Proposed RAP Extensions for RA Class Templates to support LNI Usecases

Andreas Meisinger (LNI4.0)

July 2023

Content

Content

Introduction

Introduction

- **LNI 4.0** applications use **Enhancements for Scheduled Traffic (EST)** that is specified in IEEE 802.1Q-2018 8.6.8.4 to meet tight real-time requirements (network latency, short reaction times) for streams.
- Using LRP RAP based stream reservations for future **Industrial Applications**.

Please note that **grey boxes** are informative; **green boxes** are for request throughout this document.

Legend

Information

Request

LNI 4.0 utilizes EST

Introduction

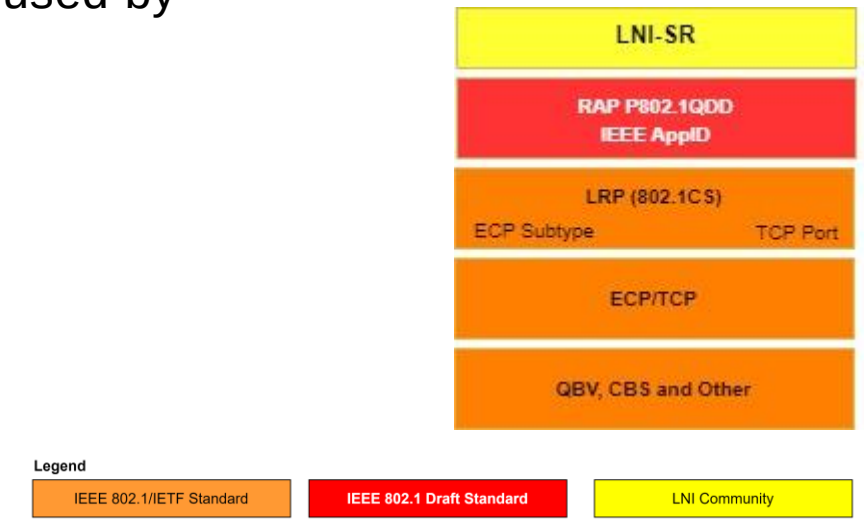
Status

- RAP Draft 0.7 already includes two RA class templates: Strict Priority and ATS (Asynchronous Traffic Shaping).
- Strict Priority
  - For a given queue that supports strict priority transmission selection, the algorithm determines that there is a frame available for transmission if the queue contains one or more frames.
- ATS
  - For a given queue that supports ATS transmission selection, a frame is eligible for transmission if the assigned eligibility time is earlier than or at the current time.

Introduction

Status

- LNI-SR is the temporary name for two RA class templates used by LNI 4.0 based on RAP RA class template mechanism.



Note: LNI evaluates two RA class templates:

- LNI Class High (Synchronized)
- LNI Class Low (Non-Synchronized)

Request: To extend the RA class template support to cover LNI-SR use-case

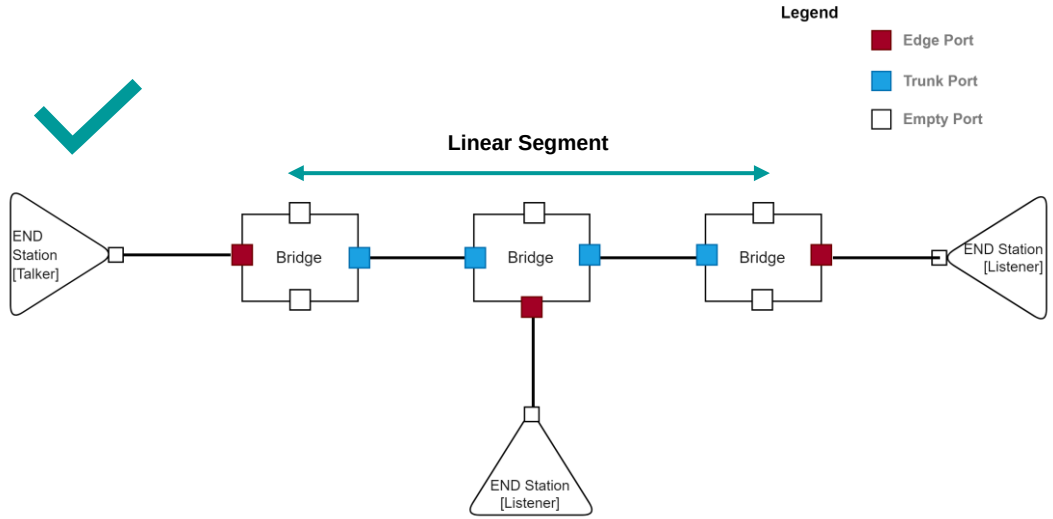
Content

LNI Use-Cases

LNI Use-Case
In Industrial Environment

Topological Constraints

- Homogenous **Line topology** is very common in Industrial Applications.
- **Latency** in long linear topologies/segments with high hop counts is very important.
- **Gigabit link speed in all trunk ports**
- **Gigabit and 100 Mb** speed is allowed in **edge ports**.
- Reservations are verified on a per bridge base



LNI Use-Case Accepted Constraints In Industrial Environment

Synchronization and EST Constraints

- All Bridges in the topology must support **Synchronization** and **EST**.
- The deviation of a TSN Bridge local working clock to the grandmaster clock shall not exceed a per RA class configurable value (default: **|1µs|)**
- This maximum synchronization inaccuracy is incorporated into the worst-case stream latency calculations.
- EST based RA classes are bound to certain time domain.

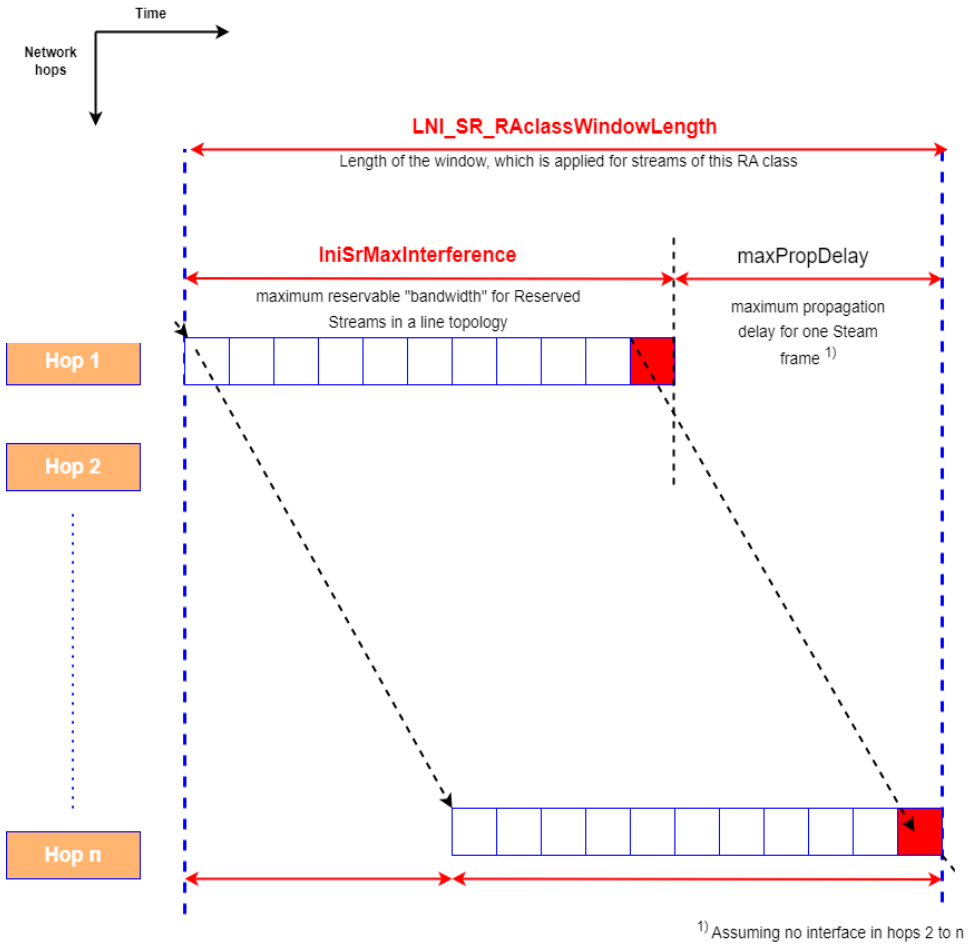
Content

Data Plane

Data Plane

Principles of Data Flow

- All frames of an RA class traverse a TSN network as a burst, starting at Bridge 1 (Hop 1) and ending at Bridge n (Hop n)
- The worst-case assumption is all frames of the stream class are transmitted to the last Bridge within the associated stream class window.
- Previous representation for IEEE can be accessed here.

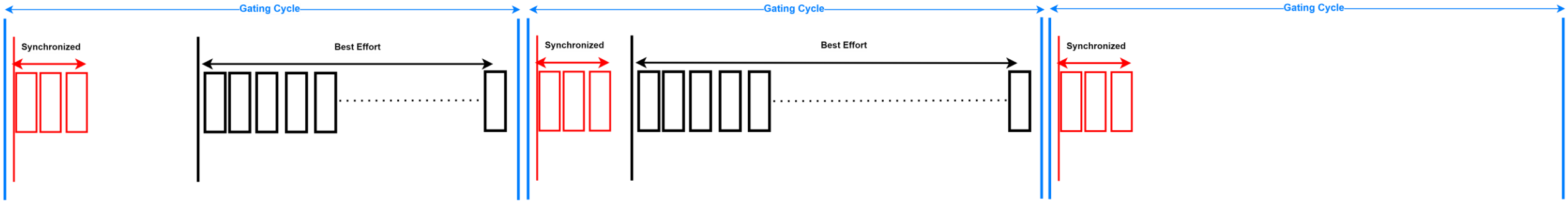


Data Plane

Frame to Window relationship

- Synchronized to the gating cycle
  - **End Station:** all frames of **synchronized transmission** must be available **‘in time’** in the first Bridge transmission port

Frame to window alignment in first Bridge transmission Port:



Content

LNI-SR Enhancements of RAP

LNI-SR

Properties

- Constraint linear segment with two distinct port roles: **Edge port** or **Trunk port**.
- **Edge/Trunk ports** are detected to perform accumulated latency calculations correctly.
- Simple control of supported stream count is accomplished by a few template specific parameters:
  - Maximum hop count
  - Maximum LAN propagation delay
  - Maximum Bridge forwarding delay
  - Maximum stream frame size
  - Protected window size

RAP

RA Class Attribute

- The LNI based RTIDs indicate the LNI specific reservation mode for support of the LNI4.0 data plane requirements.
- LNI-SR makes use of RA Class TLV extension within **RaClassTemplateDefinedData.**

Request: Add Time and Window TLVs into RA Class Descriptor TLV as Optional

RA Class Enhancement of RAP

to support EST

RAClass_Window Sub-TLV

Name	Octet	Length
Type = 0x0?	1	1
Length = 12	2	2
CycleTime	4	4
WindowOffset	8	4
WindowLength	12	4

- This is required by any EST based RA class.
- The EST gate control list can be derived from the window configuration but is not necessary identical.

RA Class Enhancement of RAP

RAClass_TimeDomain Sub-TLV

Name	Octet	Length
Type = 0x0?	1	1
Length = 9	2	2
MaximumPerClassDeviation	4	4
DomainID	8	1
<further WorkingClockDomainIDs if supported>	9	variable

- **Support of multiple Working Clock Domains for hot standby can be added when the forthcoming IEEE 802.1AS amendment is available.**

RA Class Specific Protection Port Handling

- **LNI-SR evaluated behavior**
  - LNI-SR **exchanges** RA Class enhancements (window, time domain configurations) within **RaClassTemplateDefinedData**
  - LNI-SR additionally compares **Window and Time Domain SubtIvs** for the protection port evaluation.
  - Main reason for this comparison is to avoid effort for propagation when EST windows do not fit at all.
- **RAP**
  - RAP only compares RA Class **priority** values. Please refer to *IEEE P802.1Qdd/D0.7 51.8.5.14:setDomainBoundaryStatus*

Suggestion: Extended comparison of RA Classes to include template defined checks

RA Class Specific Talker Propagation

- **LNI-SR evaluated behavior**
  - Different neighbor RA Class parameters on different ports are possible. If the RA Class parameters do not match, Talker can be forwarded as Talker failed due to RA Class parameters mismatch.
  - If a talker is failed or accepted with a given RA Class configuration may depend on there current state of the device
- **RAP**
  - RAP only evaluates talker forwarding process based on **preservability** condition. Please refer to *IEEE P802.1Qdd/D0.7 51.8.5.3:processTaEgress.* It checks the preservability and fails the talker if the stream is not reservable.

Suggestion: Extended evaluation of Talker Announce declaration to consider RA Class template rules.

For example, "reception port" as EST and "transmission port" as Strict Priority are an acceptable propagation schema

LNI-SR Bridge Configuration Enhancement of RAP

LNI-SR RA Class specific

- Some additional LNI-SR specific configurations are used for the **latency calculations** in TSN Bridge within an LNI4.0 data plane.
  - per-Bridge parameters:
    - lniSrLocMaxBridgeDelay
  - per-Bridge and LNI-SR class parameters
    - **lniSrLocMaxHops**
    - lniSrLocMaxE2ELanDelay
    - lniSrLocClassMaxFrameSize

How to handle RA Class specific local configuration parameters?

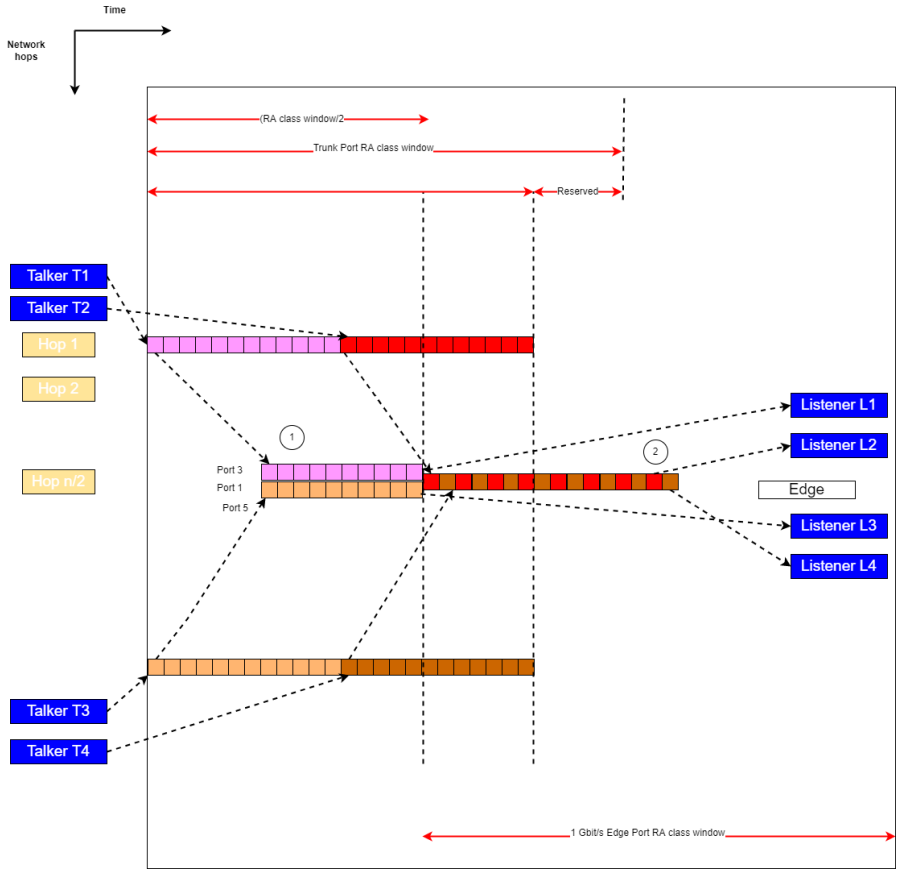
Content

Reasons for Detection of Edge Ports in LNI Environment

RA Class Window Configuration of Edge Ports Gigabit Edge Ports

- The Edge Port RA class window is shifted forwards so that even in the worst-case scenario all frames of streams can be transferred via the last hop to the Listener end stations with deterministic maximum delay while the RA class window is open.
- 1 Gb/s Edge Port RA class window is configured with:
  - window length = RA class window length
  - window offset =

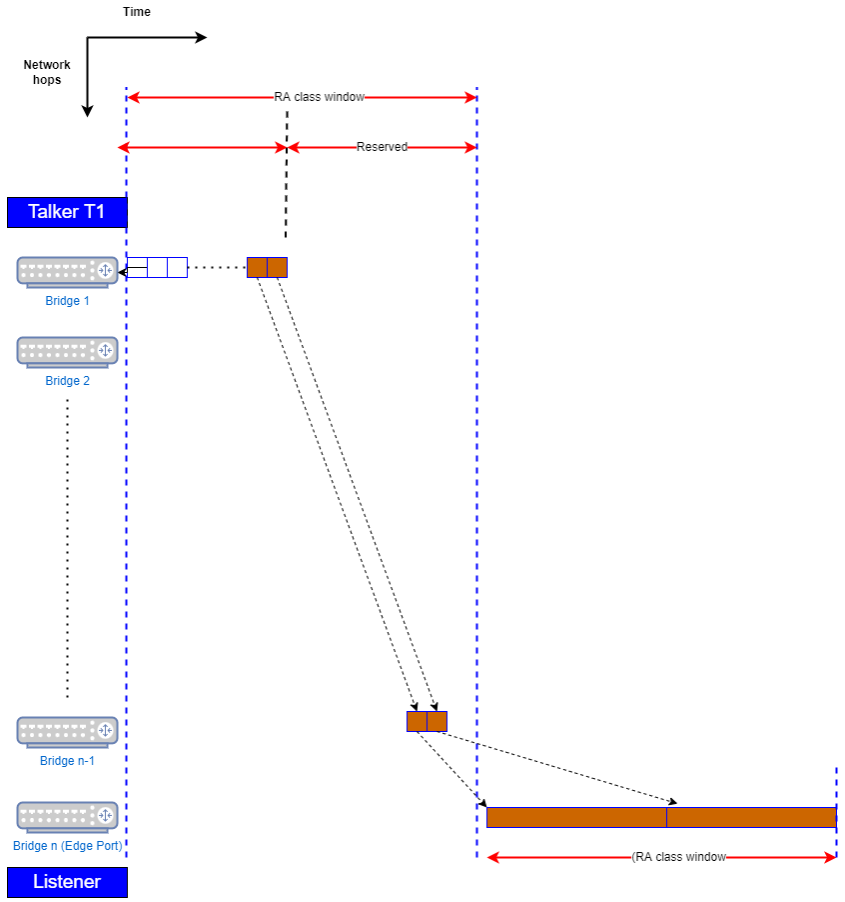
    RA class window offset + (RA class window length/2)



worst-case delay scenario connected to an end station acting as Listener for multiple streams

RA Class Window Configuration of Edge Ports
100 Mb Edge Ports

- Edge Port RA class window is shifted even further,
  so that even in the worst-case scenario all frames of streams
  can be transferred via the last hop to the Listener end stations
  with deterministic maximum delay while the RA class window is open.
- 100 Mb/s Edge Port RA class windows is configured with
  - window length = RA class window length
  - window offset = RA class window offset + RA class window length



worst-case delay scenario connected to an end station acting as Listener for multiple streams.

Content

LNI-SR Accumulated Latency Calculation

LNI-SR Accumulated Latency Calculation

Definition

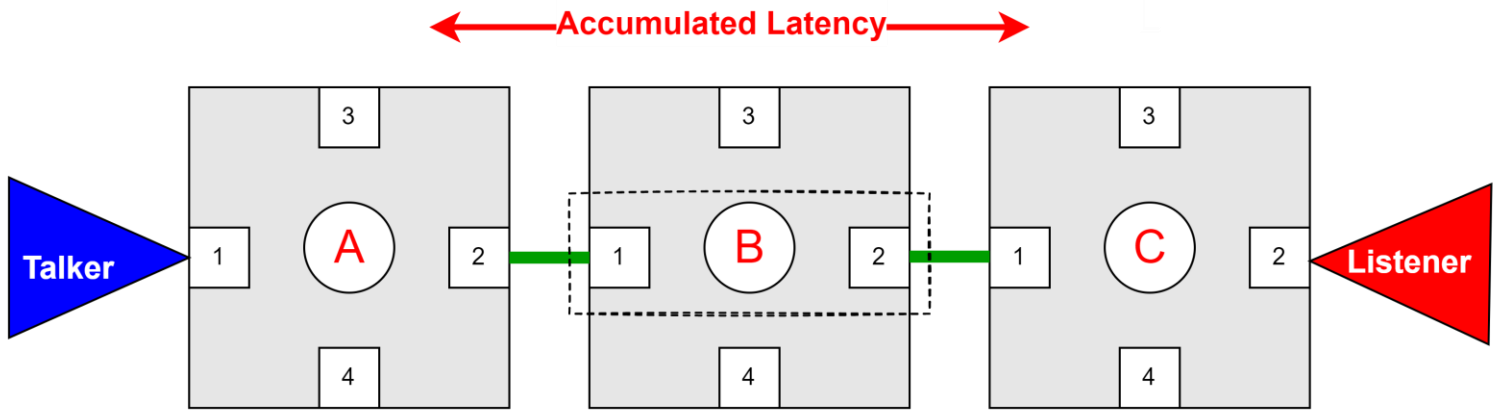
- **Accumulated Maximum Latency** (AML) is a member of the Talker Announce attribute.
- It is **updated** in every **Bridge** and provides the worst-case latency that a frame of a stream can encounter along the path from Talker to Listener.
- The main task of AML computation in LNI-SR is to assure that the LNI-SR data plane usage model is kept, i.e., that all stream frames will arrive at the Listeners within the associated RA class window. Therefore, the defined **maximum latency (first Bridge to last Bridge)** for streams of an LNI-SR RA class is the configured **RA class window length**.
- Due to the burst traffic pattern LNI is enforcing, the In-Class Interference only needs to be added at the beginning of linear segment.
- Additional interference needs to be considered when exiting the linear segment.

LNI-SR Accumulated Latency Calculation

LNI-SR AML Scheme Detection

- LNI-SR defines three different update calculation schemes for the following figure
  - transmission port (2) is part of linear segment, reception port (1) is not part of linear segment
  - reception port (1) and transmission port (2) are part of linear segment
  - reception port (1) is part of linear segment, transmission port (2) is not part of linear segment

➔ RAP is expected to provide the option to a template to allow this latency calculation



LNI-SR Accumulated Latency Calculation

- **LNI-SR**
  - LNI-SR AML calculation requires **reception** and **transmission** port RA class information to provide correct latency values according to the first to last Bridge latency calculation.

- **RAP**
  - RAP defines AML calculation based on only RA Class information. Please refer to *IEEE P802.1Qdd/D0.7 51.8.5.15 adjustAccumulatedLatencies*

Suggestion: Extended AML calculation to include reception and transmission port information.

Summary/Recap

1. **Request: To extend the RA class template support to cover LNI-SR use-case**
2. **Request: Add Time and Window TLVs into RA Class Descriptor TLV as Optional**
3. **Suggestion: Extended comparison of RA Classes to include template defined checks**
4. **Suggestion: Extended evaluation of Talker Announce declaration to consider RA Class template rules.**
   For example, "reception port" as EST and "transmission port" as Strict Priority are an acceptable propagation schema
5. **Question: How to handle RA Class specific local configuration parameters?**
6. **Suggestion: Extended AML calculation to include reception and transmission port information.**

Thank You

Content

References

References

References

- ISO 15745-1, Industrial automation systems and integration – Open systems application integration framework – Part 1: Generic reference description
- ISO/IEC 11801, Information technology—Generic cabling for customer premises
- IEEE Std 802®-2014, IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture
- IEEE Std 802.1Q™-2018, IEEE Standard for Local and Metropolitan Area Networks: Bridges and Bridged Networks
- IEEE Std 802.1BA™-2011, IEEE Standard for Local and metropolitan area networks - Audio Video Bridging (AVB) Systems
- IEEE Std 802.1CB-2017, IEEE Standard for Local and metropolitan area networks - Frame Replication and Elimination for Reliability
- IEEE Std 802.1AS-2020, IEEE Standard for Local and Metropolitan Area Networks - Timing and Synchronization for Time-Sensitive Applications

References

References

- IEEE 802.1CS, Draft Standard for Local and Metropolitan Area Networks - Link-local Registration Protocol, https://standards.ieee.org/project/802_1CS.html
- IEEE P802.1Qdd/D0.7, Draft Standard for Local and Metropolitan Area Networks - Bridges and Bridged Networks - Amendment: Resource Allocation Protocol (RAP), https://standards.ieee.org/project/802_1Qdd.html
- IEC/IEEE 60802, D1.1 - Time-Sensitive Networking Profile for Industrial Automation

Content

Annex

Term and Definitions

Term	Definition
AML	Accumulated Maximum Latency
CBS	Credit Bases Shaper
CD	Control Data
LAN	Local Area Network
Listener	see IEEE 802.1Q 3.256 / 3.265 / 3.125
LNI	Labs Network Industry
LRP	Link-local Registration Protocol
RA	Resource Allocation
RA Class	A reservation service class offered by RAP
RAP	Resource Allocation Protocol

Term and Definitions

Term	Definition
SR	Stream Reservation
SRP	Stream Reservation Protocol
Stream	see IEEE 802.1Q 3.256 / 3.265 / 3.125
Talker	see IEEE 802.1Q 3.256 / 3.265 / 3.125
TDM	Time-Division-Multiplexing
TG	Task Group
TLV	Type Length Value
TSN	Time Sensitive Networking