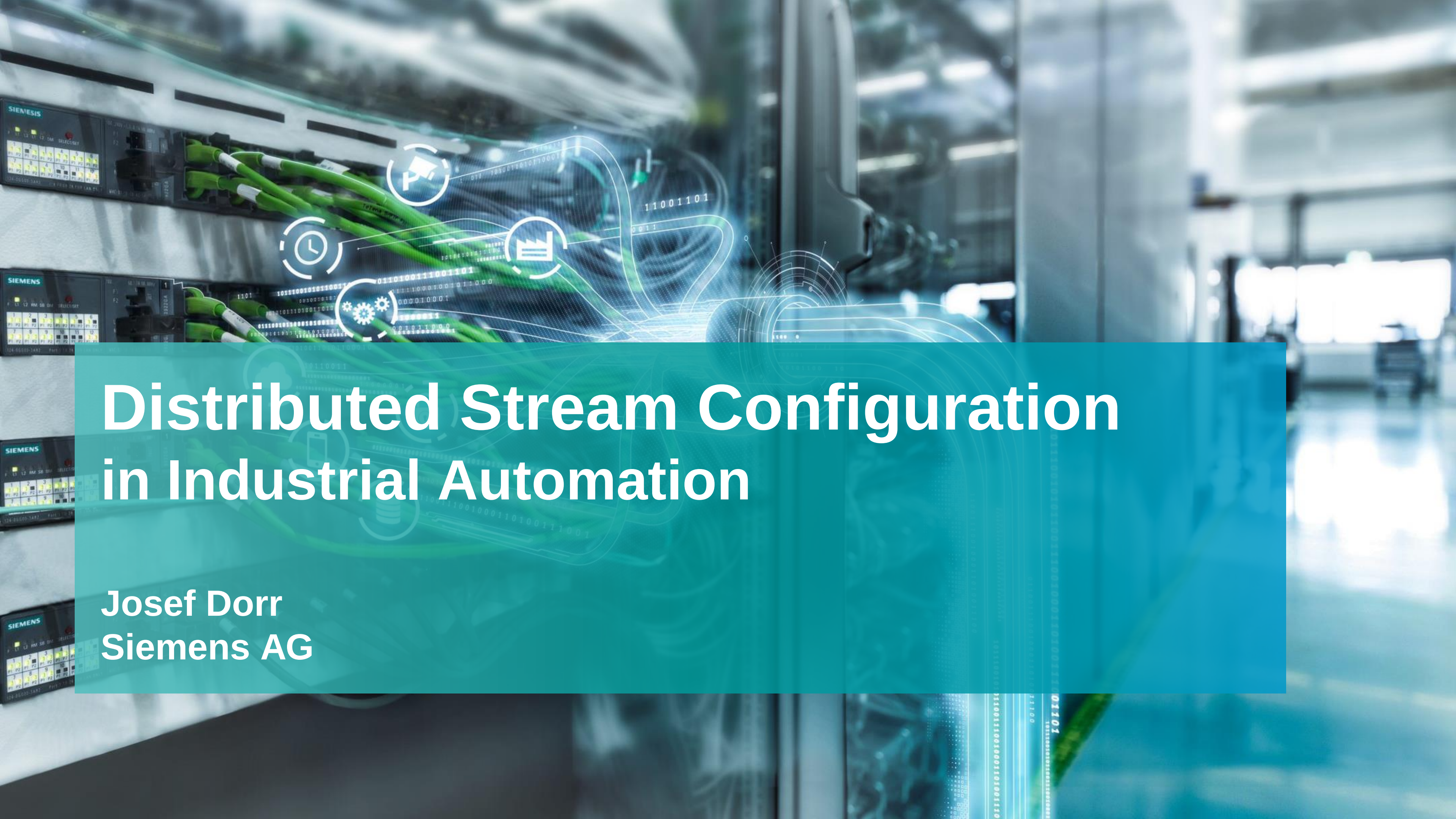

# Distributed Stream Configuration in Industrial Automation


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# Status Quo - Configuration Model Selection in P60802

There have been several contributions covering: Coexistence, Convergence, Intercommunication, Gaps, … of TSN configuration models

- 60802-stanica-convergence-coexistence-0718-v03.pptx — *Coexistence of the TSN configuration models*
- 60802-Hantel-TSN-Interdomain-Communications-0718.pdf — *Interdomain – Fully Distributed Requirements*
- 60802-Steindl-ConfigurationModelAlignment-0918-v02.pdf — *Configuration Model Alignment*
- 60802-chen-TSN-management-0119-v00.pdf — *Alignment to current cnfiguration considerations*

Therein all models (distributed, centralized, hybrid) are considered relevant

→ **All models are optional in Profile Draft D1-0**

| | | | | | |
|---|---|---|---|---|---|
| B-Q-10 | Does the Bridge support MSRP per IEEE802.1Q 5.4.4 and Table 9? | O | **6.2.1.1**Table 9 | Yes [ ] | No [ ] |
| | | | | | |
| B-Q-14 | Does the Bridge support IEEE802.1Qcc-2018 per Table 10? | O | Table 10 | Yes [ ] | No [ ] |
| B-Q-15 | Does the Bridge support IEEE P802.1Qdd per Table 10? | O | Table 10 | Yes [ ] | No [ ] |

# Criteria to select configuration options

**All configuration approaches have pros and cons.**

**What are criteria to be considered for the selection of a configuration option in Industrial Automation?**

- All relevant Use Cases have to be fulfilled.
- Support of:
  (1) Convergence of multiple time sensitive applications
  (2) Latency and availability (QoS) of different levels
  (3) Dynamic stream (re-)establishment
  (4) Abstract network interface (UNI) for stream establishment
  (5) Bandwidth utilization / throughput
  (6) Scalabity from entry level to high end

This contribution provides considerations about the **distributed configuration** approach only!

# Distributed Stream Configuration in Industrial Automation

(1) Workflow of Distributed Stream Configuration

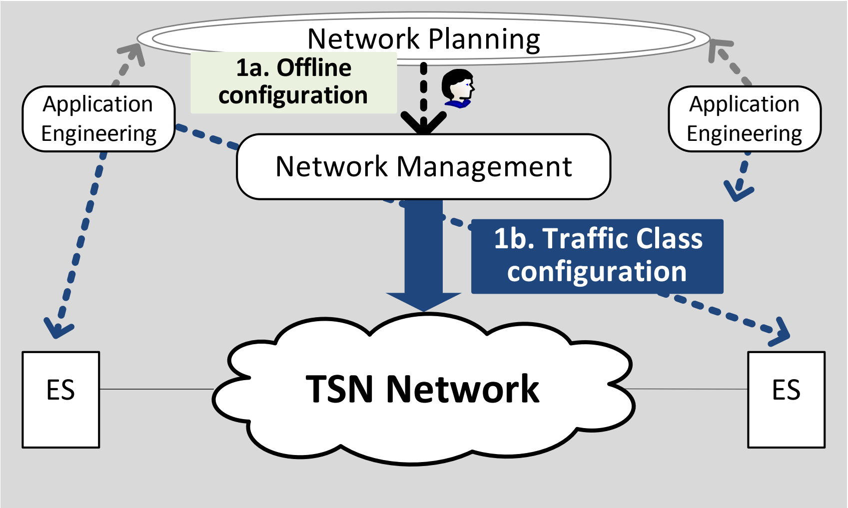
(2) LRP/RAP enhancements for Distributed Stream Configuration

(3) Summary of selection criteria contributions of Distributed Stream Configuration

# Workflow of distributed configuration (1)

## Step 1: Network planning and engineering

- End-station / application requirements determine network planning
- Network layout and setup can be configured offline
- Multiple managed (e.g. by profile or policy) Traffic Classes for streams with different QoS requirements are configured in the bridges of the network




→ A **convergent** TSN network is established for

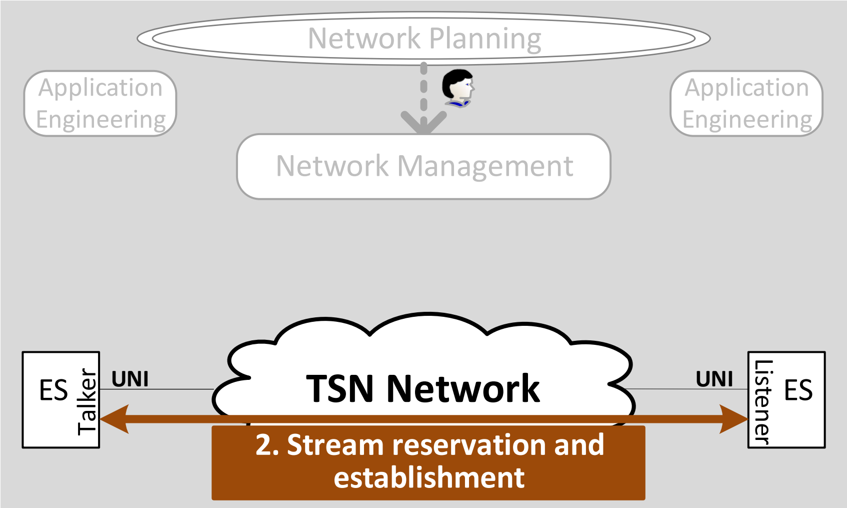
- multiple time sensitive applications
- with different latency and availability (QoS) requirements

- Applications are configured by Application Engineering

# Workflow of distributed configuration (2)

## Step 2: Stream reservation and establishment (a)

- Streams are characterized by
  - unique StreamID (control), and
  - unique StreamDA (per VLAN), and
  - TSpec (MaxFrameSize, MaxIntervalFrames, ...)
- Talker-UNI: Periodic Talker attribute declaration;
  - Peer-to-peer attribute **propagation with accumulated max latency per hop** (in accordance to the traffic selection algorithm assigned by management) on an active loop free topology.
- Listener-UNI: Periodic Listener attribute declaration;
  - Peer-to-peer attribute propagation back to the talker defines the stream path with **bandwidth and resource control per hop**.




- Lifetime control by periodic attribute refresh.
- Diagnostic information for end-stations and bridges.

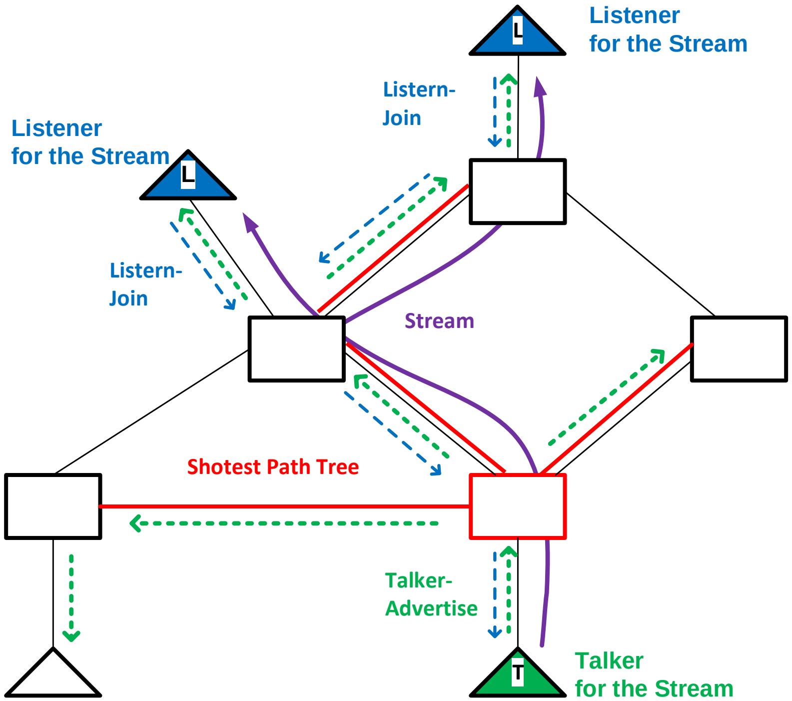
# Workflow of distributed configuration (3)

## Step 2: Stream reservation and establishment (b)

- New **attached end-stations** get stream class information from the network (domain attribute), can check and adapt to it.
  - New Talkers acquire unique StreamID / StreamDA and declare Talker advertise attribute
  - New Listeners acquire StreamID by e.g. higher layer protocol and declare Listener join attribute
- Streams of **removed** end-stations are released after the refresh timeout expired (if not actively removed)

→ Dynamic (ad hoc) stream establishment/release without network/traffic impact on established streams is built-in

- New **attached bridges** get stream class information from the network (domain attribute), expand the TSN domain if suitably configured.

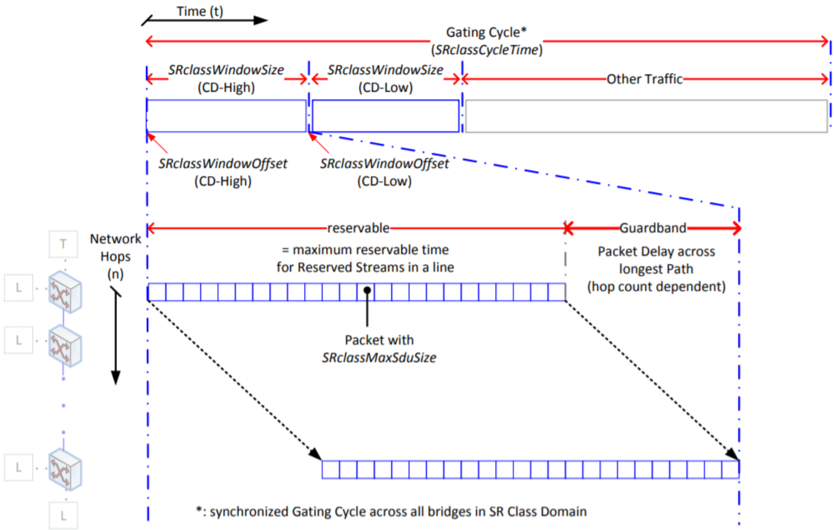



*See e.g. UC21: Dynamic plugging and unplugging of machines (subnets), or*
*UC27 DCS device level reconfiguration*

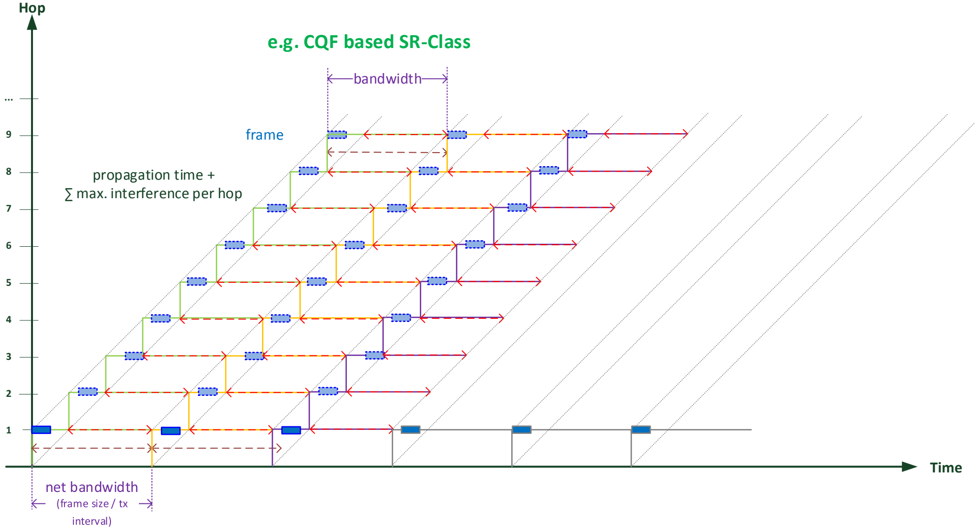
# LRP/RAP enhancements for Distributed Stream Configuration (1)

- all **IEEE 802.1 queuing/transmission selections** can be combined with distributed stream reservation *for e.g UC02: Isochronous Control Loops with guaranteed low latency*

*E.g. Reservation combined with TAS*




*e.g. Reservation combined with CQF, …*



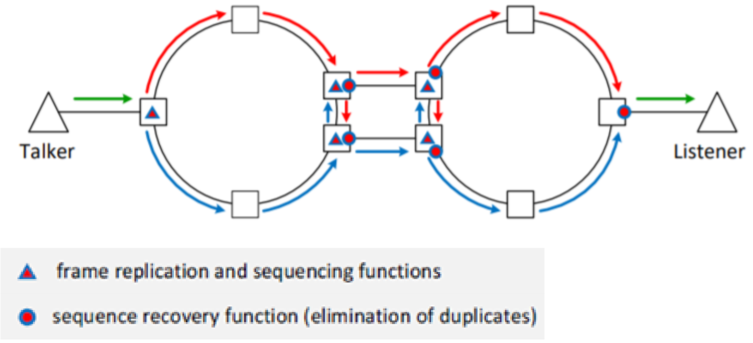

*See also* [*http://www.ieee802.org/1/files/public/docs2018/liaision-LNI40-Testbed-TSN-0918-v00.pdf*](http://www.ieee802.org/1/files/public/docs2018/liaision-LNI40-Testbed-TSN-0918-v00.pdf)

# LRP/RAP enhancements for Distributed Stream Configuration (2)

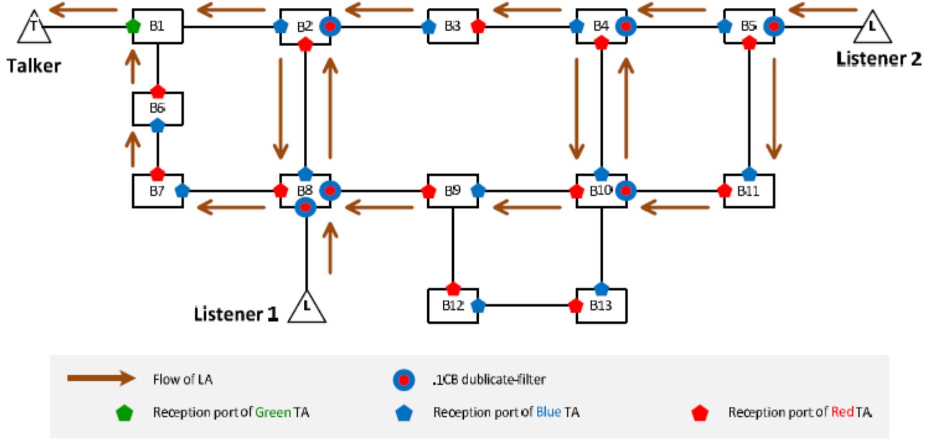
- stream transmission over **redundant paths** (e.g. 802.1CB FRER) can be combined with distributed stream reservation

  *See UC07: Redundant networks*

*with "autoconfig" in constrained topologies, or*



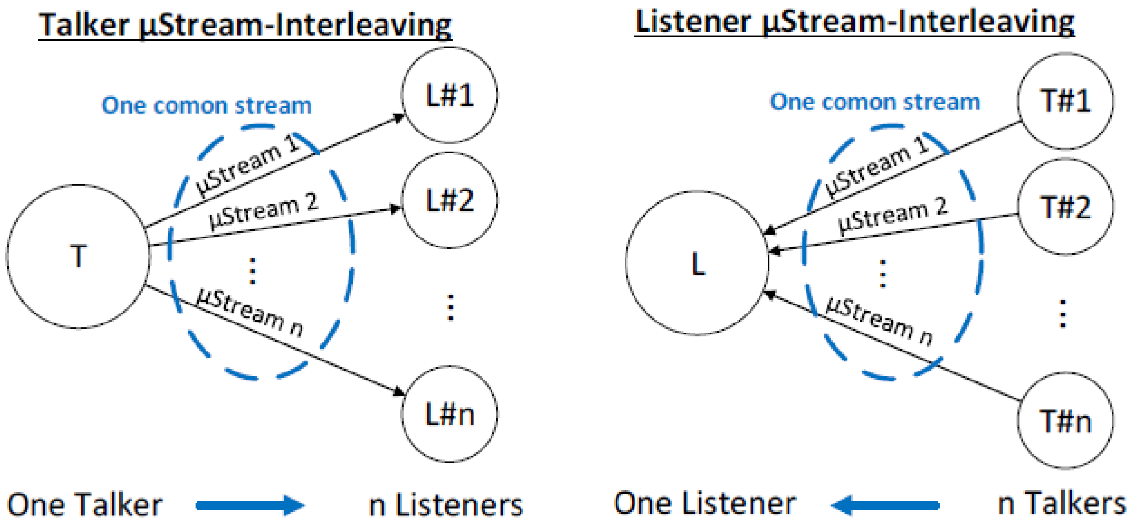

*ISIS-PCR based in any meshed network*




See *http://www.ieee802.org/1/files/public/docs2017/new-chen-RAP-white-paper-update-1117-v02.pdf*

# LRP/RAP enhancements for Distributed Stream Configuration (4)

- improved bandwidth utilization by Aggregation: combines multiple µStreams into one common Stream
  *See UC17: Machine to Machine/Controller to Controller Communication, e.g. with Supervisory PLC*



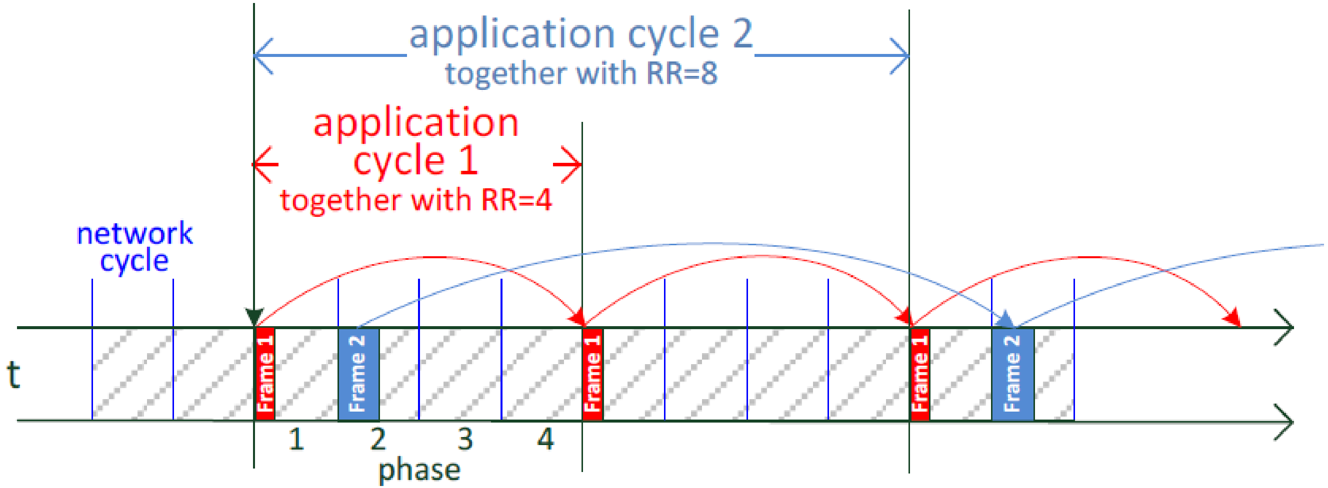

See: http://www.ieee802.org/1/files/public/docs2019/dd-chen-flow-aggregation-0119-v03.pdf

# Additional LRP/RAP enhancement required for Distributed Stream Configuration (5)

- improved bandwidth utilization by ReductionRatio for application cycle times of $2^{\wedge n}$ * network cycle time

  *See UC4: Reduction Ratio of network cycle or*
  *UC06: Drives without common application cycle but common network cycle*

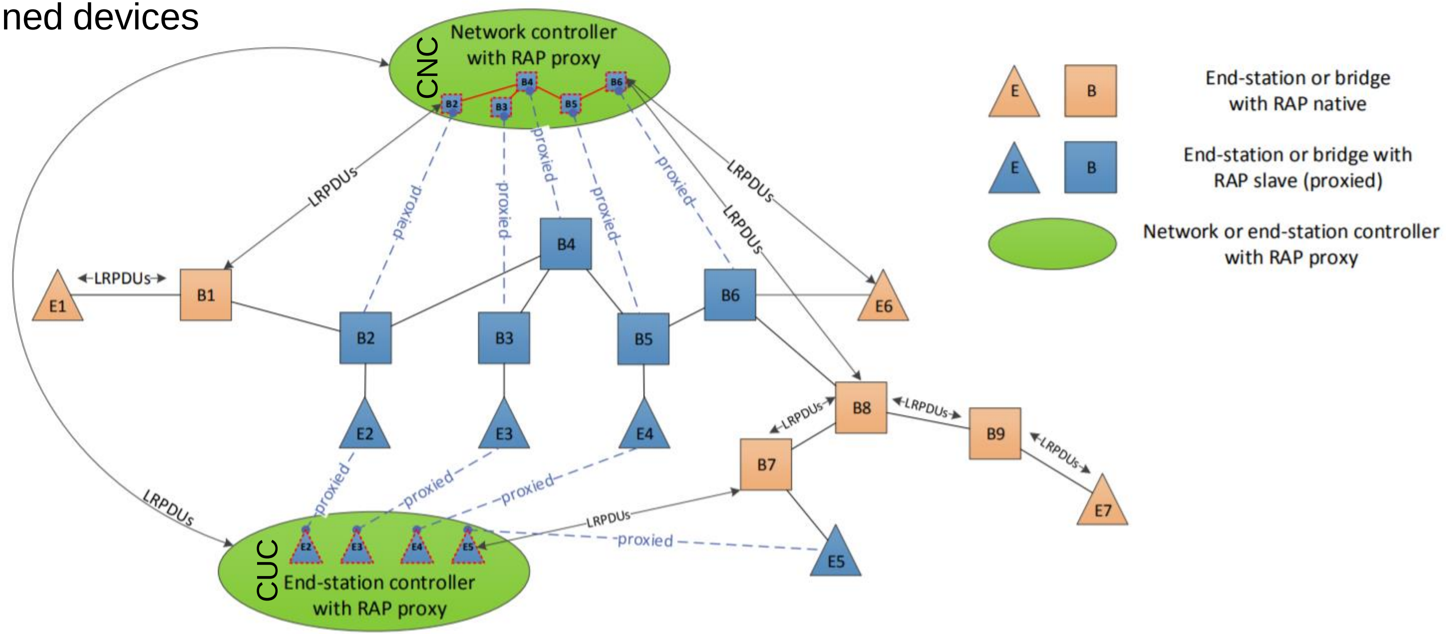
  **Requires RR and Phase as additional information in the TSpec!**




See: http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0918-v13.pdf

# LRP/RAP enhancements for Distributed Stream Configuration (6)

- **proxying capabilities** can be combined with distributed stream reservation to support
  - Centralized components (CUC/CNC)
  - Constrained devices




*See http://www.ieee802.org/1/files/public/docs2018/cs-chen-RAP-LRP-interaction-0918-v01.pdf and http://www.ieee802.org/1/files/public/docs2018/dd-finn-RAP-LRP-MSRP-Qcc-0918-v03.pdf*

# Summary of selection criteria contributions for Distributed Stream Configuration

(1) Convergent TSN networks are designed by network planning and established by network management.

(2) Latency and availability requirements of different Traffic Types are included in network planning and management.

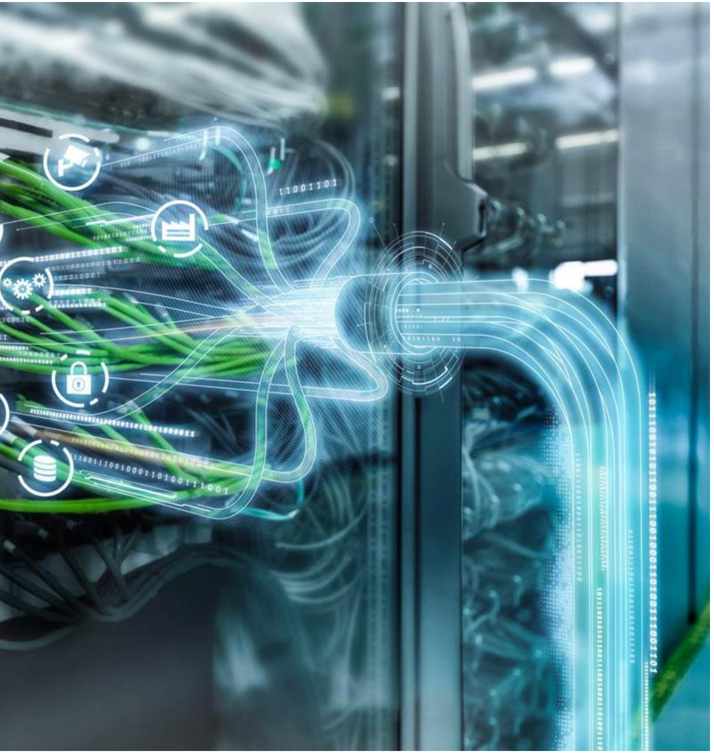
(3) Dynamic (ad hoc) stream establishment/release without network/traffic impact on established streams is built-in.

(4) Talker-/Listener UNI serve as abstract User Network Interface for stream reservation with QoS properties.

(5) Efficient use of bandwidth, i.e. high number of reservable streams with given QoS is achieved by
- IEEE 802.1 traffic queuing/selection mechanisms, and
- aggregation / reduction ratio
- even with mixed link speeds.

(6) Scalabity is given from entry level to high end:
- from constrained to meshed topologies – including FRER support
- from constrained to non-constrained devices – with proxying as an option
- bounded latency can be guaranteed independent of chosen topology – with traffic shaping
- expandable to layer 3 support

# Thank You



Questions?