Control Plane Extensions for Wireless-Aware Traffic Engineering

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Background

- Former contributions to P802.1Qdj on support for wireless
  - "Configuration Enhancements for 5G as TSN Bridge" https://www.ieee802.org/1/files/public/docs2020/dj-farkas-configuration-enhancements-for-5G-0920-v01.pdf
  - "Configuration Enhancements for Wireless TSN" https://www.ieee802.org/1/files/public/docs2021/dj-seewald-wireless-tsn-0721-v01.pdf
  - *These contributions were not considered in P802.1Qdj for wireless being out of scope*

- Recent contribution on adding support for wireless
  - "Control Plane Extensions for Wireless-Aware Traffic Engineering with Corresponding YANG Data Models" https://www.ieee802.org/1/files/public/docs2024/new-duerr-control-plane-extensions-and-YANG-for-wireless-aware-TE-0924-v01.pdf
  - "Control Plane Extensions for Wireless-Aware Traffic Engineering" https://www.ieee802.org/1/files/public/docs2025/new-farkas-control-plane-extensions-for-wireless-aware-TE-0225-v01.pdf

Recap: Nodal Representation

- From outside, a Domain / Region often appears as a network node, e.g., MST Region, see IEEE Std 802.1Q

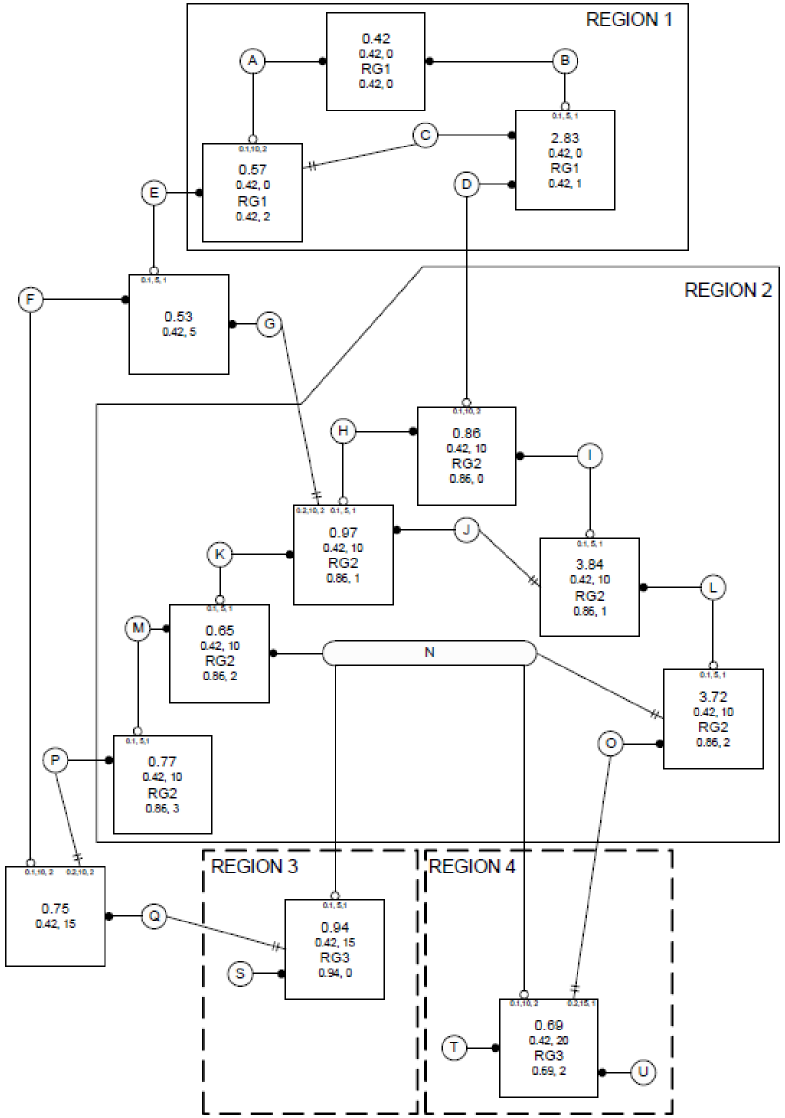
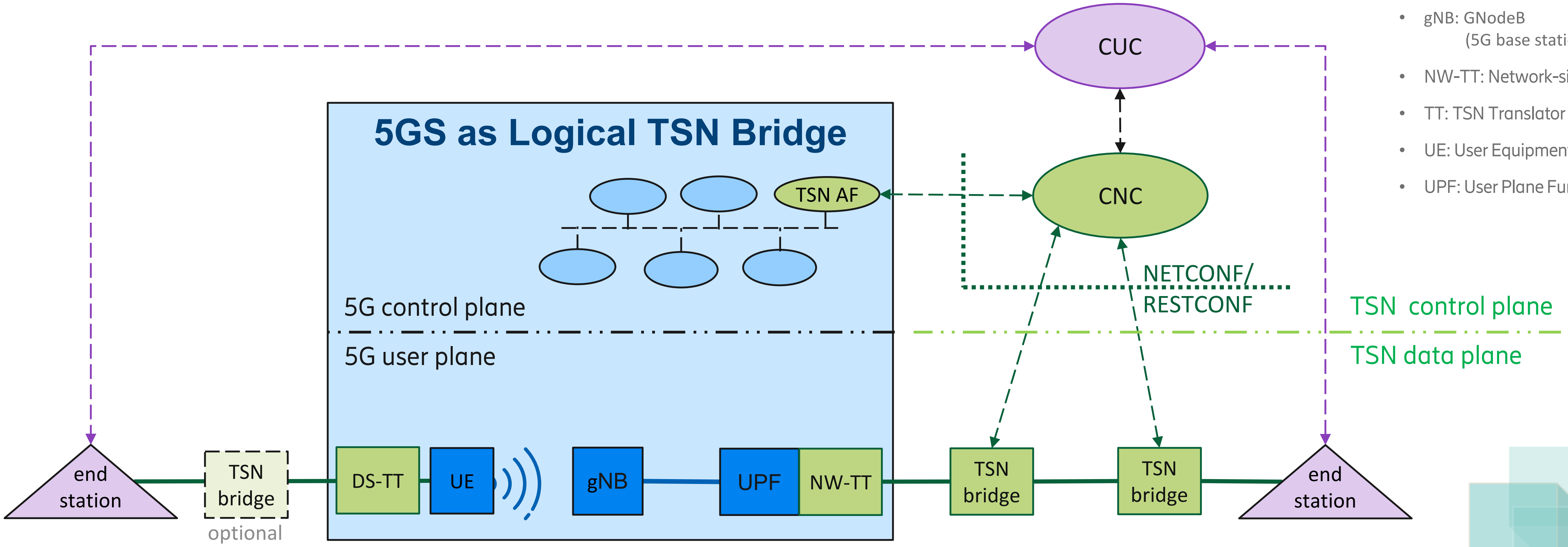


Figure 13-7—CIST Priority Vectors, Port Roles, and MST Regions

Recap: 5G as Logical TSN Bridge

- As per 3GPP standards, the 5G System (5GS) acts as a logical (virtual) TSN bridge

- AF: Application Function
- DS-TT: Device-Side TT
- gNB: GNodeB (5G base station)
- NW-TT: Network-side TT
- TT: TSN Translator
- UE: User Equipment
- UPF: User Plane Function



Recap: Bridge Delay

- "Each set of Bridge Delay attributes is accessed using three indices: **ingress Port**, **egress Port**, and **traffic class**."
- "The delays represent the **worst-case range per the design of the Bridge**, and are **not measured**."

Table 12-38—Bridge Delay attributes

Name	Data type	Operations supported[a]	Conformance[b]	References
independentDelayMin	unsigned integer	R	B	12.32.1.1
independentDelayMax	unsigned integer	R	B	12.32.1.1
dependentDelayMin	unsigned integer	R	B	12.32.1.2
dependentDelayMax	unsigned integer	R	B	12.32.1.2

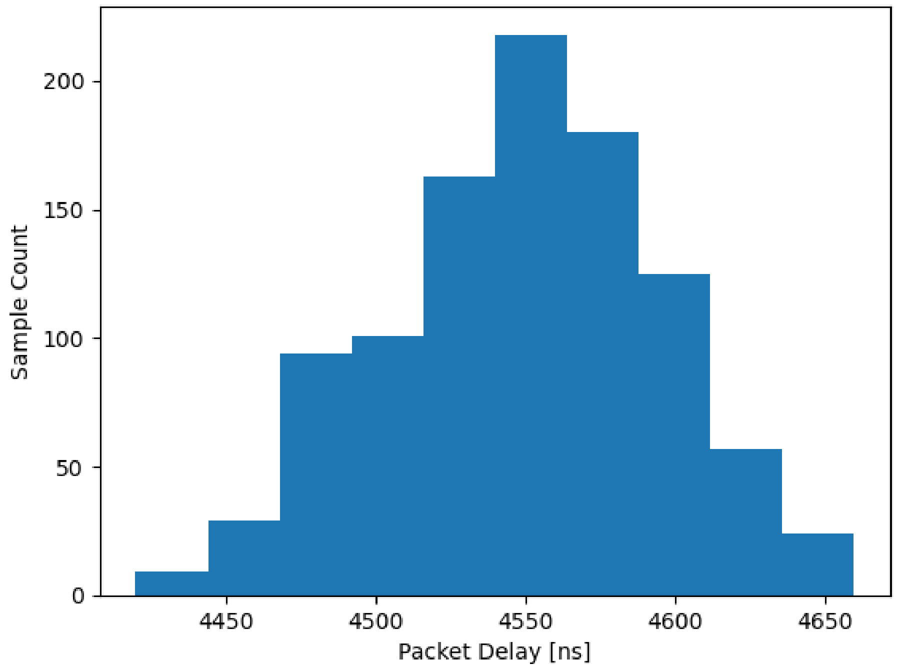
[a] R = Read only access; RW = Read/Write access.
[b] B = Required for Bridge or Bridge component support of Stream reservation remote management; b = Optional for Bridge or Bridge component support of Stream reservation remote management.

[IEEE Std 802.1Q 2022]

The Challenge: Wireline vs Wireless

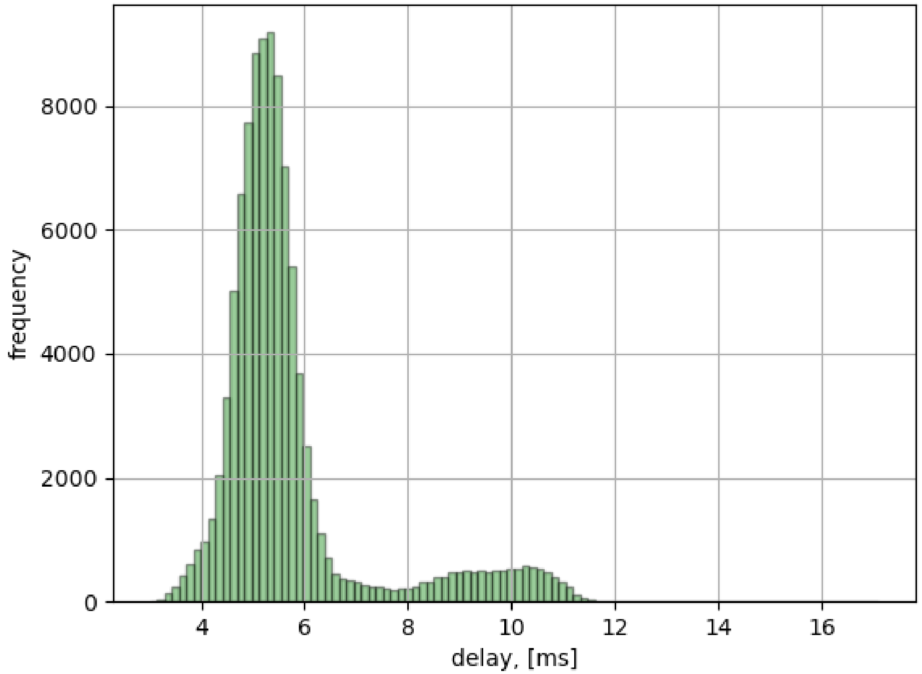
- Ignoring the differences between wireline and wireless characteristics makes Traffic Engineering (e.g., scheduling) very difficult and inefficient in heterogeneous deployments

Wireline Bridge



vs

5GS Virtual Bridge

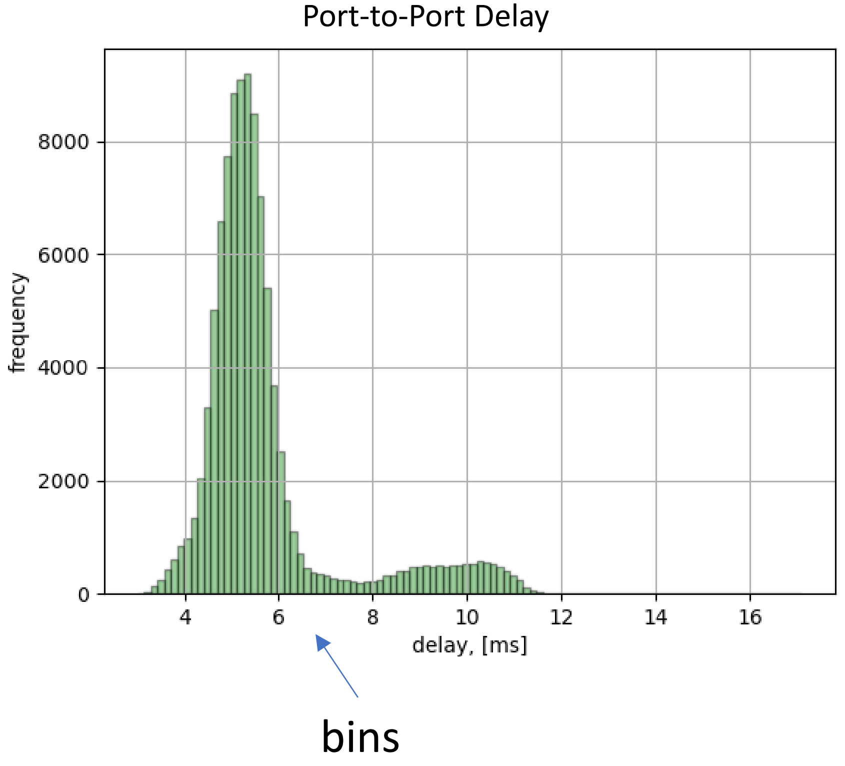


Delay data from measurements: https://github.com/DETERMINISTIC6G/deterministic6g_data

A Solution: Extend Bridge Delay to Histogram

- Extending Bridge Delay to a histogram (instead of the current min and max values) enables capturing wireless characteristics in a chosen granularity in support of Traffic Engineering

```
grouping delay-histogram {
    description "Delay histogram";
    leaf start {
        type uint64;
        description
            "The start value of the first bin in nano-seconds.
            If not specified, the first bin starts at 0.";
    }
    leaf bin-count {
        type uint32;
        mandatory true;
        description "Number of bins.";
    }
    list bin {
        description "Bins of histogram.";
        key index;
        leaf index {
            type uint32;
            mandatory true;
            description "The index of this bin.";
        }
        leaf width {
            type uint64;
            mandatory true;
            description "The width of this bin in nano-seconds.";
        }
        leaf count {
            type uint32;
            mandatory true;
            description "Count of values in this bin.";
        }
    }
```



Proposal

- Start a new project to amend the Bridge Delay attributes in IEEE 802.1Q
- The amendment could introduce histogram for Bridge Delay attributes
- This would enable exposing wireless characteristics, e.g., to CNC
- This would enable more efficient Traffic Engineering, i.e., save resources and energy
- This might be beneficial for some non-wireless use cases as well

Proposal – cont'd

- Proposed motion:
  - 802.1 authorizes the TSN TG to generate PAR and CSD at the May 2025 interim session for pre-circulation to the EC for an amendment to IEEE 802.1Q allowing bridged networks to support LANs with more uncertain delays than those of point-to-point wireline MAC technologies.

Further References

- Delay measurements of virtual TSN bridge (documentation and data):
  - D4.2: Latency measurement framework https://deterministic6g.eu/images/deliverables/DETERMINISTIC6G-D4.2_v1.0.pdf
  - Github: https://github.com/DETERMINISTIC6G/deterministic6g_data
- Wireless-friendly scheduling
  - D3.4: Report on Optimized Deterministic End-to-End Schedules for Dynamic Systems, https://deterministic6g.eu/images/deliverables/DETERMINISTIC6G-D3.4-v1.0.pdf
  - Contact authors for more information: simon.egger@ipvs.uni-stuttgart.de
- YANG models, NETCONF integration (files and documentation)
  - D3.4: Report on Optimized Deterministic End-to-End Schedules for Dynamic Systems, https://deterministic6g.eu/images/deliverables/DETERMINISTIC6G-D3.4-v1.0.pdf
  - Github: https://github.com/DETERMINISTIC6G/deterministic6g_yang_models

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