



# TSN Basic Concepts

DetNet – TSN workshop

# Before We Start – Disclaimer



- This presentation should be considered as the personal views of the presenter not as a formal position, explanation, or interpretation of IEEE.
- Per IEEE-SA Standards Board Bylaws, December 2017
  - “At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.”

# Outline



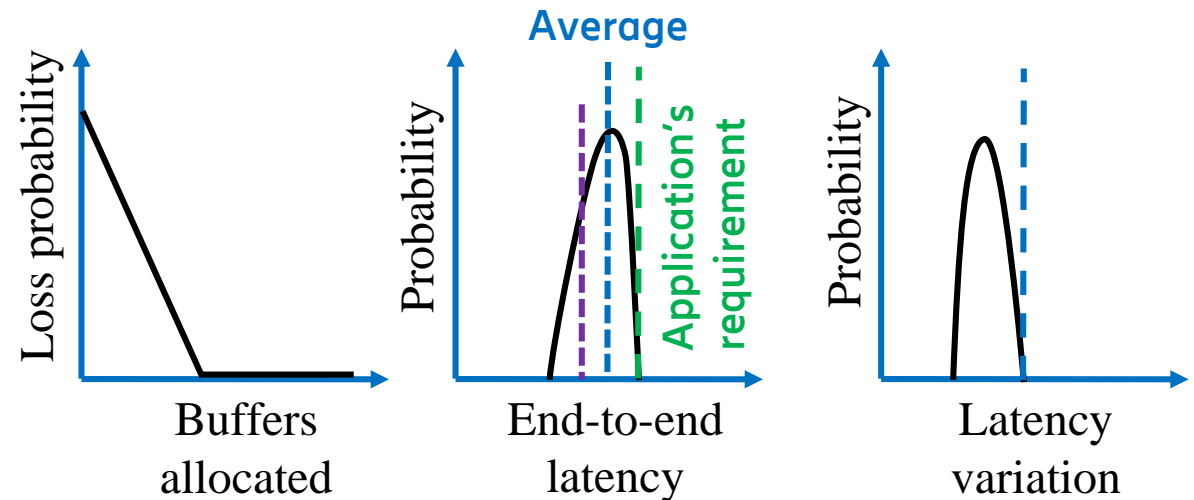
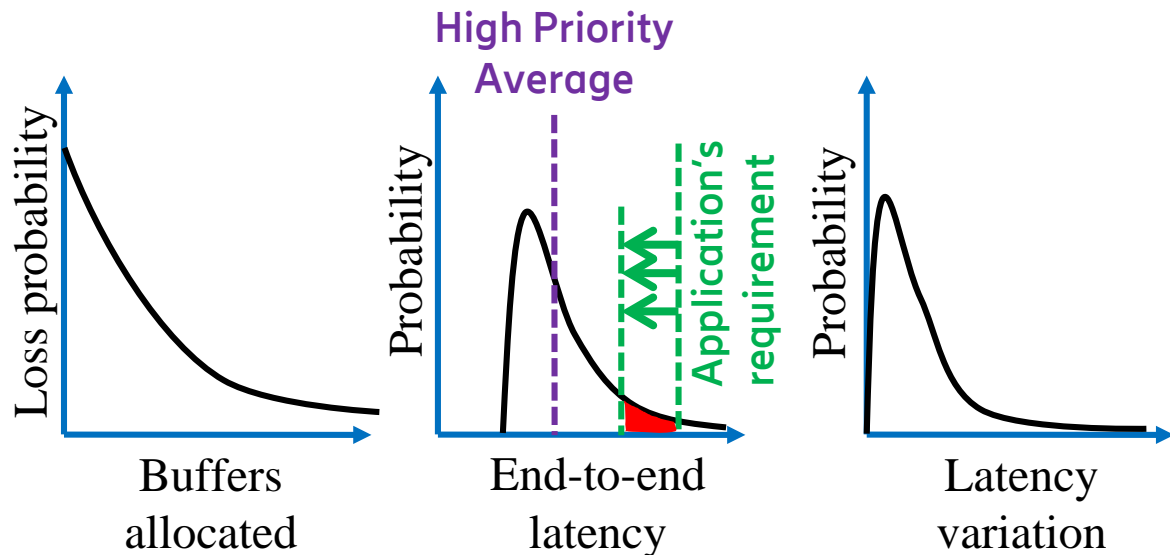
- Deterministic service
- TSN tools overview
- Basic terms
- Bridging basics
- Quality of Service
- High availability / ultra reliability
- Explicit routes
- Configuration

# We Are Interested in Deterministic Service



- Traditional Service
  - Curves have long tail
  - Average latency is good
  - Lowering the latency means losing packets (or overprovisioning)

- Deterministic Service
  - Packet loss is at most due to equipment failure (zero congestion loss)
  - Bounded latency, no tails
  - The right packet at the right time



# IEEE 802.1 TSN Tools Overview



## TSN Components Common Standards

Synchronization

Reliability

Latency

Resource Mgmt

Zero congestion loss

### Time synchronization:

Timing and Synchronization (802.1AS)  
includes a profile of IEEE 1588  
(revision ongoing: P802.1AS-Rev)

### Ultra reliability:

Frame Replication and Elimination (802.1CB)  
Path Control and Reservation (802.1Qca)  
Per-Stream Filtering and Policing (802.1Qci)  
Reliability for time sync (P802.1AS-Rev)

### Bounded low latency:

Credit Based Shaper (802.1Qav)  
Frame preemption (802.3br & 802.1Qbu)  
Scheduled Traffic (802.1Qbv)  
Cyclic Queuing and Forwarding (802.1Qch)  
Asynchronous Traffic Shaping (P802.1Qcr)  
QoS Provisions (P802.1DC)

### Dedicated resources & API

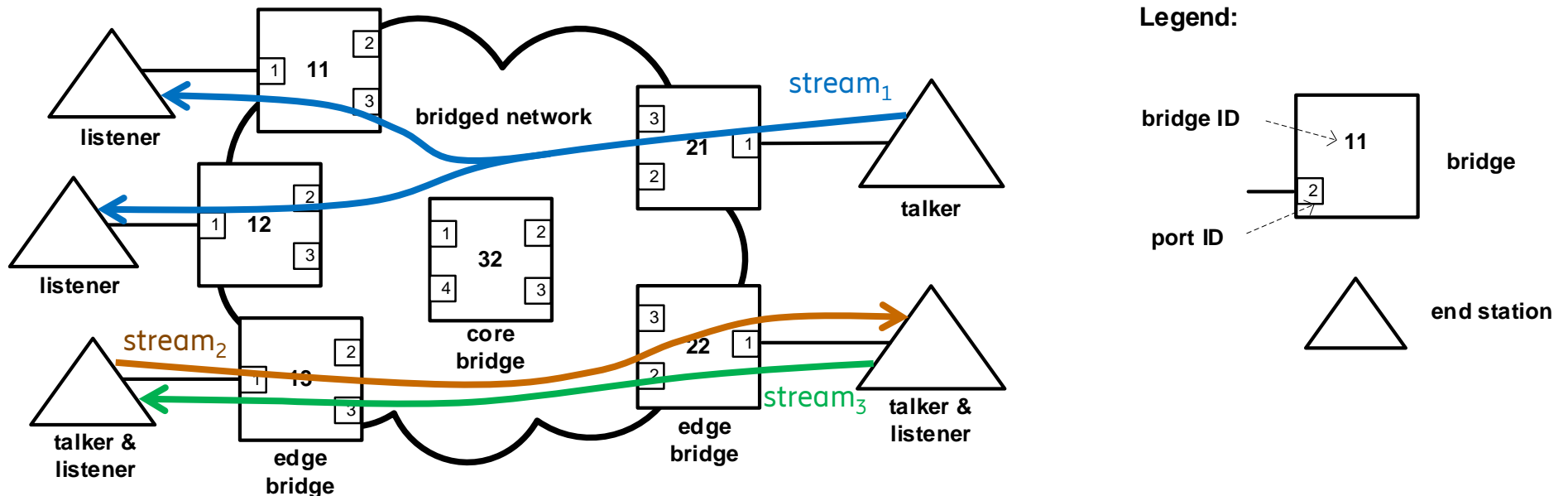
Stream Reservation Protocol (802.1Qat)  
TSN configuration (802.1Qcc)  
Basic YANG (802.1Qcp)  
Link-local Registration Protocol (P802.1CS)  
Resource Allocation Protocol (P802.1Qdd)  
YANG for CFM (P802.1Qcx)  
YANG for LLDP (P802.1ABcu)  
YANG for Qbv, Qbu, and Qci (P802.1Qcw)  
YANG & MIB for FRER (P802.1CBcv)  
Extended Stream Identification (P802.1CBdb)

Note: P upfront of an ID indicates ongoing Project

# Basic Components

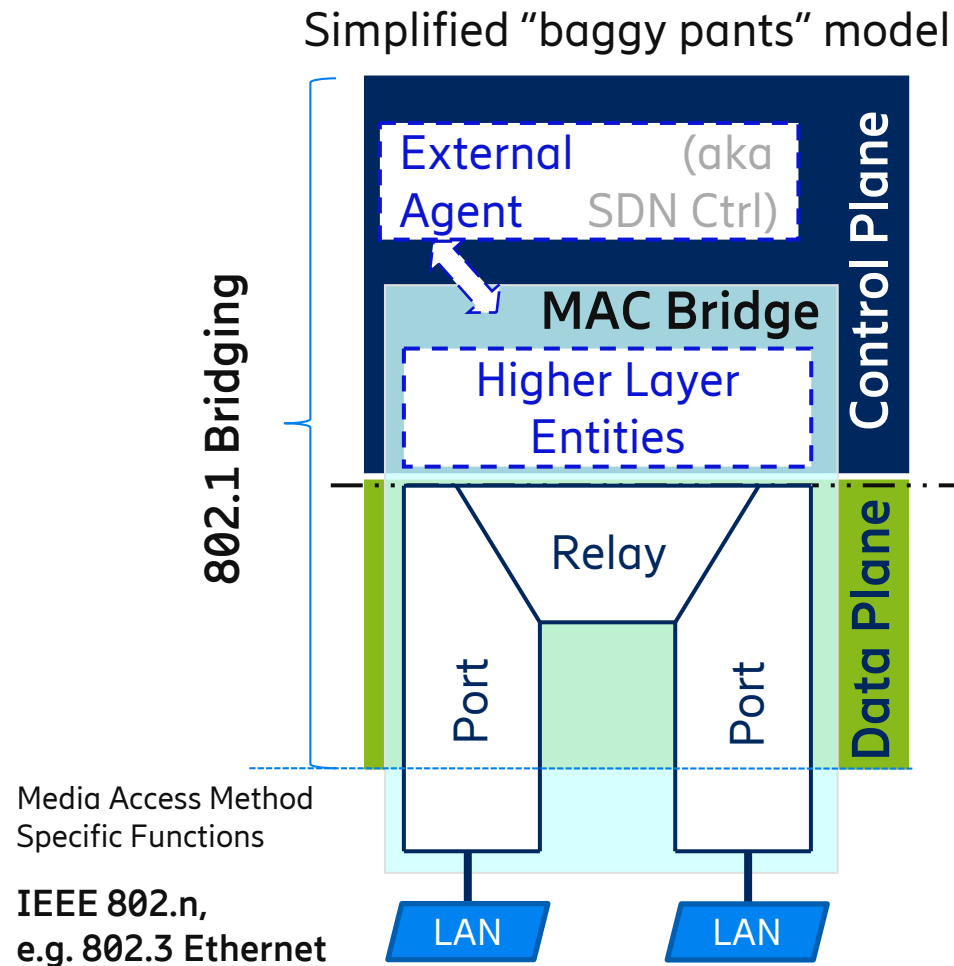


- From IEEE 802.1 perspective, the world is divided into two types of devices: bridges and end stations
- Talker: The end station that is the source or producer of a stream
- Listener: The end station that is the destination, receiver, or consumer of a stream
- Stream: A unidirectional flow of data from a Talker to one or more Listeners
- Bridge: see next slides



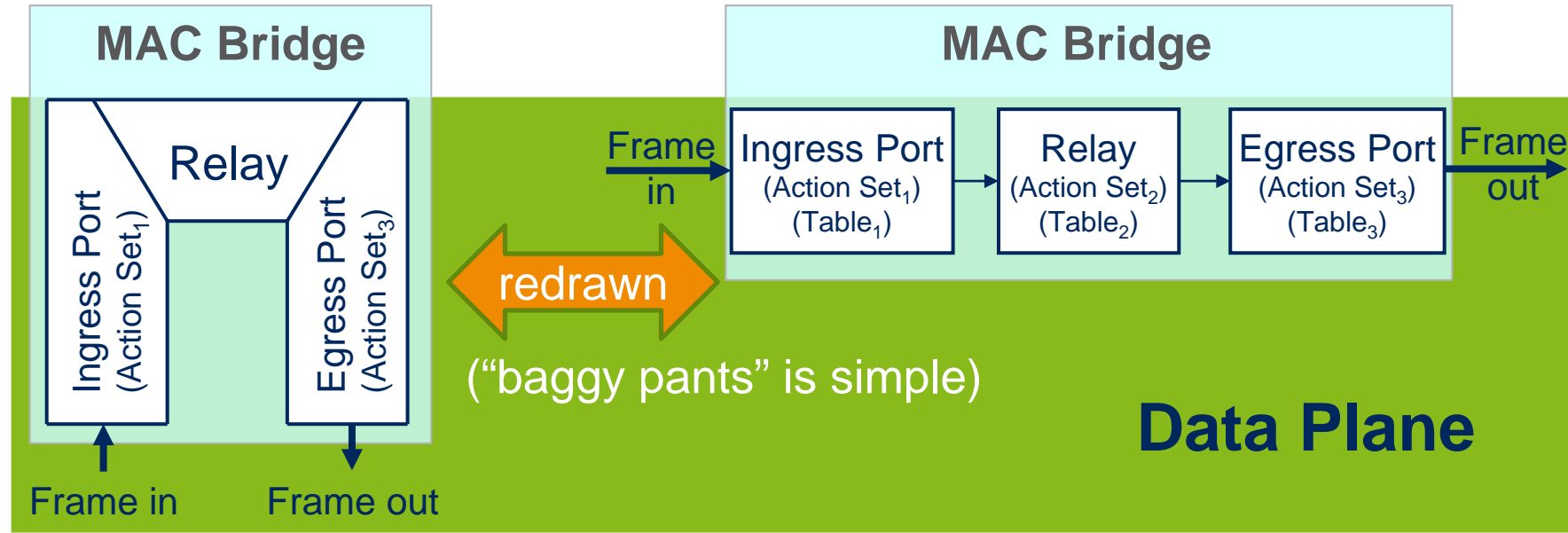
# Bridge Architecture

## Control Plane Separated from Data Plane



- Control protocols are implemented as Higher Layer Entities
- External Agent (SDN Controller) may provide control instead of the distributed protocols
- The data plane is comprised of
  - A MAC Relay and
  - At least two ports

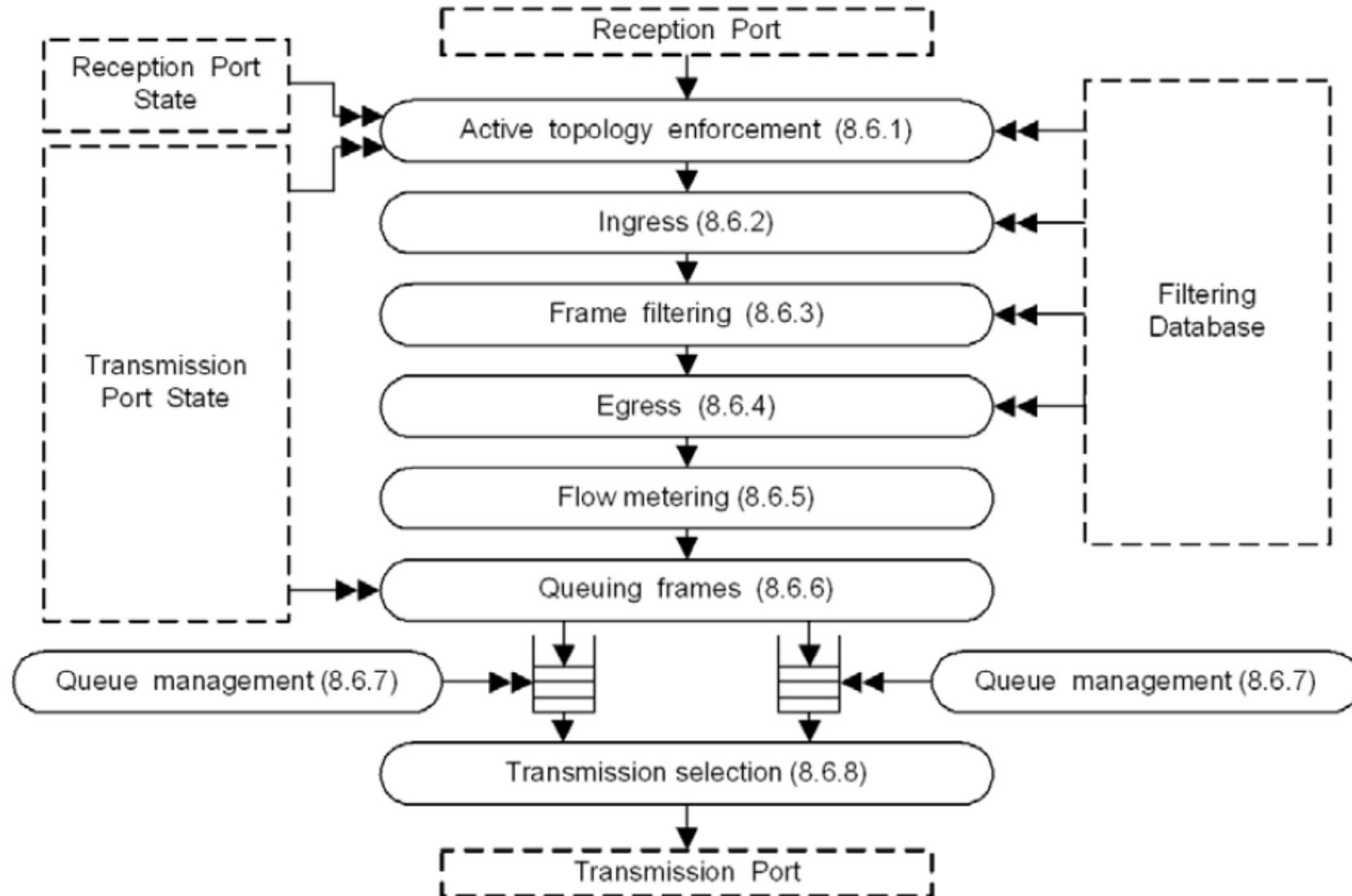
# Bridge Data Plane Actions



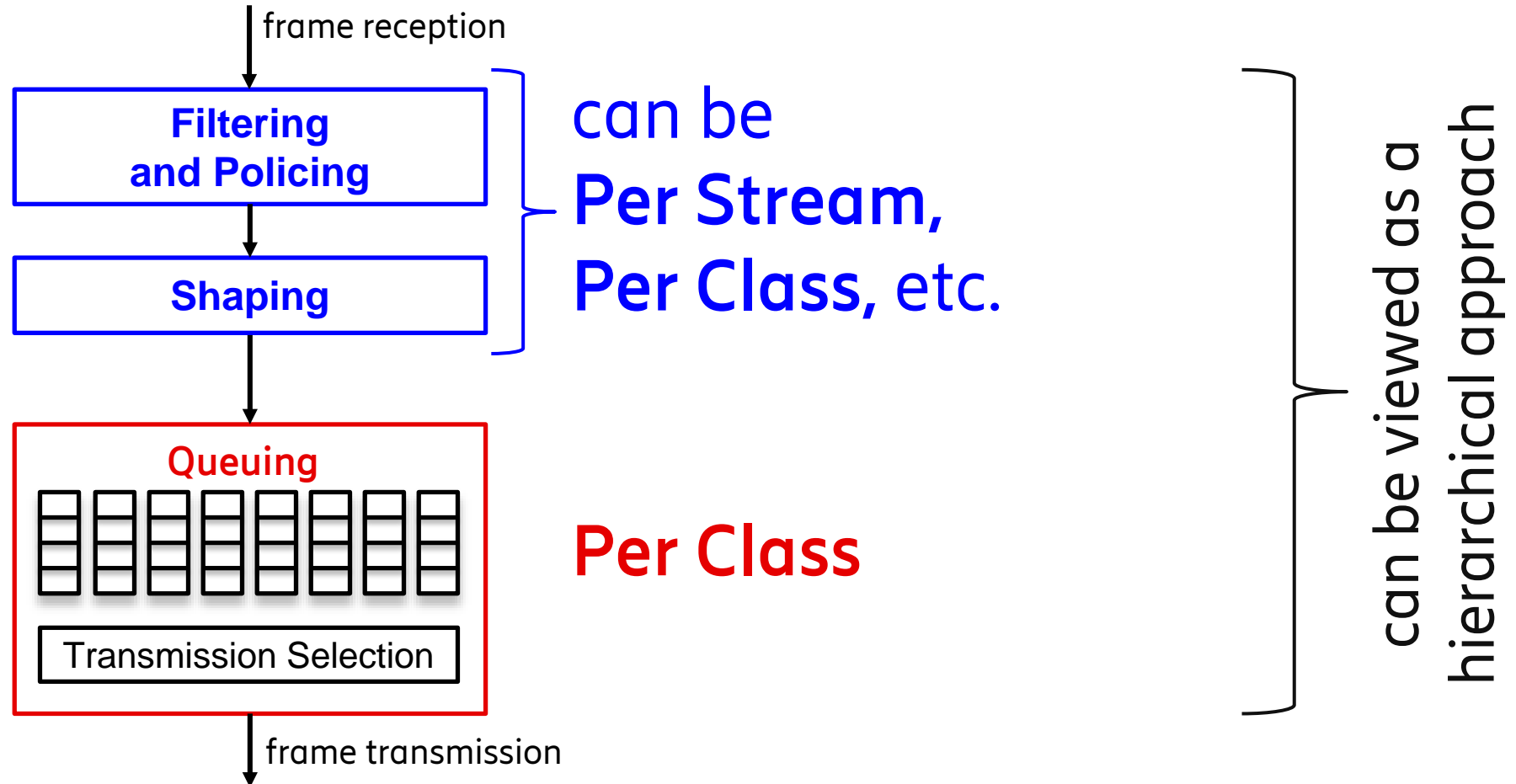
- Ingress Port (Action Set<sub>1</sub>)
  - Filtering (drop), (un)tagging, VID translation, de/en-capsulation
- Relay (Action Set<sub>2</sub>)
  - Forwarding, filtering
- Egress Port (Action Set<sub>3</sub>)
  - Filtering, (un)tagging, VID translation, de/en-capsulation, metering, queuing, transmission selection



# Bridge Forwarding Process

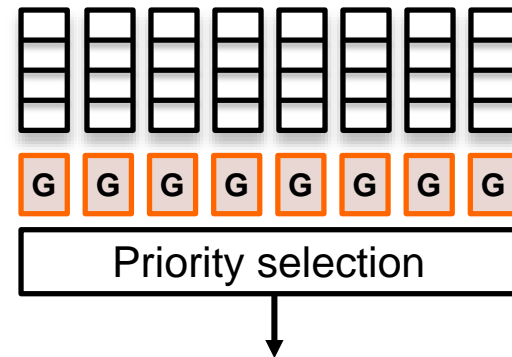
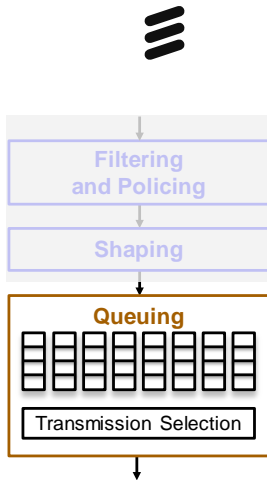


# Illustration of QoS Functions



# Scheduled Traffic (802.1Qbv)

- Reduces latency variation for frames with known timing
- Time-based control and programming of the bridge queues
- Time-Gated queues
- Gate (G): **Open** or **Closed**
- Periodically repeated time schedule
- Time synchronization is needed



frame transmitted:  
critical / non-critical

gate(s) for  
non-critical traffic

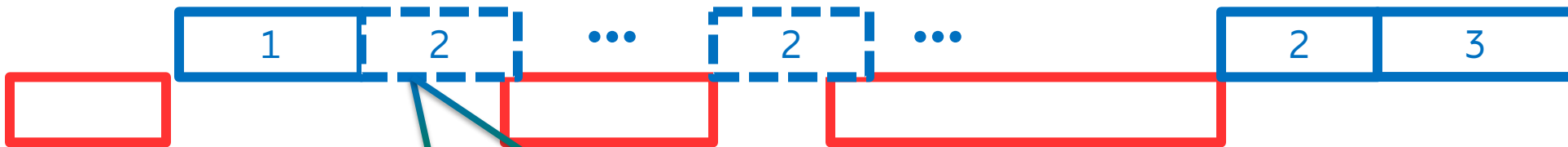
Note: gate of non-critical data can be closed in advance to protect critical data

# Frame Preemption (802.3br and 802.1Qbu)

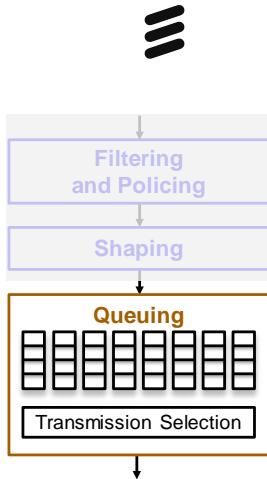
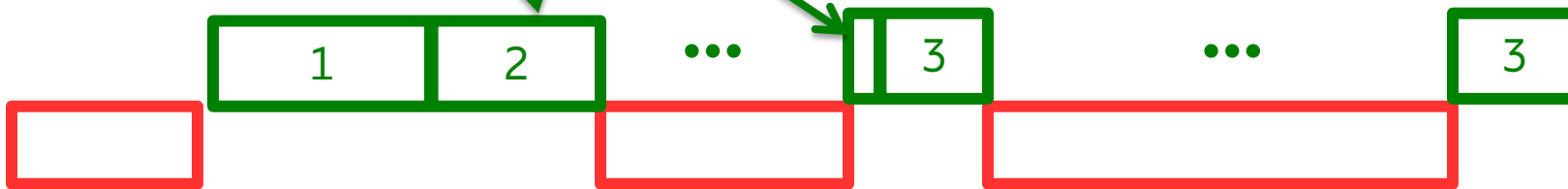
- **Express** frames suspend the transmission of **preemptable** frames
  - Decrease delay variation for **express**, increase bandwidth for **preemptable**
  - It is link local per hop, i.e., it is not IP fragmentation
- Scheduled **rocks of critical packets** in each cycle:



- Conflict excessively with **non-guaranteed packet rocks**:

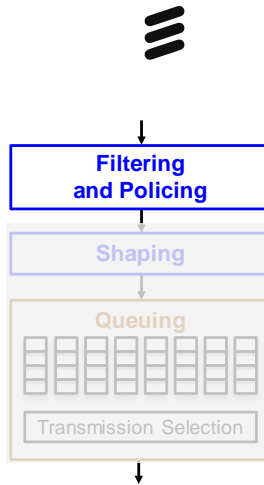
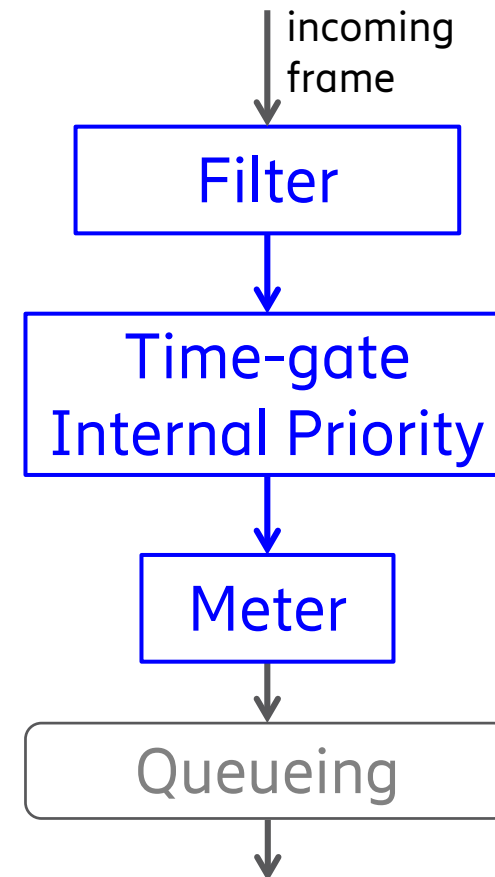


- Problem solved by **preemptable sand** between the **rocks**:



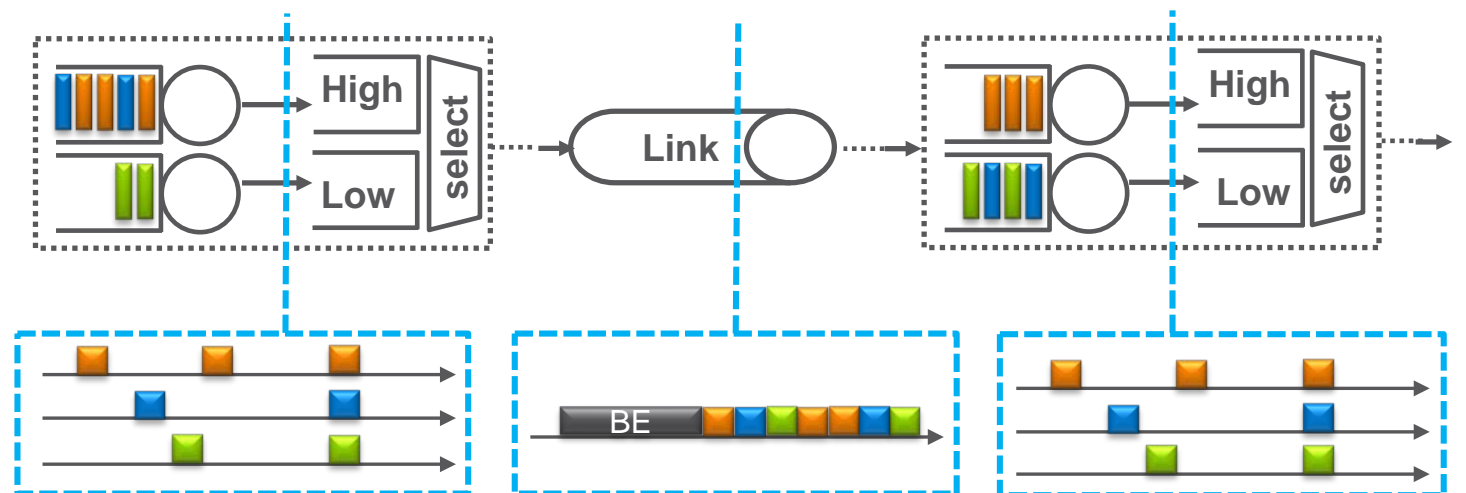
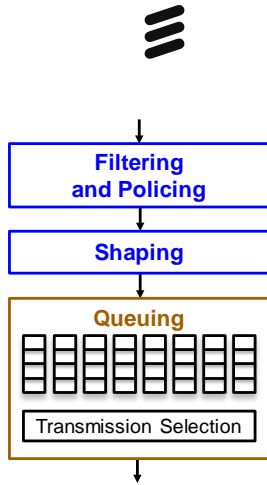
# Per-Stream Filtering and Policing (802.1Qci)

- Protection against bandwidth violation, malfunctioning, attacks, etc.
- Decisions on per-stream, per-priority, etc.
- Filter
  - Filters, Counters
- Time-gate
  - Time scheduled gate
  - **Open** or **Closed**
- Internal Priority Value (IPV)
  - Bridge internal traffic class of the frame
- Meter
  - Bandwidth Profile of MEF 10.3
  - **Red/Orange/Green** Marking



# Asynchronous Traffic Shaping (ATS) (P802.1Qcr)

- Zero congestion loss without time sync
- Similar to per-flow IntServ shaping, except that:
  - All streams from one input port to the same output port share the same queue
  - A shaper state machine for a set of streams, and the right shaper applied to the packet upfront of the queue
- Smoothen traffic patterns by re-shaping per hop
- Prioritize urgent traffic over relaxed traffic



# ATS Components (P802.1Qcr)

## —Filter

- Selects treatment for frames of a stream, e.g., IPV, shaper

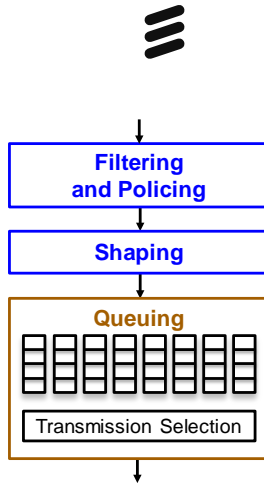
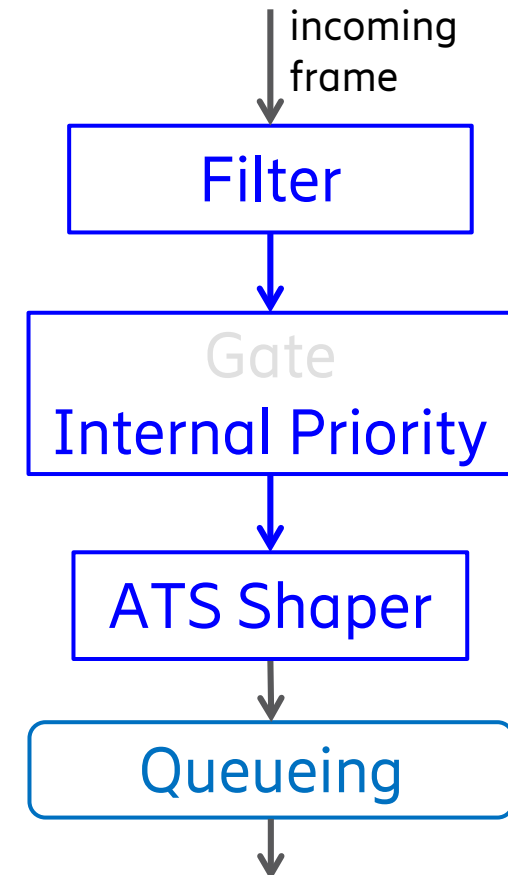
## —Internal Priority Value (IPV)

- Bridge internal traffic class of the frame
- Used for ATS operations

## —ATS Shaper

- Applies a token bucket algorithm
- Uses bridge local time variables
- Pre-computes local transmission time for each frame
  - Eligibility time assigned to each frame
  - Eligibility time becomes effective in the queueing

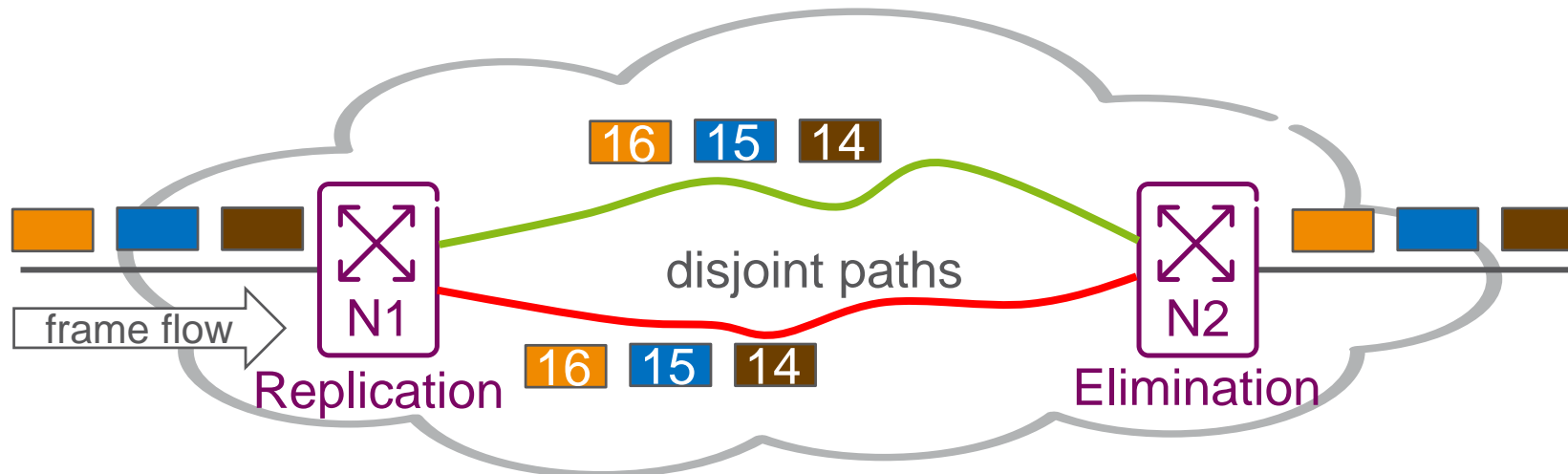
## —Strict priority queueing is used for ATS



# Frame Replication and Elimination for Reliability (FRER) (802.1CB)



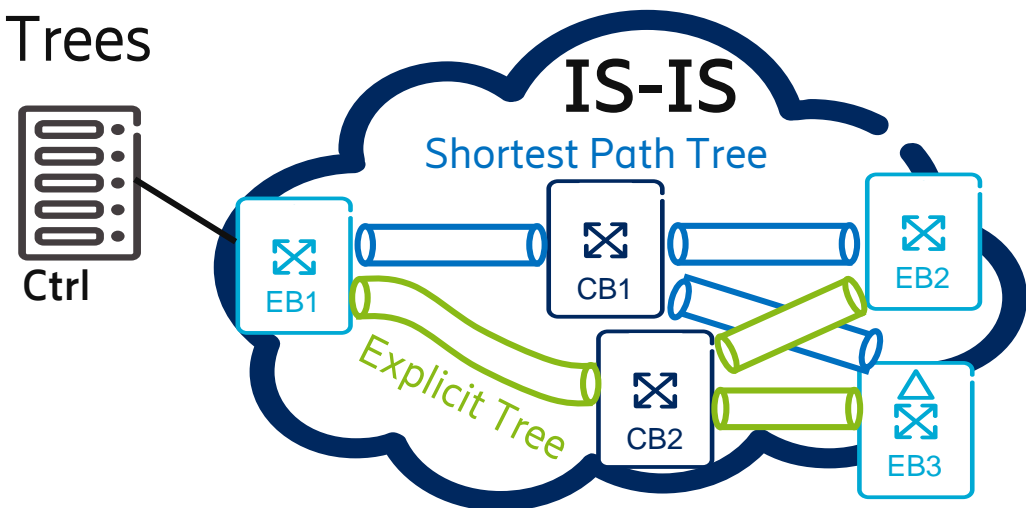
- Avoid frame loss due to equipment failure
- It is a per-frame 1+1 (or 1+n) redundancy
  - NO failure detection / switchover
- Send frames on 2 (or more) maximally disjoint paths, then combine and delete extras





# Explicit Trees by IS-IS Path Control & Reservation (802.1Qca, RFC 7813)

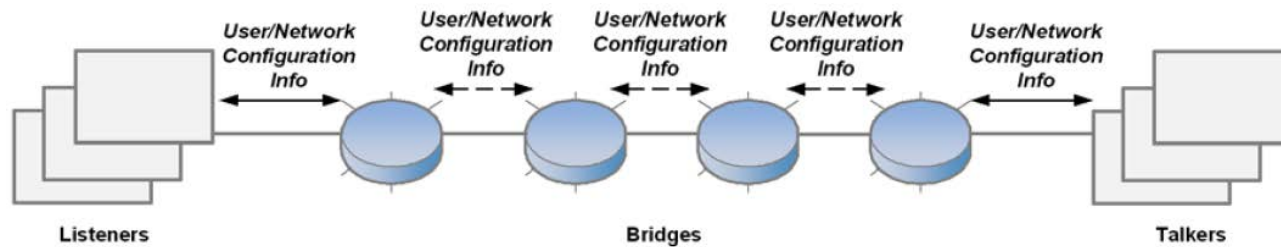
- Provide IS-IS control beyond Shortest Path Trees (SPTs)
  - Augmenting IS-IS with non-shortest path capabilities
- No protocol changes, only a couple of new sub-TLVs and reuse of existing ones as much as possible
- A hybrid Software Defined Networking (SDN) approach
  - IS-IS provides basic functions, e.g., topology discovery, default paths
  - One or more controllers control Explicit Trees
- Example
  - Exception traffic steering
  - SPT of Edge Bridge (EB1) is via Core Bridge (CB1)
  - Explicit Tree (ET) of EB1 is via CB2



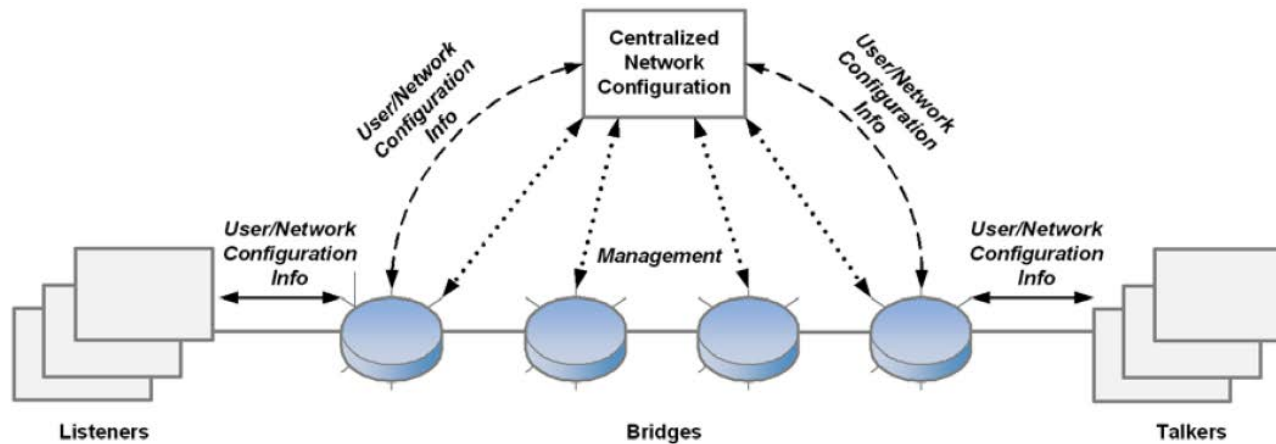
# TSN Configuration (802.1Qcc)



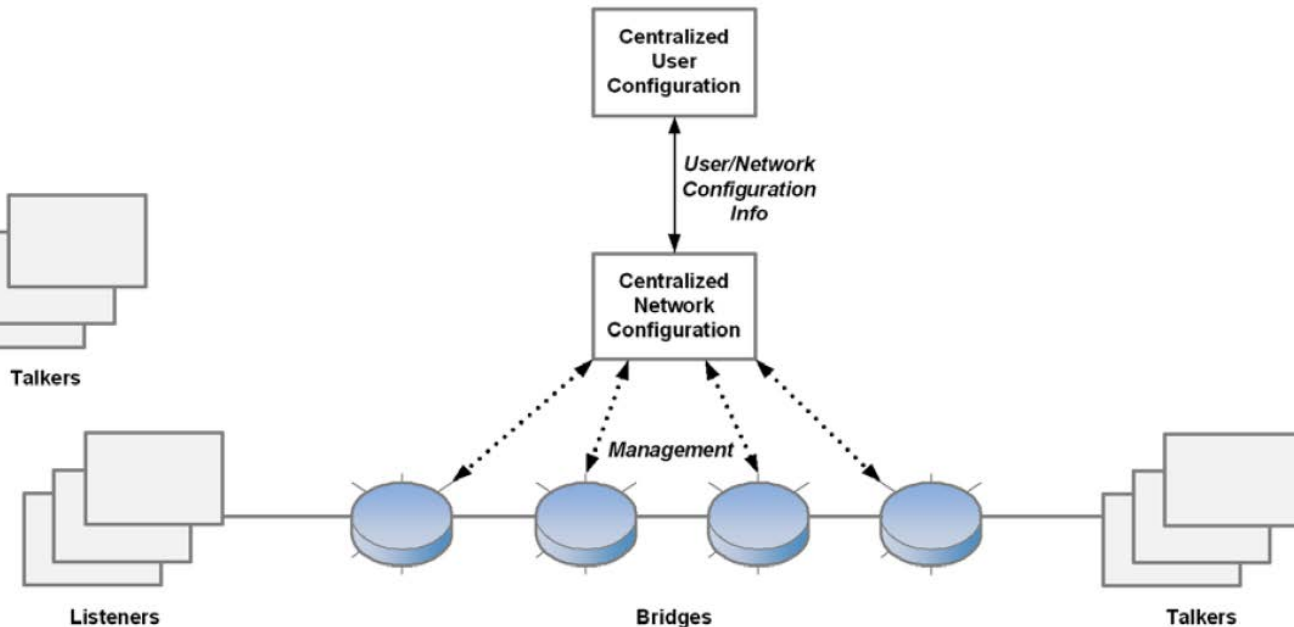
— Fully distributed



— Centralized network & distributed user



— Fully centralized



# Summary



- TSN provides deterministic service
- Multiple TSN tools provide bounded low latency
  - Time-based control of queueing provides deterministic behavior
    - Time synchronization is required
  - Asynchronous Traffic Shaping
- High availability / ultra reliability
- Explicit routes
- Configuration and resource reservation



# Q & A