Cut-Through Forwarding (CTF) in Bridges and Bridged Network – Status Update –

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DCN 1-22-0017-02-ICne

Activities, Dates & Venues

Past Timeline (1)

Time	Venue(s)	Event
November 2016	IEEE 802.1, IEEE 802 Plenary	Avnu Industrial's Use of Cut-through and Request for Guidance https://www.ieee802.org/1/files/public/docs2016/liaison-woods-Avnurequest-1116-v00.pdf
March 2017	IEEE 802.1, IEEE 802 Plenary	Use of Cut-Through for Industrial and Automotive Markets https://www.ieee802.org/1/files/public/docs2017/liaison-AVnuResponseCutthrgh-0313-v00.pdf
May 2017	IEEE 802.1 Interim	Cut-Through Considerations and Impacts to Industrial Networks https://www.ieee802.org/1/files/public/docs2017/new-woods-cutthroughconsiderations-0518-v01.pdf
January 24, 2018	IEEE 802.3 NEA Ad-hoc	New Ethernet Applications - Accumulated switch latency in industrial applications https://www.ieee802.org/3/ad_hoc/ngrates/public/18_01/woods_nea_01a_0118.pdf
March 6, 2018	IEEE 802.3 NEA Ad-hoc	New Ethernet Applications – Industrial Networking Requirements https://www.ieee802.org/3/ad_hoc/ngrates/public/18_03/woods_nea_01_0318.pdf
April 12, 2018	IEEE 802.3 NEA Ad-hoc	Accumulated switch latency in industrial applications Call for Interest DRAFT https://www.ieee802.org/3/ad_hoc/ngrates/public/calls/18_0412/woods_nea_01a_180412.pdf
July 11, 2018	IEEE 802.1, IEEE 802 Plenary	Status of Accumulated latency in industrial applications Call for Interest https://www.ieee802.org/1/files/public/docs2018/new-woods-CFI-accumulated-latency-0710-v01.pdf
November 2018	IEEE 802.3 NEA Ad-hoc	Status of Accumulated latency in industrial applications Call for Interest https://www.ieee802.org/3/ad_hoc/ngrates/public/18_11/woods_nea_01_1118.pdf
February 14, 2019	IEEE 802.1	Running with scissors -- Cut-through in bridged networks https://www.ieee802.org/1/files/public/docs2019/new-seaman-cut-through-scissors-0119-v01.pdf
September 7, 2019	IEEE 802.1 Interim	Cut-Through -- IEC/IEEE 60802 https://www.ieee802.org/1/files/public/docs2019/60802-Ademaj-et-al-CutThrough-0919-v10.pdf

Past Timeline (2)

Time	Venue(s)	Event
December 2020	IEEE 802.1	Update on Cut-Through Forwarding (CTF) https://www.ieee802.org/1/files/public/docs2020/new-specht-cut-through-update-1220-v02.pdf
January 25, 2021	IEEE 802.1 Interim, TSN	Presentation on CTF → New work for discussion, use IEEE 802 Nendica as venue for CTF
March 11, 2021	IEEE 802 Nendica	Initiation of the CTF Study Item (https://1.ieee802.org/nendica-ctf/)
March – July 2021	IEEE 802 Weekly Nendica Meetings	Weekly technical discussion on CTF, preparation of an IEEE 802 Plenary Tutorial on CTF
July 7, 2021	IEEE 802.1, IEEE 802 Plenary	Tutorial on CTF (https://mentor.ieee.org/802.1/dcn/21/1-21-0037-00-ICne-ieee-802-tutorial-cut-through-forwarding-ctf-among-ethernet-networks.pdf)
August 5, 2021	IEEE 802 Nendica	Administrative discussion (https://mentor.ieee.org/802.1/dcn/21/1-21-0041-02-ICne-ctf-tutorial-follow-up-slides.pdf), mailing list notifications in advance
Aug 2021 – Sept 2021	IEEE 802 Weekly Nendica Meetings	Nendica as a venue for weekly 802.1&802.3 discussion on CTF, exact timing determined by poll
September 23, 2021	IEEE/IEC 60802	Discussion on CTF forwarding timing in Industrial Automation (https://mentor.ieee.org/802.1/dcn/21/1-21-0058-01-ICne-ctf-forwarding-timing-in-industrial-automation.pdf)
September 24, 2021	IEEE 802.1 Interim, TSN	Discussion towards an IEEE 802.1 Standard for CTF (https://mentor.ieee.org/802.1/dcn/21/1-21-0051-02-ICne-ctf-discussing-next-steps.pdf
September 2021 – October 2021	IEEE 802 Nendica	Discussion towards an IEEE 802.1 Standard for CTF, on technical aspects (https://mentor.ieee.org/802.1/dcn/21/1-21-0051-07-ICne-ctf-discussing-next-steps.pdf)
November 10, 2021	IEEE 802.1	Presentation towards an IEEE 802.1 Standard for CTF, on technical aspects (https://www.ieee802.org/1/files/public/docs2021/new-specht-ctf-802-1-1121-v01.pdf)

Past Timeline (3)

Time	Venue(s)	Event
November 16, 2021	IEEE 802.1, IEEE 802 Plenary	Motion (passed): Authorize TSN TG to generate PAR and CSD at the January 2022 interim session for pre-circulation to the EC for an IEEE 802.1 standard on Cut-Through Forwarding https://www.ieee802.org/1/files/public/minutes/2021-11-closing-plenary-slides.pdf
January 2022	IEEE 802.1 Interim, TSN	PAR and CSD Draft completion for Cut-Through Forwarding (P802.1DU) https://www.ieee802.org/1/files/public/docs2022/du-draft-PAR-0122-v01.pdf, https://www.ieee802.org/1/files/public/docs2022/du-draft-CSD-0122-v01.pdf
February 24, 2022	IEEE 802.3 Ad-hoc	PAR & CSD draft review (including P802.1DU) https://www.ieee802.org/3/email_dialog/msg01286.html, https://www.ieee802.org/3/email_dialog/msg01302.html
March 11, 2022	IEEE 802.1, IEEE 802 Plenary	Discussion on P802.1DU comments from other WGs https://www.ieee802.org/1/files/public/docs2022/du-PAR-CSD-comments-0322-v02.pdf
March 16, 2022	IEEE 802.1, IEEE 802 Plenary	Motions (all passed) to authorize - TSN TG to generate PAR and CSD for pre-circulation to the EC for the July 2022 plenary session for an IEEE 802.1 standard on Cut-Through Forwarding. - 802.1WG to hold joint meetings with the 802.3 WG to discuss Cut-Through Forwarding. - the 802.1 WG chair to present status of P802.1DU to the 802.3 WG and request joint meetings to continue discussion. https://www.ieee802.org/1/files/public/minutes/2022-03-closing-plenary-slides.pdf
March 17, 2022	IEEE 802.3, IEEE 802 Plenary	802.1 response to 802.3 & 802.11 on P802.1DU Cut -Through Forwarding Bridges and Bridged Networks https://www.ieee802.org/1/files/public/docs2022/du-PAR-CSD-comments-response-0322-v2.pdf
April 14, 2022	IEEE 802 Weekly Nendica Meeting	Idealistic Model for P802.1DU https://mentor.ieee.org/802.1/dcn/22/1-22-0015-00-ICne-idealistic-model-for-p802-1du.pdf

Technical

Proposed Directions (1)

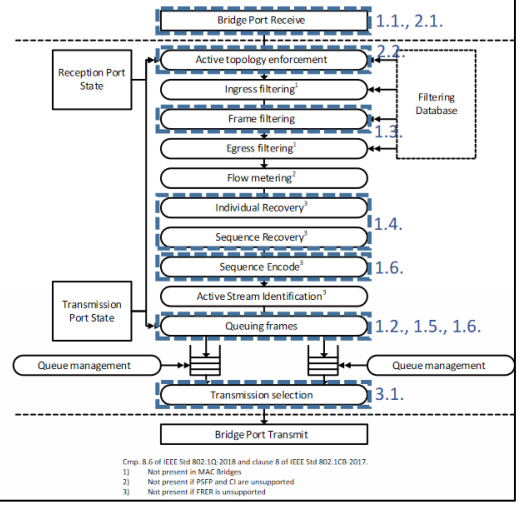
- Purpose and Need
  - Communication delays lower than achievable by Bridges and bridged networks solely supporting store-and-forward operations
  - Already found in various proprietary implementations - standardizing enables interoperability
- Market Potential
  - Widely used in industrial automation and data center networks
  - Can be an enabling technology for professional audio-video
- Feasibility and Interoperability
  - It is already in use, although based on proprietary implementations
  - Interoperability is an issue (e.g., management and error handling)

Proposed Directions (2)

- Standards Document Allocation
  - New stand-alone 802.1 base standard
    - No changes in existing IEEE 802.1 Stds (e.g., 802.1Q, 802.1AC, 802.1CB) possible
    - Avoid redundant description by references
  - Cover network-level aspects, as well as Bridge operation
- Network-Level Aspects
  - Circulating frame handling
  - Congestion handling
  - Security/Privacy
- Bridge Operation
  - Relay and Ports
  - Device local error handling
  - (Conservative) Fallbacks to S&F

CTF in Bridges: Fallbacks to S&F

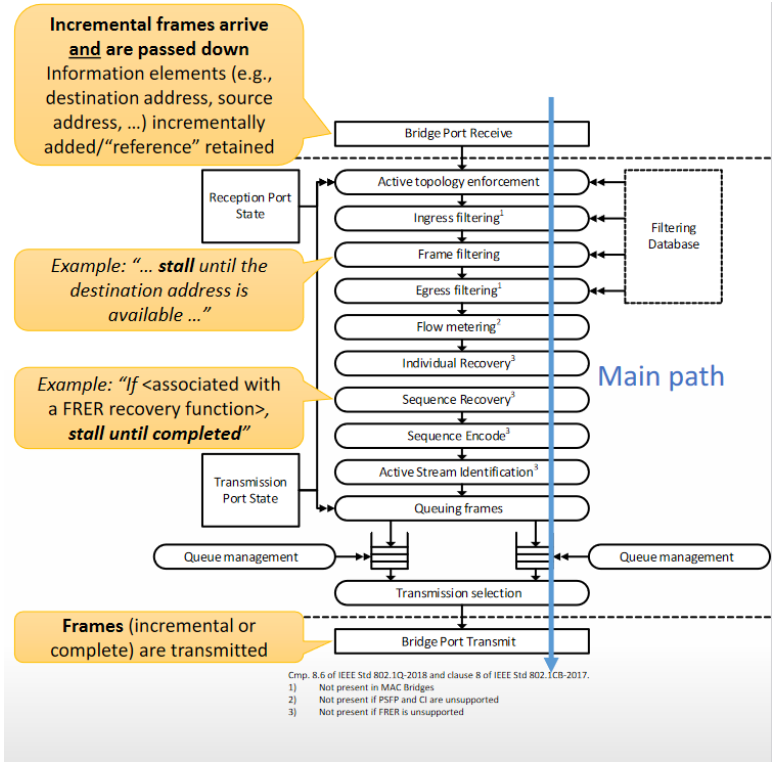
1. On the main relay path
   1. CTF reception is disabled on a reception port.
   2. CTF is disabled/unsupported for/by a traffic class on a transmission port.
   3. No matching filtering entry in the FDB (i.e., flooding).
   4. Association of a frame under reception with a FRER recovery function.
   5. Slow-to-fast link speed transitions.
   6. Frame length changes (e.g., TAG removal).
2. Leaving the main relay path
   1. To Higher Layer Entities
   2. To FDB for learning
3. Implicit
   1. Interfering frames



Source: https://mentor.ieee.org/802.1/dcn/21/1-21-0037-00-ICne-ieee-802-tutorial-cut-through-forwarding-ctf-among-ethernet-networks.pdf

Proposed Directions (3)

- Bridge Relay Operation
  - Similar to published (S&F) Relay
  - Extra operations (e.g., stalls)
- Modelling options and alternatives so far
  1. Focus on externally visible behavior
  2. Look-ahead based idealized internal behavior
  3. Combinations
- Related documents
  - https://www.ieee802.org/1/files/public/docs2022/du-draft-PAR-0122-v01.pdf
  - https://www.ieee802.org/1/files/public/docs2022/du-draft-CSD-0122-v01.pdf
  - https://mentor.ieee.org/802.1/dcn/21/1-21-0037-00-ICne-ieee-802-tutorial-cut-through-forwarding-ctf-among-ethernet-networks.pdf
  - https://www.ieee802.org/1/files/public/docs2021/new-specht-ctf-802-1-1121-v01.pdf
  - https://mentor.ieee.org/802.1/dcn/22/1-22-0015-01-ICne-idealistic-model-for-p802-1du.pdf



Source: https://www.ieee802.org/1/files/public/docs2021/new-specht-ctf-802-1-1121-v01.pdf

Major* Technical Concerns from IEEE WG 802.3

- Written WG 802.3 response on item h) in 1.2.2 of the CSD draft
  - *At a time when IEEE 802 is attempting to develop greater consistency on architectural alignment, a "No" response will detract from this effort. A "No" response is inconsistent with the use of an 802.3 MAC (or other 802 MAC) because those MACs include **service interfaces** that match the **802.1AC service interface**.*
- Written WG 802.3 response on item p) in 1.2.5 of the CSD draft
  - *CTF bridges violate the **802.3 MAC Service interface** where a transmission request is an **atomic action**. CTF starts a **transmission before** an **entire frame is received** and **error checked**. The CSD ignores the impact CTF bridges have on individual 802 MAC specifications and therefore **are not compatible with the MAC models** and therefore may not be compatible with other IEEE 802 MAC standards also.*
  - *The CSD also ignores the **impact on management**. Please indicate in this item that specifications will require features that minimize distortion of various management attributes or behaviours.*

Source: https://www.ieee802.org/1/files/public/docs2022/du-PAR-CSD-comments-0322-v02.pdf
*: To the author's current understanding

Technical Concerns Noted from Prior Meetings

- Verbally, by individual participants during
  February 24, 2022 (IEEE WG 802.3 PAR&CSD review ad-hoc),
  March 11, 2022 (IEEE WG 802.1 PAR&CSD comment resolution) and
  March 17, 2022 (IEEE WG 802.3 closing plenary)

1. CTF may **belong into WG 802.3** (rather than WG 802.1), or at least **needs a companion project** in WG 802.3 (similar to preemption)
2. CTF may require transfers of **frames with invalid FCS** to MAC clients
3. CTF may violate **minimum frame size constraints** (64 octets)
4. CTF may cause **buffer underruns** during frame transmission (slow-to-fast link speed transitions)
5. CTF may require **octet-by-octet** frame transfers between MAC clients and MACs
6. CTF may be a **layer violation**
7. CTF may be in conflict with **existing implementations**

Discussion:
NEA & Nendica Joint Ad-Hocs – Potential Goals

- Analyze Standards
  Source: https://mentor.ieee.org/802.1/dcn/22/1-22-0010-04-ICne-proposals-for-ctf-ad-hoc-progress.pdf
  - list relevant standards
  - summarize requirements, from standards, for frame error checking by the entities
  - summarize understanding of service interfaces and the meaning and implications of atomicity in primitives
  - summarize any inconsistency of MAC and higher-layer standards with a CTF standard
- Identify reasonable constraints
  - Examples: Forwarding no earlier than after reception of 64 octets, no CTF on slow-to-fast link speed transitions, no CTF from/to end stations …
  - Document for consideration (and potential acceptance) by WGs during Stds development
- Compare options for standardization/allocate remaining issues
  Source: https://mentor.ieee.org/802.1/dcn/22/1-22-0010-04-ICne-proposals-for-ctf-ad-hoc-progress.pdf
  - P802.1DU alone
  - P802.1DU + IEEE WG 802.3 companion project

Thank You for Your Attention!

Questions,
Comments,
Opinions,
Ideas?