IEEE P802.1Qdd Resource Allocation Protocol (RAP)

Motivations, Features and Prospects

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Disclaimer

This presentation on RAP includes descriptions of work in progress in the IEEE P802.1Qdd project and expresses the current intentions of certain contributors to, and the editor of, the project. The eventual standard outputs from IEEE 802.1Qdd may differ from these descriptions.

Outline

- History of stream configuration in 802.1
- Motivations
- RAP architecture
- Leveraging LRP
- Proxy systems
- Resource Allocation class (RA class)
- RA class Template
- Seamless redundancy
- Reservation styles
- Preloaded reservations
- DetNet over TSN with RAP

History of Stream Configuration in 802.1

- 802.1Qat-2010: **Multiple Stream Registration Protocol (MSRPv0)**
  - A distributed protocol oriented to and optimized for AV applications.
  - Fixed SR classes A and B settings with support for CBS only.

- 802.1Qcc-2018: **SRP Enhancements and Performance Improvements**
  - Focus on use of centralized network configuration (CNC) to support TSN features, primarily driven by the need for centralized scheduling.
  - No support for TSN features provided by MSRPv1 in its distributed operations.

- P802.1Qdd (work in progress): **Resource Allocation Protocol (RAP)**
  - Further development of the distributed approach already successfully applied in AV markets.
  - Aimed at providing a more scalable, fully dynamic and autonomous stream reservation with support for major TSN features (shaping, policing, redundancy, etc.).
  - Addresses use cases in a variety of industries (industrial, Pro AV, automotive, etc.).

Motivations of Industrial for RAP

- Network builder for industrial applications provides guidance for management in form of e.g. RA classes and per-hop latency.
- Distinguish between management and control.
- One protocol supporting both distributed and virtualized (centralized) stream reservation.
- Establishment of streams at runtime with a single protocol that provides standardized:
  - User-Network Interface (UNI) for end stations (end stations are TSN-aware, no need for CUC).
  - Network-Network Interface (UNI) for e.g. inter-TSN domains.
  - Distributed resource allocation (no need for a centralized component at runtime).
  - Reservation status information for end-stations.
- Standardized resource allocation algorithms in terms of RA class Templates with standardized network diagnosis.
- Particularly suited for constrained networks with simple topologies (line, comb, ring) in production lines (e.g. LNI4.0 use cases).

Please refer to contributions:

- https://www.ieee802.org/1/files/public/docs2017/new-chen-RAP-proposal-and-requirements-0517-v02.pdf
- https://www.ieee802.org/1/files/public/docs2021/60802-dorr-RAPinIndustrialAutomation-0521-v02.pdf
- https://www.ieee802.org/1/files/public/docs2021/60802-Weber-MMinteract-0521-v02.pdf

RAP Architecture

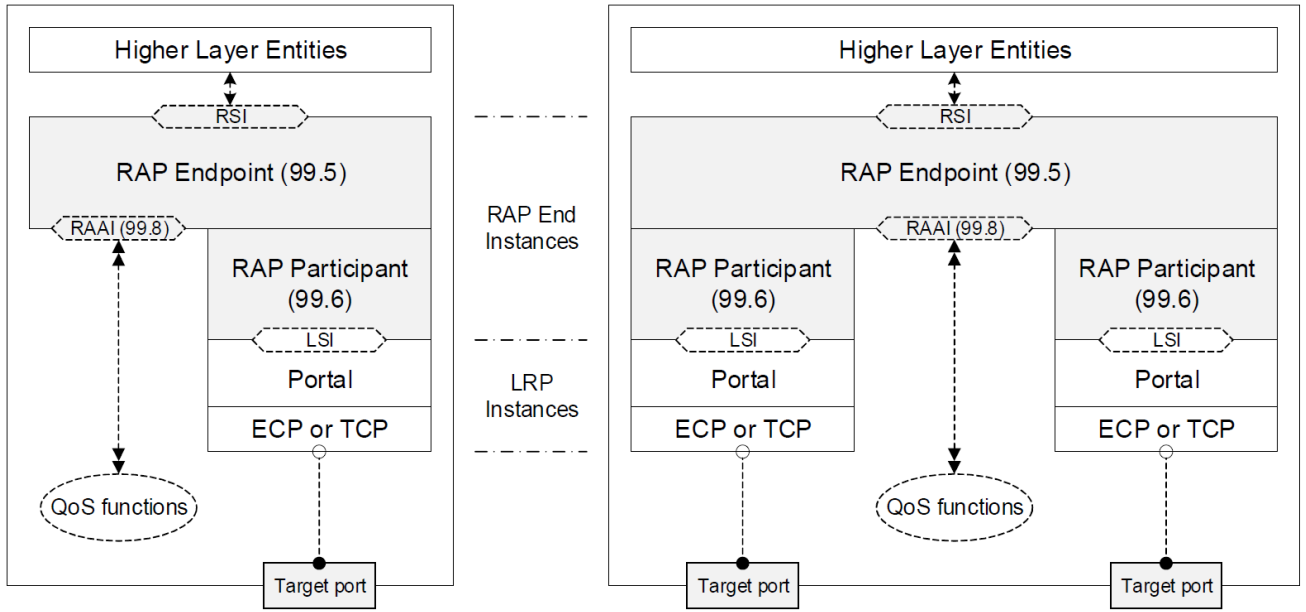


Figure 99-1—RAP Native end stations

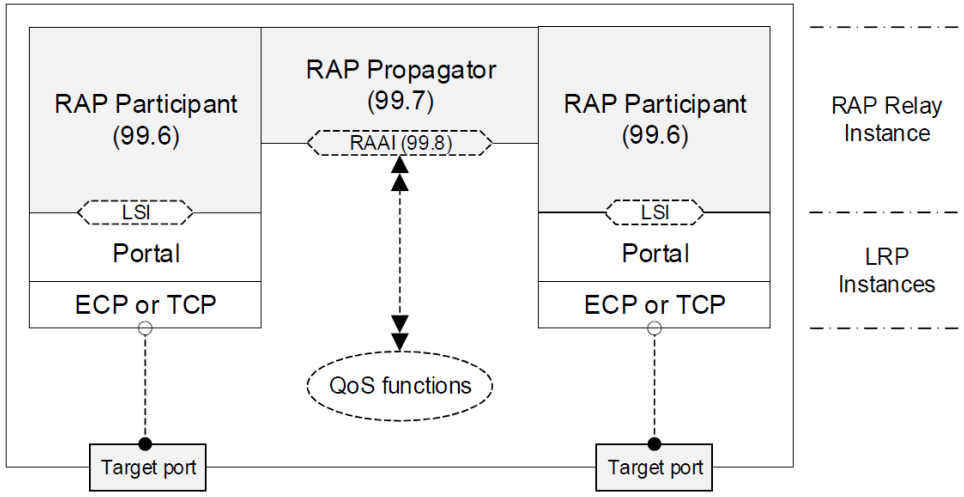
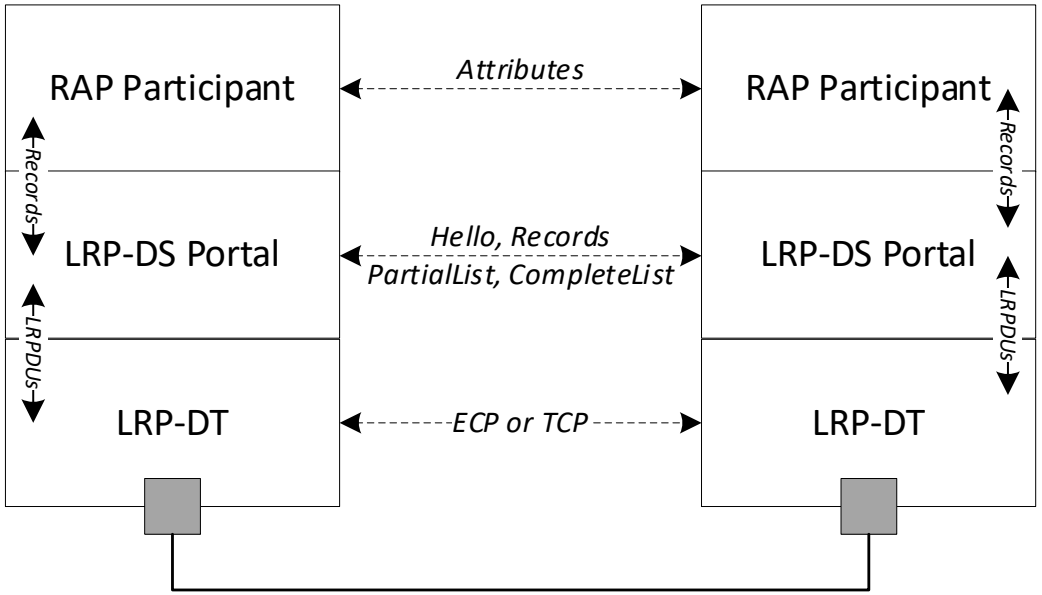


Figure 99-2—RAP Native Bridge

- **RAP Endpoint**: per-end station attributes generation and processing
- **RAP Propagator**: per-bridge attributes processing and propagation
- **LRP + RAP Participant**: per-port, attributes declaration/registration
- **RSI**: RAP Service Interface
- **RAAI**: Resource Allocation Abstract Interfaces
- **LSI**: LRP Service Interface

Leveraging LRP

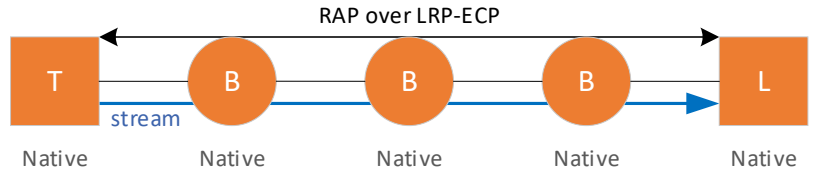
- In contrast to MSRP built upon MRP, RAP makes use of the **Link-local Registration Protocol (LRP)** specified in IEEE 802.1CS for port local registration operations.
- LRP provides enhanced scalability, efficiency and improved performance.
  - Optimized for a larger database of about 1 Mbyte.
  - IS-IS like database operations (ID, SN and checksum) with support for incremental updates.
  - Keep-live through light-weight Hello exchanges.
  - Use of either ECP or TCP, both providing flow controlled, sequenced and reliable data transport.

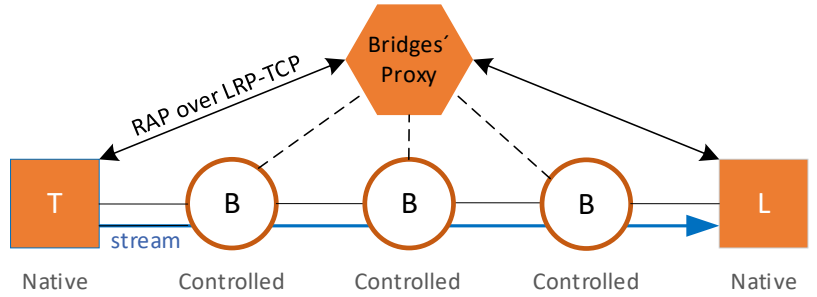


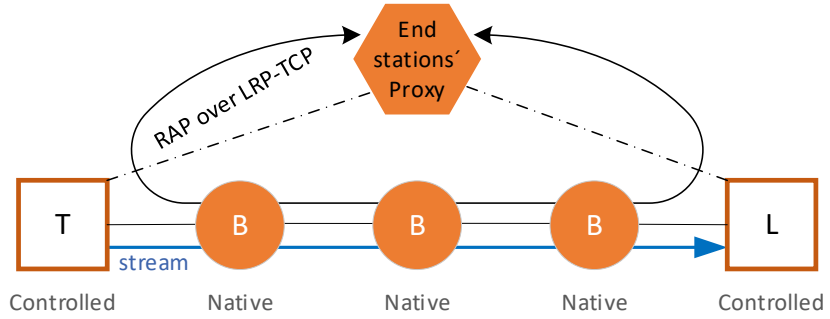
Proxy Systems

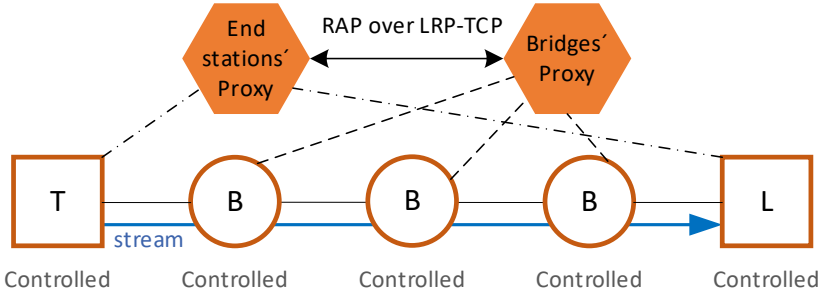
- By leveraging the proxying capability of LRP, RAP can operate in a great variety of configuration models, ranging from fully distributed to fully centralized.
  - In the context of RAP, “centralized” operations of a RAP Proxy system should be interpreted as “emulation of peer-to-peer reservations”, to mean that RAP retains its nature of a distributed protocol that only supports functions achievable with a peer-to-peer implementation.
  - This rule is made to meet the goal of proxy concept that a station does not need to know or care whether the other end is native or proxied.

See: dd-finn-RAP-LRP-MSRP-Qcc-0918-v03.pdf









Resource Allocation Class (RA class)

- RA class is an extension of SR class for use in RAP to address the following goals:
  - support for various transmission functions (shaping, scheduling, SP, etc.) applicable in conjunction with distributed reservations to supply bounded latency and zero congestion loss to time-sensitive streams.
  - fully configurable via management.

- Each RA class on a bridge is characterized by:
  - **RA class ID**: numeric identifier of an RA class, like SR class ID
  - **RA class priority**: PCP value for associated streams, also the mapping to traffic class(es)
  - **RA class Template ID (RTID):** the identifier of the used RA class Template (see next slide)

- Managed objects for management of reservation budgets on each RA class:
  - Max. hop latency, reservable bandwidth, max/min frame sizes, etc.

RA Class Template

- An RA class Template describes a scheme for making up an RA class.
  - RTID: an OUI encoded identifier for this template.
  - The transmission selection algorithm
  - Scheduled traffic (if used)
  - TSpec type (Token bucket or interval-based)
  - Reservation algorithms, e.g. per-hop latency math
  - End station behaviors
  - Interoperability with other Templates
  - …
- This concept offers a means of defining different usage models for selective QoS functions to meet needs of different applications.
  - Conceptually, SR class A and B in AVB standards can be viewed as an RA class Template describing a usage model with CBS for AV applications.

A TSN profile can choose the required RA class Templates or define its own RA class Templates for its needs.

An RA Class Template for
CBS (AVB)

(per ***802.1BA-2011***)

- RTID (OUI-Index): ***xxxx-aa***
- TSA: ***Credit-based shaper***
- TSpec type: ***MSRP TSpec***
- Latency math: ***6.5 in 802.1BA-2011***
- End station behavior: ***34.6 in 802.1Q-2018***
- Required parameters in RA class Attributes:
  class measurement interval
- **…**

An RA Class Template for
CQF
(per ***Annex T of 802.1Q-2008)***

- RTID (OUI-Index): ***xxxx-cc***
- …

An RA Class Template for
SP

- RTID (OUI-Index): ***xxxx-dd***
- …

An RA Class Template for
ATS

- RTID (OUI-Index): ***xxxx-bb***
- TSA: ***Asynchronous Traffic Shaping***
- TSpec type: ***Token Bucket TSpec***
- Latency math: ***Annex V in 802.1Qcr-2020***
- End station behavior: ***Clause 49 in 802.1Qcr***
- …

An RA Class Template for
SP+TAS

- RTID (OUI-Index): ***xxxx-ee***
- …

Examples RA class Templates
(see Annex Z.3 of Qdd/D0.4 for a list of contributions).

Reservations over Redundant Paths

- RAP supports reservations for streams using .1CB FRER for seamless redundancy.
  - Support for CB scenarios incl. E2E FRER, Network FRER, and also a mix of both.
  - Autoconfiguration of FRER functions, such as stream identification, sequence generation and sequence recovery, at the acting points pre-configured by management.

- Signaling process for redundancy
  - Based on redundant trees (VLAN topologies) pre-established by other means.
  - Propagation of Talker/Listener attributes in multiple VLAN contexts with splitting and merging.
  - A generic VID-vector encoding in Talker Announce attributes supporting any number of redundant paths used by a stream.
  - Per-path diagnostics (failure code), e.g. reporting which path (VID) fails.

  See dd-chen-multiple-context-talker-announce-examples-0520-v01.pdf

Preloaded Reservations

- MSRPv1 supports preloaded reservations for automotive and pro-A/V use-cases: https://www.ieee802.org/1/files/public/docs2016/cc-cgunther-srp-reservation-types-0716-v02.pdf

- RAP can also support this feature in a similar manner as MSRP.
  - RAP attributes that include reservation information can be directly loaded from flash upon power-up to the RAP resource allocation engine.
  - Reservations can be made before RAP signaling functions become operational after neighbor discovery and association has been completed by underlying LRP.
  - When RAP signaling is operational, the preloaded reservations will be validated in the signaling procedures.
  - Preload tables with a set of writable managed objects similar to those defined for MSRP in 12.22.6 and 12.22.7 would be provided to allow configuration of preloaded streams through management interface.

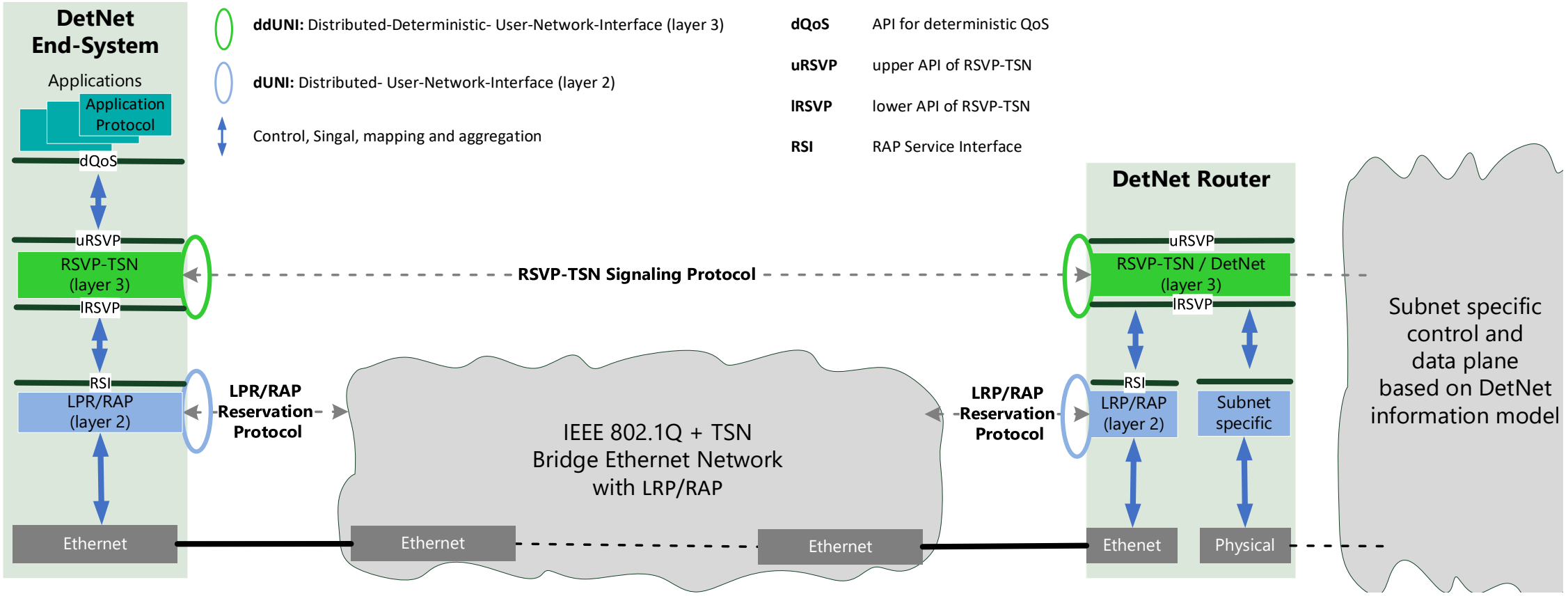
Reservation Styles

- **Distinct reservations:**
  - Intended for 1-to-N talker-listener relations.
  - Resources are reserved exclusively for use by a single stream.
  - Possible use-cases: real-time image processing.
- **Shared reservations:**
  - Intended for N-to-M talker-listener relations.
  - Resources are shared by several streams of a given application that can ensure these streams are not transmitted simultaneously.
  - Possible use-cases: tool-change in industrial, max. one person allowed to speak in audio conference.
- **Coordinated shared reservations:**
  - Intended for N-to-1 talker-listener relations (with a common listener)
  - Resources are shared by several streams whose transmissions from the talkers are coordinated such that no more than one of these streams is being queued in the same bridge (multiplexing for shared resources).
  - A receiving schedule is generated by the common Listener and then converted to sending schedule for Talkers by RAP.
  - Possible use-cases: sensors to controller communication.

  See: https://www.ieee802.org/1/files/public/docs2019/dd-chen-flow-aggregation-0119-v03.pdf (a generalized approach is under preparation)

DetNet over TSN with RAP

Contribution to DetNet Control Plane Signaling for DetNet-aware End systems.



Links:

- Deterministic networking https://datatracker.ietf.org/wg/detnet/about/
- RSVP-TSN signaling contribution https://datatracker.ietf.org/doc/draft-trossen-detnet-control-signaling/?include_text=1

Thank You!