal, and even
17 minor rearrangement can lead to a lot of 'change', not all of which is noteworthy from the point of the reviewer,
18 so the use of automatic change bars is not very effective. In early drafts change bars may be omitted or
19 applied manually, with a view to drawing the readers attention to the most significant areas of change.
20 Readers interested in viewing every change are encouraged to use Adobe Acrobat to compare the document
21 with their selected prior draft. Note that the FrameMaker change bar feature is useless when it comes to
22 indicating changes to Figures.

23 This draft has been prepared from a set of Framemaker files with conditional text that supports the production
24 of the present amendment draft and a preliminary roll up of that amendment draft into the text of the base
25 standard, i.e. IEEE Std 802.1Q as of the last Revision as amended by prior amendments (usually as of the
26 close of their successful SA ballots) as noted on the Title Page and the first Cover Page. The editor may
27 make preliminary roll ups available to check consistency with the base standard and cross-references to text
28 that does not appear in this amendment. Roll ups may also be recorded as part of the approved P802.1Q
29 Revision project.

30 For a description of the use of conditional text and other FrameMaker and IEEE Std 802.1Q Style
31 considerations applicable to this draft see the EDITOR-PLEASE-READ-ME file in the FrameMaker books
32 used to generate these drafts.

33 There are generally multiple amendments under development at any time, and while they will add or amend
34 different clauses in the base standard, there are some clauses (notably Clauses 12, 48, and the PICS
35 Annexes that all are likely to change). They will need to be fully integrated before or during SA Ballot, and
36 complete that ballot in serial order to avoid future problems.

37 Records of participants in the development of the standard are added after SA Ballot, as part of
38 pre-publication editing by IEEE Staff.

39 MIB and YANG modules

40 The MIB and YANG modules that are modified or added by this amendment are attached to the draft pdf as
41 plain text (UTF-8) .mib and .yang files. When a roll up of the current base standard plus this amendment is
42 made available, all the MIB and YANG modules for the roll up are attached.

1 Introduction to the current draft¹

2 This introduction is not part of the draft, and should not be the subject of ballot comments.

3 P802.1Qdj/D1.2 was prepared by the P802.1Qdj Editor, Stephan Kehrer, for first Working Group recirculation
4 ballot as described below (P802.1Qdj/D1.2 resolution of D1.1 Working Group Ballot comments) and
5 subsequently integrated into the P802.1Q-Rev sources (see P802.1Qdj/D1.2 Integration) by the P802.1Q
6 Editor, Mick Seaman.

7 Revision bars in D1.2 are relative to Draft 1.1.

8 **P802.1Qdj/D1.2 Integration:** P802.1Qdj/D1.2 has been prepared from a set of Framemaker files with
9 conditional text that that supports the production of the present amendment draft and a preliminary rollup of
10 that amendment draft into the text of the base standard,² IEEE Std 802.1Q-2022 as amended by prior
11 amendments as of the close of their successful SA ballots. This preparation is intended to identify issues that
12 might otherwise not become apparent until an attempt is made to from apply this and other amendments in a
13 revision project. A P802.1Q-Rev rollup adding the P802.1Qdj/D1.2 amendment changes to the whole of
14 P802.1Q-2022 Revision, including prior amendments, as of August 16, 2023 is available as
15 802-1Q-Rev-Qdj-d1-2.pdf.

16 The prior amendments are listed on the cover and front matter pages of the amendment and the rollup. In
17 order to be clear as to the text used, the proposed P802.1Qcw and P802.1Qcj draft numbers are currently
18 used. When those amendments are published, this amendment will be updated if and as necessary. The V2
19 pre-publication proof edits of the IEEE Std 802.1Qcz text have been applied, so that standard (as opposed to
20 its Draft 2.7) is listed, but should be checked post-publication.

21 Naturally integration has led to additional changes, beyond those discussed as part of the Working Group
22 ballot comments. As discussed in the Berlin meeting it is better to address these now, rather than in SA Ballot
23 with a changed ballot pool. The following changes have been made as part of the integration of this draft:

- 24 — This editors' introduction has been removed from the Q-frontmatter.fm file and placed in a separate
25 Q-wg-cover.fm file. This allows the file to be simply excluded in the FrameMaker book, reducing the
26 editing that needs to be done pre-publication, as the Q-frontmatter.fm file will be retained (largely if
27 not entirely 'as is'). This also allows simple substitution of appropriate SA Ballot cover material
28 (Q-sa-ballot-cover.fm) the WG Cover material at SA Ballot time. Information on participation in 802.1
29 has been added, and the information on the PAR and CSD expanded so it is readily accessible prior
30 to confirmation votes on conformamnce to those documents.
- 31 — 'Amendment XX' has been replaced by 'Amendment 38' (this can be changed easily if needed) and
32 headers and footers updated.
- 33 — The frontmatter boilerplate text has been updated to the latest (or at least to a very recent) version.
34 Hopefully this will avoid a further change before SA Ballot as a result of MEC
- 35 — The Keywords (following the Abstract in the frontmatter pages) have been updated. These are
36 typically neglected. Important keywords (CUC, CNC, and their expansions) were missing, some
37 entries were more phrases than keywords, and some (like 'amendment') would have provided
38 potential readers with little help in identifying relevant document from the millions available. These
39 keywords used to be outside the scope of the ballot process, and finalized in pre-publication editing,
40 but are now in scope.
- 41 — The text for the 'Introduction' in the frontmatter pages (follows the list of participants) also appears to
42 have been neglected (as usual). It has been updated to follow the changes agreed in ballot resolution
43 for the Abstract (for the same reasons). This text is relevant because it will persist in the next
44 Revision of 802.1Q (readers should look at the rollup of this amendment, and those for P802.1Qcj
45 and P802.1Qcw to understand the plan for this text).
- 46 — Various editing instructions have been made more explicit, without themselves changing what is to be
47 added/removed by the amendment. Some missing intermediate level headers have been supplied,

¹ The whole or parts of the introduction, possibly updated, to past drafts may be retained at the Editor's discretion, with the most recent introduction first. The introduction to each draft may solicit input on specific subjects.

² The EDITOR-PLEASE-READ-ME file in the FrameMaker books used to generate this amendment provides details for editors.

- 1 as per current staff editor practice. Some prior edits used change marking for inserted text, or applied
2 change marks to new text. These have been fixed. Cross-reference formatting in 46.1.3.2 has been
3 fixed.
- 4 — Figure 46-3 has been redrawn. It previously was OLE included and scaled down from a large size.
5 Experience is that OLE inclusion becomes problematic (crashes) with large numbers of figures, and
6 scaling does not always render correctly on all devices. It is now drawn 1:1 and included as svg. The
7 content remains the same, with the exception of expanding “Info” to “Information”. The plan is to
8 redraw Figures 46-1 and 46-3 similarly.
- 9 — The note added in 46.2.1 has been indented so that it clearly belongs (in the rollup) to the relevant
10 dashed list item.
- 11 — Figures 48-21 and 48-22 have been redrawn to remove the shading (which is used as a code for
12 augmentation in all the existing similar figures), to place the boxes and lines strictly on a 9 point grid,
13 to remove excess grouping, to change line widths to Vision defaults, to use Arial 6 pt consistently
14 rather than a mix of Arial and Calibri (which appears significantly smaller, which is not satisfactory at
15 that size if physically printed). These changes address known past rendering and maintenance
16 issues.
- 17 — The YANG tree and module text have been include as straight inserts (as per past agreement with
18 YANGsters) rather than as intermediate MIFs. The same font/font size as used for prior includes is
19 used.
- 20 — The Bibliography is shown in full, with changes applied, as per pre-publication editing of IEEE Std
21 802.1Qcz. In that case the IEEE editor reached the conclusion that just showing the Inserts and
22 Deletes was too confusing. Examination of the previously proposed list of six additions to the
23 Bibliography revealed that only one (802.1CM) was not already in the Normative References or in the
24 Bibliography.

25 The following inconsistencies in the use of terms and capitalization have been noted, but not fixed, in this
26 amendment and in the text of the 802.1Q base:

- 27 — ‘TSN Streams’ vs ‘TSN streams’ vs ‘Streams’ vs ‘streams’
28 — ‘User/Network Interface’ vs ‘user/network interface’ vs ‘User network/interface’

29 **P802.1Qdj/D1.2 resolution of D1.1 Working Group Ballot comments:** P802.1Qdj/D1.2 is based on a draft
30 prepared by Stephan Kehrer as a result of comment resolution on Draft D1.1, finalized during the meeting of
31 the TSN Task Group on July 10, 2023.

32 The changes in 1.3 are following the response to comment #49 in the final disposition of ballot comments
33 against draft D1.1, found at

34 <https://www.ieee802.org/1/files/private/dj-drafts/d1/802-1Qdj-d1-1-dis-v01.pdf>.

35 More details can be found at

36 <https://www.ieee802.org/1/files/public/docs2023/dj-seaman-1-3-of-d1-1-comment-0723-v00.pdf>.

37 Figure 48-21 User/Network Interface model has been split into two figures, Figure 48-21—User/Network
38 Interface model A, and Figure 48-22—User/Network Interface model B, to increase readability.

39 Editing instructions in clause 46 have been updated to allow easier identification of the paragraphs that need
40 to be changed in the base standard.

41 **P802.1Qdj/D1.1:** This draft was prepared by Stephan Kehrer for second Working Group ballot as a result of
42 comment resolution on Draft D1.0, finalized during the meeting of the TSN Task Group on March 17, 2023.

43 Revision bars in D1.1 are relative to Draft 1.0.

44 Some comments in the comment resolution provided different wording for the same parts of the document in
45 their respective responses. The current wording in D1.1 is an attempt of the editor to satisfy the spirit of all of
46 the comments relating to the same text. This is the case for the following comments:

- 47 — **Comment #9** and **comment #39**
48 — **Comment #20** and **comment #64**

1 The responses of **comment #10**, **comment #125**, **comment #126**, **comment #138**, and **comment #24**
2 (make changes to the editing instructions for 48.6.3, adding the clause title, and providing a diff-marked
3 version of the YANG module showing the changes made) have been made obsolete by the response to
4 **comment #143** (remove the YANG module in 48.6.3 due to the fact that the intended change to the module is
5 not being implemented in this amendment). The response to **comment #143** is the one being implemented.

6 In deviation from the response to **comment #136** the first occurrence of “Centralized User Configuration
7 (CUC)” has been kept in 1.3. This is in line with the introduction of other abbreviations in this clause. For the
8 CNC only the abbreviated form is used because it has been introduced in IEEE Std 802.1Q-2022 in the bullet
9 point cq) already.

10 For **comment #137** only four of the occurrences of “TSN” have been removed from the draft. For the other
11 occurrences the editor feels that removing them would cause inconsistencies with already existing text in
12 IEEE Std 802.1Q-2022.

13 **P802.1Qdj/D1.0**: This draft was prepared by Stephan Kehrer for first Working Group ballot as a result of
14 comment resolution on Draft D0.3, finalized during the meeting of the TSN Task Group on September 12,
15 2022.

16 D1.0 has been rebased on P802.1Q-2022.

17 The compact YANG data scheme definition for `ieee802-dot1q-tsn-config-uni.yang` in 48.5.13 has been
18 removed, as indicated by the editor’s note.

19 **P802.1Qdj/D0.3**: This draft was prepared by Stephan Kehrer for third Task Group ballot as a result of
20 comment resolution on Draft D0.2, finalized during the electronic meeting of the TSN Task Group on May 9,
21 2022.

22 Revision bars in D0.3 are relative to Draft 0.2.

23 The following comments have not or only partially been partially implemented in D0.3:

24 **Comment #59**: The editor decided that this standard will be rebased on P802.1Q-Rev in a subsequent draft,
25 as discussed during comment resolution.

26 **Comment #83**: After review of the terms listed in the comment and their used in this standard, the editor is of
27 the opinion that the terms are used correctly. The commenter is asked to review D0.3 and if he still has
28 concerns, make a comment against D0.3 that provides additional detail on where the terms are used in an
29 inconsistent way.

30 **P802.1Qdj/D0.2**: This draft was prepared by Stephan Kehrer for second Task Group ballot as a result of
31 comment resolution on Draft D0.1, finalized during the electronic meeting of the TSN Task Group on March
32 15, 2021.

33 Revision bars in D0.2 are relative to Draft 0.1.

34 The YANG module in Clause 48 has not been updated for D0.2. It will be updated in a future version, once
35 additional elements that need to be implemented in the YANG module, e.g., YANG actions or YANG
36 notifications, have been sufficiently discussed in the WG and have stabilized.

37 The following comments have not or only partially been partially implemented in D0.2:

38 **Comment #4**: Only deleted the first bullet item and rephrased the second one.

39 **Comment #6**: In the understanding of the editor and after double checking against IEEE Std 802.1Qcc-2018,
40 the current YANG model matches the text in IEEE Std 802.1Qcc-2018, 46.2. StreamID, in the current model,
41 is a leaf of the stream-id-type. This type consists of a MAC-Address and a unique StreamID. For this reason
42 no changes have been made to the document because no further alignment was necessary. If the commenter
43 feels that the understanding of the editor is incorrect, a comment to this effect is encouraged.

Comment #8: The configuration group in the YANG module provided in this document is a container for StatusInfo and FailedInterfaces as well as for AccumulatedLatency and InterfaceConfiguration. AccumulatedLatency and InterfaceConfiguration are distinct for each Talker or Listener and are therefore grouped under separate containers in the model. Naming the group “configuration” is indeed confusing. It would most likely be more adequate to name the group “status” to be in line with the naming provided in IEEE Std 802.1Qcc-2018. Since the YANG module has not been edited in this draft of P802.1Qdj an item in Annex Z has been created to address the topic with the next revision of the YANG module.

Comment #18: An item for this topic has been added to Annex Z. No text has been added to the main part of the document at this time because it is unclear to the editor how to best integrate the requested features into the new clause 46.1.7.1. The editor will work together with the original contributor to add the item in a future draft. Additional contributions on the topic are welcome.

Comments #23 and #24: No actions and notifications have been added to the YANG model because the YANG model was not updated for this draft. A specification of actions and notifications is not only required in the YANG model but also in clause 46.2. As there have been discussions and contributions to the topic after comment resolution on D0.1 was finished the editor feels it would be beneficial to work together further with the contributors before adding the content to a draft. Two items for these comments have been created in Annex Z. The editor intends to add content on actions and notifications in the next draft.

Comments #43 and #51: After reviewing clauses 46.1.3.2 and 46.1.3.3 in IEEE Std 802.1Qcc-2018 the editor is of the opinion that the information in these clauses and the additional information and clarification in 46.1.6 and 46.1.5 are not in conflict with each other. The already existing clauses in IEEE Std 802.1Qcc-2018 provide an overview over the different management models, the added information in this document describe that actual tasks assigned to the CUC and CNC entities in more detail. Removing the information in 46.1.3.2 and 46.1.3.3 of IEEE Std 802.1Qcc-2018 and moving them into the new clauses of this document would make it very hard to understand the management models since information would be missing in their description. On the other hand moving the information from the new clauses to 46.1.3.2 and 46.1.3.3 of IEEE Std 802.1Qcc-2018 would overload the description of the model with a more detailed description of the responsibilities of CUC and CNC. For this reason the editor did not try to consolidate the text at this time. If the commenter still thinks this needs to be done the editor would like to ask for another comment against this draft so the topic can be further discussed in the WG.

Comment #48: After a review of the base standard IEEE P802.1Q-Rev the editor decided nothing needs to be done for this comment. At the beginning of Clause 3 of IEEE P802.1Q-Rev it is clearly stated that the standard makes use of the term “station”, as defined in IEEE Std 802. Since this standard is an amendment to IEEE 802.1Q the use of “station” as stand alone term seems justified to the editor.

P802.1Qdj/D0.1: This draft was prepared by Stephan Kehrer for a first Task Group ballot. Everything in this draft can be considered a contribution to the Time-Sensitive Networking Task Group by the editor; nothing has been approved by the Task Group or Working Group.

P802.1Qdj/D0.0: This draft was prepared by Stephan Kehrer as the first draft. Everything in this draft can be considered a contribution to the Time-Sensitive Networking Task Group by the editor; nothing has been approved by the Task Group or Working Group.

Maintenance items

The following maintenance change request items have been actioned in this revised text:

0312: <https://www.802-1.org/items/423>.

43

Draft Standard for Local and Metropolitan Area Networks—

Bridges and Bridged Networks

Amendment 38: Configuration Enhancements for Time-Sensitive Networking

Prepared by the
Time-Sensitive Networking (TSN) Task Group of IEEE 802.1

Sponsor
**LAN/MAN Standards Committee
of the
IEEE Computer Society**

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Abstract: This amendment to IEEE Std 802.1Q™ describes the relationships and division of responsibilities between Centralized User Configuration (CUC) components, that can be used to configure end stations' use of Time-Sensitive Networking (TSN) capabilities, and a Centralized Network Configuration (CNC) component that can be used to configure network resources within an administrative Configuration Domain. A YANG model and modules that can be used by a network configuration protocol, such as NETCONF, to provide a CUC-CNC interface is specified.

Keywords: Bridged Network, Centralized Network Configuration, CNC, Centralized User Configuration, CUC, IEEE 802.1Q™, LAN, local area network, Time-Sensitive Networking, TSN, Virtual Bridged Network, virtual LAN, VLAN Bridge, YANG.

10

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3 At the time this standard was submitted to the IEEE-SA Standards Board for approval, the IEEE 802.1
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5 **Glenn Parsons**, *Chair*
6 **Jessy V. Rouyer**, *Vice Chair*
7 **János Farkas**, *Chair, Time-Sensitive Networking Task Group*
8 **Craig Gunther**, *Vice Chair, Time-Sensitive Networking Task Group*
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10

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1 Introduction

This introduction is not part of IEEE Std 802.1Qdj™-2024, IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks—
Amendment 37: Configuration Enhancements for Time-Sensitive Networks.

2 IEEE Std 802.1Qdj™-2024: Configuration Enhancements for Time-Sensitive Networks described the
3 relationships and division of responsibilities between Centralized User Configuration (CUC) components,
4 that can be used to configure end stations' use of Time-Sensitive Networking (TSN) capabilities, and a
5 Centralized Network Configuration (CNC) component that can be used to configure network resources
6 within an administrative Configuration Domain. The specification included a YANG model and modules that
7 can be used by a network configuration protocol, such as NETCONF, to provide a CUC-CNC interface.

8 This standard contains state-of-the-art material. The area covered by this standard is undergoing evolution.
9 Revisions are anticipated within the next few years to clarify existing material, to correct possible errors, and
10 to incorporate new related material. Information on the current revision state of this and other IEEE 802
11 standards may be obtained from

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1

2 **IEEE Standard for**
3 **Local and metropolitan area networks—**

4 **Bridges and Bridged Networks**

5 **Amendment 38:**
6 **Configuration Enhancements for**
7 **Time-Sensitive Networking**

8 [This amendment is based on IEEE Std 802.1Q™-2022 as amended by IEEE Std 802.1Qcz™-2023,
9 IEEE Std 802.1Qcw™-2023, and IEEE Std 802.1Qcj™-2023.]

10 NOTE—The editing instructions contained in this amendment define how to merge the material contained therein into
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12 The editing instructions are shown in ***bold italics***. Four editing instructions are used: change, delete, insert, and replace.
13 ***Change*** is used to make corrections in existing text or tables. The editing instruction specifies the location of the change
14 and describes what is being changed by using ~~strikethrough~~ (to remove old material) and underscore (to add new
15 material). ***Delete*** removes existing material. ***Insert*** adds new material without disturbing the existing material. Deletions
16 and insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. ***Replace*** is
17 used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new
18 one. Editing instructions, change markings, and this note will not be carried over into future editions because the
19 changes will be incorporated into the base standard.

20 **1. Overview**

21 **1.3 Introduction**

22 ***Change the paragraph beginning “This standard specifies enhancements to protocols, procedures, and***
23 ***managed objects for the configuration of network resources “ as follows:***

24 This standard specifies enhancements to protocols, procedures, and managed objects for the configuration of
25 network resources for time-sensitive ~~(i.e., bounded latency)~~ applications that require timely, high
26 probability, delivery of frames without end station retransmission. ~~The enhancements address~~
27 ~~Time-Sensitive Networking (TSN) application requirements beyond audio/video (AV) traffic.~~ To this end, it:

28 cm) ~~Specifies a software interface between the user (i.e., time-sensitive application) and network~~
29 ~~components, such that the user provides Stream requirements (e.g., for bounded latency), and the~~

- 1 ~~network configures resources from Talker to Listeners to meet these requirements. This~~
2 ~~user/network interface (UNI) is specified as an information model that can be applied to any~~
3 ~~protocol.~~
- 4 cn) Describes three approaches to network configuration: ~~Specifies three models for the UNI:~~ fully
5 distributed, centralized network/distributed user, and fully centralized.
- 6 co) ~~Specifies enhancements to the Stream Reservation Protocol (SRP), using a new application version,~~
7 ~~MSRPv1. MSRPv1 integrates the UNI TLVs for the benefits of enhanced configuration. For~~
8 ~~compatibility, MSRPv1 translates to the previous version (MSRPv0).~~
- 9 cp) Specifies ~~enhancements to the~~ managed objects for forwarding and queuing ~~enhancements~~ for
10 time-sensitive streams (FQTSS).
- 11 cq) ~~Specifies enhancements to the managed objects for SRP.~~
- 12 cr) Describes Centralized User Configuration (CUC) and Centralized Network Configuration (CNC)
13 entities.
- 14 cs) Specifies managed objects for configuration of Bridges by a ~~Centralized Network Configuration~~
15 ~~(CNC) component.~~
- 16 ct) Defines YANG configuration and operational state models (Clause 48) in support of Scheduled
17 Traffic, Frame Preemption, ~~and~~ Per-Stream Filtering and Policing, and CUC configuration.

18

3. Definitions

Insert the following definitions in the appropriate collating sequence, renumbering accordingly:

3.1 Configuration Domain: A set of stations that are under a common configuration and management scheme, and a single administration.

3.2 TSN features: The protocols and mechanisms that define the set of tools available for building a time-sensitive network.

NOTE—See Annex X for more information.

8

1 5. Conformance

2 5.29 TSN CNC station requirements

3 *Change item d) in 5.29, as follows*

- 4 d) If a YANG-based protocol is supported by the TSN CNC for the user/network configuration
5 information, that protocol shall use the YANG module [s](#) specified in 46.3.

6

46. Time-Sensitive Networking (TSN) configuration

46.1 Overview of TSN configuration

46.1.3 TSN configuration models

46.1.3.2 Centralized network/distributed user model

Change the paragraph beginning “The centralized network/distributed user model is similar” as follows:

The centralized network/distributed user model is similar to the fully distributed model in that end stations communicate their Talker/Listener requirements directly over the ~~TSN~~ UNI. In contrast, in the centralized network/distributed user model, the configuration information is directed to/from a Centralized Network Configuration (CNC, [46.1.6](#)) entity. All configuration of Bridges for TSN Streams is performed by this CNC using a remote network management protocol.

46.1.3.3 Fully centralized model

Change the paragraph beginning “In order to accommodate this sort of TSN use case” as follows:

In order to accommodate this sort of TSN use case, the fully centralized model enables a Centralized User Configuration (CUC, [46.1.5](#)) entity to discover end stations, retrieve end station capabilities and user requirements, and configure TSN features in end stations. The protocols that the CUC uses for this purpose are specific to the user application and outside the scope of this standard.

Change the paragraph beginning “Figure 46-3 provides a graphical representation” as follows:

Figure 46-3 provides a graphical representation of the fully centralized model [with multiple CUCs](#).

Replace Figure 46-3 with the following figure:

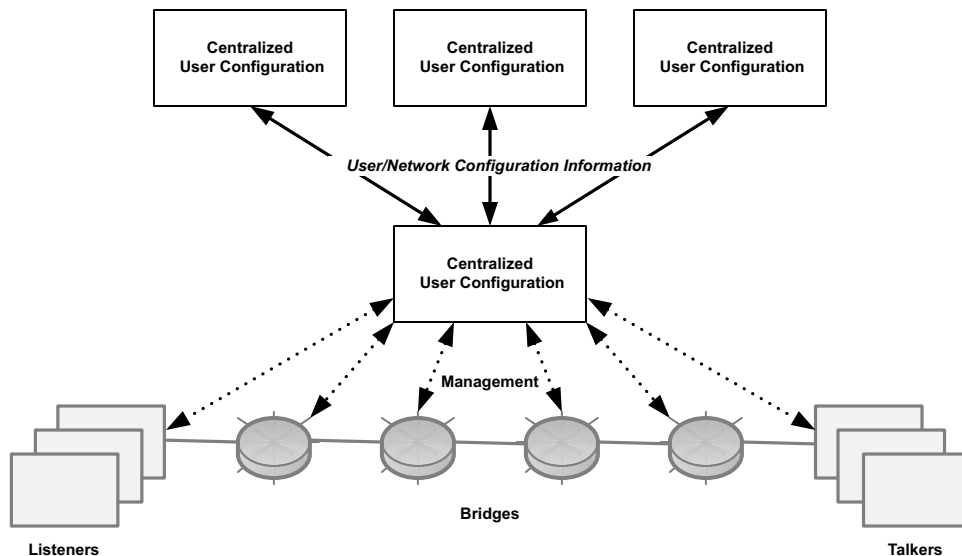


Figure 46-3—Fully centralized model

1 *Insert 46.1.5, 46.1.6, and 46.1.7 after 46.1.4 as follows:*

2 **46.1.5 Centralized User Configuration**

3 A Centralized User Configuration (CUC) delivers user requirements to the CNC. The CUC delivers
4 information for configuring TSN features to end stations. It is a logical entity that can be located in any
5 station of a network.

6 The CUC is responsible for:

- 7 a) Reconciling the requirements from Talkers and Listeners to Stream requirements, if necessary.
- 8 b) Sending the Stream requirements to the CNC.
- 9 c) Receiving the end station communication-configuration from the CNC.
- 10 d) Distributing the end station communication-configuration to Talkers and Listeners.

11 NOTE—It is the responsibility of the CNC to ensure that Streams are assigned a unique StreamID group. For this a
12 remote procedure call (RPC) RequestFreeStreamId (46.2.7.5) is available so the CUC can request a free StreamID from
13 the CNC.

14 Stream requirements, in the context of the CUC, result from combining the Stream requirements of one
15 Talker with the Stream requirements of one or multiple Listeners that, together, apply to form a Stream.
16 Reconciling the requirements for the Stream does not change the parameters in the Stream request
17 originating from the Talker or the Listener(s).

18 The end station communication-configuration that is received by the CUC from the CNC and then
19 distributed to the Talkers and Listeners does not directly configure features on the end stations. It consists of
20 configuration information that a CUC can provide for a Talker and Listeners to configure the Stream. An end
21 station could, for example, make use of the information it receives in the communication-configuration from
22 the CUC to configure an application in a way that ensures different TSN Streams are sent by the application
23 in a specific order that correlates with the expected Stream's transmission on the network.

24 A CUC affects only one Configuration Domain. Talkers and Listeners can only make use of the CUC to
25 reconcile their Stream requirements into a Stream request, if they are part of the same Configuration
26 Domain. If a Talker wants to communicate with one or more Listeners in a different Configuration Domain,
27 this needs to be done through dedicated inter-domain communication mechanisms. Such inter-domain
28 communication mechanisms are not specified by this standard.

29 The protocols that the CUC uses for communication with end stations are not specified by this standard. A
30 CUC exchanges information with a CNC in order to configure TSN features on behalf of its end stations. It
31 communicates with the CNC through the CUC-CNC interface specified in 46.2. The CUC can request
32 computation of paths and configurations for Streams in the following ways:

- 33 e) Request computation of the paths and configurations for a set of Streams, using the protocol
34 operation described in 46.2.7.1. The computation is performed by the CNC on the complete set of
35 Streams of this request. This allows for optimized scheduling of Streams in the network.
- 36 f) Request computation of the paths and configurations for new or modified Streams, using the
37 protocol operation described in 46.2.7.2. The computation is performed by the CNC on all Streams
38 in a Configuration Domain that have a StreamStatus (46.2.3.8) of either planned or modified.
- 39 g) Request computation of the paths and configurations for all Streams of a CUC, using the protocol
40 operation described in 46.2.7.3. The computation is performed by the CNC on all Streams in a
41 Configuration Domain that belong to the CUC specified in the request.
- 42 h) Request the joining of a set of Listeners to an already existing Stream. The paths are extended to
43 allow forwarding of the Stream to the new Listeners. Computation for the changes has to be
44 triggered via RPC.
- 45 i) Request the removal of an existing Stream, using the protocol operation described in 46.2.8.1.

- j) Request the removal of one or more Listeners from an existing Stream. Computation for the changes has to be triggered via RPC.

A CUC can be present for initial configuration, to manage changes to a running network, or both. Multiple CUCs can co-exist and operate in parallel in the same Configuration Domain as shown in Figure 46-3.

46.1.6 Centralized Network Configuration

The Centralized Network Configuration (CNC) is a logical entity that configures network resources on behalf of applications (users) and can be located in any station of a network.

The CNC is responsible for:

- a) Receiving the Stream requirements for one or more Streams from the corresponding CUC.
- b) Providing a way for a CUC to request a free StreamID.
- c) Assigning a unique destination MAC address in the Configuration Domain it is responsible for to each of the requested Streams.
- d) Computing paths for requested Streams.
- e) Performing computation of scheduling and/or shaping configuration for the requested Streams.
- f) Configuring the network devices to provide the required resources for the Streams (e.g. FDB entries, configuration of transmission gates, etc.), using remote management.
- g) Providing the end station communication-configuration for the Streams to the corresponding CUC. If the paths for the Streams impact existing Streams the CNC is also responsible for providing that information to the CUCs that originally requested the impacted Streams.
- h) Removing of Streams as requested by a CUC.
- i) Discovering physical topology, using remote management.
- j) Retrieving Station capabilities, using remote management.

The CNC communicates with a CUC through the CUC-CNC interface specified in 46.2. It communicates with the stations using the managed objects defined in this and other IEEE 802.1 standards. There can only be one active CNC per Configuration Domain.

46.1.7 Configuration Domain

A Configuration Domain is a set of stations that are under a common configuration and management scheme, and a single administration. The Configuration Domain provides boundary information for the common management scheme and in support of the responsibilities of the CUC and CNC regarding Streams. Whether a CNC and one or more CUCs are present in a Configuration Domain depends on the TSN configuration model (46.1.3) that is used in the domain (e.g., whether the fully centralized model or a different configuration model is used). The CNC and the CUCs required for the configuration of a Configuration Domain affect only one Configuration Domain.

46.2 User/network configuration information

46.2.2 Protocol integration

Change the paragraph beginning “Each TSN configuration protocol shall use the StreamID” as follows:

Each TSN configuration protocol shall use the StreamID of ~~this clause (46.2.3.1)~~ as the unique identifier of each Stream’s configuration. The StreamID identifies configuration, not data, so it has no formal relation to the data frame encoding for the Stream.

1 *Insert the following NOTE after the dashed list item beginning "— Response: Bridge":*

2 NOTE—The Response can be unsolicited in order to update configuration, e.g., to address a change in the
3 network.

4 *Change the paragraph beginning "The protocol message(s) that invoke the join or leave operation" as
5 follows:*

6 The protocol message(s) that invoke the join or leave operation are not required to coincide with the protocol
7 message(s) that contain the associated groups (Talker, Listener, or Status). Nevertheless, the groups specify
8 elements that are required for a subsequent join or leave operation to be valid. For example, for the fully
9 centralized model (46.1.3.3), the CUC can transfer a list of Talker/Listener groups to the CNC, followed by
10 a separate protocol message with a join request that applies to the entire list. For the join request to succeed,
11 each of the Talker/Listener groups ~~must~~ contains the required elements. At a later time, the CUC can read
12 the resulting list of Status groups from the CNC, which provides the response to the join.

13 *Insert 46.2.2.1, 46.2.2.2, 46.2.2.3 as follows:*

14 **46.2.2.1 DomainID**

15 DomainID uniquely identifies the Configuration Domain of a CUC, and the Streams associated with that
16 CUC. DomainID is only used if the centralized network/distributed user model (46.1.3.2) or the fully
17 centralized model (46.1.3.3) is used.

18 **46.2.2.2 CucID**

19 CucID uniquely identifies a CUC within a Configuration Domain and is used in configuration models that
20 include a CNC. It is used along with the DomainID to associate Streams with a CUC.

21 **46.2.2.3 CncEnabled**

22 CncEnabled is used to enable or disable the CNC functionality of a station capable of acting as a CNC. If
23 CncEnabled is set to TRUE the CNC functionality is enabled. If it is set to FALSE the CNC functionality is
24 disabled. The default value for CncEnabled is FALSE.

25 **46.2.3 Talker**

26 *Change the paragraph beginning "The Talker group contains the following groups:" as follows:*

27 The Talker group contains the following groups:

- 28 — StreamID (46.2.3.1)
- 29 — StreamRank (46.2.3.2)
- 30 — EndStationInterfaces (46.2.3.3)
- 31 — DataFrameSpecification (46.2.3.4)
- 32 — TrafficSpecification (46.2.3.5)
- 33 — UserToNetworkRequirements (46.2.3.6)
- 34 — InterfaceCapabilities (46.2.3.7)
- 35 — [StreamStatus \(46.2.3.8\)](#)

36 *Insert the following sentence as a new paragraph, prior to 46.2.3.1:*

37 For the join and leave operation, StreamStatus shall be included.

1 Insert 46.2.3.8 and Table 46-12 as follows, renumbering subsequent tables as required:

2 46.2.3.8 StreamStatus

3 StreamStatus is an enumeration specified in Table 46-12 that indicates the status of a Stream. The status is
4 maintained by the CNC and is used to determine which Streams are computed by calling the RPC
5 ComputePlannedAndModifiedStreams (46.2.7.2).

Table 46-12—StreamStatus enumeration

Name	Value	Description
Planned	0	Stream has been requested but has not yet been configured.
Configured	1	Stream has been computed and configured.
Modified	2	Stream has been configured but Stream parameters have been modified after configuration..

6 Insert 46.2.6, 46.2.7, 46.2.8, and 46.2.7 at the end of 46.2, as follows:

7 46.2.6 Protocol operations

8 The TSN user/network configuration makes use of protocol operations to request specific actions and to
9 receive notifications. The following operations are supported:

- 10 — **Remote Procedure Calls (RPC):** this protocol operation allows requesting an action for the
11 complete YANG data model.
- 12 — **Actions:** this protocol operation allows requesting an action on a specific part of the YANG data
13 model.
- 14 — **Notifications:** this protocol operation provides information, e.g., it allows the CNC to inform the
15 CUC that computing the configuration has finished.

16 46.2.7 Remote Procedure Calls

17 The TSN user/network configuration provides the following RPCs:

- 18 — ComputeStreams (46.2.7.1)
- 19 — ComputePlannedAndModifiedStreams (46.2.7.2)
- 20 — ComputeAllStreams (46.2.7.3)
- 21 — RequestDomainId (46.2.7.4)
- 22 — RequestFreeStreamId (46.2.7.5)

23 46.2.7.1 ComputeStreams

24 This RPC starts the computation of path and resource allocation for one or more Streams. The Streams that
25 are to be included in the computation are specified by providing their associated DomainID (46.2.2.1),
26 CucID (46.2.2.2), and StreamID (46.2.3.1). This RPC can be applied to compute new Streams as well as
27 recompute already configured Streams.

28 The RPC returns information that indicates only if the Stream computation has been started successfully or
29 not. It does not return information on whether the Stream configuration itself has been successful or not,
30 because computation and configuration can take an arbitrary amount of time. The notifications

1 ComputeStreamsCompleted (46.2.9.1) and ConfigureStreamsCompleted (46.2.9.2) are available to the CNC
2 to return information on success or failure of the Stream computation and configuration, after the actions
3 have finished.

4 **46.2.7.2 ComputePlannedAndModifiedStreams**

5 This RPC starts the computation of path and resource allocation for Streams that have not been configured
6 or that have been configured and have been modified since configuration. The Streams that are to be
7 included in the computation are specified by providing their associated DomainID (46.2.2.1) and CucID
8 (46.2.2.2). The object StreamStatus (46.2.3.8) is used to determine if a Stream is included in the computation
9 initiated by this RPC.

10 The RPC returns information that indicates only if the Stream computation has been started successfully or
11 not. It does not return information on whether the Stream configuration itself has been successful or not,
12 because computation and configuration can take an arbitrary amount of time. The notifications
13 ComputeStreamsCompleted (46.2.9.1) and ConfigureStreamsCompleted (46.2.9.2) are available to the CNC
14 to return information on success or failure of the Stream computation and configuration, after the actions
15 have finished.

16 **46.2.7.3 ComputeAllStreams**

17 This RPC starts the computation of path and resource allocation for all Streams in a Configuration Domain
18 and that are belonging to a specified CUC. The Streams that are to be included in the computation are
19 specified by providing their associated DomainID (46.2.2.1) and CucID (46.2.2.2).

20 The RPC returns information that indicates only if the Stream computation has been started successfully or
21 not. It does not return information on whether the Stream configuration itself has been successful or not,
22 because computation and configuration can take an arbitrary amount of time. The notifications
23 ComputeStreamsCompleted (46.2.9.1) and ConfigureStreamsCompleted (46.2.9.2) are available to the CNC
24 to return information on success or failure of the Stream computation and configuration, after the actions
25 have finished.

26 **46.2.7.4 RequestDomainId**

27 This RPC allows a CUC to request the DomainID (46.2.2.1) of the Configuration Domain that the CUC
28 belongs to from the CNC. If a CUC already knows the Configuration Domain it belongs to, this RPC can be
29 used to verify that the information the CUC has is correct.

30 **46.2.7.5 RequestFreeStreamId**

31 This RPC allows a CUC to request a free StreamID group (46.2.3.1) from a CNC. Requesting a free
32 StreamID group allows a CUC to provide an unused, i.e., unique, StreamId group for a Stream when
33 requesting that Stream from the CNC.

34 **46.2.8 Actions**

35 The TSN user/network configuration provides the following actions:

36 — RemoveStreams (46.2.8.1)

1 **46.2.8.1 RemoveStreams**

2 This action starts the removal of one or more Streams. The Streams that are to be removed are specified by
3 providing their associated StreamIDs (46.2.3.1). This action returns information that indicates only if the
4 Stream removal has been started successfully or not. It does not return information on whether the Stream
5 removal itself has been successful or not, because execution can take an arbitrary amount of time. When a
6 Stream is successfully removed, the StreamId associated with that Stream can be used as a free StreamId by
7 the RPC RequestFreeStreamId (46.2.7.5) again.

8 The notification RemoveStreamsCompleted (46.2.9.3) is available to the CNC to return information on
9 success or failure of the Stream removal.

10 **46.2.9 Notifications**

11 The TSN user/network configuration provides the following notifications:

- 12 — ComputeStreamsCompleted (46.2.9.1)
- 13 — ConfigureStreamsCompleted (46.2.9.2)
- 14 — RemoveStreamsCompleted (46.2.9.3)

15 **46.2.9.1 ComputeStreamsCompleted**

16 This notification is used by the CNC to inform a CUC that has requested the computation of Streams, that
17 the computation for these Streams has finished. If the computation of these Streams impacts other Streams
18 that are already configured in the network, it can also be used to notify the CUCs that originally requested
19 the impacted Streams about the modification.

20 NOTE—ComputeStreamsCompleted returns only information on the computation of Streams. This does not provide any
21 information on whether the configuration of these Streams has been performed successfully or not.

22 It returns a list of Domains, identified by their DomainIDs (46.2.2.1), CUCs in that domain, identified by
23 their CucIDs (46.2.2.2) and Streams associated with a CUC, identified by their StreamIDs (46.2.3.1). For
24 each Stream it also returns either 0, if the Stream computation was successful, or a FailureCode (46.2.5.1.3),
25 if it was not.

26 **46.2.9.2 ConfigureStreamsCompleted**

27 This notification is used by the CNC to inform a CUC that has requested the computation of Streams, that
28 the computation and configuration for these Streams has finished. If the computation or configuration of
29 these Streams impacts other Streams that are already configured in the network, it can also be used to notify
30 the CUCs that originally requested the impacted Streams about the modification.

31 It returns a list of Domains, identified by their DomainIDs (46.2.2.1), CUCs in that domain, identified by
32 their CucIDs (46.2.2.2) and Streams associated with a CUC, identified by their StreamIDs (46.2.3.1). For
33 each Stream it also returns either 0, if the Stream computation and configuration was successful, or a
34 FailureCode (46.2.5.1.3), if it was not.

35 **46.2.9.3 RemoveStreamsCompleted**

36 This notification is used by the CNC to inform a CUC that has requested the removal of Streams, that the
37 removal of these Streams has finished. It returns a list of Domains, identified by their DomainIDs (46.2.2.1),
38 CUCs in that domain, identified by their CucIDs (46.2.2.2) and Streams associated with a CUC, identified
39 by their StreamIDs (46.2.3.1). For each Stream it also returns either 0, if the Stream computation and Stream
40 configuration were successful, or 1, if they were not.

1 **46.3 YANG for TSN user/network configuration**

2 *Change 46.3, as follows:*

3 In order to support the use of YANG-based protocols for the fully centralized model (46.1.3.3), 48.6.3, [and](#)
4 [48.6.23](#) ~~specifies a~~ [specify](#) YANG modules.

5 If a YANG-based protocol is specified by another standard for the TSN user/network configuration
6 information (46.2), that specification shall use the YANG module specified in 48.6.3 [and 48.6.23](#) [see
7 item d) in 5.29].

8 The YANG module of 48.6.3 provides YANG text for each group of elements in 46.2. Each element is
9 specified using a YANG `leaf`. Each group is specified as a YANG `typedef` or `grouping`. The YANG
10 module for user/network configuration ([48.6.23](#)) imports the YANG module of 48.6.3 and uses the
11 `typedef` and `grouping` nodes in order to specify the schema tree used for communication between CUC
12 and CNC.

13 YANG identifiers use a naming convention of hyphens between lowercase names (e.g., “mac-address”).
14 Identifiers for elements and groups in 46.2 use a naming convention of camel case (e.g., “MacAddress”).
15 The specifications for an identifier in 48.6.3 [and 48.6.23](#) shall be interpreted as applying to the
16 corresponding identifier in 46.2 regardless of differences in naming convention (e.g., requirements for
17 “MacAddress” in 46.2 apply to “mac-address” in 48.6.3).

18 In the YANG module definitions of 48.6.3 [and 48.6.23](#), if any discrepancy between the “description” text
19 and the corresponding specifications in 46.2 occurs, the specifications in 46.2 take precedence.

20

48. YANG Data Models

48.2 IEEE 802.1Q YANG models

Insert 48.2.12 at the end of 48.2 as follows:

48.2.12 User/Network Interface model

The UNI allows communication between a CUC and a CNC and can be implemented in an end station or Bridge.

The UNI consists of three high-level groups, Talker (46.2.3), Listener (46.2.4), and Status (46.2.5) and is modeled as illustrated in Figure 48-21 and Figure 48-22.

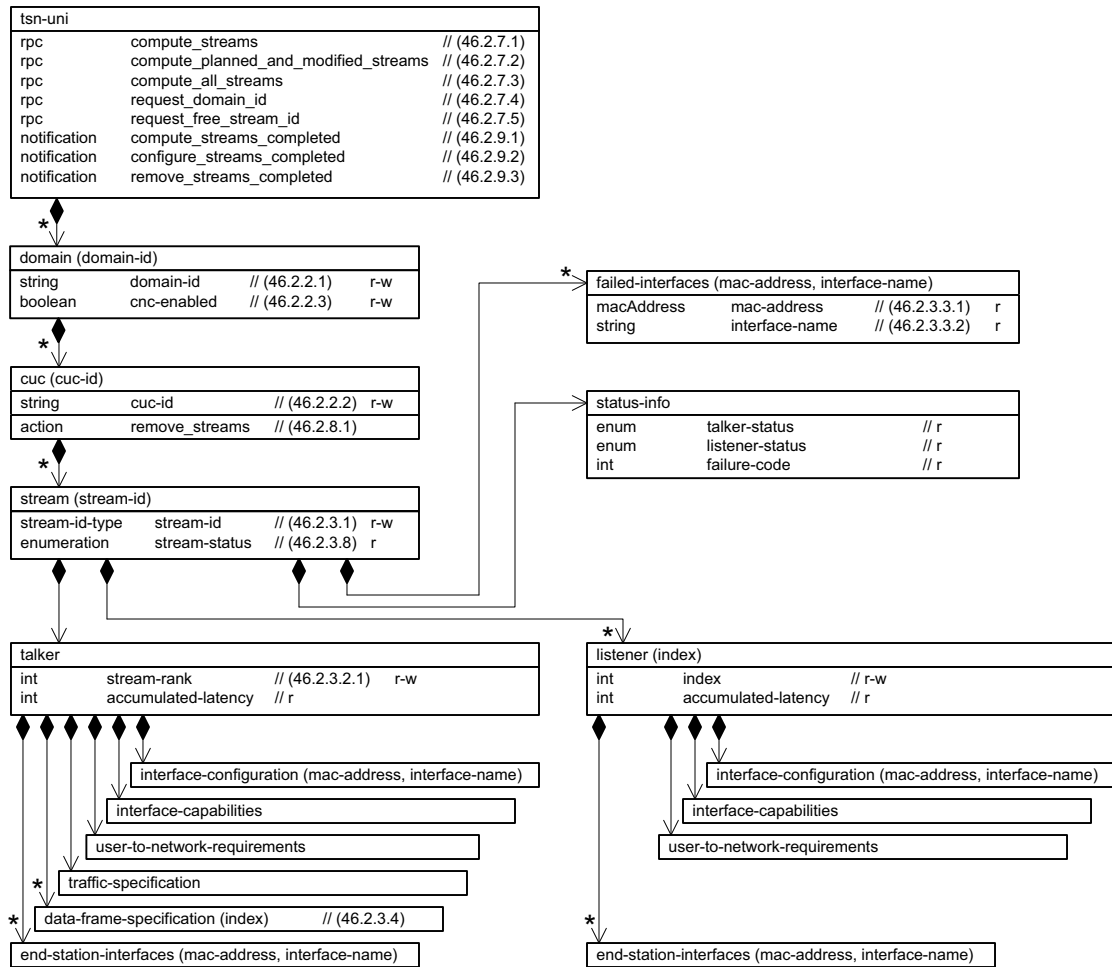


Figure 48-21—User/Network Interface model A

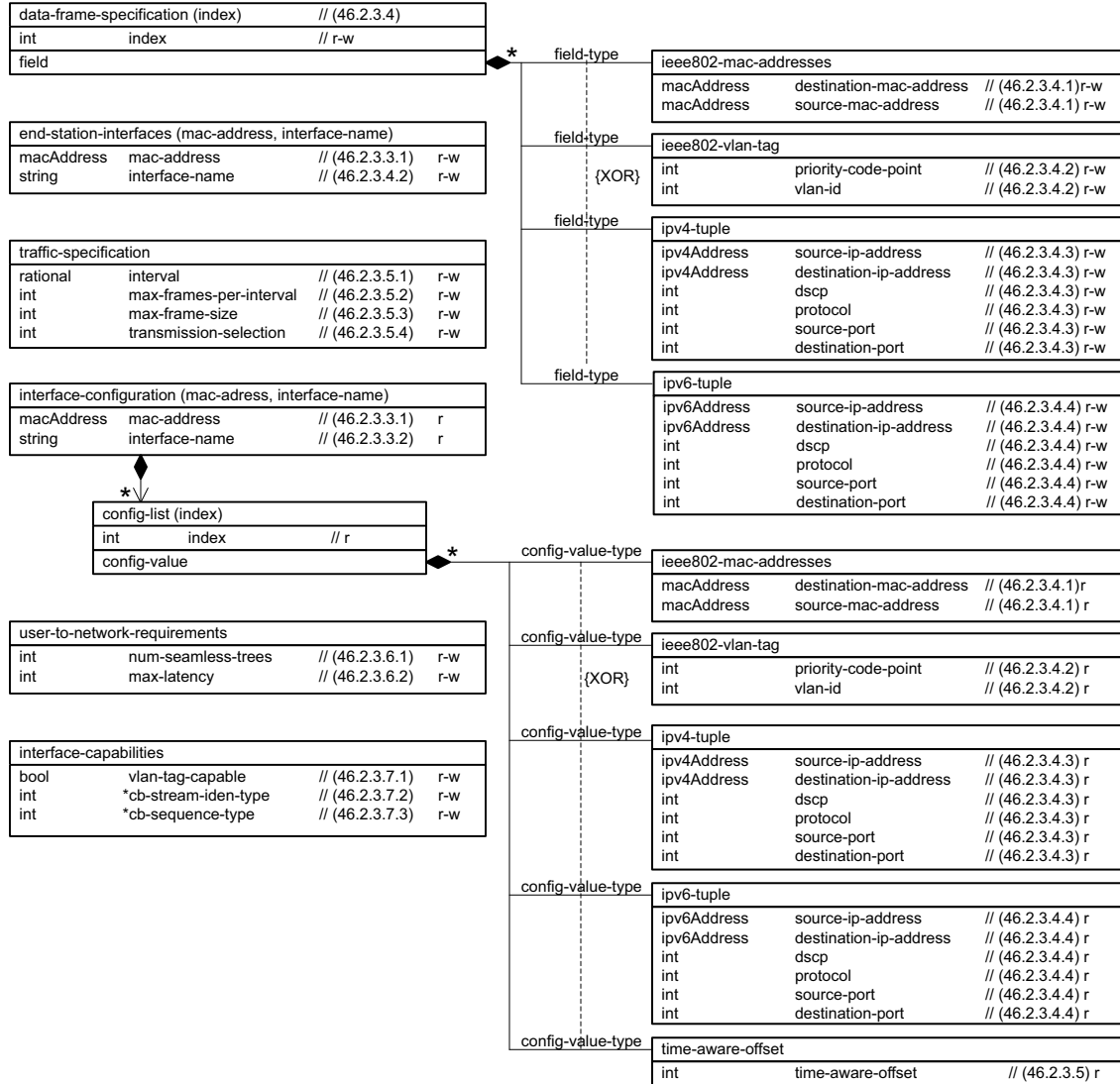


Figure 48-22—User/Network Interface model B

1 48.3 Structure of the YANG models

2

Table 48-1—Summary of the YANG modules

Insert the following row at the end of Table 48-1 as shown:

Module	References	Managed functionality	Initial YANG specification Notes
ieee802-dot1q-tsn-config-uni	48.5.23, 48.6.23	46.1.5, 46.1.6, 46.2	IEEE Std 802.1Qdj Time-Sensitive Networking configuration UNI

3 *Insert 48.3.12 and Table 48-13 at the end of clause 48.3 as follows:*

4 48.3.12 User/Network Interface model

5 A station implementing the User/Network Interface model (48.2.1) implements the YANG modules in
6 Table 48-12.

Table 48-13—User/Network Interface model YANG modules

YANG module
ieee802-dot1q-tsn-types
ieee802-dot1q-tsn-config-uni

1 **48.4 Security considerations**

2 *Insert 48.4.12 at the end of clause 48.4, as follows:*

3 **48.4.12 Security considerations of the User/Network Interface model**

4 The following objects in the ieee802-dot1q-tsn-config-uni YANG module could be manipulated to interfere
5 with the operation of streams in a configuration domain and, for example, be used to cause network
6 instability:

7 tsn-uni/domain/cuc/stream
8 tsn-uni/domain/cuc/remove_stream

9

1 48.5 YANG schema tree definitions

2 *Insert new 48.5.23 at the end of 48.5, as follows:*

3 48.5.23 Schema for the ieee802-dot1q-tsn-config-uni YANG module

```
4 module: ieee802-dot1q-tsn-config-uni
5   +--rw tsn-uni
6     +--rw domain* [domain-id]
7       +--rw domain-id      string
8       +--rw cnc-enabled?   boolean
9       +--rw cuc* [cuc-id]
10        +--rw cuc-id       string
11        +--rw stream* [stream-id]
12          | +--rw stream-id      tsn:stream-id-type
13          | +--ro stream-status? enumeration
14          | +--rw talker
15          | | +--rw stream-rank
16          | | | +--rw rank?      uint8
17          | | | +--rw end-station-interfaces* [mac-address interface-name]
18          | | | | +--rw mac-address      string
19          | | | | +--rw interface-name   string
20          | | | +--rw data-frame-specification* [index]
21          | | | | +--rw index           uint8
22          | | | | +--rw (field)?
23          | | | |   +--:(ieee802-mac-addresses)
24          | | | | | +--rw ieee802-mac-addresses
25          | | | | | | +--rw destination-mac-address? string
26          | | | | | | +--rw source-mac-address?    string
27          | | | |   +--:(ieee802-vlan-tag)
28          | | | | | +--rw ieee802-vlan-tag
29          | | | | | | +--rw priority-code-point?  uint8
30          | | | | | | +--rw vlan-id?              uint16
31          | | | |   +--:(ipv4-tuple)
32          | | | | | +--rw ipv4-tuple
33          | | | | | | +--rw source-ip-address?    inet:ipv4-address
34          | | | | | | +--rw destination-ip-address? inet:ipv4-address
35          | | | | | | +--rw dscp?                uint8
36          | | | | | | +--rw protocol?            uint16
37          | | | | | | +--rw source-port?         uint16
38          | | | | | | +--rw destination-port?    uint16
39          | | | |   +--:(ipv6-tuple)
40          | | | | | +--rw ipv6-tuple
41          | | | | | | +--rw source-ip-address?    inet:ipv6-address
42          | | | | | | +--rw destination-ip-address? inet:ipv6-address
43          | | | | | | +--rw dscp?                uint8
44          | | | | | | +--rw protocol?            uint16
45          | | | | | | +--rw source-port?         uint16
46          | | | | | | +--rw destination-port?    uint16
47          | | +--rw traffic-specification
48          | | | +--rw interval
49          | | | | +--rw numerator?      uint32
50          | | | | +--rw denominator?   uint32
51          | | | +--rw max-frames-per-interval? uint16
52          | | | +--rw max-frame-size?    uint16
53          | | | +--rw transmission-selection? uint8
54          | | | +--rw time-aware!
55          | | | | +--rw earliest-transmit-offset? uint32
56          | | | | +--rw latest-transmit-offset?  uint32
57          | | | | +--rw jitter?                uint32
58          | | +--rw user-to-network-requirements
59          | | | +--rw num-seamless-trees? uint8
60          | | | +--rw max-latency?        uint32
61          | +--rw interface-capabilities
62          | | +--rw vlan-tag-capable?    boolean
63          | | +--rw cb-stream-iden-type-list* uint32
64          | | +--rw cb-sequence-type-list* uint32
65          | | +--ro accumulated-latency?  uint32
66          | +--ro interface-configuration
67          | | +--ro interface-list* [mac-address interface-name]
68          | | +--ro mac-address        string
```

```

1      | |      +--ro interface-name      string
2      | |      +--ro config-list* [index]
3      | |      +--ro index                                uint8
4      | |      +--ro (config-value)?
5      | |      +--:(ieee802-mac-addresses)
6      | |      | +--ro ieee802-mac-addresses
7      | |      | | +--ro destination-mac-address?      string
8      | |      | | +--ro source-mac-address?           string
9      | |      +--:(ieee802-vlan-tag)
10     | |      | +--ro ieee802-vlan-tag
11     | |      | | +--ro priority-code-point?          uint8
12     | |      | | +--ro vlan-id?                       uint16
13     | |      +--:(ipv4-tuple)
14     | |      | +--ro ipv4-tuple
15     | |      | | +--ro source-ip-address?
16     | |      | | | inet:ipv4-address
17     | |      | | +--ro destination-ip-address?
18     | |      | | | inet:ipv4-address
19     | |      | | +--ro dscp?                           uint8
20     | |      | | +--ro protocol?                        uint16
21     | |      | | +--ro source-port?                     uint16
22     | |      | | +--ro destination-port?                uint16
23     | |      +--:(ipv6-tuple)
24     | |      | +--ro ipv6-tuple
25     | |      | | +--ro source-ip-address?
26     | |      | | | inet:ipv6-address
27     | |      | | +--ro destination-ip-address?
28     | |      | | | inet:ipv6-address
29     | |      | | +--ro dscp?                           uint8
30     | |      | | +--ro protocol?                        uint16
31     | |      | | +--ro source-port?                     uint16
32     | |      | | +--ro destination-port?                uint16
33     | |      +--:(time-aware-offset)
34     | |      | +--ro time-aware-offset?                uint32
35     | +--rw listener* [index]
36     | | +--rw index                                uint32
37     | | +--rw end-station-interfaces* [mac-address interface-name]
38     | | | +--rw mac-address      string
39     | | | +--rw interface-name   string
40     | | +--rw user-to-network-requirements
41     | | | +--rw num-seamless-trees?  uint8
42     | | | +--rw max-latency?         uint32
43     | +--rw interface-capabilities
44     | | +--rw vlan-tag-capable?      boolean
45     | | +--rw cb-stream-iden-type-list*  uint32
46     | | +--rw cb-sequence-type-list*    uint32
47     | +--ro accumulated-latency?      uint32
48     | +--ro interface-configuration
49     | | +--ro interface-list* [mac-address interface-name]
50     | | | +--ro mac-address      string
51     | | | +--ro interface-name   string
52     | | +--ro config-list* [index]
53     | | | +--ro index                                uint8
54     | | | +--ro (config-value)?
55     | | | +--:(ieee802-mac-addresses)
56     | | | | +--ro ieee802-mac-addresses
57     | | | | | +--ro destination-mac-address?      string
58     | | | | | +--ro source-mac-address?           string
59     | | | +--:(ieee802-vlan-tag)
60     | | | | +--ro ieee802-vlan-tag
61     | | | | | +--ro priority-code-point?          uint8
62     | | | | | +--ro vlan-id?                       uint16
63     | | | +--:(ipv4-tuple)
64     | | | | +--ro ipv4-tuple
65     | | | | | +--ro source-ip-address?
66     | | | | | | inet:ipv4-address
67     | | | | | +--ro destination-ip-address?
68     | | | | | | inet:ipv4-address
69     | | | | | +--ro dscp?                           uint8
70     | | | | | +--ro protocol?                        uint16
71     | | | | | +--ro source-port?                     uint16
72     | | | | | +--ro destination-port?                uint16

```

```

1      | | | +--:(ipv6-tuple)
2      | | | +---ro ipv6-tuple
3      | | | +---ro source-ip-address?
4      | | | | inet:ipv6-address
5      | | | +---ro destination-ip-address?
6      | | | | inet:ipv6-address
7      | | | +---ro dscp? uint8
8      | | | +---ro protocol? uint16
9      | | | +---ro source-port? uint16
10     | | | +---ro destination-port? uint16
11     | | | +---:(time-aware-offset)
12     | | | +---ro time-aware-offset? uint32
13     | | +---ro status-info
14     | | | +---ro talker-status? enumeration
15     | | | +---ro listener-status? enumeration
16     | | | +---ro failure-code? uint8
17     | | +---ro failed-interfaces* [mac-address interface-name]
18     | | | +---ro mac-address string
19     | | | +---ro interface-name string
20     +---x remove_streams
21         +---w input
22         | +---w stream-list* [stream-id]
23         | | +---w stream-id tsn:stream-id-type
24         +---ro output
25             +---ro result? string
26
27 rpcs:
28 +---x compute_streams
29 | +---w input
30 | | +---w domain* [domain-id]
31 | | | +---w domain-id -> /tsn-uni/domain/domain-id
32 | | | +---w cuc* [cuc-id]
33 | | | | +---w cuc-id -> /tsn-uni/domain/cuc/cuc-id
34 | | | | +---w stream-list* [stream-id]
35 | | | | +---w stream-id -> /tsn-uni/domain/cuc/stream/stream-id
36 | +---ro output
37 | | +---ro result? string
38 +---x compute_planned_and_modified_streams
39 | +---w input
40 | | +---w domain* [domain-id]
41 | | | +---w domain-id string
42 | | | +---w cuc* [cuc-id]
43 | | | | +---w cuc-id string
44 | +---ro output
45 | | +---ro result? string
46 +---x compute_all_streams
47 | +---w input
48 | | +---w domain* [domain-id]
49 | | | +---w domain-id string
50 | | | +---w cuc* [cuc-id]
51 | | | | +---w cuc-id string
52 | +---ro output
53 | | +---ro result? string
54 +---x request_domain_id
55 | +---w input
56 | | +---w cuc-id? string
57 | +---ro output
58 | | +---ro result? string
59 +---x request_free_stream_id
60 | +---w input
61 | | +---w domain-id? string
62 | | +---w cuc-id? string
63 | +---ro output
64 | | +---ro result? string
65
66 notifications:
67 +---n compute_streams_completed
68 | +---ro domain* [domain-id]
69 | | +---ro domain-id string
70 | | +---ro cuc* [cuc-id]
71 | | | +---ro cuc-id string
72 | | | +---ro stream* [stream-id]
```



```
1 |          +--ro stream-id          tsn:stream-id-type
2 |          +--ro failure-code?    uint8
3 +---n configure_streams_completed
4 |   +--ro domain* [domain-id]
5 |       +--ro domain-id    string
6 |       +--ro cuc* [cuc-id]
7 |           +--ro cuc-id    string
8 |           +--ro stream* [stream-id]
9 |               +--ro stream-id    tsn:stream-id-type
10 |               +--ro failure-code?    uint8
11 +---n remove_streams_completed
12 |   +--ro domain* [domain-id]
13 |       +--ro domain-id    string
14 |       +--ro cuc* [cuc-id]
15 |           +--ro cuc-id    string
16 |           +--ro stream* [stream-id]
17 |               +--ro stream-id    tsn:stream-id-type
18 |               +--ro failure-code?    uint8
19
```

1 48.6 YANG modules^{3 4 5}

2 *Insert 48.6.23 and the following YANG module at the end of 48.6:*

3 48.6.23 The ieee802-dot1q-tsn-config-uni YANG module

```
4 module ieee802-dot1q-tsn-config-uni {
5   yang-version "1.1";
6   namespace urn:ieee:std:802.1Q:yang:ieee802-dot1q-tsn-config-uni;
7   prefix dot1q-tsn-config-uni;
8   import ieee802-dot1q-tsn-types {
9     prefix tsn;
10    reference
11      "48.6.3 of IEEE Std 802.1Q";
12  }
13  organization
14    "Institute of Electrical and Electronics Engineers";
15  contact
16    "WG-URL: http://ieee802.org/1/
17     WG-EMail: stds-802-1-1@ieee.org
18
19    Contact: IEEE 802.1 Working Group Chair
20    Postal: C/O IEEE 802.1 Working Group
21           IEEE Standards Association
22           445 Hoes Lane
23           Piscataway, NJ 08854
24           USA
25
26    E-mail: stds-802-1-chairs@ieee.org";
27  description
28    "Time-Sensitive Networking (TSN) User/Network Interface (UNI) for the
29     exchange of information between CUC and CNC that are required to
30     configure TSN Streams in a TSN network.
31
32    Copyright (C) IEEE (2023).
33
34    This version of this YANG module is part of IEEE Std 802.1Qd; see
35    the standard itself for full legal notices.";
36  revision 2023-07-31 {
37    description
38      "Published as part of IEEE Std 802.1Qd. Initial version.";
39    reference
40      "IEEE Std 802.1Q: IEEE Std 802.1Q-2022 Bridges and Bridged
41       Networks., IEEE Std 802.1Qd Configuration Enhancements for
42       Time-Sensitive Networking";
43  }
44  container tsn-uni {
45    description
46      "Top-level container for the TSN UNI module.";
47    list domain {
48      key "domain-id";
49      description
50        "List of Configuration Domains.
51
52        This list exists so CUCs can be associated with the Configuration
53        Domain they are located in and can be used to restrict access to
54        CUCs, e.g., by using standard mechanism as described in RFC 8341.";
55      leaf domain-id {
56        type string;
57        description
58          "The Domain ID is a unique identifier of a Configuration
59          Domain. It is used to identify the Configuration Domain a CUC
60          belongs to.";
```

³ Copyright release for YANG: Users of this standard may freely reproduce the YANG modules contained in this standard so that they can be used for their intended purpose.

⁴ An ASCII version of each YANG module is attached to the PDF of this standard and can also be obtained from the IEEE 802.1 Website at <https://1.ieee802.org/yang-modules/>.

⁵ References in this standard's YANG module definitions are not clickable, as each module has been incorporated unchanged after development and verification using YANG tools.

```

1      reference
2      "46.2.2.1 of IEEE Std 802.1Qdj";
3  }
4  leaf cnc-enabled {
5      type boolean;
6      default "false";
7      description
8          "cnc-enabled is used to enable or disable the CNC functionality
9            of a station capable of acting as a CNC. If this object is set
10           to TRUE the CNC functionality is enabled. If it is set to FALSE
11           the CNC functionality is disabled.";
12      reference
13          "46.2.2.3 of IEEE Std 802.1Qdj";
14  }
15  list cuc {
16      key "cuc-id";
17      description
18          "List of CUCs.
19
20          This list exists so Streams can be associated with the CUC that
21          initially requested them and can be used to restrict access to
22          Streams, e.g., by using standard mechanisms as described in RFC
23          8341.";
24      leaf cuc-id {
25          type string;
26          description
27              "The CUC ID is a unique identifier of a CUC. It is used to
28              identify the CUC that a Stream belongs to, i.e., that
29              requested the creation of a Stream.";
30          reference
31              "46.2.2.2 of IEEE Std 802.1Qdj";
32      }
33      list stream {
34          key "stream-id";
35          description
36              "List of Streams.
37
38              Each Stream consists of a Stream ID, a request container, and
39              a configuration container.
40
41              In the fully centralized model of TSN configuration, the
42              Stream ID and request originate from the CUC and is delivered
43              to the CNC, while the configuration originates from the CNC
44              and is delivered to the CUC.";
45          leaf stream-id {
46              type tsn:stream-id-type;
47              description
48                  "The Stream ID is a unique identifier of a Stream request
49                  and corresponding configuration. It is used to associate a
50                  CUC's Stream request with a CNC's corresponding response.";
51          }
52          leaf stream-status {
53              type enumeration {
54                  enum planned {
55                      value 0;
56                      description
57                          "The Stream has been requested but has not yet been
58                          configured by the CNC.";
59                  }
60                  enum configured {
61                      value 1;
62                      description
63                          "The Stream has been computed and configured by the
64                          CNC.";
65                  }
66                  enum modified {
67                      value 2;
68                      description
69                          "The Stream has been configured but Stream parameters
70                          have been modified after configuration.";
71                  }
72              }

```

```

1      config false;
2      description
3          "The stream-status indicates what status the Stream has in
4          the CNC.";
5      reference
6          "46.2.3.8 of IEEE Std 802.1Qdj";
7  }
8  container talker {
9      description
10         "The Talker container contains: - Talker's behavior for
11         Stream (how/when transmitted) - Talker's requirements from
12         the network - TSN capabilities of the Talker's
13         interface(s).";
14     uses tsn:group-talker;
15     uses tsn:group-status-talker-listener {
16         refine "accumulated-latency" {
17             config false;
18         }
19         refine "interface-configuration" {
20             config false;
21         }
22     }
23 }
24 list listener {
25     key "index";
26     description
27         "Each Listener list entry contains: - Listener's
28         requirements from the network - TSN capabilities of the
29         Listener's interface(s).";
30     leaf index {
31         type uint32;
32         description
33             "This index is provided in order to provide a unique key
34             per list entry.";
35     }
36     uses tsn:group-listener;
37     uses tsn:group-status-talker-listener {
38         refine "accumulated-latency" {
39             config false;
40         }
41         refine "interface-configuration" {
42             config false;
43         }
44     }
45 }
46 uses tsn:group-status-stream {
47     refine "status-info" {
48         config false;
49     }
50     refine "failed-interfaces" {
51         config false;
52     }
53 }
54 }
55 action remove_streams {
56     description
57         "Removes the Streams with the ids provided in the stream-id
58         list.";
59     reference
60         "46.2.8.1 of IEEE Std 802.1Qdj";
61     input {
62         list stream-list {
63             key "stream-id";
64             description
65                 "List of stream-ids that are used to identify the Streams
66                 that are requested to be removed.";
67             leaf stream-id {
68                 type tsn:stream-id-type;
69                 description
70                     "Unique identifier that is used to request a Stream
71                     that is to be removed from the configuration.";
72             }

```

```

1      }
2    }
3    output {
4      leaf result {
5        type string;
6        description
7          "Returns status information indicating if Stream removal
8            has been successfully started.";
9      }
10   }
11 }
12 }
13 }
14 }
15
16 // RPCs
17 rpc compute_streams {
18   description
19     "Starts computation of path and resource allocation for one or more
20       Stream. The Streams that are included in the computation are the
21       ones that have their domain-id, cuc-id, and stream-id provided.
22       This RPC can be applied to compute new Streams as well as recompute
23       Streams that have been modified.";
24   input {
25     list domain {
26       key "domain-id";
27       description
28         "List of Configuration Domains.
29
30         This list exists so CUCs can be associated with the
31         Configuration Domain they are located in.";
32       reference
33         "46.2.7.1 of IEEE Std 802.1Qdj";
34       leaf domain-id {
35         type leafref {
36           path '/tsn-uni/domain/domain-id';
37         }
38         description
39           "A unique identifier of a Configuration Domain. It is used to
40             identify the Configuration Domain a CUC belongs to.";
41       }
42       list cuc {
43         key "cuc-id";
44         description
45           "List of CUCs.
46
47           This list exists so Streams can be associated with the CUC
48           that initially requested them.";
49         leaf cuc-id {
50           type leafref {
51             path '/tsn-uni/domain/cuc/cuc-id';
52           }
53           description
54             "A unique identifier of a CNC. It is used to identify the
55             CUC that a Streams belong to, i.e., that requested the
56             creation of a Stream.";
57         }
58         list stream-list {
59           key "stream-id";
60           description
61             "List of stream-ids that are used to identify the Streams
62             that are requested to be computed and configured.";
63           leaf stream-id {
64             type leafref {
65               path '/tsn-uni/domain/cuc/stream/stream-id';
66             }
67             description
68               "Unique identifier that is used to request a Stream that
69               is to be computed and configured.";
70           }
71         }
72       }

```

```

1     }
2   }
3   output {
4     leaf result {
5       type string;
6       description
7         "Only returns status information indicating if the computation
8         has been started. It does not return status information on the
9         success or failure of the actual Stream computation. A
10        notification can be used to inform the caller of this RPC on the
11        results of Stream computation after the computation has
12        finished.";
13     }
14   }
15 }
16 rpc compute_planned_and_modified_streams {
17   description
18     "Starts computation of path and resource allocation for all Streams
19     that are in the domain provided by domain-id and are associated
20     with the CUC provided by cuc-id, and that have not been computed
21     (i.e., that have a Stream status of planned or modified.";
22   reference
23     "46.2.7.2 of IEEE Std 802.1Qdj";
24   input {
25     list domain {
26       key "domain-id";
27       description
28         "List of Configuration Domains.
29
30         This list exists so CUCs can be associated with the
31         Configuration Domain they are located in.";
32     }
33     leaf domain-id {
34       type string;
35       description
36         "A unique identifier of a Configuration Domain. It is used to
37         identify the Configuration Domain a CUC belongs to.";
38     }
39     list cuc {
40       key "cuc-id";
41       description
42         "List of CUCs.
43
44         This list exists so Streams can be associated with the CUC
45         that initially requested them.";
46     }
47     leaf cuc-id {
48       type string;
49       description
50         "A unique identifier of a CNC. It is used to identify the
51         CUC that a Streams belong to, i.e., that requested the
52         creation of a Stream.";
53     }
54   }
55   output {
56     leaf result {
57       type string;
58       description
59         "Only returns status information indicating if the computation
60         has been started. It does not return status information on the
61         success or failure of the actual Stream computation. A
62         notification can be used to inform the caller of this RPC on the
63         results of Stream computation after the computation has
64         finished.";
65     }
66   }
67 }
68 rpc compute_all_streams {
69   description
70     "Starts computation of path and resource allocation for all Streams
71     that are in the domain provided by domain-id and are associated
72     with the CUC provided by cuc-id.";

```

```

1  reference
2  "46.2.7.3 of IEEE Std 802.1Qdj";
3  input {
4      list domain {
5          key "domain-id";
6          description
7              "List of Configuration Domains.
8
9              This list exists so CUCs can be associated with the
10             Configuration Domain they are located in.";
11         leaf domain-id {
12             type string;
13             description
14                 "A unique identifier of a Configuration Domain. It is used to
15                 identify the Configuration Domain a CUC belongs to.";
16         }
17         list cuc {
18             key "cuc-id";
19             description
20                 "List of CUCs.
21
22                 This list exists so Streams can be associated with the CUC
23                 that initially requested them.";
24             leaf cuc-id {
25                 type string;
26                 description
27                     "A unique identifier of a CNC. It is used to identify the
28                     CUC that a Streams belong to, i.e., that requested the
29                     creation of a Stream.";
30             }
31         }
32     }
33 }
34 output {
35     leaf result {
36         type string;
37         description
38             "Only returns status information indicating if the computation
39             has been started. It does not return status information on the
40             success or failure of the actual Stream computation. A
41             notification can be used to inform the caller of this RPC on the
42             results of Stream computation after the computation has
43             finished.";
44     }
45 }
46 }
47 rpc request_domain_id {
48     description
49         "Returns the DomainId of the Configuration Domain that the
50         requesting CUC belongs to.";
51     reference
52         "46.2.7.4 of IEEE Std 802.1Qdj";
53     input {
54         leaf cuc-id {
55             type string;
56             description
57                 "A unique identifier of a CNC. It is used to identify the CUC,
58                 allowing the CNC to return the DomainId this CUC belongs to.";
59         }
60     }
61     output {
62         leaf result {
63             type string;
64             description
65                 "Returns the DomainId of the Configuration Domain that the
66                 requesting CUC belongs to.";
67         }
68     }
69 }
70 rpc request_free_stream_id {
71     description
72         "Returns a free StreamId available for the Configuration Domain

```

```

1     identified by the DomainId.";
2     reference
3     "46.2.7.5 of IEEE Std 802.1Qdj";
4     input {
5         leaf domain-id {
6             type string;
7             description
8                 "A unique identifier of a Configuration Domain. It is used to
9                 identify the Configuration Domain a CUC belongs to.";
10        }
11        leaf cuc-id {
12            type string;
13            description
14                "A unique identifier of a CNC. It is used to identify the CUC,
15                allowing the CNC to return the DomainId this CUC belongs to.";
16        }
17    }
18    output {
19        leaf result {
20            type string;
21            description
22                "Returns a free StreamId available for the Configuration Domain
23                identified by the DomainId.";
24        }
25    }
26 }
27
28 // Notifications
29 notification compute_streams_completed {
30     description
31         "Notifies the caller of an RPC or action that initiated the
32         computation of one or multiple Streams, that the computation is
33         complete. It also returns information on the success or failure for
34         each of the Streams in the computation.";
35     reference
36         "46.2.9.1 of IEEE Std 802.1Qdj";
37     list domain {
38         key "domain-id";
39         description
40             "List of Configuration Domains.
41
42             This list exists so CUCs can be associated with the Configuration
43             Domain they are located in.";
44         leaf domain-id {
45             type string;
46             description
47                 "A unique identifier of a Configuration Domain. It is used to
48                 identify the Configuration Domain a CUC belongs to.";
49         }
50         list cuc {
51             key "cuc-id";
52             description
53                 "List of CUCs.
54
55                 This list exists so Streams can be associated with the CUC that
56                 initially requested them.";
57             leaf cuc-id {
58                 type string;
59                 description
60                     "A unique identifier of a CNC. It is used to identify the CUC
61                     that a Stream belongs to, i.e., that requested the creation
62                     of a Stream.";
63             }
64             list stream {
65                 key "stream-id";
66                 description
67                     "List of Streams.
68
69                     Each Stream consists of a Stream ID, a request container, and
70                     a configuration container.
71
72                     In the fully centralized model of TSN configuration, the

```



```
1      Stream ID and request originate from the CUC and is delivered
2      to the CNC, while the configuration originates from the CNC
3      and is delivered to the CUC.";
4  reference
5      "46.2.3 of IEEE Std 802.1Qdj";
6  leaf stream-id {
7      type tsn:stream-id-type;
8      description
9          "The Stream ID is a unique identifier of a Stream request
10         and corresponding configuration. It is used to associate a
11         CUC's Stream request with a CNC's corresponding response.";
12  }
13  leaf failure-code {
14      type uint8;
15      description
16          "A code that indicates if the computation for the Stream
17          was successful (0) or not. In the case of a failure a code
18          is returned to indicate what kind of failure occurred.";
19  }
20  }
21  }
22  }
23  }
24  notification configure_streams_completed {
25      description
26          "Notifies the caller of an RPC or action that initiated the
27          computation of one or multiple Streams, that the computation and
28          configuration is complete. It also returns information on the
29          success or failure for each of the Streams in the computation and
30          configuration.";
31      reference
32          "46.2.9.2 of IEEE Std 802.1Qdj";
33      list domain {
34          key "domain-id";
35          description
36              "List of Configuration Domains.
37
38              This list exists so CUCs can be associated with the Configuration
39              Domain they are located in.";
40      leaf domain-id {
41          type string;
42          description
43              "A unique identifier of a Configuration Domain. It is used to
44              identify the Configuration Domain a CUC belongs to.";
45      }
46      list cuc {
47          key "cuc-id";
48          description
49              "List of CUCs.
50
51              This list exists so Streams can be associated with the CUC that
52              initially requested them.";
53      leaf cuc-id {
54          type string;
55          description
56              "A unique identifier of a CNC. It is used to identify the CUC
57              that a Streams belong to, i.e., that requested the creation
58              of a Stream.";
59      }
60      list stream {
61          key "stream-id";
62          description
63              "List of Streams.
64
65              Each Stream consists of a Stream ID, a request container, and
66              a configuration container.
67
68              In the fully centralized model of TSN configuration, the
69              Stream ID and request originate from the CUC and is delivered
70              to the CNC, while the configuration originates from the CNC
71              and is delivered to the CUC.";
72      reference
```

```

1      "46.2.3 of IEEE Std 802.1Qdj";
2      leaf stream-id {
3          type tsn:stream-id-type;
4          description
5              "The Stream ID is a unique identifier of a Stream request
6              and corresponding configuration. It is used to associate a
7              CUC's Stream request with a CNC's corresponding response.";
8      }
9      leaf failure-code {
10         type uint8;
11         description
12             "A code that indicates if the computation and configuration
13             for the Stream was successful (0) or not. In the case of a
14             failure a code is returned to indicate what kind of failure
15             occurred.";
16     }
17 }
18 }
19 }
20 }
21 notification remove_streams_completed {
22     description
23         "Notifies the caller of an RPC or action that initiated the removal
24         of one or multiple Streams, that the removal is complete. It also
25         returns information on the success or failure for each of the
26         Streams in the removal request.";
27     reference
28         "46.2.9.3 of IEEE Std 802.1Qdj";
29     list domain {
30         key "domain-id";
31         description
32             "List of Configuration Domains.
33
34             This list exists so CUCs can be associated with the Configuration
35             Domain they are located in.";
36     }
37     leaf domain-id {
38         type string;
39         description
40             "A unique identifier of a Configuration Domain. It is used to
41             identify the Configuration Domain a CUC belongs to.";
42     }
43     list cuc {
44         key "cuc-id";
45         description
46             "List of CUCs.
47
48             This list exists so Streams can be associated with the CUC that
49             initially requested them.";
50     }
51     leaf cuc-id {
52         type string;
53         description
54             "A unique identifier of a CNC. It is used to identify the CUC
55             that a Streams belong to, i.e., that requested the creation
56             of a Stream.";
57     }
58     list stream {
59         key "stream-id";
60         description
61             "List of Streams.
62
63             Each Stream consists of a Stream ID, a request container, and
64             a configuration container.
65
66             In the fully centralized model of TSN configuration, the
67             Stream ID and request originate from the CUC and is delivered
68             to the CNC, while the configuration originates from the CNC
69             and is delivered to the CUC.";
70     }
71     reference
72         "46.2.3 of IEEE Std 802.1Qdj";
73     leaf stream-id {
74         type tsn:stream-id-type;
75         description

```

```
1         "The Stream ID is a unique identifier of a Stream request
2         and corresponding configuration. It is used to associate a
3         CUC's Stream request with a CNC's corresponding response.";
4     }
5     leaf failure-code {
6         type uint8;
7         description
8             "A code that indicates if the removal of the Stream was
9             successful (0) or unsuccessful (1).";
10    }
11 }
12 }
13 }
14 }
15 }
16 }
```

1 *Insert new Annex X (informative) “TSN Features” after Annex W, as follows:*

2 **Annex X**

3 (informative)

4 **TSN features**

5 TSN features are a set of protocols and mechanisms specified by IEEE 802 standards from which one can
6 select the mechanisms that are best suited to meet the needs of the applications supported by a given
7 network. These TSN mechanisms are add-ons to generic networking mechanisms in order to establish a
8 common network that supports TSN Streams as well as other kinds of traffic. The goals of using TSN
9 features typically include providing guaranteed data transport with low and bounded latency, low and
10 bounded delay variation, and extremely low packet loss for TSN Streams. TSN features evolve and new
11 capabilities are added as part of IEEE 802 standardization efforts. Therefore, the following list is incomplete
12 and just provides a snapshot of TSN features:

- 13 a) Timing and Synchronization for Time-Sensitive Applications (IEEE Std 802.1AS-2020)
- 14 b) Credit-Based Shaper: (IEEE Std 802.1Q-2022, 5.4.1.5)
- 15 c) Frame Preemption (IEEE Std 802.3-2018 [B16] and IEEE Std 802.1Q-2022, 5.26)
- 16 d) Scheduled Traffic (IEEE Std 802.1Q-2022, 8.6.8.4)
- 17 e) Cyclic Queuing and Forwarding (IEEE Std 802.1Q-2022, 5.4.1.9)
- 18 f) Asynchronous Traffic Shaping (IEEE Std 802.1Q-2022, 5.4.1.10)
- 19 g) Per-Stream Filtering and Policing (IEEE Std 802.1Q-2022, 5.4.1.8)
- 20 h) Frame Replication and Elimination for Reliability (IEEE Std 802.1CB-2017)
- 21 i) Stream Reservation Protocol (IEEE Std 802.1Q-2022, Clause 35)
- 22 j) Link-local Registration Protocol (IEEE Std 802.1CS-2020)
- 23 k) Path Control and Reservation (IEEE Std 802.1Q-2022, 5.4.6)
- 24 l) TSN Configuration (IEEE Std 802.1Q-2022, 5.29)
- 25 m) Configuration Enhancements for Time-Sensitive Networking (IEEE Std 802.1Qdj-2023)

26 NOTE—There is no need to apply all the TSN features in a network and none of the TSN features are a requirement. The
27 application area or actual deployment determine which TSN features are used in a given network, e.g., whether or not
28 time synchronization is used. TSN profile standards, e.g., IEEE Std 802.1BA and IEEE Std 802.1CM [B12] select TSN
29 features and give guidelines on their use in a particular application area.

30

Annex Y

(informative)

Bibliography

Change Annex Y (renumbered from Annex X by the insertion of new Annex X above) as follows, updating cross-references as necessary:

Bibliographical references are resources that provide additional or helpful material but do not need to be understood or used to implement this standard. Reference to these resources is made for informational use only.

[B1] Alizadeh, M., B. Atikoglu, A. Kabbani, A. Lakshmikantha, R. Pan, B. Prabhakar, and M. Seaman, “Data Center Transport Mechanisms: Congestion Control Theory and IEEE Standardization,” *Proceedings of the 46th Annual Allerton Conference on Communication, Control and Computing*, Urbana-Champaign, Sept. 2008.

[B2] Asynchronous Transfer Mode (ATM): A collection of equipment and standards used for telecommunications and data transfer, <https://www.itu.int/ITU-T/> and <https://www.broadband-forum.org>.

[B3] Calculating the Delay Added by Qav Stream Queue, <https://www.ieee802.org/1/files/public/docs2009/av-fuller-queue-delay-calculation-0809-v02.pdf>.

[B4] Duato, J., A Necessary and Sufficient Condition Deadlock-Free Routing in Cut-Through Store-and-Forward Networks. *IEEE Transactions on Parallel and Distributed Systems*, vol. 7, no. 8, pp. 841-854, Aug. 1996. doi: 10.1109/71.532115

[B5] Hu, H., Zhu Y., Cheng P., Guo C., Tan K., Padhye J., and Chen K. Tagger: Practical PFC Deadlock Prevention in Data Center Networks. *Proceedings of the 13th International Conference on emerging Networking EXperiments and Technologies (CoNEXT '17)*. ACM, New York, NY, USA, 451-463. DOI: <https://doi.org/10.1145/3143361.3143382>

[B6] IEC 62439-3:2016, Industrial communications networks—High availability automation networks—Part 3: Parallel Redundancy Protocol (PRP) and High-availability Seamless Redundancy (HSR).⁶

[B7] IEEE Std 802™-2014, IEEE Standard for Local and Metropolitan Area Networks—Overview and Architecture.^{7, 8}

[B8] IEEE Std 802.1AB™-2005, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

[B9] IEEE Std 802.1AB™-2009, IEEE Standard for Local and metropolitan area networks—Station and Media Access Control Connectivity Discovery.

[B10] IEEE Std 802.1AC™-2016, IEEE Standard for Local and metropolitan area networks—Media Access Control (MAC) Service Definition.

[B11] IEEE Std 802.1BA™, IEEE Standard for Local and Metropolitan Area Networks—Audio Video Bridging (AVB) Systems.

⁶ IEC publications are available from the International Electrotechnical Commission (<https://www.iec.ch>) and the American National Standards Institute (<https://www.ansi.org/>).

⁷ The IEEE standards or products referred to in Annex Y are trademarks owned by The Institute of Electrical and Electronics Engineers, Incorporated.

⁸ IEEE publications are available from The Institute of Electrical and Electronics Engineers (<https://standards.ieee.org/>).

1 [B12] [IEEE Std 802.1CM™-2018, IEEE Standard for Local and Metropolitan Area](#)
2 [Networks—Time-Sensitive Networking for Fronthaul.](#)

3 [B13] IEEE Std 802.1D™, 1993 Edition [ISO/IEC 10038:1993], IEEE Standard for Information
4 technology—Telecommunications and information exchange between systems—Local area
5 networks—Media Access Control (MAC) bridges.

6 [B14] IEEE Std 802.1D™, 1998 Edition [ISO/IEC 15802-3:1998], IEEE Standard for Information
7 technology—Telecommunications and information exchange between systems—Local and metropolitan
8 area networks—Common specifications—Part 3: Media Access Control (MAC) Bridges.

9 [B15] IEEE Std 802.1D™-2004, IEEE Standard for Local and metropolitan area networks—Media Access
10 Control (MAC) Bridges.

11 [B16] IEEE Std 802.3™-2018, IEEE Standard for Ethernet.

12 [B17] IEEE Std 802.11™-2016, IEEE Standard for Information technology—Telecommunications and
13 information exchange between systems—Local and metropolitan area networks—Specific
14 requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY)
15 Specifications.

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