Cut-Through Forwarding (CTF): Towards an IEEE 802.1 Standard

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Introduction

About this slide set

- This slide set contains several result of discussions on CTF in IEEE 802 Nendica. Nonetheless, this slide set is in doubt an individual contribution by the author.
- Several slides, including earlier versions, are found on Mentor (https://mentor.ieee.org/802.1/documents?is_group=ICne, "CTF Discussing next steps").
- The focus on this slide set is tailored towards IEEE 802.1, compared to the material presented earlier in IEEE 802 Nendica.
- The author is happy for discussion and comments!
  In addition to today's IEEE 802.1 TSN meeting, there is additional time available during the first hour of tomorrow's IEEE 802 Nendica meeting
  - Tentatively, 35 Minutes within 9-10 ET
  - https://1.ieee802.org/802-nendica-agenda-2021-11-11

A Summary of the Past (with some links)

Time	Venue(s)	Event
...*	...*	*Subsequent rows summarizer some, but not all past activities on CTF in multiple IEEE 802 venues. There was work before 2021 - by the author, and others.*
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 – Now	IEEE 802 Nendica	Discussion towards an IEEE 802.1 Standard for CTF, on technical aspects – improvements leading to this slide set for IEEE 802.1
Now	IEEE 802.1	Proposed IEEE 802.1 motion (Closing Plenary)

General

Proposal to IEEE WG 802.1

- Motion to develop PAR&CSD for an IEEE 802.1 project to standardize CTF as standalone IEEE 802.1 standard (not amendments to 802.1 Standards).

- Some aspects that appear important to mention:
  1. Support for IEEE Std 802.3-2018 compatible **real implementations**.
  2. Allow to incorporate/standardize IEEE 802.1 aspects of a joint model across IEEE WG 802.1 and 802.3 with support for CTF, if possible and available.

A clear specification of CTF in the scope of IEEE WG 802.1 appears technically feasible.

- **Options**, but **not** pre-conditions/requirements for the suggested 802.1 Stds development project.

Difference may be small, but worth to talk about (figuratively):
"A MAC …"
v.s.
"A MAC with the externally visible behavior perceived on network physical media and in managed objects as specified in IEEE Std 802.3-2018 …"

- If both WGs see the technical need to drive this, the model should become part of a running IEEE WG 802.1 project!
- The other way around, decisions documented in associated IEEE 802.1 Stds drafts could be helpful input for development of such a model.

CTF as a standalone 802.1 Standard, not amendments to existing 802.1 standards

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

Recap: Proposed Location in IEEE 802.1 Standards

| 802.1Q | 802.1AC | 802.1CB | [802.1AE] |

standardized[1]

- -

not yet standardized
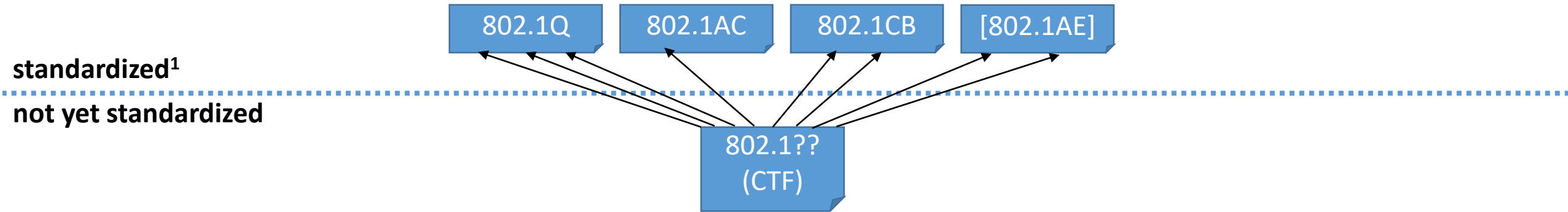
| 802.1??
(CTF) |

Separate stand alone IEEE 802.1 base standard for CTF

- **Single document**
  Avoids distribution of CTF across existing standards (compared to multiple amendment projects).

- **Exclusion, inclusion/re-use and adjustment of existing protocols**

  - Existing protocols not referred to are basically beyond specification.

  - If no adjustments for CTF are needed:
    Inclusion by reference (e.g., *"as specified in x.y.z of IEEE Std 802.1Xxx-20XX"*) can be sufficient.

  - If adjustments for CTF are needed:

    - Additional description of the differences can be sufficient.

    - Adjustments apply for CTF only; no side effects on existing protocols in absence of CTF support.

1)   The latest published base standards, corrigenda, and a subset of the published amendments.

Recap: Proposed Content Categories and (some) Contents

CTF in Networks

- Application and Limitations:
  - Quality of Service
  - Security Considerations
  - Resulting Network Requirements/Recommendations
- Usage/Performance aspects
- …

CTF in Bridges

- Bridge relay behavior
  - MAC Relay Entity/Forwarding Process
  - Bridge Port Transmit and Receive
- Managed Objects/YANG
- …

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

On the next slides

Aspects of externally visible Behavior
(on the relevant path from frame reception to frame transmission)
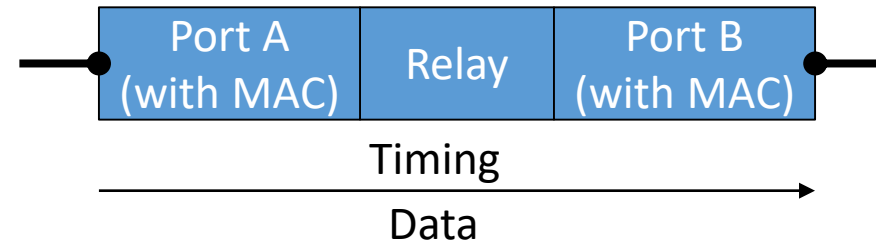
Two types of aspects define the externally visible behavior of a bridge

1. Data
- What data goes into a bridge, and comes out of the bridge?
  - <u>Ports:</u>   What data in frames is transmitted by a Port B, as a result of data in frames received on a Port A?
  - <u>Management:</u>   What are the management interfaces, and how can management parameters change/be set?

2. Timing
- When are frames transmitted at a Port B as a result of frame reception at a Port A?

Recap: CTF in Bridges - Relay with CTF Support

Coexistence of CTF & S&F

- **Traffic separation**
  - Decoded priority (VLAN-Tags, IPV assignment)
  - Ports/traffic classes (FDB & decoded priority)
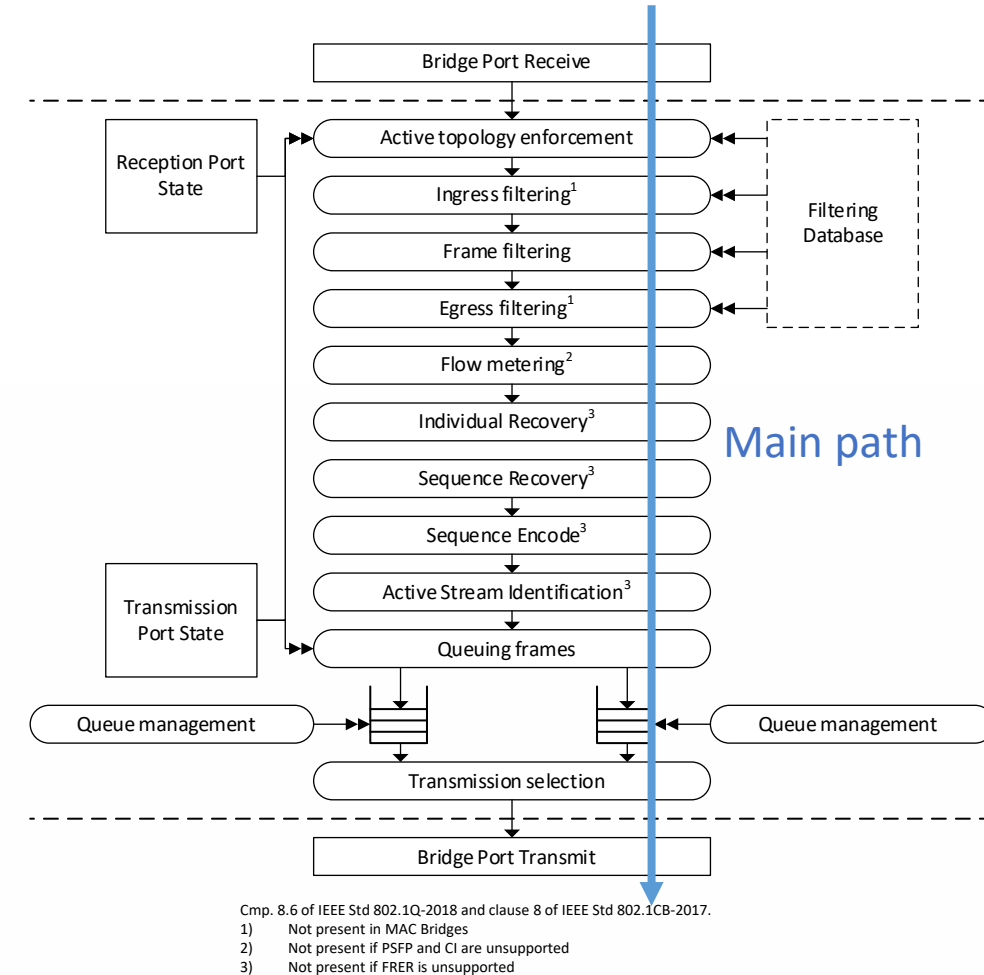- **Enabling/disabling CTF**
  - Per reception port (the entire port)
  - Per transmission port per traffic class

The standardized model extended

- **Perception of *incremental frames*:** Frames inside of a Bridge for which contained information elements are added during processing.
- **Flow**
  (Incremental) frames pass through processing stages, remain visible to earlier stages (i.e., frames can be visible to multiple stages in parallel).
- **Stalls (incremental frames)**
  Waiting for more information elements of an incremental frame before passing it to the next stage.
- **Stall until completed (incremental frames)**
  Stalling incremental frames until completed (i.e., all information elements are present) before passing it to the next stage → Fallback to S&F
- **Late errors (incremental frames)**
  - Causes (earlier stage)
  - Handling (same or later stage)

Bridge Port Receive

Reception Port State

Active topology enforcement

Ingress filtering[1]

Frame filtering

Egress filtering[1]

Flow metering[2]

Individual Recovery[3]

Sequence Recovery[3]

Sequence Encode[3]

Active Stream Identification[3]

Transmission Port State

Queuing frames

Queue management

Queue management

Transmission selection

Bridge Port Transmit

Filtering Database

Main path

Cmp. 8.6 of IEEE Std 802.1Q-2018 and clause 8 of IEEE Std 802.1CB-2017.
1) Not present in MAC Bridges
2) Not present if PSFP and CI are unsupported
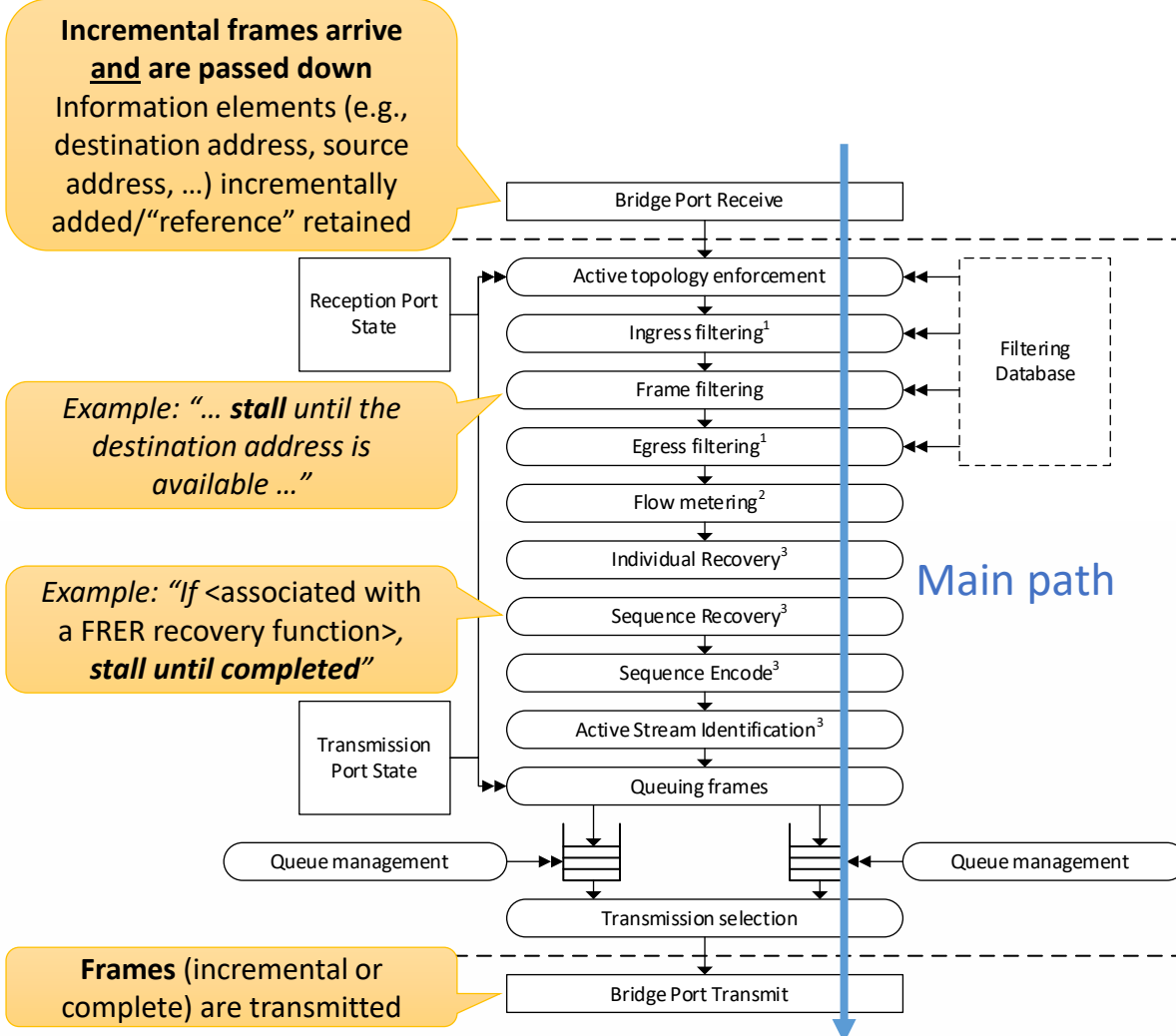3) Not present if FRER is unsupported

CTF in Bridges: Data and Flow of the Model Illustrated

Upfront: Relevant implications of an IEEE 802.1 standalone Standard for CTF

- **No (*full*)** conformance with IEEE Stds 802.1Q, 802.1AC, etc. required.
- *Partial* <u>re-use</u> of elements from existing IEEE 802.1 Stds is <u>reasonable</u> (e.g., individual data transformations), <u>omitting</u> others is <u>possible</u> (e.g., omitting MAC service definition with ISO/IEC 10731 service primitives, handle information elements in frames individually, both)

Resolution of Information Elements

- Information elements of (incremental) frames at the resolution necessary for the behavior in stages.
  → Keep definitions at a minimum.
- It may be discussed in detail if higher resolutions (e.g., octets) are helpful/needed …
- … it likewise appears that such detailed discussions can/should happen during a potential IEEE 802.1 Stds development project according to the defined process.

Incremental frames arrive <u>and</u> are passed down Information elements (e.g., destination address, source address, …) incrementally added/"reference" retained

*Example: "… **stall** until the destination address is available …"*

*Example: "If <associated with a FRER recovery function>, **stall until completed**"*

Main path

Frames (incremental or complete) are transmitted

Bridge Port Receive

Active topology enforcement

Reception Port State

Ingress filtering[1]

Frame filtering

Egress filtering[1]

Filtering Database

Flow metering[2]

Individual Recovery[3]

Sequence Recovery[3]

Sequence Encode[3]

Active Stream Identification[3]

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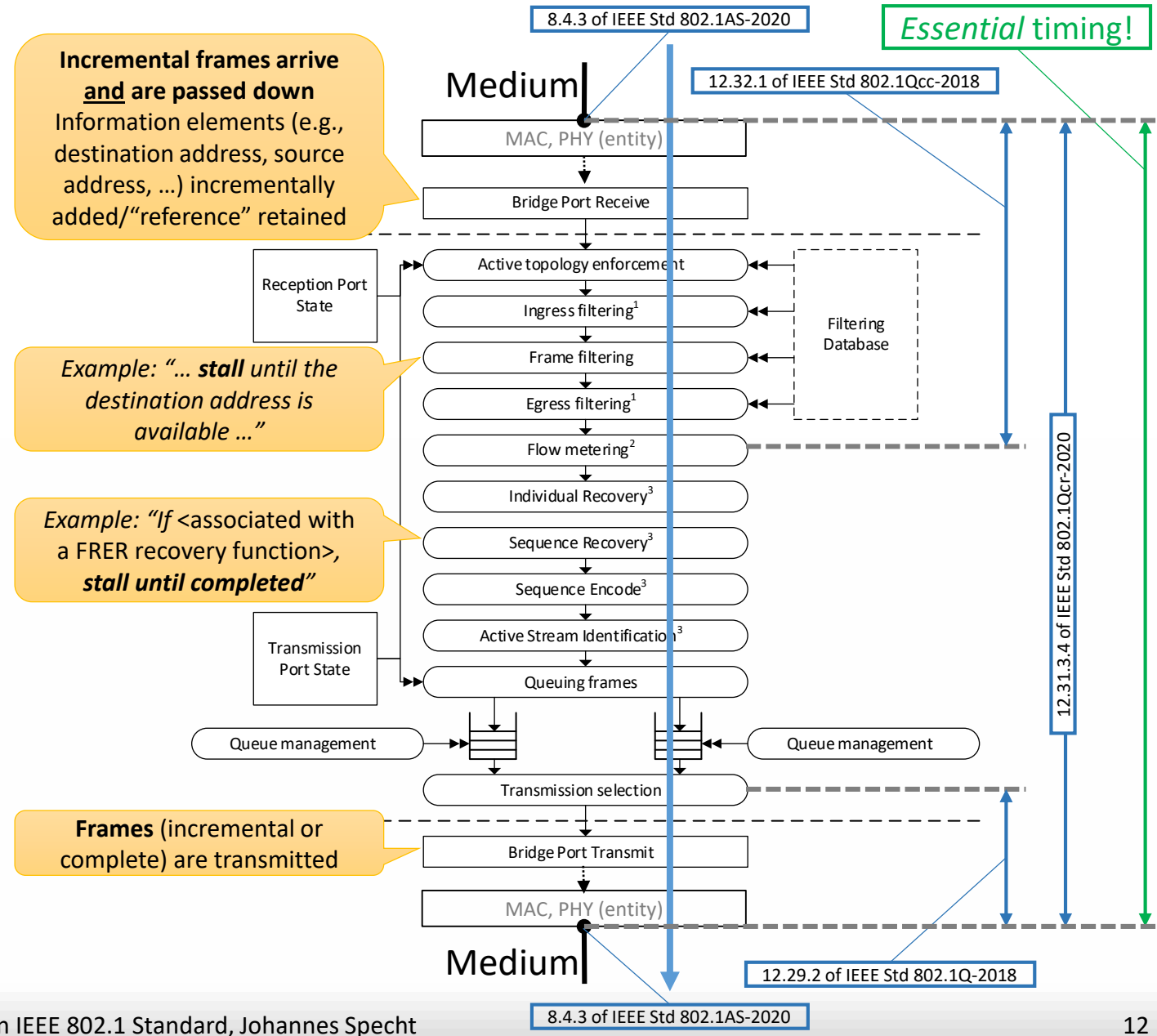3) Not present if FRER is unsupported

Timing

Essential Timing

- Required for clear specification of the externally visible behavior on the path *medium → bridge → medium* with CTF.

Can it be specified in an IEEE 802.1 Std?

- An IEEE 802.1 Std is the right place to do this:
  - A perception of this timing only exists if there is "*something*" (i.e., bridge) between the network media from one port to the other.
  - ➤ For S&F Bridges, the essential timing (and more) is found in existing 802.1 standards.

Medium

8.4.3 of IEEE Std 802.1AS-2020

Essential timing!

12.32.1 of IEEE Std 802.1Qcc-2018

Incremental frames arrive and are passed down Information elements (e.g., destination address, source address, …) incrementally added/"reference" retained

MAC, PHY (entity)

Bridge Port Receive

Active topology enforcement

Reception Port State

Ingress filtering[1]

Frame filtering

Filtering Database

Example: "… **stall** until the destination address is available …"

Egress filtering[1]

Flow metering[2]

Individual Recovery[3]

Example: "If <associated with a FRER recovery function>, **stall until completed**"

Sequence Recovery[3]

Sequence Encode[3]

Active Stream Identification[3]

Transmission Port State

Queuing frames

Queue management

Queue management

Transmission selection

Frames (incremental or complete) are transmitted

Bridge Port Transmit

MAC, PHY (entity)

Medium

12.31.3.4 of IEEE Std 802.1Qcr-2020

12.29.2 of IEEE Std 802.1Q-2018
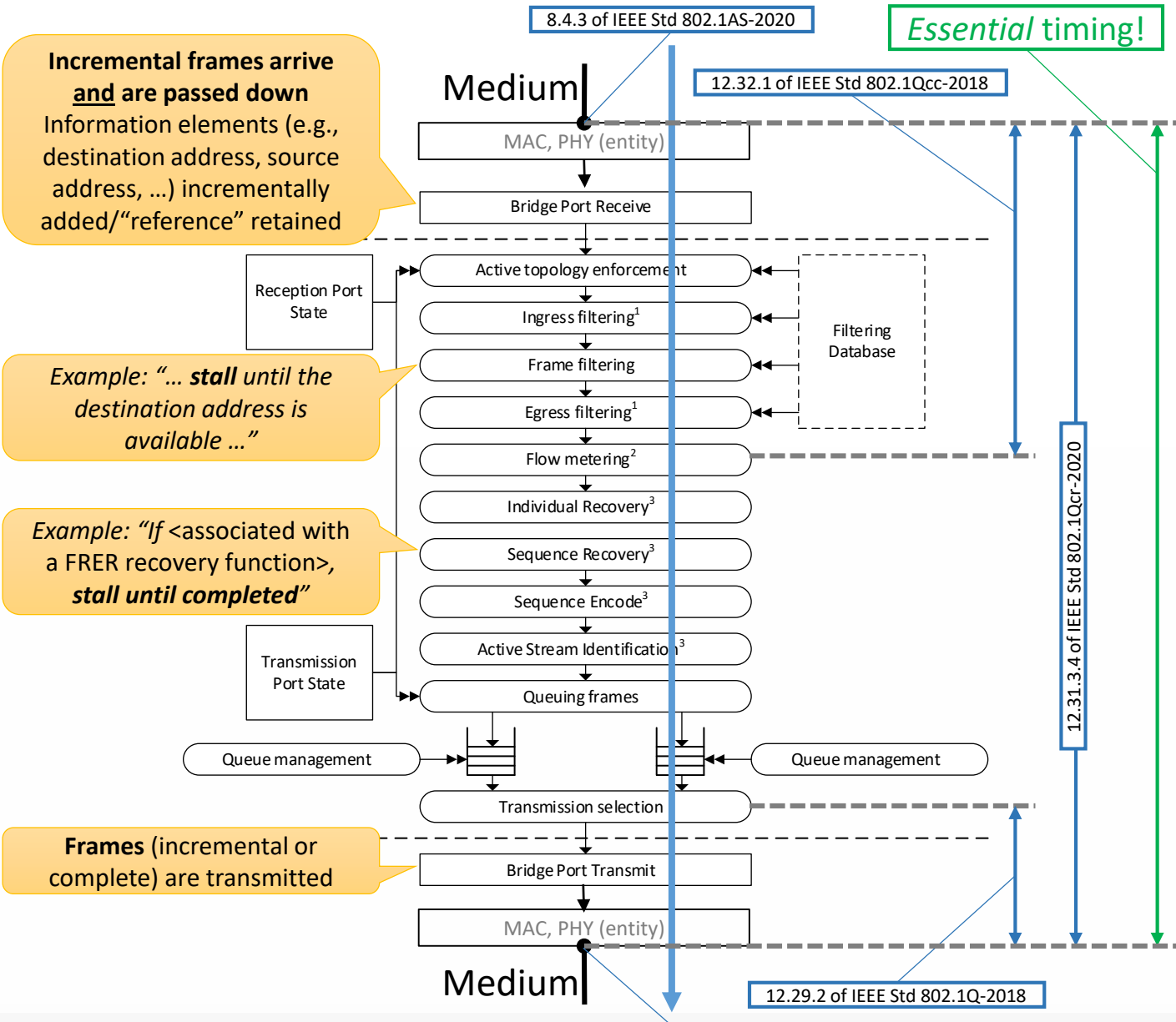
8.4.3 of IEEE Std 802.1AS-2020

Stimulating Discussion

Technical questions

- Fundamentally missing elements that prevent clear specification of the behavior of a bridge with support for CTF?
- Items beyond the scope of IEEE WG 802.1?

Non-technical questions

- Comments for getting a better impression about the "for and against" of standardizing CTF?
- Other non-technical aspects?

Incremental frames arrive and are passed down Information elements (e.g., destination address, source address, …) incrementally added/"reference" retained

Example: "… stall until the destination address is available …"

Example: "If <associated with a FRER recovery function>, stall until completed"

Frames (incremental or complete) are transmitted

8.4.3 of IEEE Std 802.1AS-2020

Essential timing!

12.32.1 of IEEE Std 802.1Qcc-2018

12.31.3.4 of IEEE Std 802.1Qcr-2020

12.29.2 of IEEE Std 802.1Q-2018

8.4.3 of IEEE Std 802.1AS-2020

Medium

MAC, PHY (entity)

Bridge Port Receive

Active topology enforcement

Reception Port State

Ingress filtering[1]

Frame filtering

Egress filtering[1]

Filtering Database

Flow metering[2]

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Bridge Port Transmit

MAC, PHY (entity)

Medium

Additional Material

Additional Material/IEEE 802 Nendica

Potential PAR&CSD Input

- Individual contributions how some PAR&CSD contents could look like.
- PAR&CSD development by IEEE WG 802.1 is not authorized (passed motion required), but this material may or may not be considered by IEEE WG 802.1 if such a development is authorized.

Technical considerations on IEEE Std 802.3 on "special FCS'"

- Addresses the question on whether frames with invalid FCS are passed from MACs to MAC clients (i.e., bridge relay), and …
- … whether MAC clients can pass frames with invalid FCS to MACs.
- Relevance:
  - Forwarding of frames with errors/avoiding "repair" of frames with errors
  - Marking erroneous frames

Reference

- https://mentor.ieee.org/802.1/dcn/21/1-21-0051-07-ICne-ctf-discussing-next-steps.pdf

Summary & Conclusions

Summary & Conclusion

Proposed to IEEE WG 802.1

- Motion to develop PAR&CSD for an IEEE 802.1 project to standardize CTF as standalone IEEE 802.1 standard (not amendments to existing 802.1 Standards).

Technical Contents in this Slide Set

- Considerations on how to refer to IEEE Std 802.3-2018 in a potential IEEE 802.1 standard for CTF.
- An approach for clear specification of bridge behavior with support for CTF appears feasible and in scope of IEEE WG 802.1.

Individual Contributions to IEEE 802 Nendica related to PAR&CSD

- IEEE WG 802.1 may or may not consider the contributed material for PAR&CSD development, if this development becomes approved.

Thank you for your Attention!

Questions, Opinions, Ideas?

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