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User Network Interface & Services

Industrial Requirements on User-Network-Interface for utilizing TSN features in End-Stations

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- **Multiple applications share the same network**
  - Guaranteed bandwidth for multiple applications (OPC_UA, Video, Condition Monitoring, etc.)
  - Guaranteed latency for streams
  - High availability
  - …

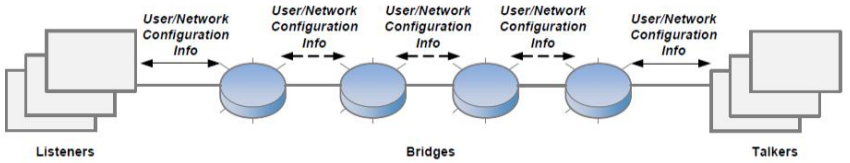


Figure 99-1 — Fully Distributed Model

- **Ad hoc Stream reservations shall be supported**
  - Also “static” Stream reservation shall be included

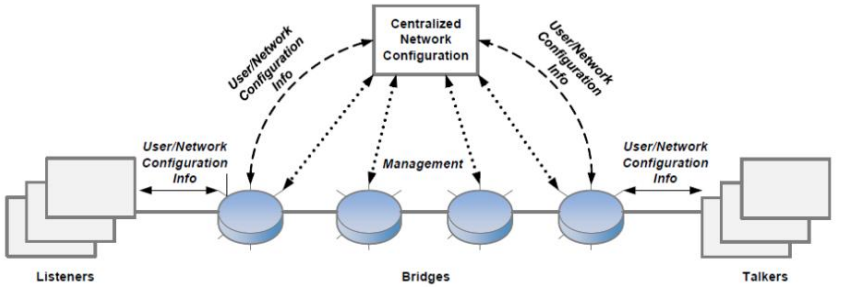


Figure 99-2 — Centralized Network / Distributed User Model

- **A standardized interface for failure propagation and diagnostic**
  - E.g. diagnostic for Stream registration and reservation

- **Different network organization models shall be supported (e.g. fully centralized, centralized, distributed)**
  - Network organization model shall be transparent to end-stations

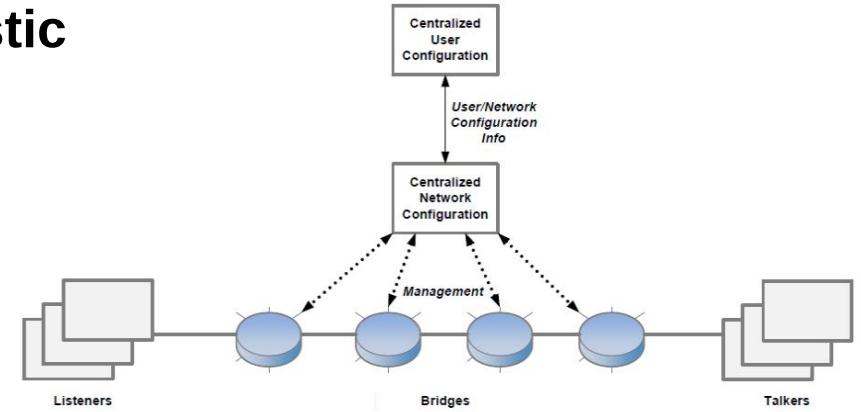
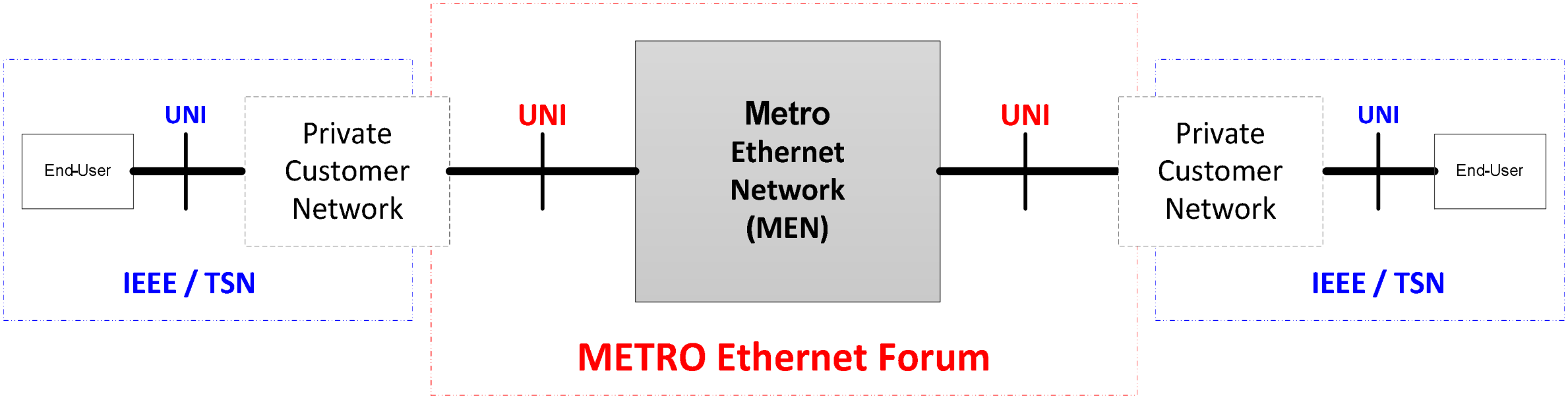


Figure 99-3 — Fully Centralized Model

What is a User Network Interface?



Metro Ethernet Forum has already specified a framework for their User Network Interface.

“This may help to focus the discussion within IEEE / TSN about UNI.”

L2 UNI Interface
to separate Applications from Network

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L2 UNI makes use of multiple protocols:

MUST for Stream configuration**:**

- LLDP (network capabilities exchange between edge-bridge and end-station)
- Stream registration and reservation (MSRP/MSRP++)

Pre-Conditions for better performance and security:

- Precision time sync (e.g. IEEE 802.1AS, IEEE 1588) to maintain a synchronized time
- Registration protocols (MMRP, MVRP) to register MAC addresses and VLANs
- Port security (IEEE 802.1X) to provide network access control
- …

Additional optional network services:

- Allocation of unique Stream ID
- Allocation of unique Stream DA (e.g. IEEE 1722 MAAP)
- Local Medium Access Control (MAC) Address Usage (802c)
- …

LLDP “Extensions” for TSN

UNI requires LLDP to exchange the network TSN capabilities between <u>edge-bridge and end-station</u>

- Supported **Stream Traffic Class Specification** for Stream Class A, B, C, …
  - Priority
  - Shaper (CBSC, TAS, Strict Priority, …)
  - Pre-emption
  - Observation interval
  - Max. bandwidth
  - Scheduled network (optional)
    - Start window
    - End window
  - Coordinated transmission in end-station
    - Start window
    - End window
  - ….

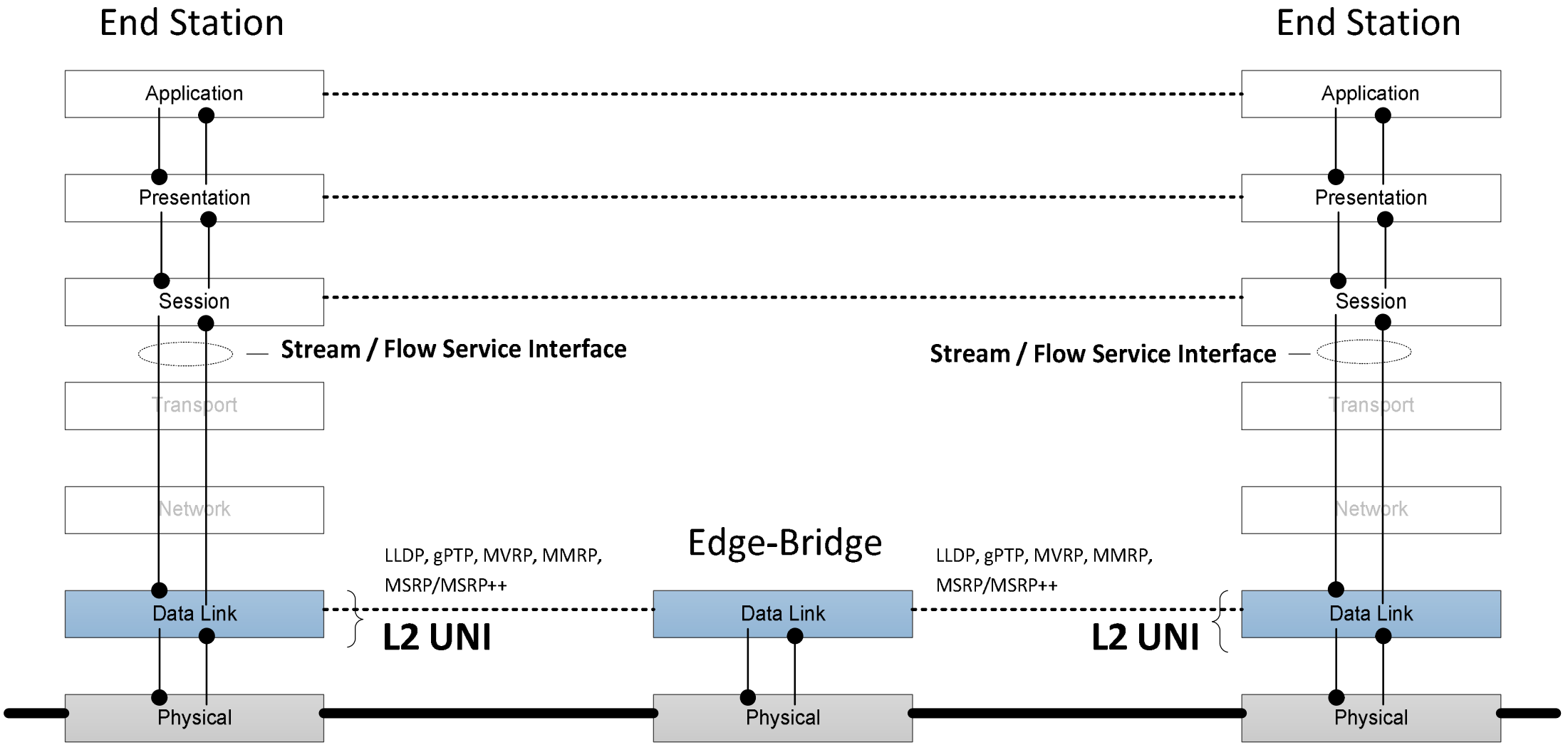
- Supported **Availability**
  - Recovery Time <100ms
    (e.g. RSTP, Shortest Path with recovery)
    - VLAN x
  - Recovery Time <10ms
    (e.g. Seamless Redundancy or maximally disjoint redundant path)
    - VLAN y
  - Recovery Time <1ms
    (e.g. Seamless Redundancy or maximally disjoint redundant path)
    - VLAN z
  - ….

- Supported **…**

Still to consider:

UNI requires LLDP to exchange the end-station TSN capabilities between <u>end-station and edge-bridge</u>

User Network Interface for MAC Streams based on OSI Reference Model



Stream / Flow Service Interface in Session Layer (Not Part of Standardization in IEEE 802.1)

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“Stream / Flow service interface in session layer for communication between session protocol (e.g OPC_UA@TSN, …) **and lower layer protocol stack within the end-station”**

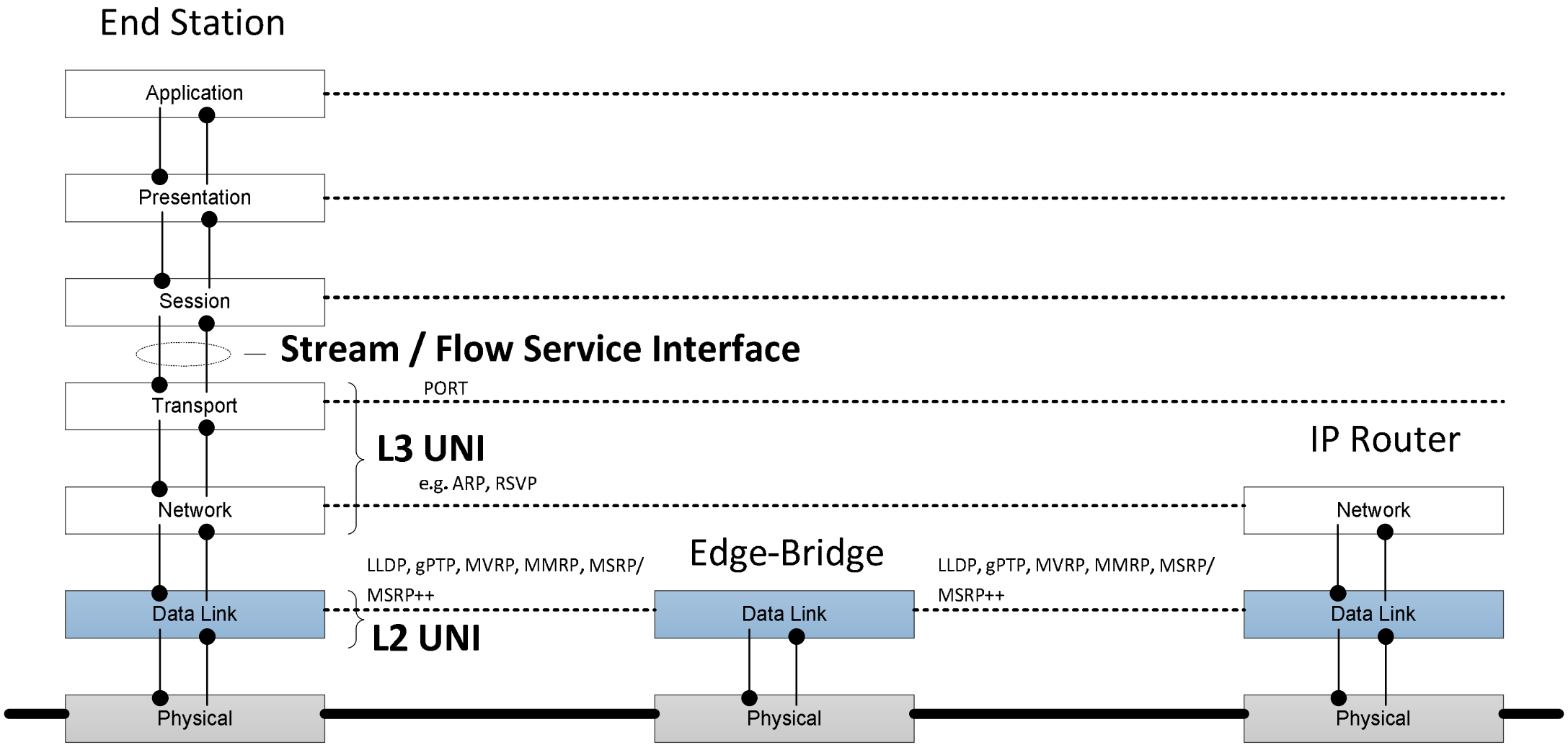
per Stream / Source (called Talker in TSN)

- **Stream-Identity** (binding to Stream ID)
- **Stream Service Class** (binding to traffic class)
- **TSpec (SDU size, period, ..)**
- **C-VLAN** (customer VLAN ID)
- **Coordinated Transmission** (scheduled)
- **Availability**
- **L2 / L3 Service**
- **…**

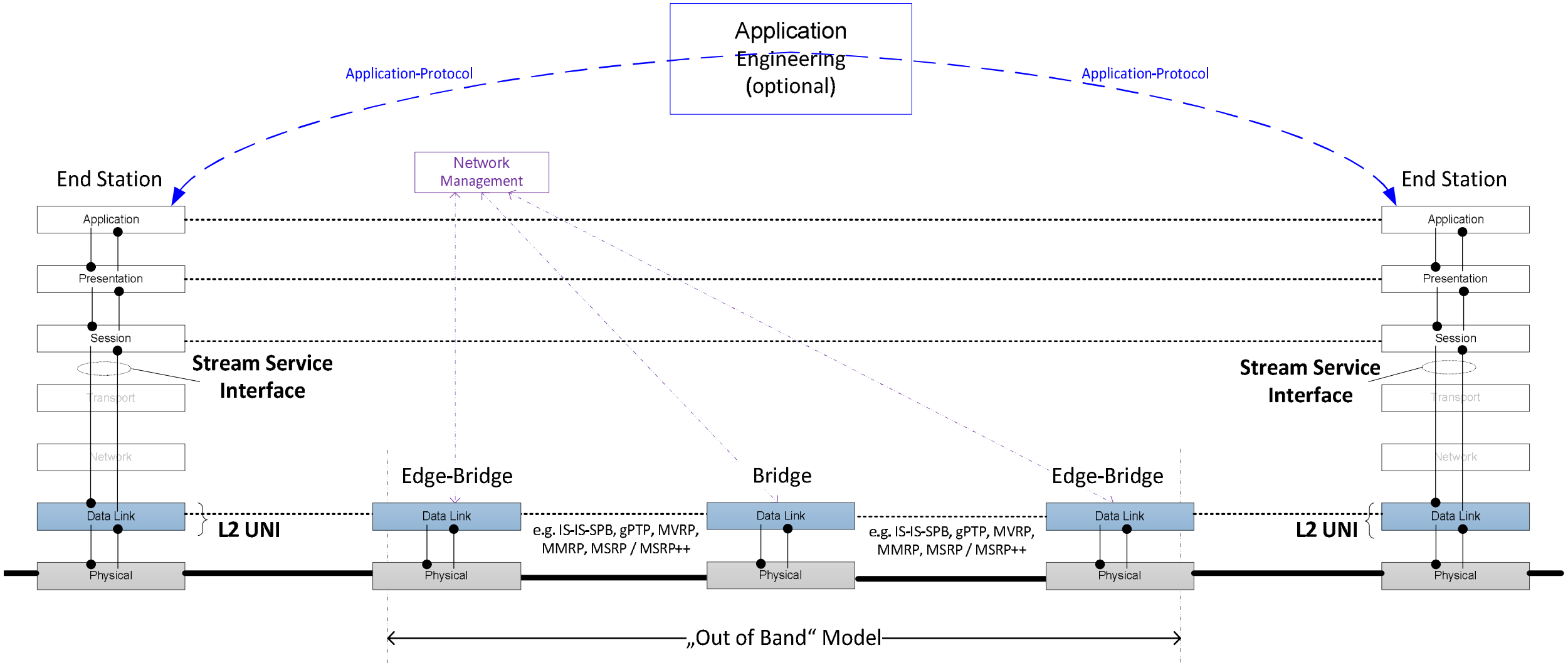
per Stream / Sink (called Listener in TSN)

- **Stream-Identity** (binding to Stream ID)
- **C-VLAN** (customer VLAN ID)
- **Required latency**
- **…**

User Network Interface for IP Flows based on OSI Reference Model



User Network Interface for MAC Streams in a distributed organized Traffic Class / Trees ("open systems")



Network Management “Extensions” for Time-Sensitive-Networks

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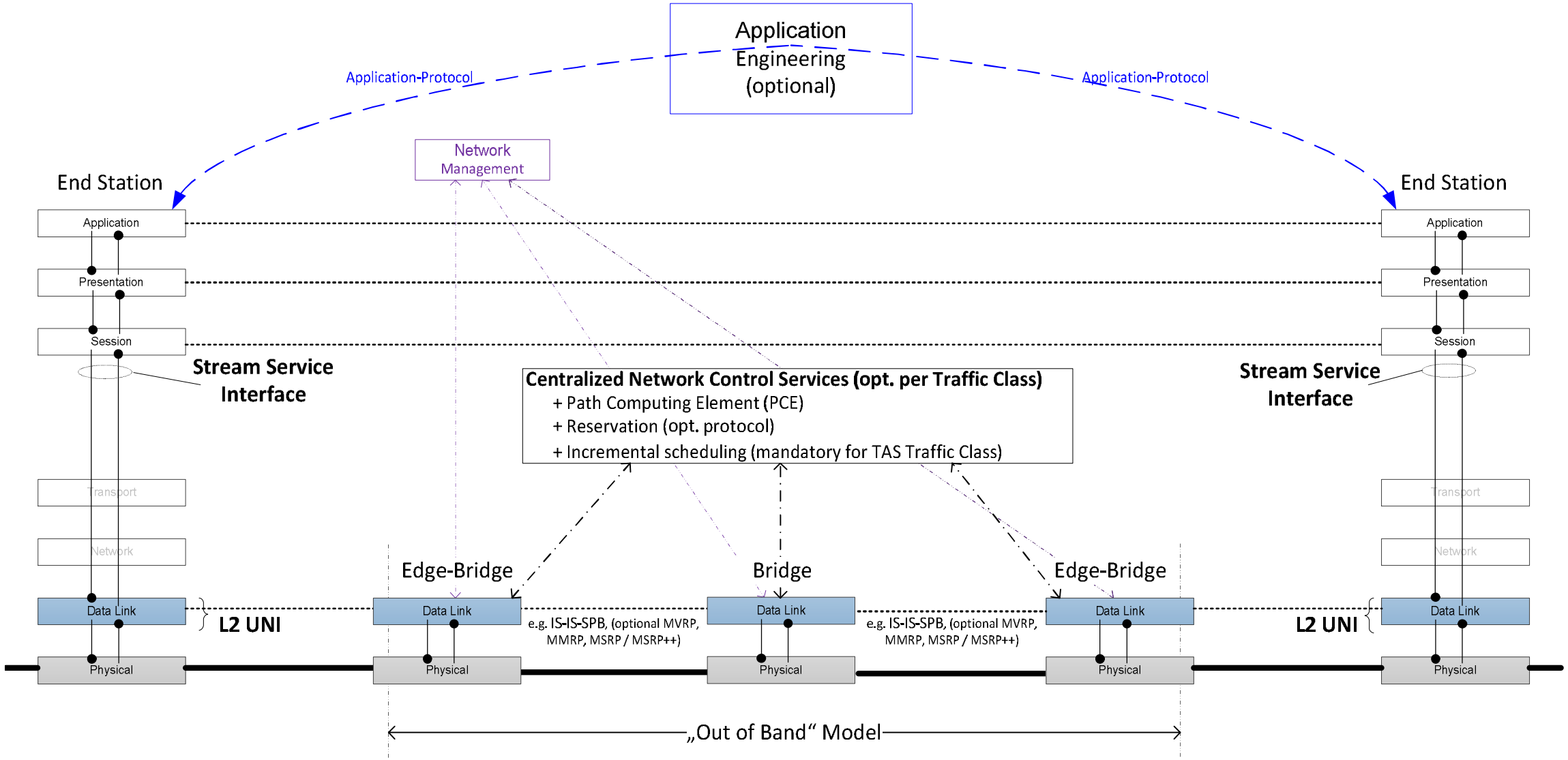
Network Management extensions for MSRP/MSRP++ in TSN

- Distribute **Stream Traffic Class Specification** for SR Class A, B, C, …
  - Priority
  - Shaper (CBSC, TAS, Strict Priority, …)
  - Pre-emption
  - Observation interval
  - Max. bandwidth
  - Scheduled network (optional)
    - Start window
    - End window
  - Coordinated transmission in end-station (optional)
    - Start window
    - End window
  - ….

Network Management extensions for Availability in TSN

- **Availability**
  - Recovery Time <100ms
    (e.g. RSTP, Shortest Path with recovery)
    - VLAN x
  - Recovery Time <10ms
    (e.g. Seamless Redundancy or maximally disjoint redundant path)
    - VLAN y
  - Recovery Time <1ms
    (e.g. Seamless Redundancy or maximally disjoint redundant path)
    - VLAN z

User Network Interface for MAC Streams
in a centralized organized Traffic Class / TE-Trees (“open systems”)



Why Centralized Network Control Service?
Why UNI is so important?

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- TSN supports converged networks

- In a converged network each traffic class / tree can be organized by a different organization model

  Example:
  - Best-Effort-Traffic:
    - “Strict Priority” / “Common Spanning Tree” can be organized **decentralized**

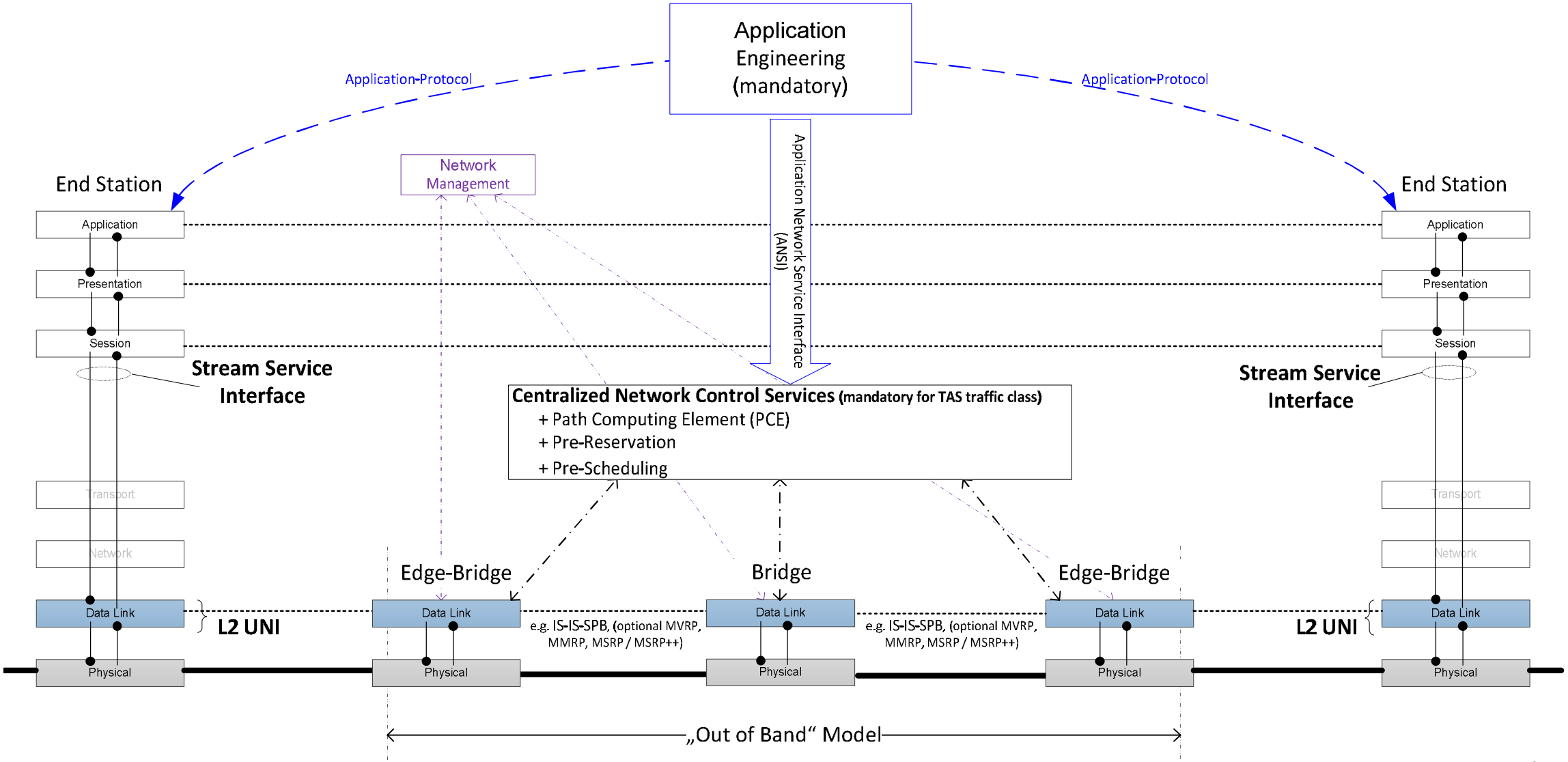
  - Stream Class Low:
    - “Credit Based Shaper” / “Shortest Path” can be organized **decentralized**

  - Stream Class High:
    - “Time Aware Shaper” / “Maximally Disjoint Redundant Path” can also be organized by a **centralized network control service**

➔ ***Centralized network control is only a service within a converged network!***

➔ **UNI between end-station and edge-bridge to make the different organization model within a network transparent for the USER!**

User Network Interface for MAC Streams
in a fully centralized organized Traffic Class / TE-Trees ("within a closed system")



Application Network Service Interface (ANSI) (Not Part of Standardization in IEEE 802.1)

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“ANSI for communication between application engineering and network control service for a application specific optimized traffic class within an converged time sensitive network”

per Source (called Talker in TSN)

- **Source-Identity** (binding to SA Talker)
- **Stream-Identity** (binding to Stream ID)
- **Stream Service Class** (binding to traffic class)
- **TSpec (SDU size, period, ..)**
- **C-VLAN** (customer VLAN ID)
- **Coordinated Transmission** (scheduled)
- **Availability**
- **L2 / L3 Service**
- **…**

per Sink (called Listener in TSN)

- **Sink-Identity** (binding to SA Listener)
- **Stream-Identity** (binding to Stream ID)
- **C-VLAN** (customer VLAN ID)
- **Required latency**
- **…**

For a time sensitive network highest performance can be achieved by combining

1. *ANSI (interface between application engineering and a centralized network control service)*
2. *Get* capabilities of network components *regarding TSN features (e.g. pre-emption, synchronization, …)*
3. *UNI (unified interface between end-station and edge-bridge)*

for a closed static system within a converged network!

MSRP/MSPR++ is Part of UNI for Stream Registration/ Reservation

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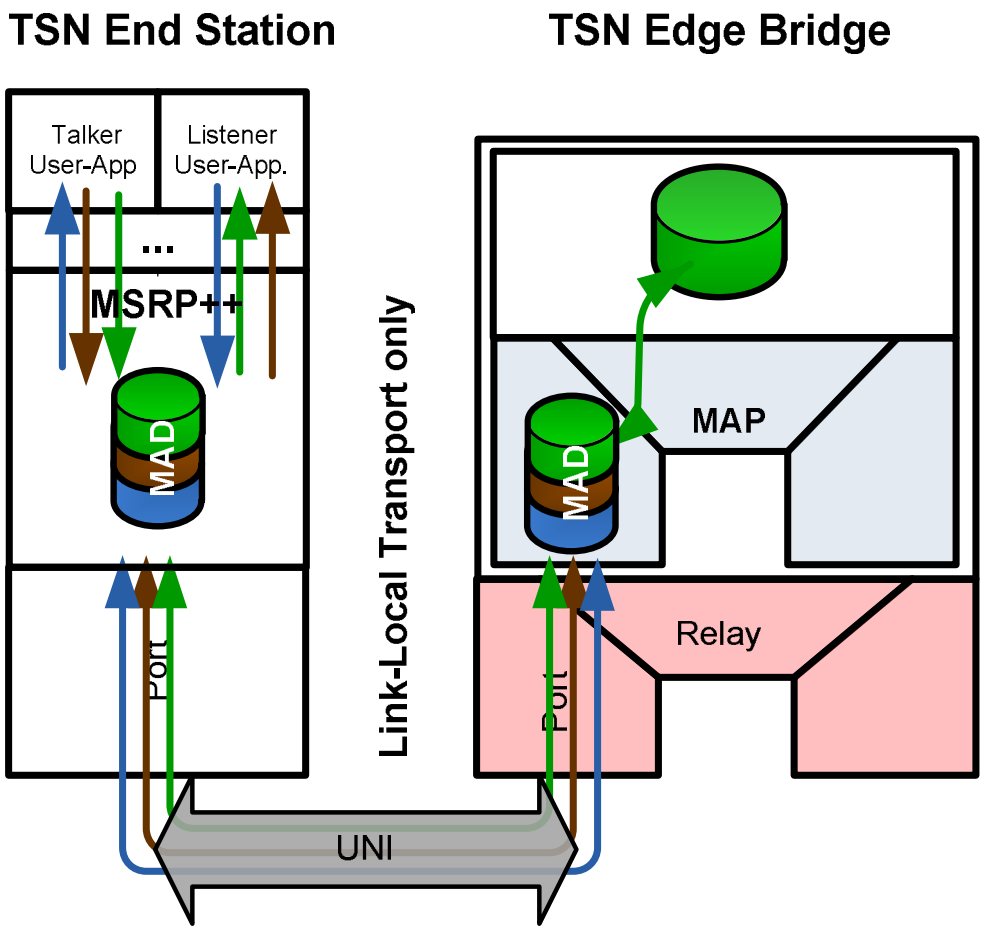
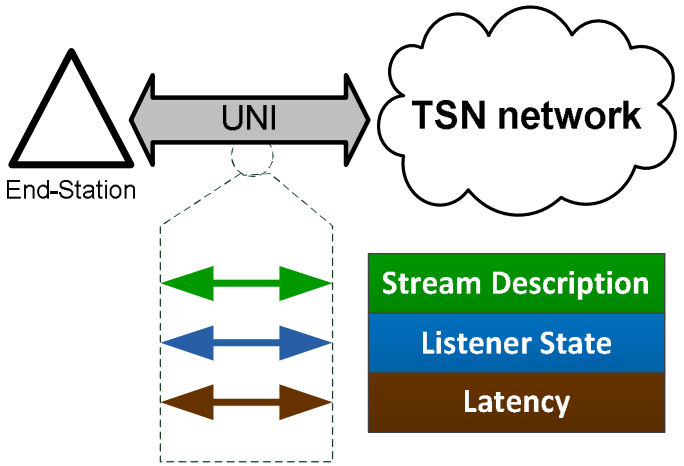
MSRP/MSRP++ between end-stations and edge-bridge for Stream registration/reservation!





MSRP/MSRP++ (with new Link-Local IS-IS mechanism) is one of the protocols of UNI for stream registration and reservation between end-stations and edge-bridge (network)

Conclusion

The OSI layering model helps to make lower layer mostly transparent for higher layer protocols.

- A higher layer protocol like OPC_UA requires a generalized **Interface** for **Stream-Services** (in this presentation called Stream-Service-Interface) within an end-station

- Tasks of lower layer shall be transparent like:
  - L2 / L3 Stream / Flow
  - Network control (e.g. path computing, Stream registration / reservation, …)
  - Network management (e.g. Stream traffic classes, supporting availability by network, …)
  - Lower layer services like Stream-DA allocation
  - ….

➔ **One UNI between end-stations and edge-brides for Stream configuration supporting all kinds of network configuration models**

➔ **UNI provides a standardized interface for failure propagation and diagnostics to end-stations**

➔ **From network perspective the centralized and fully centralized network configuration model is in principle based on the same model!**

Thank you for your attention!

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