Central and Distributed Components for TSN Configuration

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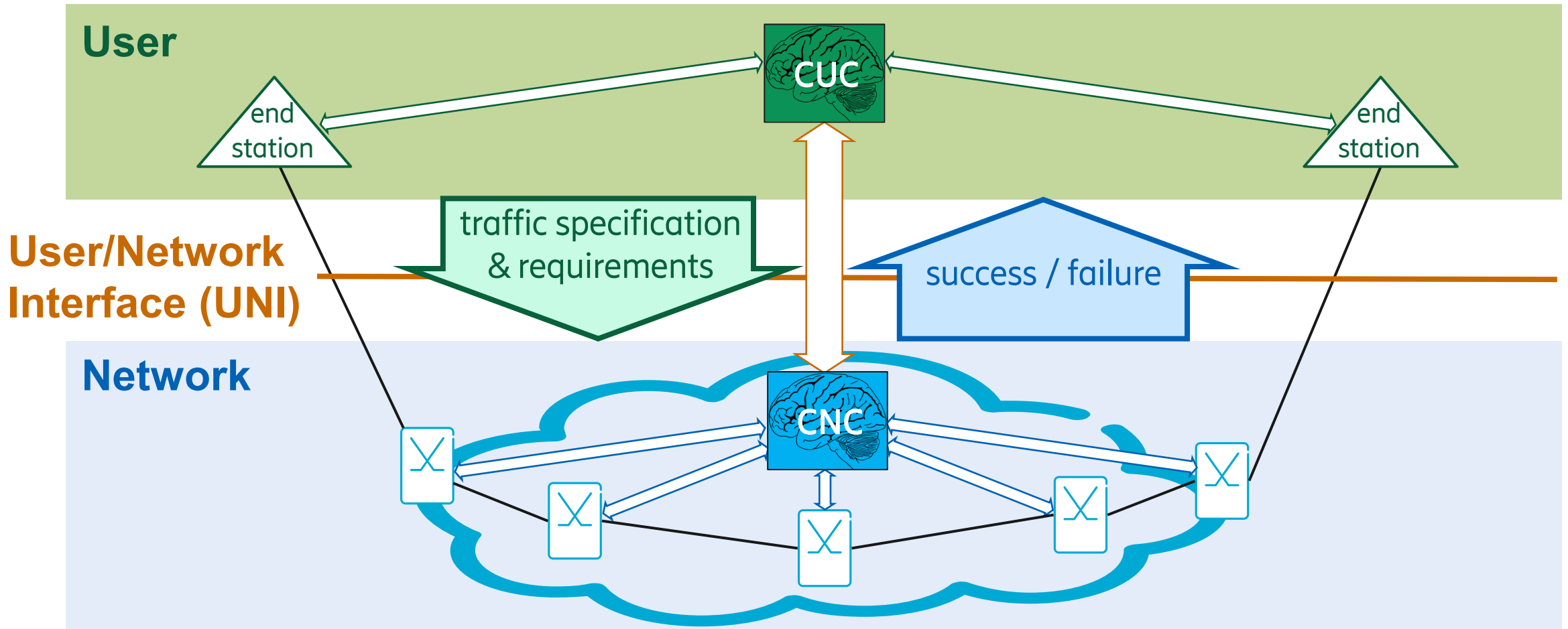individual contribution   2021-05-04

Notes

- The main goal of this presentation is to clarify components and investigate configuration differences in industrial automation with and without the use of the 802.1Qdd Resource Allocation Protocol (RAP).

- When it comes to RAP,

  - This presentation only considers the use of RAP in industrial automation, where there is Central Entity anyways, even when RAP is used.

  - The use of RAP is different in other application areas that are truly fully distributed, i.e., without a Central Entity
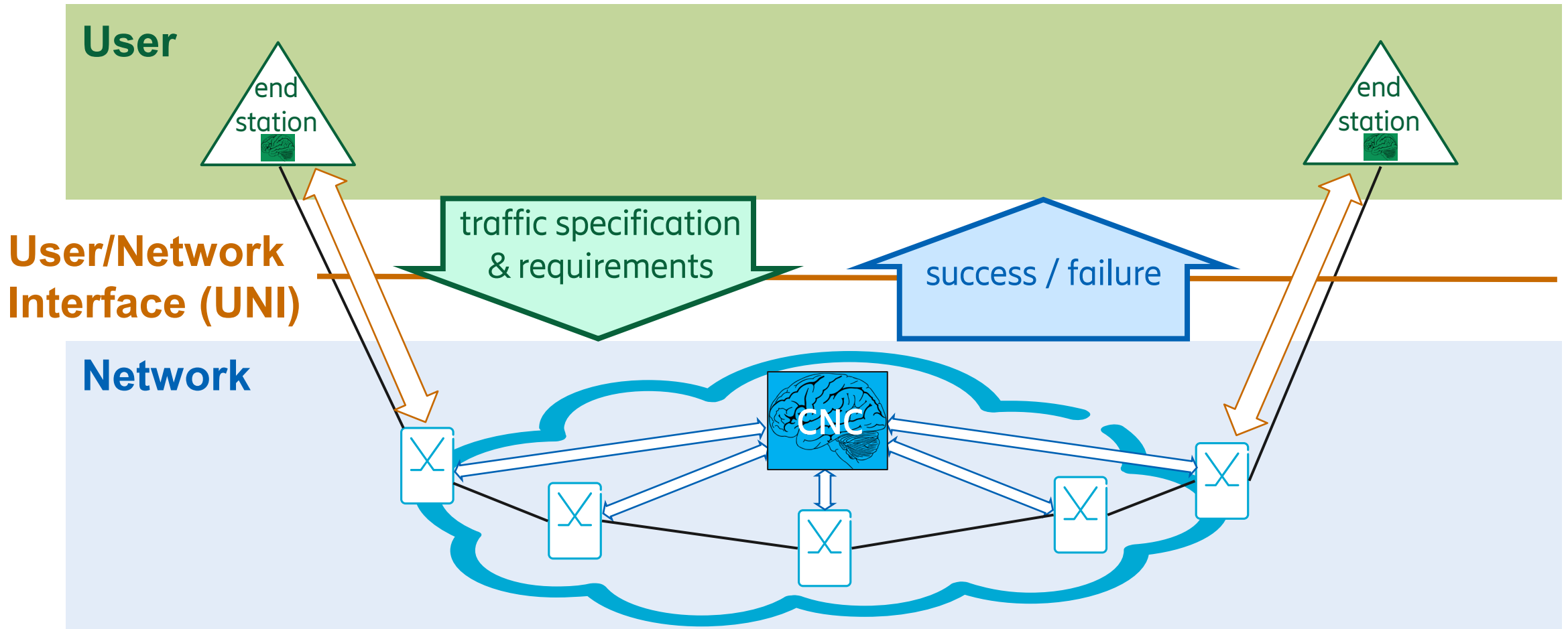
RECAP: Fully Centralized Model
IEEE Std 802.1Qcc-2018

User

end station

CUC

end station

User/Network Interface (UNI)

traffic specification & requirements

success / failure

Network

CNC

RECAP: Centralized Network/Distributed User Model
IEEE Std 802.1Qcc-2018

User

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RECAP: Fully Distributed Model
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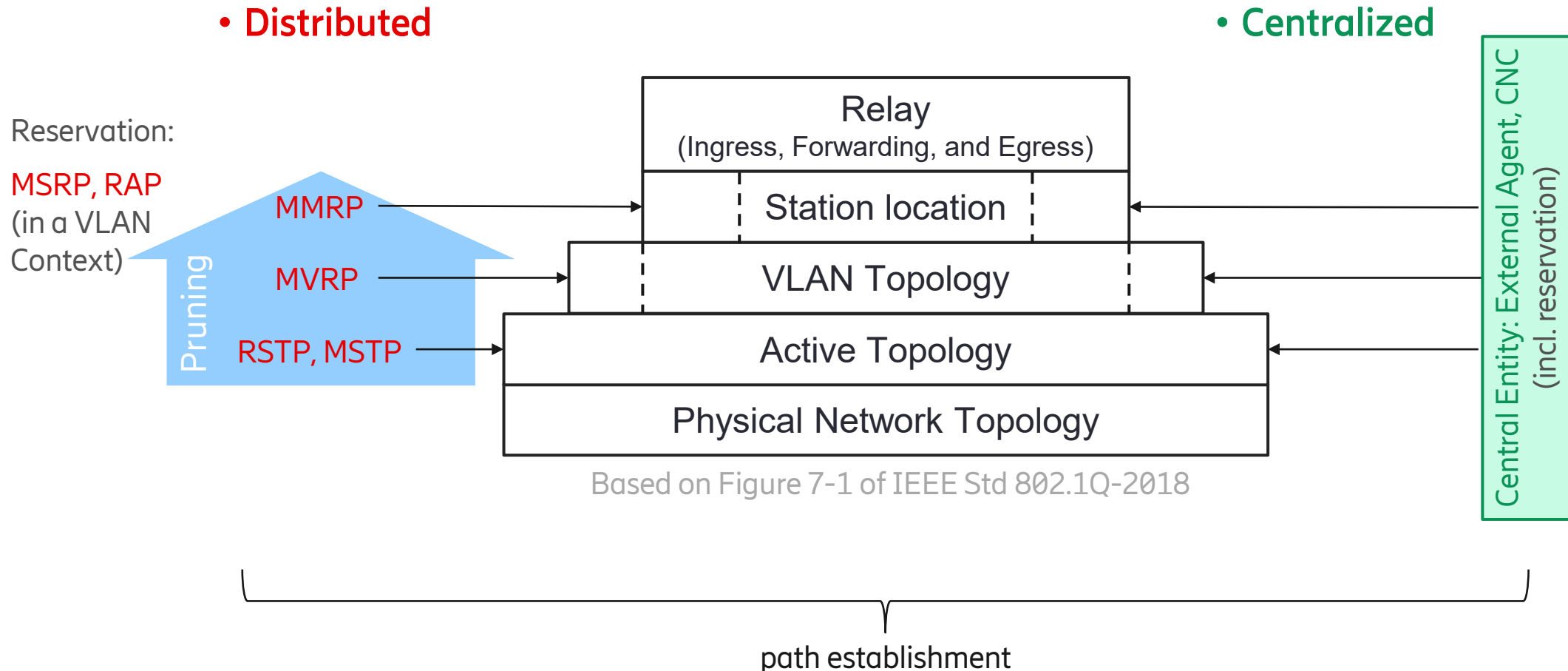
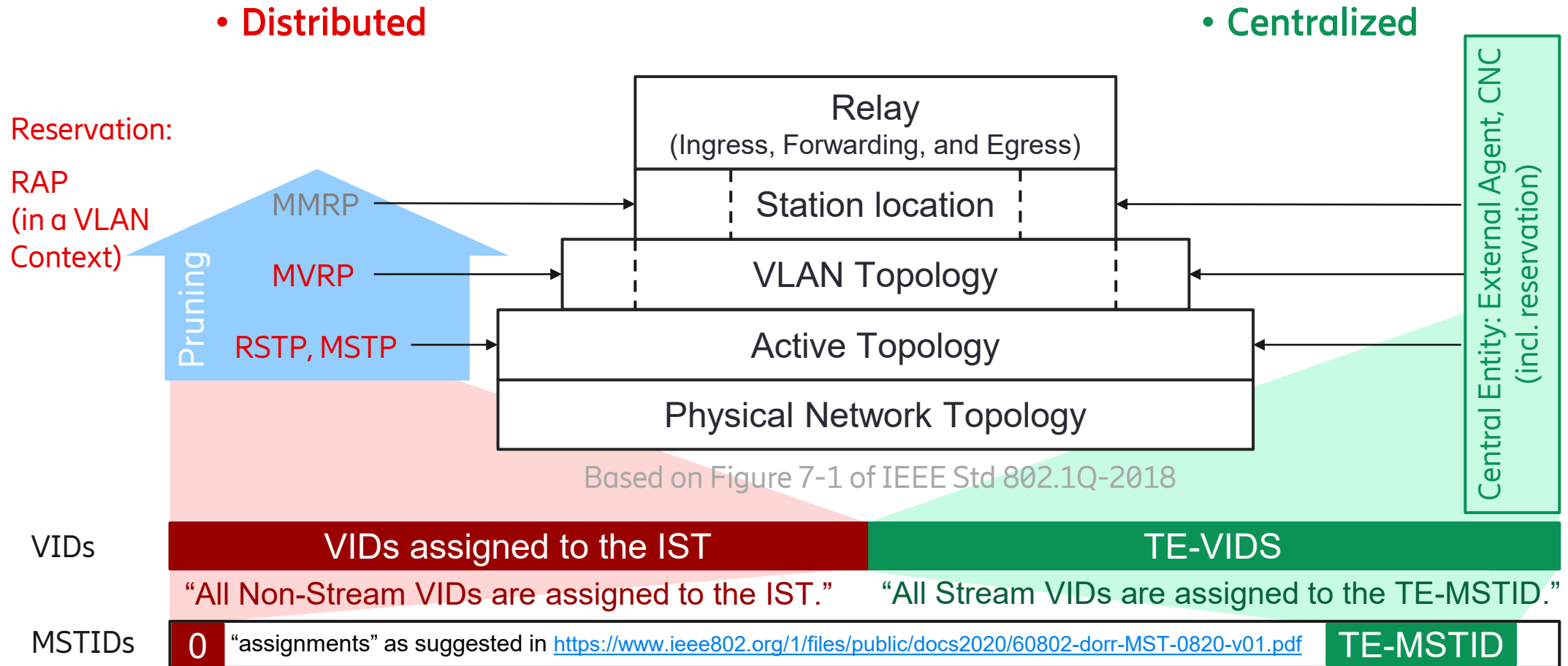traffic specification & requirements

success / failure
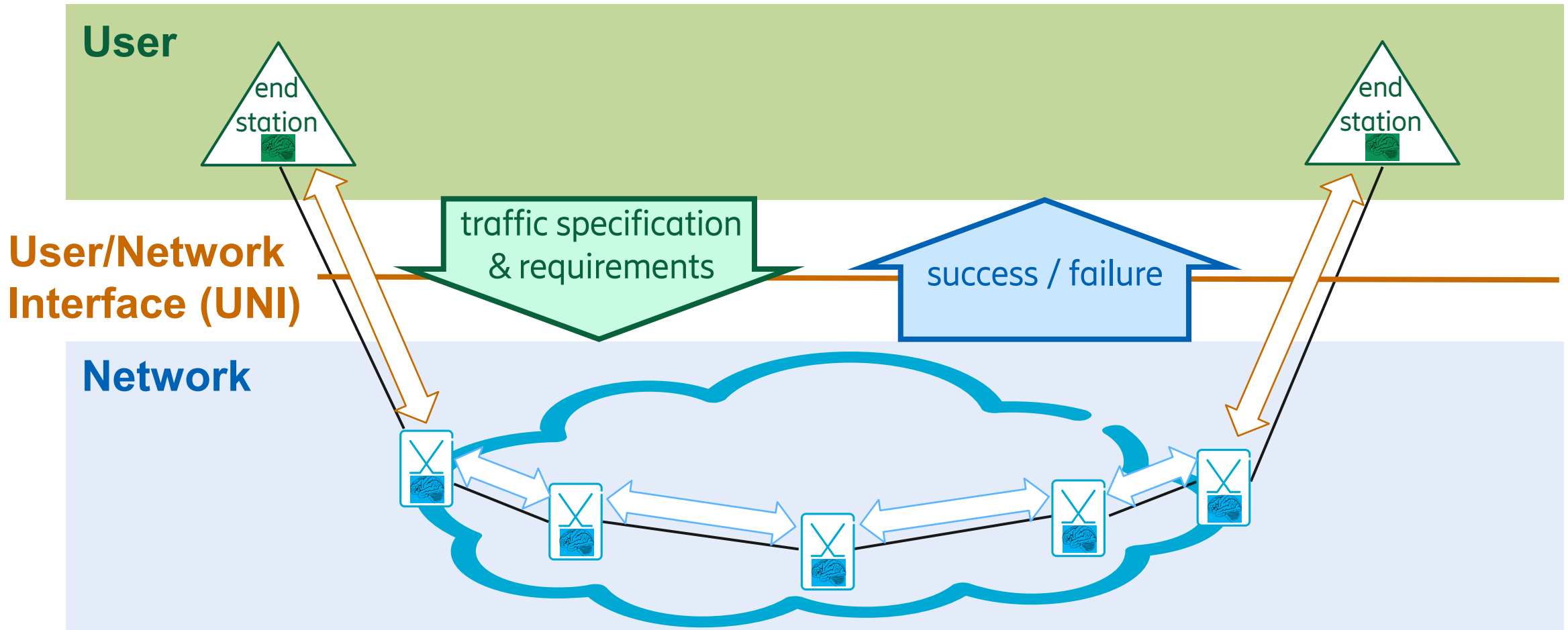
Network

Fully distributed ➜ No central entity at all (fully distributed is valuable and a main value is no central entity)

IEEE Std 802.1Qcc 46.1.3.1: "The network is configured in a fully distributed manner, without a centralized network configuration entity."

Distributed and Centralized

• Distributed

• Centralized

Reservation:

MSRP, RAP
(in a VLAN
Context)

Pruning

MMRP

MVRP

RSTP, MSTP

| Relay |
| (Ingress, Forwarding, and Egress) |
| Station location |
| VLAN Topology |
| Active Topology |
| Physical Network Topology |

Based on Figure 7-1 of IEEE Std 802.1Q-2018

Central Entity: External Agent, CNC (incl. reservation)

path establishment

Distributed and Centralized Elements in Industrial Automation

• Distributed

• Centralized

Reservation:

RAP
(in a VLAN
Context)

Pruning

MMRP

MVRP

RSTP, MSTP

| Relay (Ingress, Forwarding, and Egress) |
| Station location |
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| Physical Network Topology |

Based on Figure 7-1 of IEEE Std 802.1Q-2018

Central Entity: External Agent, CNC (incl. reservation)

VIDs

| VIDs assigned to the IST | TE-VIDS |

"All Non-Stream VIDs are assigned to the IST."

"All Stream VIDs are assigned to the TE-MSTID."

➡ **There is Central Entity for Streams**

MSTIDs

| 0 | "assignments" as suggested in https://www.ieee802.org/1/files/public/docs2020/60802-dorr-MST-0820-v01.pdf | TE-MSTID | |

NOTE – The resolution of ballot comment #289 against IEC/IEEE 60802/D1.2 includes:
"Add an item to 5.7.1: "TSN Streams shall be associated with VIDs assigned to the TE-MSTID."

RECAP: CNC as per IEEE Std 802.1Qcc-2018

- 46.1.3.2:
  - "The CNC has a complete view of the physical topology of the network as well as the capabilities of each Bridge."
- 46.1.3.2 & 46.1.3.3:
  - "The CNC uses remote management to discover physical topology, retrieve Bridge capabilities, and configure TSN features in each Bridge."

# Central Entity when Reserving Streams with RAP

- **There is a Central Entity in when using RAP** for reservation as clearly shown in page 3 in
  https://www.ieee802.org/1/files/public/docs2021/60802-dorr-RAPinIndustrialAutomation-0421-v01.pdf#page=3

  - Despite the Central Entity is not called CNC in the above linked contribution, the Central Entity there is a CNC as it implements functions of a CNC as per IEEE Std 802.1Qcc-2018, see the previous slides

- The functions the Central Entity include

  - Topology discovery

  - from the contribution: "configuration of e.g.:

    - TSN domains

    - Synchronization

    - Traffic classes

    - VLANs, active topologies, and MSTIDs

    - Resource Allocation (RA) classes for streams"

(Reservation Schemes: RA Classes, Transmission Gates, etc.)

- "fixed gate control per RA class" ➔ it is CNC's role to set TSN gates ➔ "without CNC" argument is **invalid**
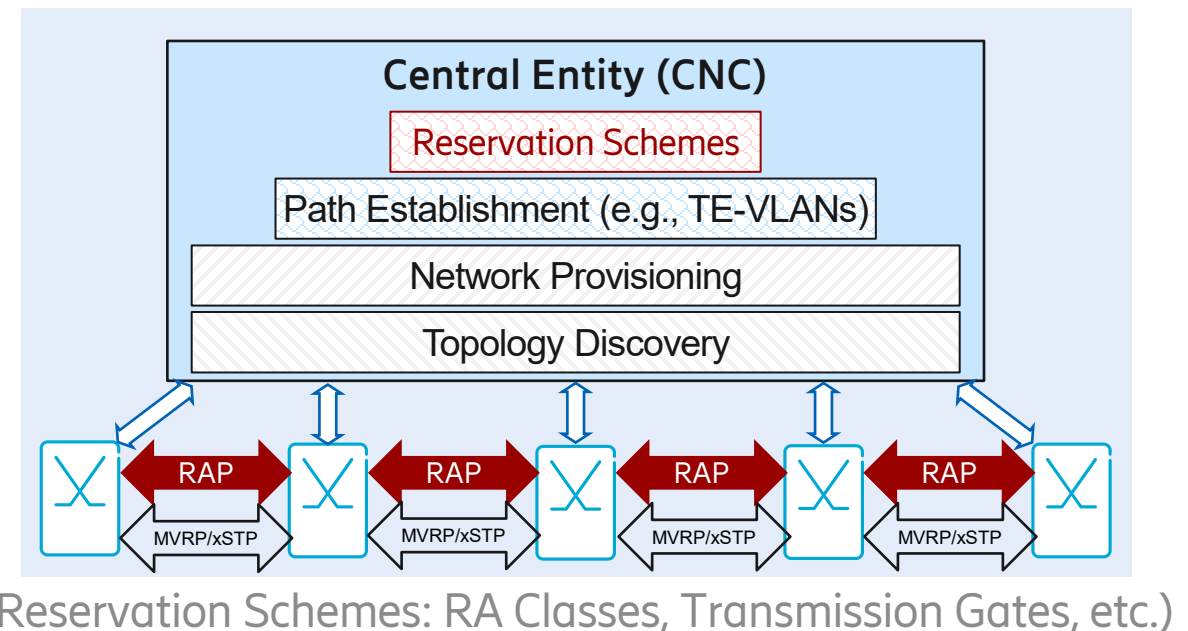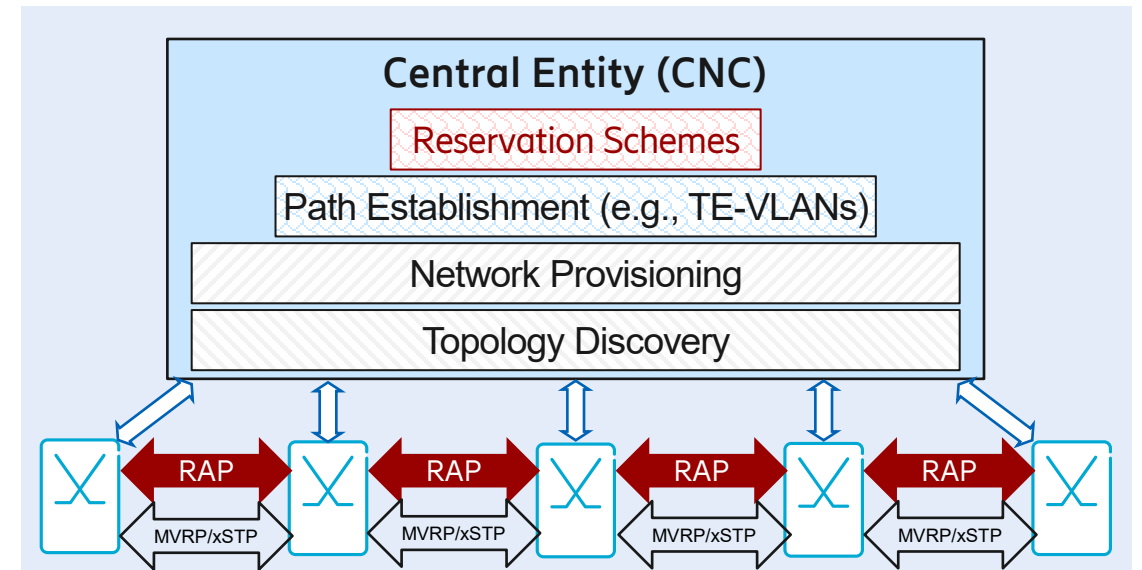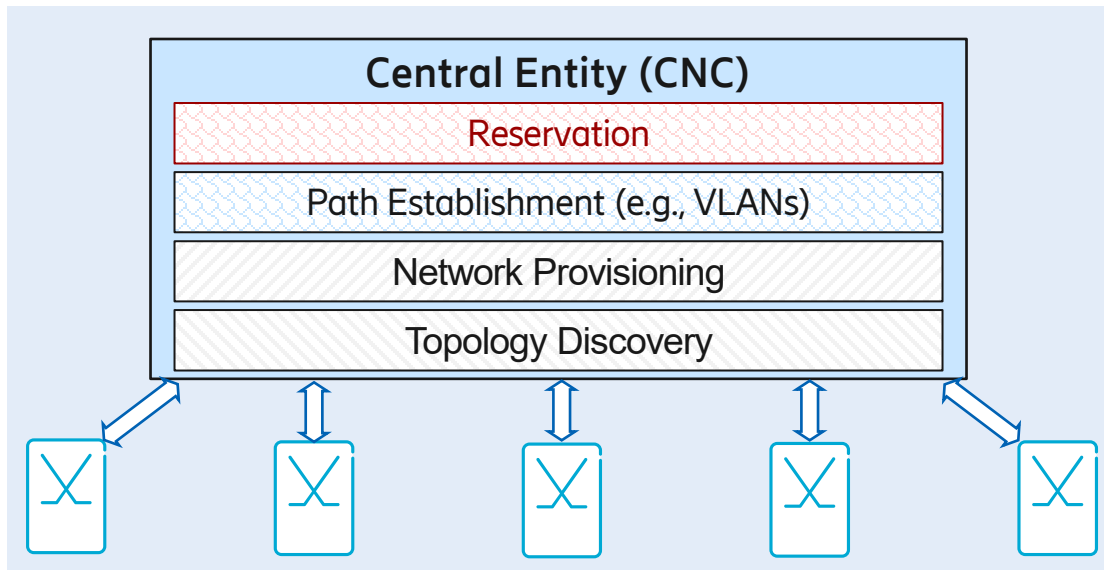
How to call it?

- For instance: **Centralized Network Configuration with Distributed Reservation**

- Actual resource reservation (resource allocation) is performed by a distributed protocol (RAP/LRP), but a Central Entity (CNC) is involved in the preparation of the network to make the distributed reservation possible for certain traffic, e.g., preparation of forwarding paths (active topologies), VLANs, reservation schemes etc.
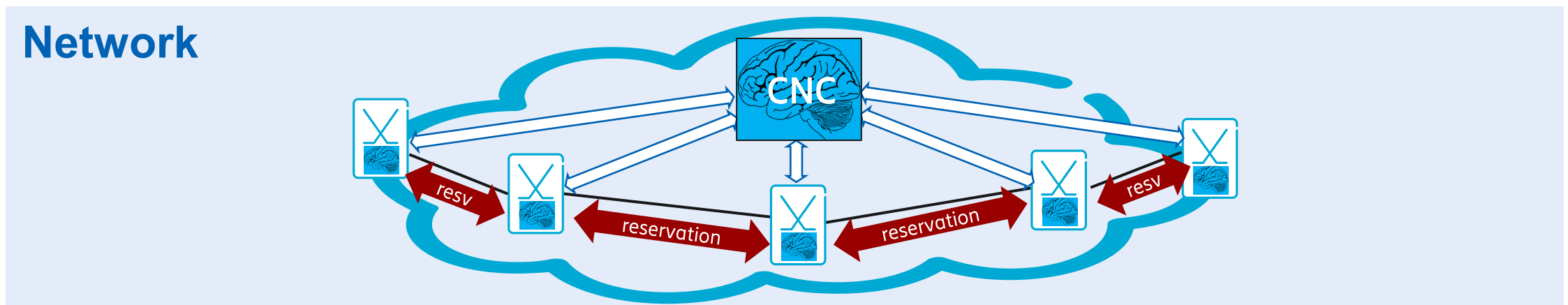
Network

Network Configuration Functions for Industrial Automation

- IEEE Std 802.1Qcc-2018: "The CNC uses remote management to discover physical topology, retrieve Bridge capabilities, and configure TSN features in each Bridge."

- **Fully centralized configuration**

Central Entity (CNC)
- Reservation
- Path Establishment (e.g., VLANs)
- Network Provisioning
- Topology Discovery

- **Centralized configuration with distributed reservation**

Central Entity (CNC)
- Reservation Schemes
- Path Establishment (e.g., TE-VLANs)
- Network Provisioning
- Topology Discovery

RAP   RAP   RAP   RAP
MVRP/xSTP   MVRP/xSTP   MVRP/xSTP   MVRP/xSTP

- RAP operates on VLAN context span by MVRP or Central Entity

- Central Entity configures RA Classes etc. and establishes reservation schemes for certain mechanisms, e.g., for Scheduled Traffic (.1Qbv)

Implementation Complexity for Network Configuration

- **Fully centralized configuration**

- **Bridges** (a number of)
  - LLDP
  - NETCONF/YANG
  - *Low entry level! Simple bridges*

- **Central Entity** (primary & hot standby)
  - Topology discovery
  - Provisioning
  - Path establishment
  - Reservation

- **Centralized configuration with distributed reservation**

- **Bridges** (a number of)
  - LLDP
  - NETCONF/YANG
  - MVRP (for non-TE-VLANs)
  - LRP
  - RAP
  - *High entry level! Each bridge must support RAP/LRP*

  implementation, test, and certification

- **Central Entity** (primary & hot standby)
  - Topology discovery
  - Provisioning
  - Path establishment
  - Reservation schemes

Benefits?

- **Fully centralized configuration**

  - Shaping

    - The CNC can leverage all shaping mechanisms supported by the devices

    - No additional work needed

  - Optimizations

    - The CNC can perform all kinds of optimizations including global optimizations for a TSN domain as the CNC has complete view of the entire TSN domain

    - Thus, the fully centralized approach is a lot more capable overall with simpler devices

- **Centralized configuration with distributed reservation**

  - Shaping

    - P802.1Qdd/D0.4 RAP does not yet support either shaping mechanism; all listed as todo in Annex Z

    - Contributions presented for some shapers (no CBS)

  - Optimizations

    - No domain-wide optimization available as the Central Entity is not aware of Stream details

    - The Token Bucket TSpec and the MSRP TSpec are not so much helpful for bridge internal "optimizations", e.g., a 5G logical bridge needs different parameters, see this presentation

Summary

- "Single point of failure" argument is **invalid** as both approaches include a Central Entity, even in case of the RAP approach when used for industrial automation

- Bridges are a lot simpler in case of the fully centralized configuration whereas each bridge must implement RAP and LRP for distributed reservation (on top of the features needed for centralized config)

- There is Central Entity in both configuration models (CNC as per IEEE Std 802.1Qcc-2018)

  - The Central Entity is involved in the same operations to some extent in both cases

  - The Central Entity in case of RAP provides the paths (e.g., VLAN) and the basis for reservation for Streams, which are Traffic Engineered in case of industrial automation

  - The Central Entity in the fully centralized case goes beyond by performing the reservations as well

  - The difference is not a big deal as the Central Entity is capable anyways

- Lot more optimizations – incl. global optimizations – are possible in case of the fully centralized model

- All, including *Plug & Produce* and dynamic addition and removal of Streams are provided by the fully centralized configuration, which is more capable overall with simpler devices

Thank You!