



AAA2C Discussion Topic: Types of Traffic in AVB 2

(Best effort traffic, Rate constraint traffic & Scheduled traffic)

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Purpose of Presentation

- Provide Information on:
 - AVB 2 Transmission Selection Algorithms (TSA) for Best Effort Traffic, Rate Constraint Traffic and Scheduled Traffic
 - Reservation mechanisms

- Discuss usage strategies
 - How we take advantage of different TSA's and reservations in automotive applications?
 - How should we use these mechanisms?
 - Where do they fit well? Where not?
 - Is something missing?

“Thought-Starters” for the group discussion !
Questions, rather than answers!

OEMs do not necessarily need to agree on a single usage strategy!

But: Discussing these strategies helps us to identify TSA's & reservation related requirements.



Overview

- Best effort traffic (BE) *TSA = “Strict Priority Algorithm”*
- The big picture: Using different types of traffic in parallel
- Rate constraint traffic (RC) *TSA = “Credit Based Traffic Shaper”*
- Scheduled traffic (TT) *TSA = “Time Aware shaper”*
- Thought Starters:
Automotive Usage Strategies for different types of traffic and reservations

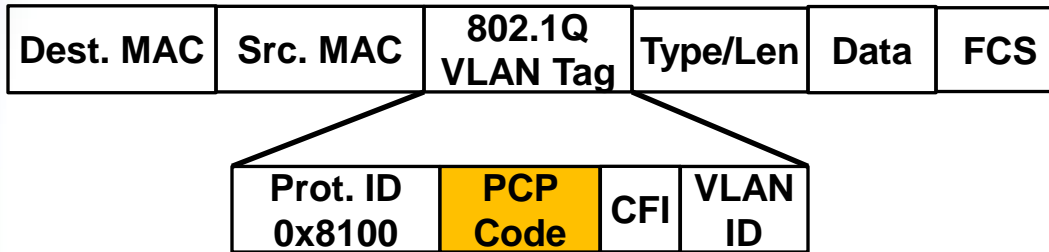


Transmission Selection
Algorithms:
“Strict Priority Algorithm”

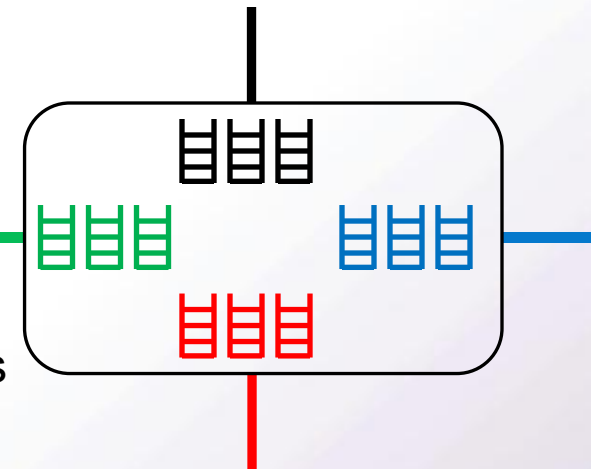


Strict Priority Algorithm

- Frames tagged with a 3 bit Priority Code Point value



- Bridge ports have between 1 and 8 outbound queues.
- Each outbound queue of a port has a traffic class number assigned (1:1 mapping).
- Traffic classes numbers range from 0 to N-1. (N = number of the ports outbound queues).



*4 Port Bridge with 3 out-
bound queues per port*



Strict Priority Algorithm

- Port is configured with a mapping: “PCP codes” to “Traffic Classes (queues)”.

Example:

PCP Code in Frame	0	1	2	3	4	5	6	7
Traffic class number	0	0	0	0	1	1	2	2

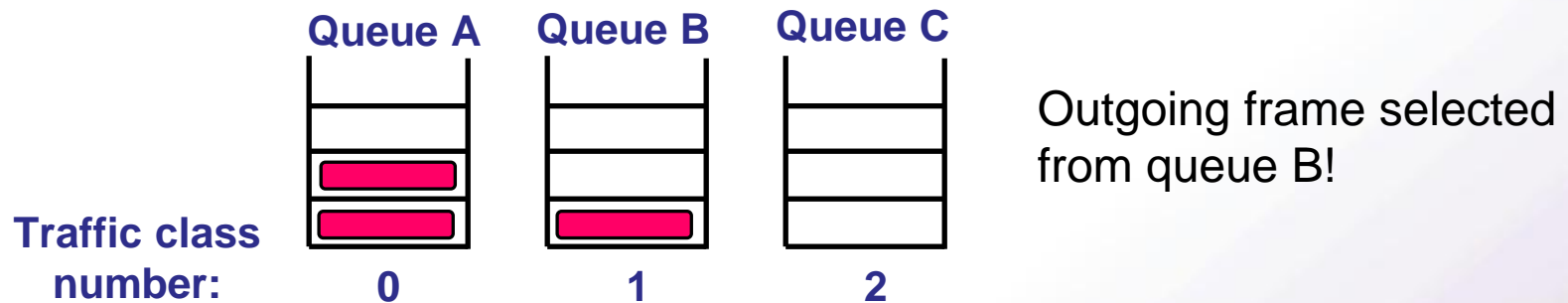
(Recommended mapping for 3 queues in cases where only strict priority scheduling is used)

==> The PCP values of a frame and the mapping will determine the traffic class (= queue into which frame will be placed).



Strict Priority Algorithm

- Strict Priority Algorithm:
Available for transmission = Queue contains one or more frames.
- Next frame for transmission:
From queue with the highest traffic class number that has a frame available for transmission.



- Note: For other TSAs, the fact that a queue contains a frame does not automatically imply that the frame is **available for transmission**.

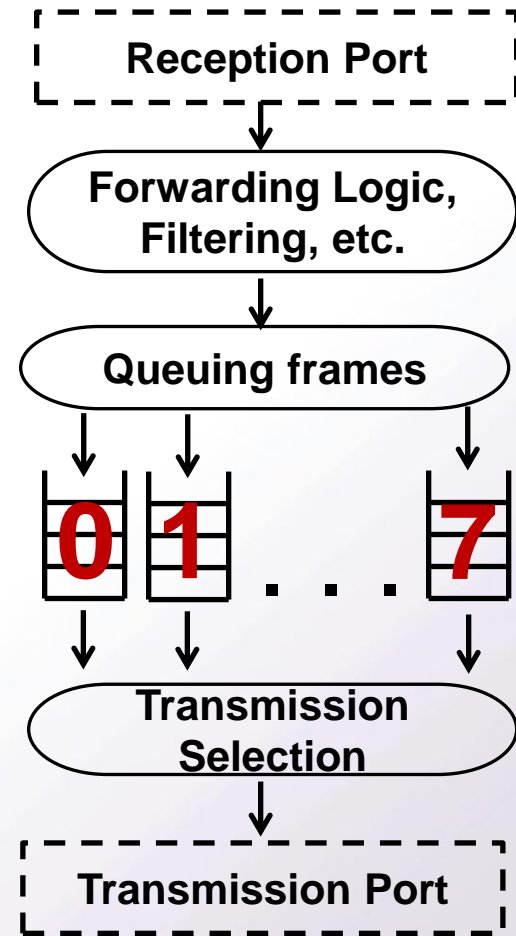
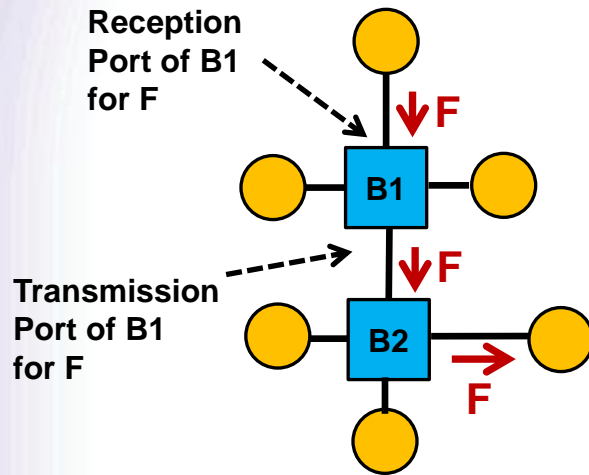


The big picture: Using different types of traffic in parallel



Using multiple TSA's

Forwarding process within the bridge:



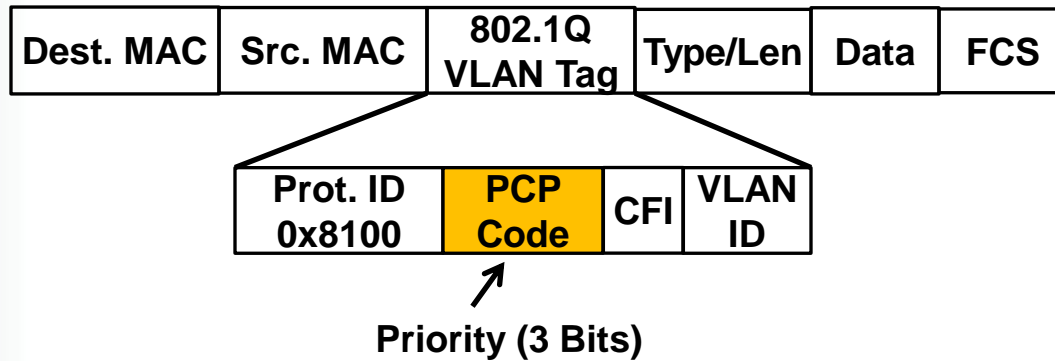
- Up to 8 outbound queues for each bridge port.
- Each queue configured with a TSA.

E.g.: **7** = Time Aware Shaper for scheduled traffic
5, 6 = Credit Based Shaper for RC traffic
0, ...,4 = Strict Priority for BE traffic

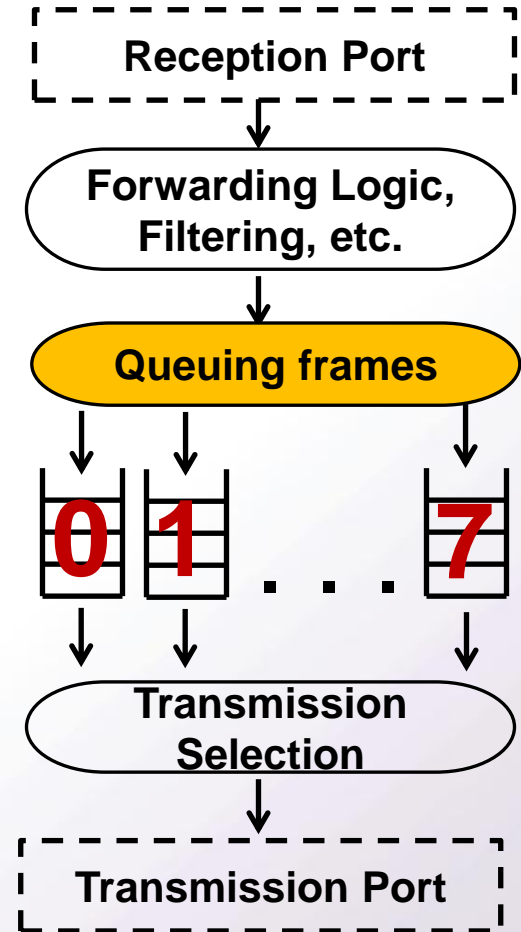


Queuing Function

- “Queuing frames” function:
Decide into which queue F needs to be placed.
- Frame format:



Selection of queue based on (PCP) and mapping of PCP codes to traffic class numbers.

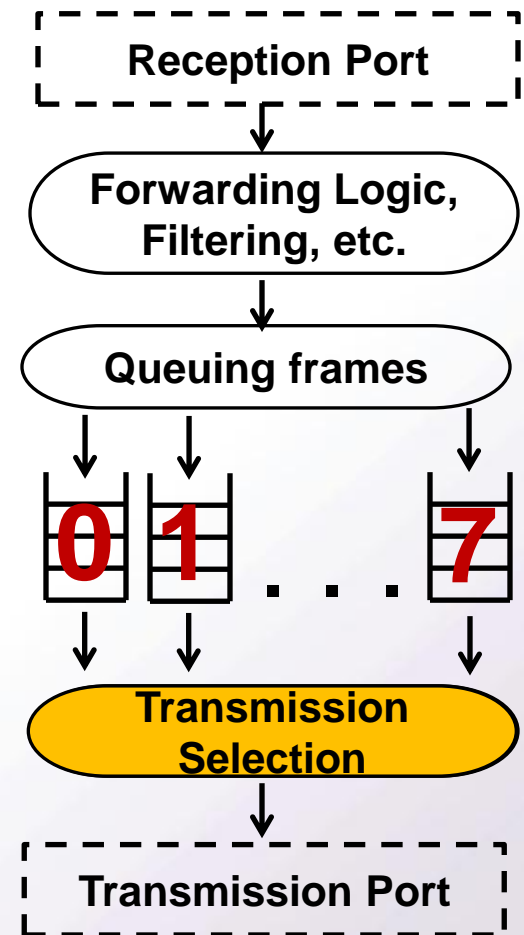




Transmission Selection

- Transmission Selection Function:
Frame selected from a queue for transmission if :
 - a. TSA associated with queue determines that there is a **frame available for transmission.** ???
 - b. No queue with a **higher traffic class** number has a frame available for transmission.

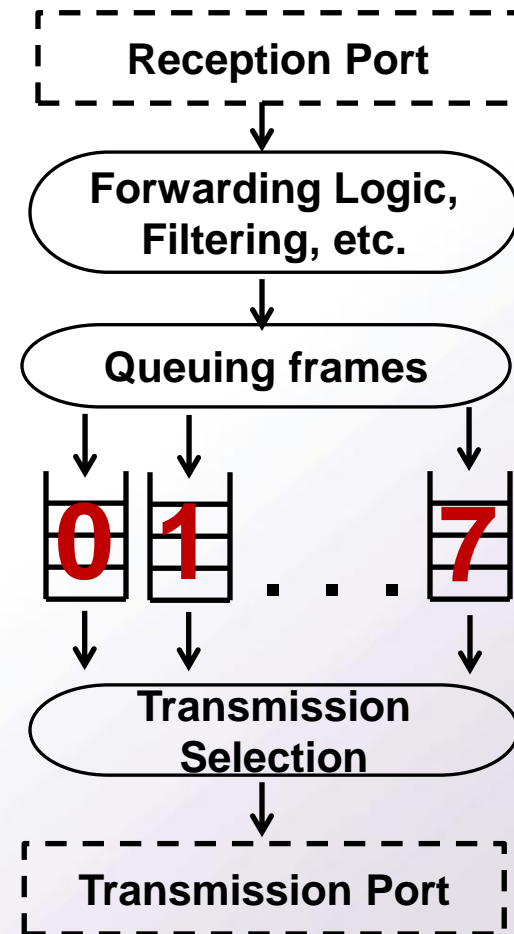
- **Traffic class numbers:**
Queues associated with the “Credit based Shaper” must be configured to have a higher traffic class number than queues associated with “Strict priority Algo.”





Available for Transmission

- What “Frame available for transmission” means, depends on the TSA associated with the queue.
- “Strict priority Algo.”:
 - a) frame is present in the queue.
- “Credit based shaper Algo.”:
 - a) a frame is present in the queue and
 - b) $\text{credit} \geq 0$.
- “Time aware shaper Algorithm”:
 - a) a frame is present in the queue and
 - b) a timing condition is fulfilled.
(To be defined within AVB 2)





Transmission Selection
Algorithms:

“Credit Based Shaper Algorithm”



Concepts / Terminology

➤ Concepts in this section:

- Time sensitive Streams
- Credit based shaper for RC Traffic
- Stream reservations

Part of AVB 1.
Support of Audio / Video.

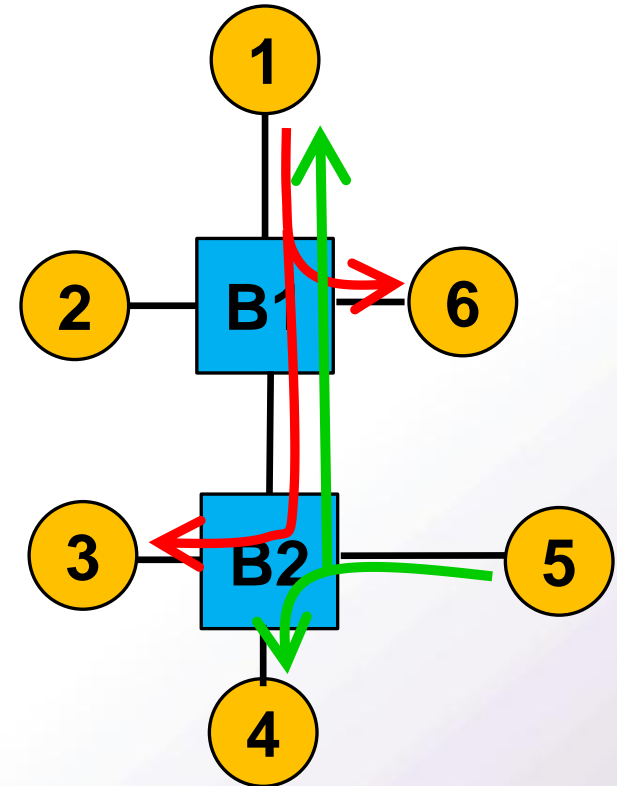
➤ AVB Terminology:

- ECU or Node = End System
- Sending Node = Talker, Receiving Node = Listener
- Stream:
Unidirectional flow of data from a Talker to one or more Listener.
- Time sensitive stream: Guaranteed bounded latency.



Streams

- Example:
 - Node 1 is talker of a stream **X** received by listeners 6 and 3
 - Node 5 is talker of a stream **Y** received by listeners 1 and 4
- Stream Reservation Protocol (SRP) registers streams.
- Once Streams are OK'd by the system, bandwidth and latency bounds are guaranteed.






Stream Reservation Classes

➤ Traffic Specification (T-Spec):

- Characterizes bandwidth a stream can consume.
- For each stream a T-Spec defines:
 - MaxFrameSize*
 - MaxIntervalFrame*
(= frames per SR class measurement interval)

So what are SR classes and measurement intervals ?



➤ Two Stream Reservation Classes: Class A & Class B

- Class measurement intervals: Class A: 125 μ s Class B: 250 μ s

➤ During stream registration SRP checks:

Sufficient resources for a stream of desired class / desired T-Spec / desired set of listeners?

Yes? = Stream is OK'd **No?** = Stream reservation not accepted.



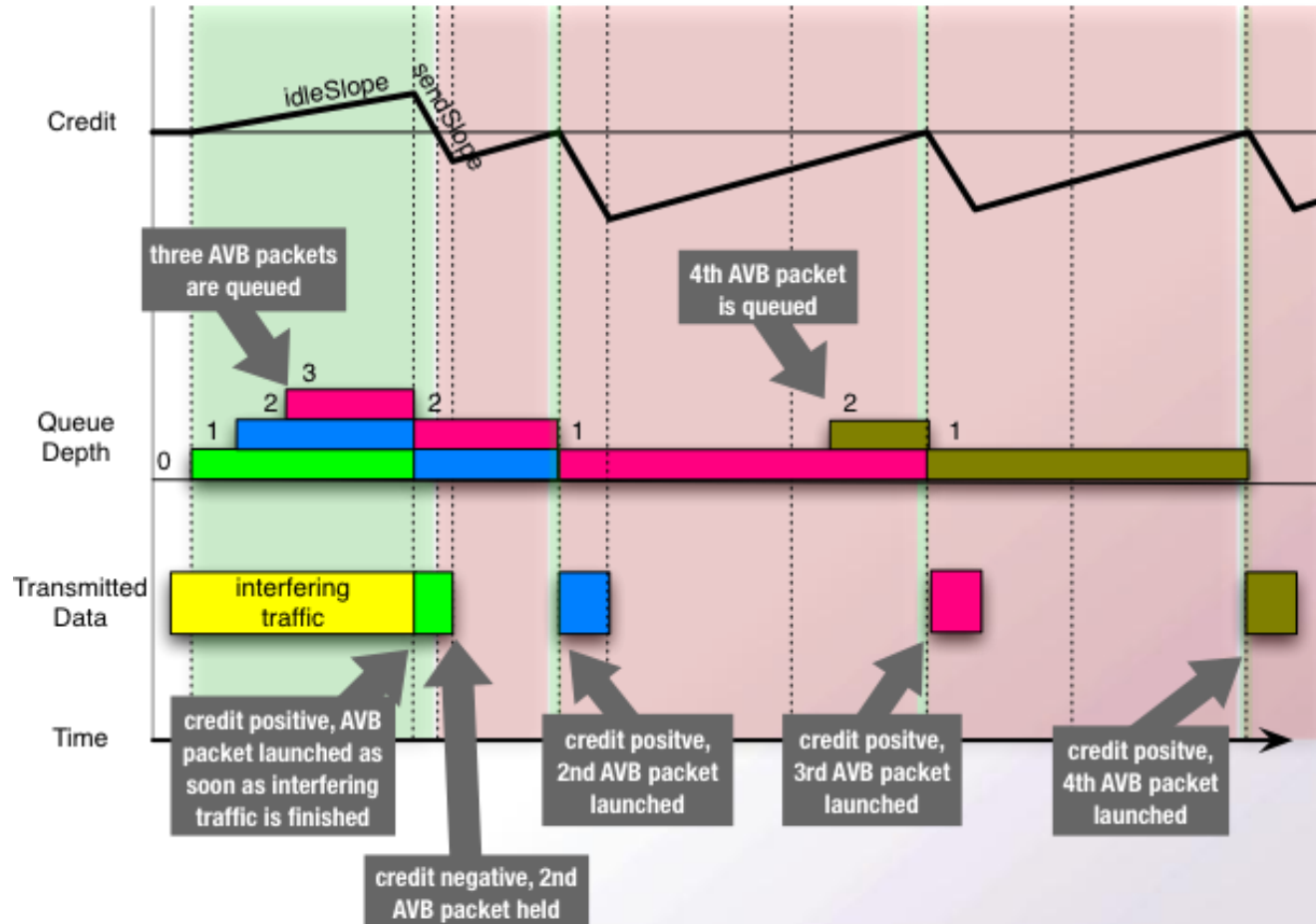
Relation between “Streams” and “Credit Based Shaper”

- Note:
 - The TSpec “promises” bandwidth.
 - But the TSpec implicitly also promises bounded latency.
(By promising a frame rate per class measurement interval)
- What mechanism ensures that the “TSpec promises” are kept during operation of the system?
- Answer: The Credit Based Traffic Shaper !
- Recall:
 - The Credit Based Traffic Shaper is a Transmission Selection Algorithm (TSA).
 - Therefore:
An outbound queue can be configured to use the Shaper!



Credit Based Shaper Algorithm

- Devices in AVB network must “shape traffic”
- Schedule transmission of packets to prevent bunching, which causes overloading of network resources.





Idle Slope & TSpec

- Question:
Why would the Shaper Algorithm on the previous slide ensure compliance with the TSpec ?
- Rough answer:
The main configuration parameter of the Shaper is *idleSlope*.
A proper value of *idleSlope* will ensure that the TSpec is in effect.



Relation between “Streams” and “Credit Based Shaper” (again)

Example “Class A streams”:

- Many class A streams can be configured.
- Several end systems can act as talkers of class A streams.
- Every node can act as a talker for several class A streams.

However:

- At the outbound port of a bridge, all class A frames will be sorted into only a single queue that is configured to use the credit based shaper as TSA.

AVB takes all that into account! T-Spec’s will be intact for all streams!



Transmission Selection
Algorithms:
“Time Aware Shaper”



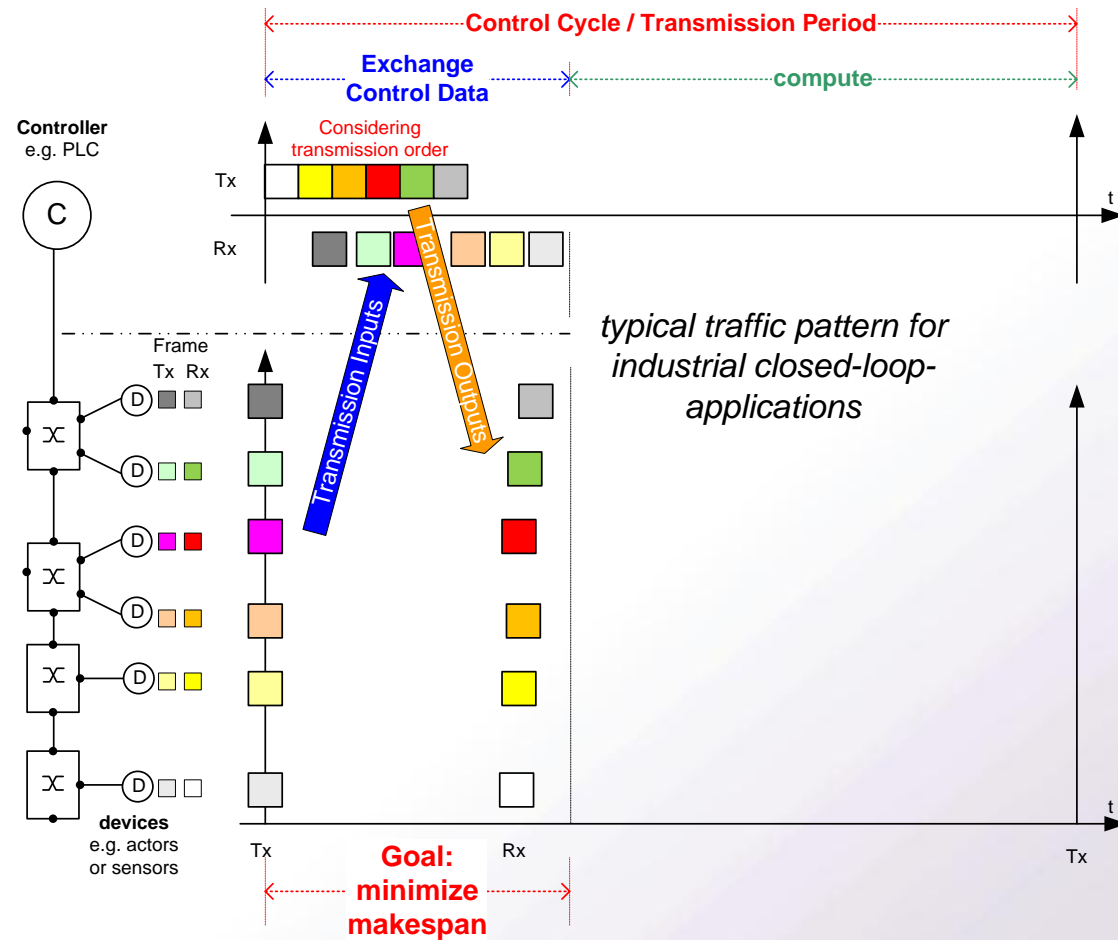
Why another shaper?

- The credit-based shaper reduces “bunching”
 - Smooths out the traffic flow to greatly reduce the possibility of dropped packets due to congestion
- Average delay is actually increased
 - Only the worst case is better
 - Control traffic needs *small-as-possible* delays



Control systems application

- Typically closed-loop, fixed cycle
 - 30 μ s to several ms, typical is 125 μ s
- Credit-based shaper delays can be too high
 - 250 μ s delays per hop!





Interfering traffic!

- If a packet has just started being transmitted on a particular egress port, then all traffic, regardless of the priority, must wait until the egress port has completed transmitting that packet



Avoiding interfering traffic

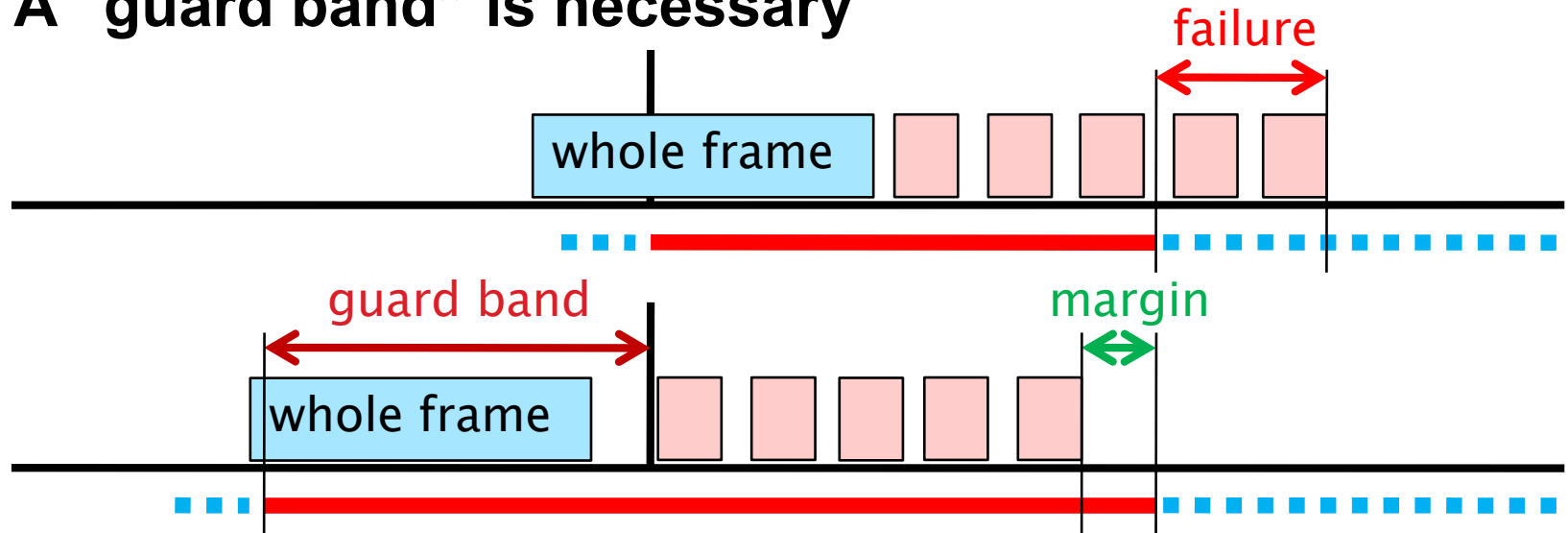
- Make switches aware of the cycle time for control traffic
 - Block non-control traffic during particular windows of time to ensure that the egress port for a control stream is idle when the control traffic is expected
 - Each egress port could have a separate schedule
- Non-trivial calculation in non-trivial networks
 - Requires a fully managed network
 - This is a well understood, but difficult problem, currently implemented in proprietary networks such as Siemens' "Profinet"





Time aware shaper issues

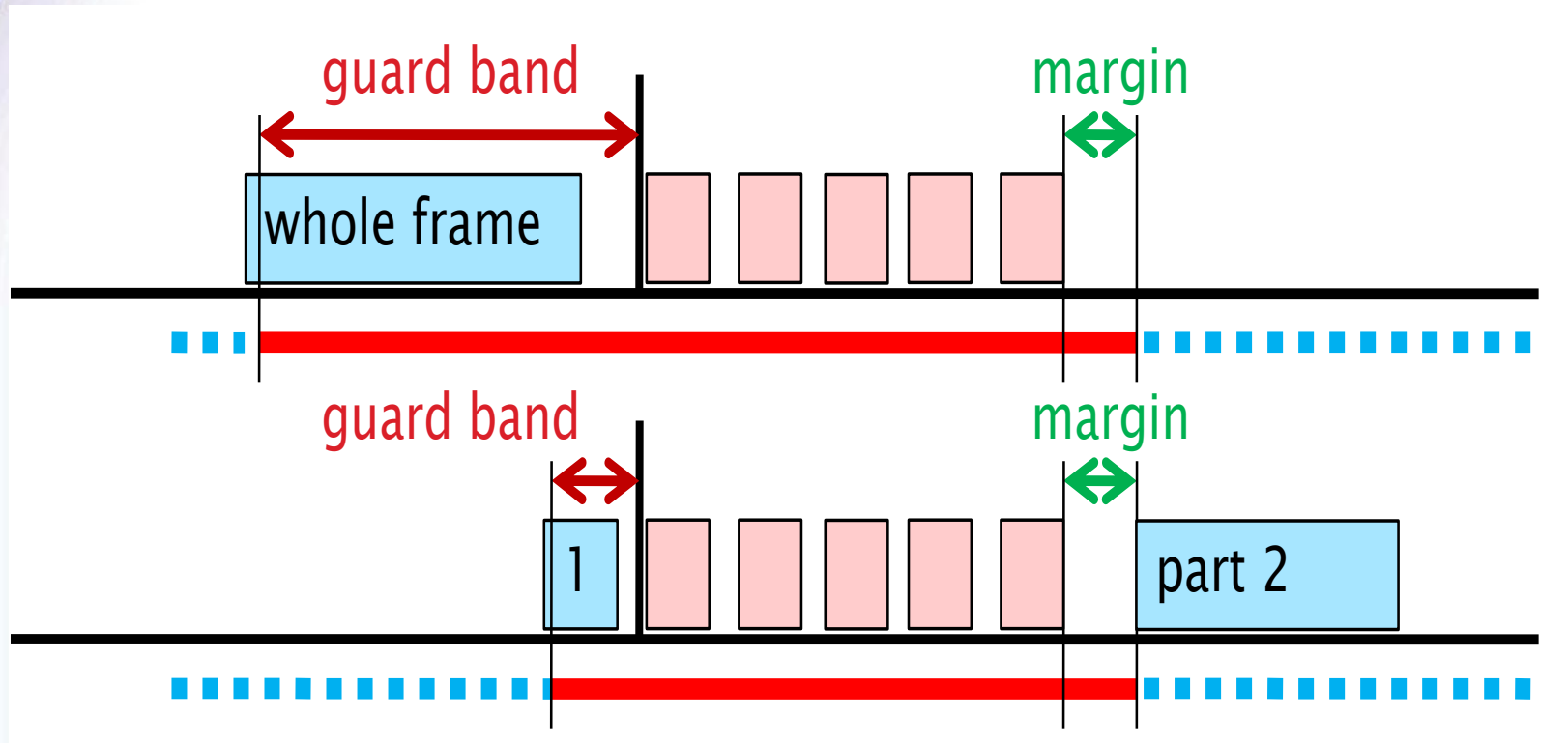
A “guard band” is necessary



- If an interfering frame starts transmission just before the start of a reserved time period, it can extend critical transmissions outside the window.
- Therefore, a guard band is required before the window starts, equal in size to the largest possible interfering frame.



Preemption to reduce the guard band



- If preemption is used, the guard band need only be as large as the largest possible interfering fragment, instead of the largest possible interfering frame.
- It is easy to see that the smaller the size of the time-reserved windows, the larger the impact of preemption.



Using Traffic Shapers:
“Stream Reservation Protocol”



Admission controls

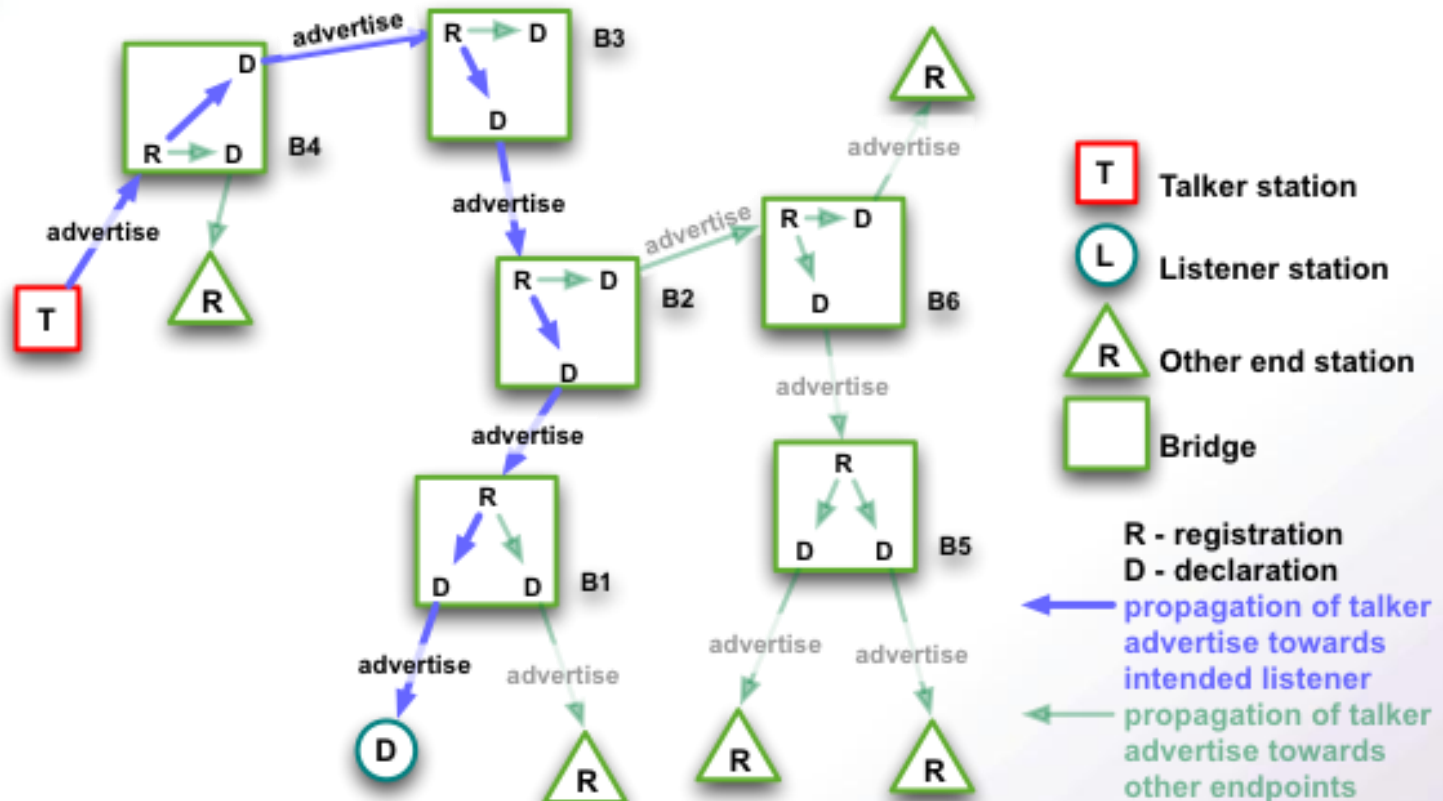
(IEEE Std 802.1Qat – added to 802.1Q)

- Priorities and shaping work only if the network resources are available along the entire path from the talker to the listener(s)
 - AVB “talkers” guarantee the path to the listener is available and reserve the resources
- Done via a new 802.1ak “Multiple Registration Protocol” application: SRP (“Stream Reservation Protocol”)
 - Registers streams as a source MAC address combined with a higher level ID (frequently the IP port address)
 - Reserves resources for streams based on bandwidth requirements and latency class
- Dynamic management of shaper parameters



Admission control (1)

(creating a path)

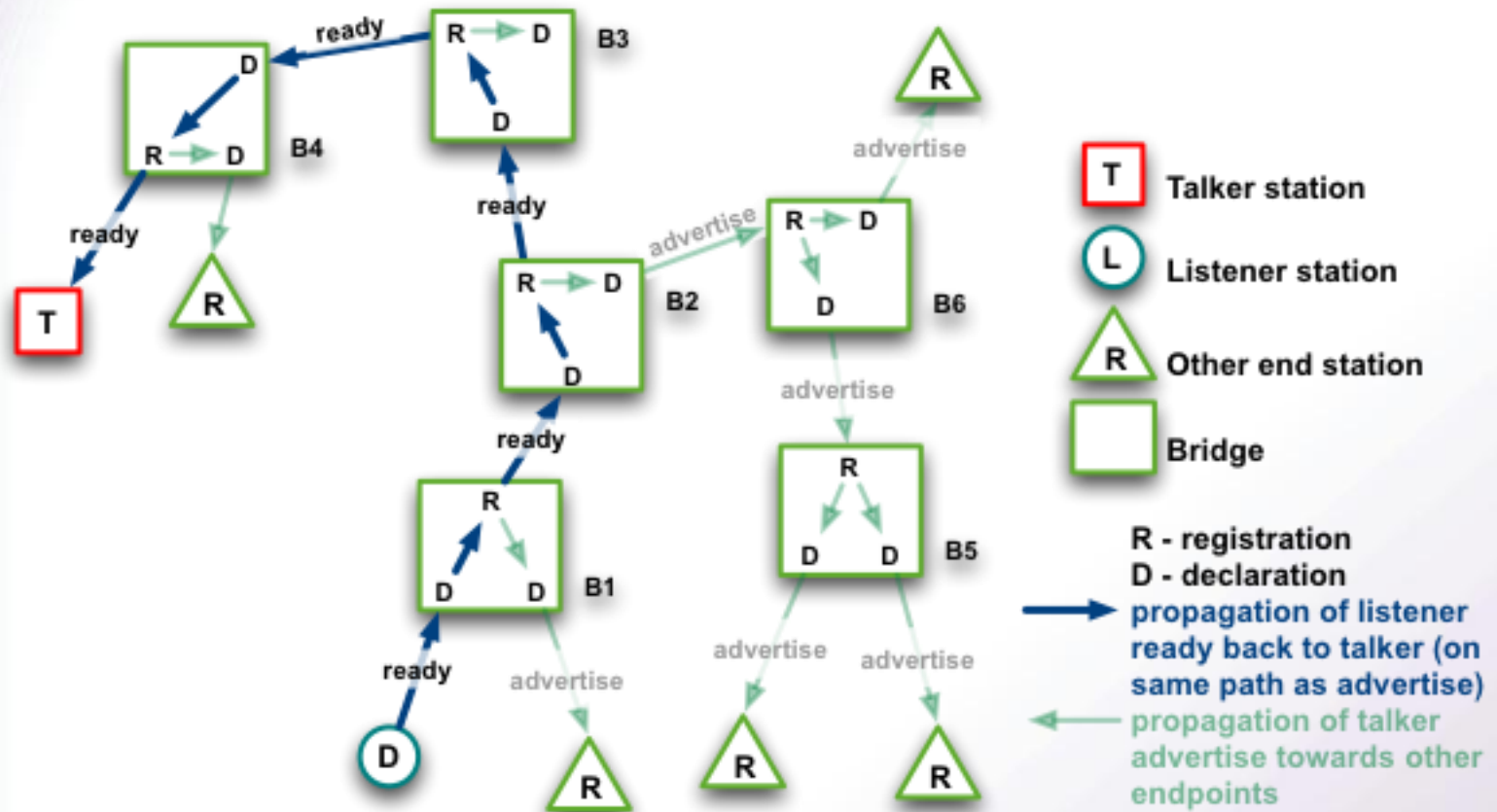


- Phase one of a reservation is a “talker advertise” that tests the path and leaves behind a “breadcrumb” trail to the talker



Admission control (2)

(listener ready)

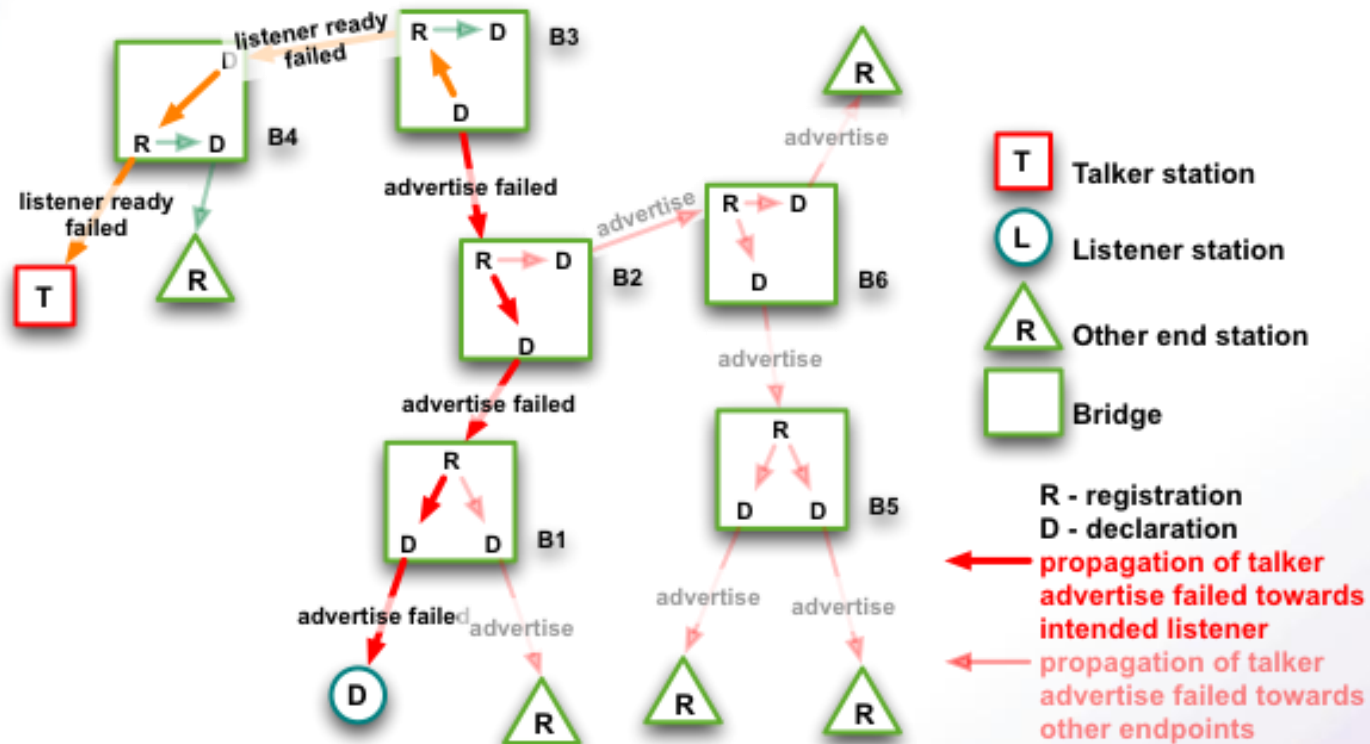


- Phase two of a successful reservation actually locks down the needed resources



Admission control (3)

(failed advertise)



- If resources are not available, the “talker advertise” is propagated as “failed”
 - No reservation is made, this is done to allow a listener to know that a reservation is not possible now
- A “listener ready failed” is propagated back towards the talker from the bridge that is unable to make the reservation
 - The talker knows that at least one listener cannot get the reservation



Thought Starters:
Automotive Usage Strategies for
different types of traffic and
reservations



- The following slides reflect some **statements and thoughts we occasionally hear when different types of traffic (BE, RC, TT) and reservation mechanisms are discussed in the auto industry.**
- Some of them are neither right nor wrong but reflect opinions that are based on previous experience.
- We have listed all these statements to **stimulate a discussion** independently of **whether or not the authors agree with the individual statements.**



Statements “Best effort” (1/2)

➤ **BE traffic is all we need !**

- BE is similar to CAN. Proven in use!
- TT is difficult to handle. (FlexRay experience).
- E2E latency of TT is high, if we miss a slot (wait for next cycle)
(Unless task scheduler synched with network time)
- RC spreads messages out in time. (Adds latency).
- We know our (typically static) traffic.
 - Simulation can show if we dropping messages.
 - Underutilizing links will help.



Statements “Best effort” (2/2)

➤ **BE alone is not sufficient !**

- There is value in isolating traffic:
 - Multiple use cases on a link
 - If overall traffic changes, guarantees granted to critical applications will still be in place (Simplifies Safety Cases).
- Latency and bandwidth guarantees!
- Simulations do not cover worst cases.



Statements “Stream Reservation Protocol” (1/2)

- **We don't need SRP:**
 - Static reservations are sufficient.
 - Engineering our networks ensures that all resources are in place.
 - SRP bears the risk that requested reservations are not OK'd.
 - How much cost will SRP drive into switches?

- **SRP makes sense:**
 - Statically preconfigure streams. Use SRP to add optional streams.
 - Future applications will be more complex & dynamic.
We cannot statically engineer these systems.



Statements “RC for Audio/Video” (2/2)

- **AVB is a great solution for Audio/Video streams !**
 - Reserve max. bandwidth required by Audio/Video
 - If the actual bandwidth is lower: BE will benefit.
 - Time synchron. & ‘presentation time’ concept reduce buffer requirements.



Statements “Future architectures” (1/2)

- AVB’s mechanisms and performance will enable new applications !
- Trend towards more critical control applications:
 - E.g. autonomous driving.
 - Isolation & Determinism required.
- Future architectures:
 - Less static traffic.
(Difficult to engineer)
 - Higher levels of abstraction.
(More dynamic powerful middleware. Less manual engineering.)
 - Network should not constraint the location of an ECU
(E.g.: Run critical apps over a converged backbone.)