TSN ethernet as core network in the centralized E/E architecture - Challenges and possible solution

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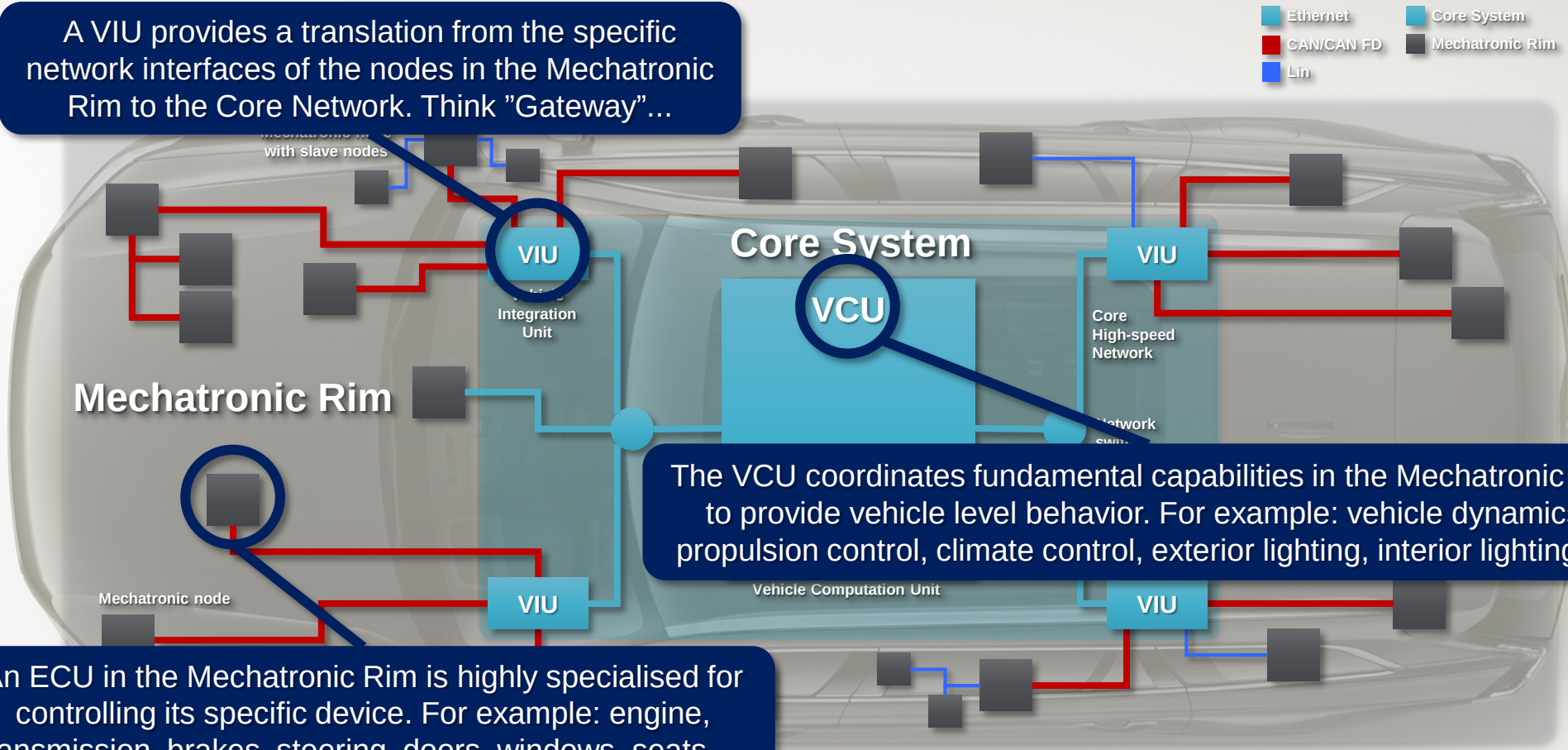
Centralized e/E architecture

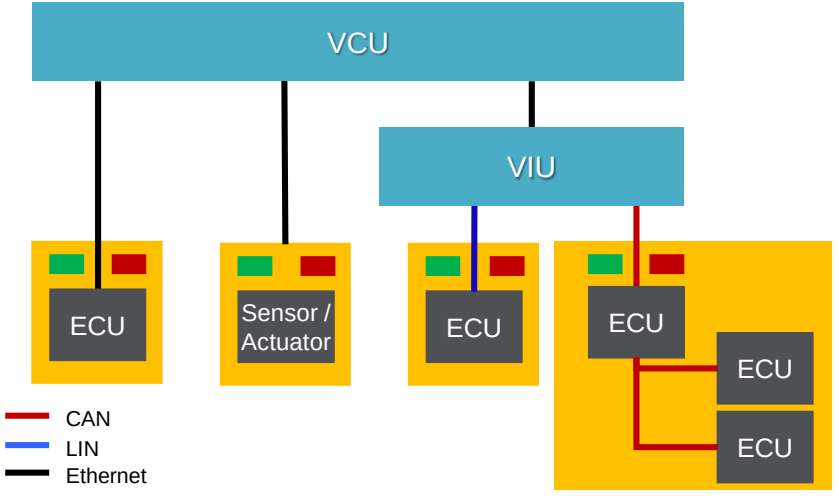
A VIU provides a translation from the specific network interfaces of the nodes in the Mechatronic Rim to the Core Network. Think ”Gateway”...

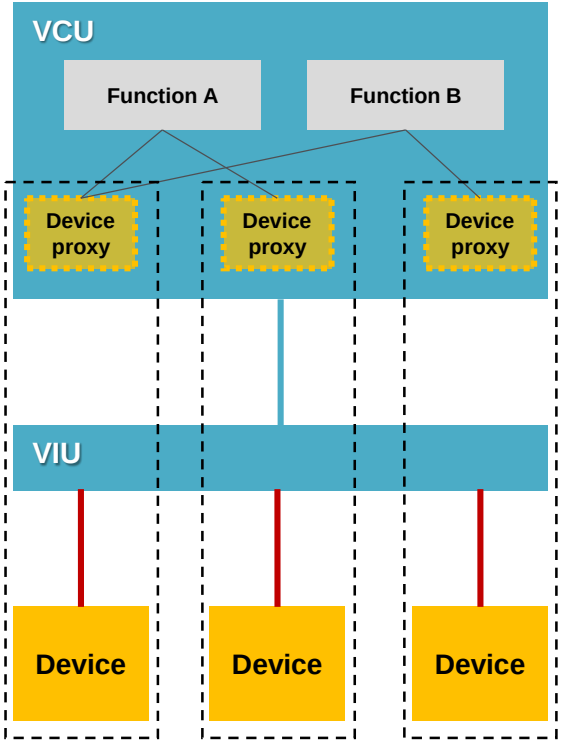


The VCU coordinates fundamental capabilities in the Mechatronic Rim to provide vehicle level behavior. For example: vehicle dynamics, propulsion control, climate control, exterior lighting, interior lighting, ...

An ECU in the Mechatronic Rim is highly specialised for controlling its specific device. For example: engine, transmission, brakes, steering, doors, windows, seats, ...

Devices-VIU-VCU Connection



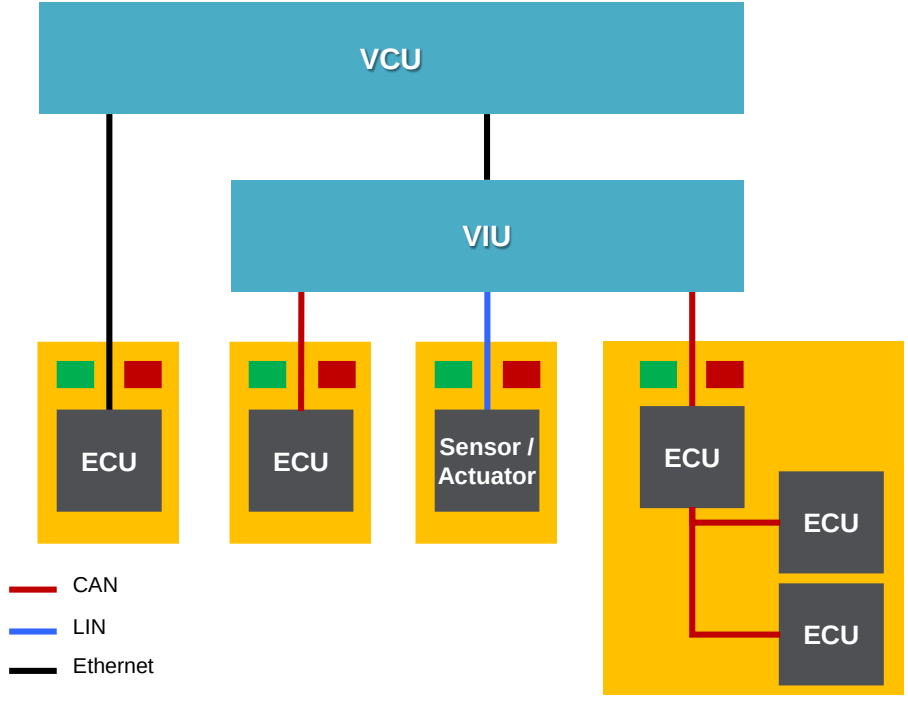


Ethernet as core network: challenges

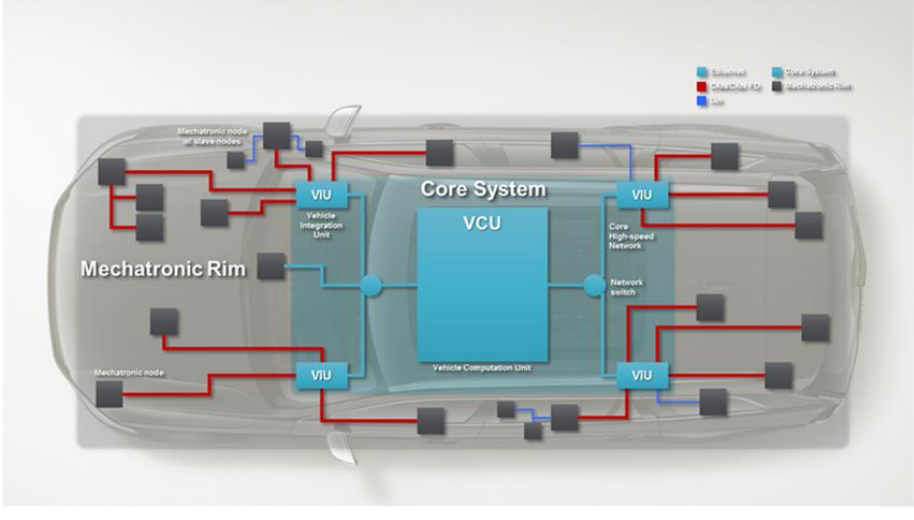
The core network must be able to handle different types of traffic

Time-critical traffic and non-real-time traffic might share the same Ethernet link

CAN-Ethernet gateway



Ethernet as core network: research pro



1. How to guarantee fulfillment of real-time requirements of different application domains across the network
2. How to minimize the interference on real-time traffic from non real-time traffic in the network
3. CAN-Ethernet bridge strategy for the gateway

using avb

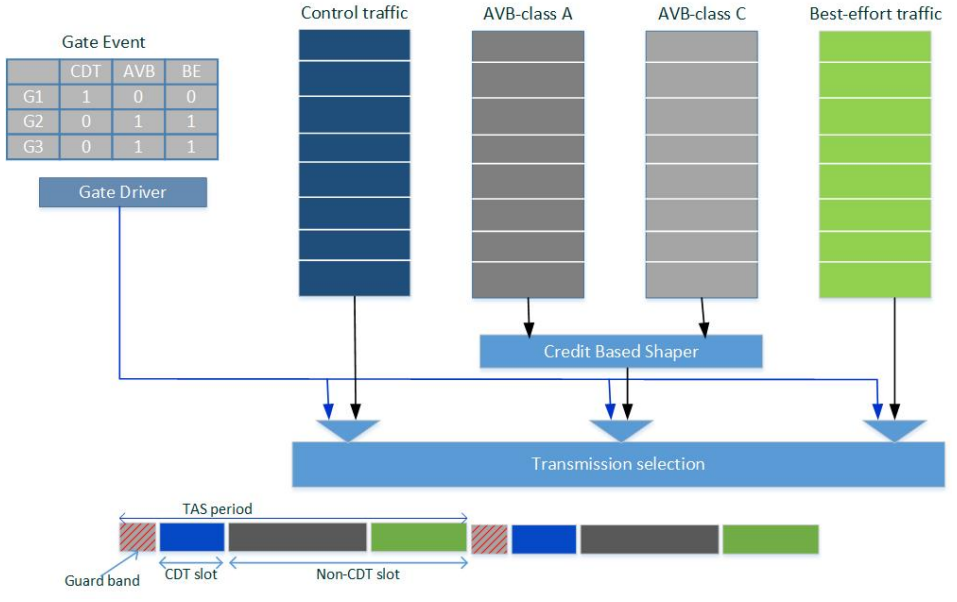
- AVB has been selected for Audio/video applications
  - 802.1AS for clock synchronization
  - 802.1 Qav for traffic shaping
  - 802.1 Qat for stream reservation
- How do we handle control traffic?
  - All control traffic from CAN are packed into UDP frames and sent with the highest priority via the core network
- UDP is the major gateway protocol

Remaining Questions?

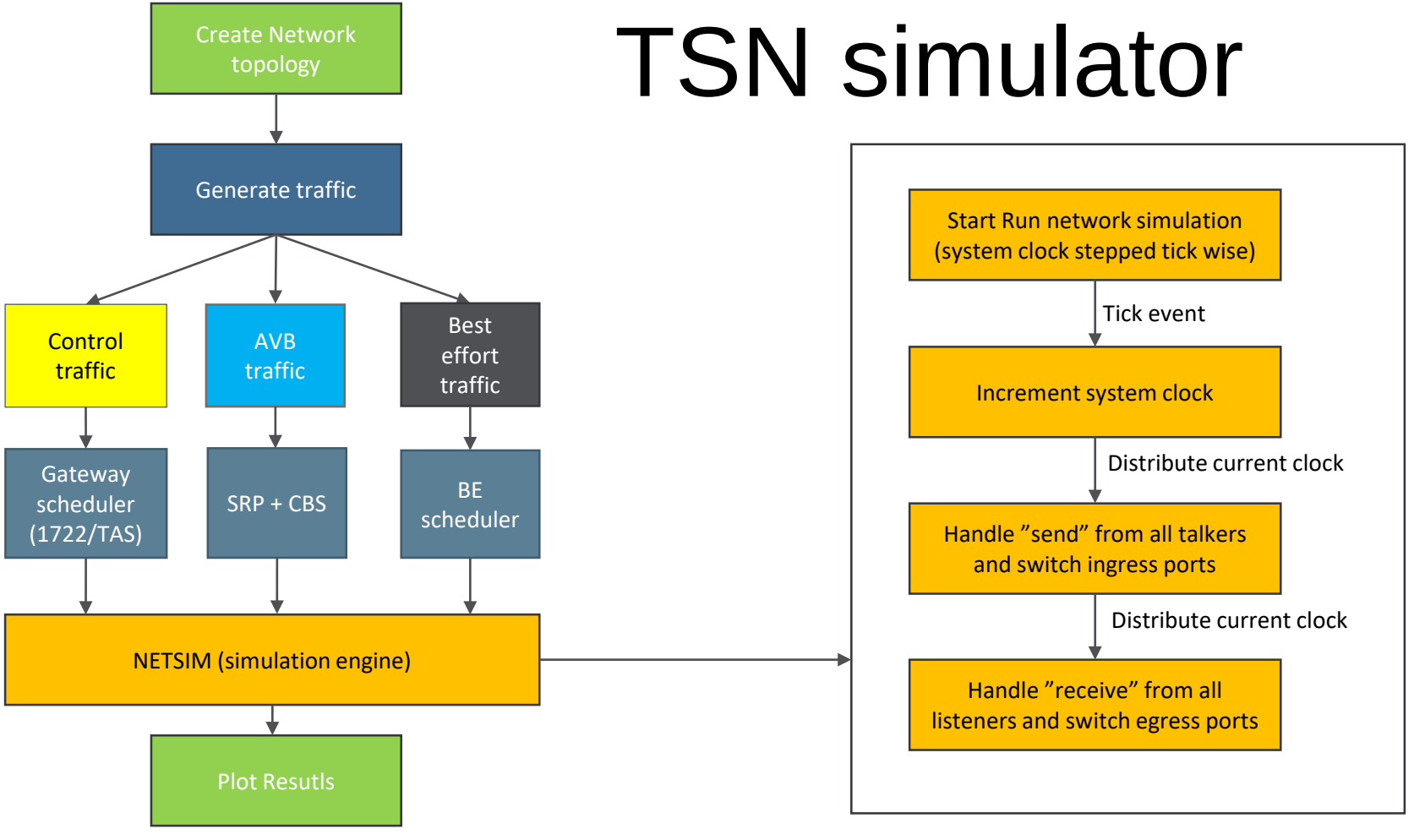
- Control traffic is sent via the UDP protocol
  - No guarantees
  - No exclusive access to the network
- How to find a configuration and use mechanisms where both control traffic and Audio can have high priority compared to the rest of the traffic
- How to guarantee hard real-time requirements for control traffic
  - While at the same time reserve bandwidth for AVB traffic

ADDING tsn

- Control traffic
  - Time Aware Shaper (802.1 Qbv)
- Audio traffic
  - AVB class A
- Video traffic
  - Video class C
- Best-effort traffic
  - TCP/IP

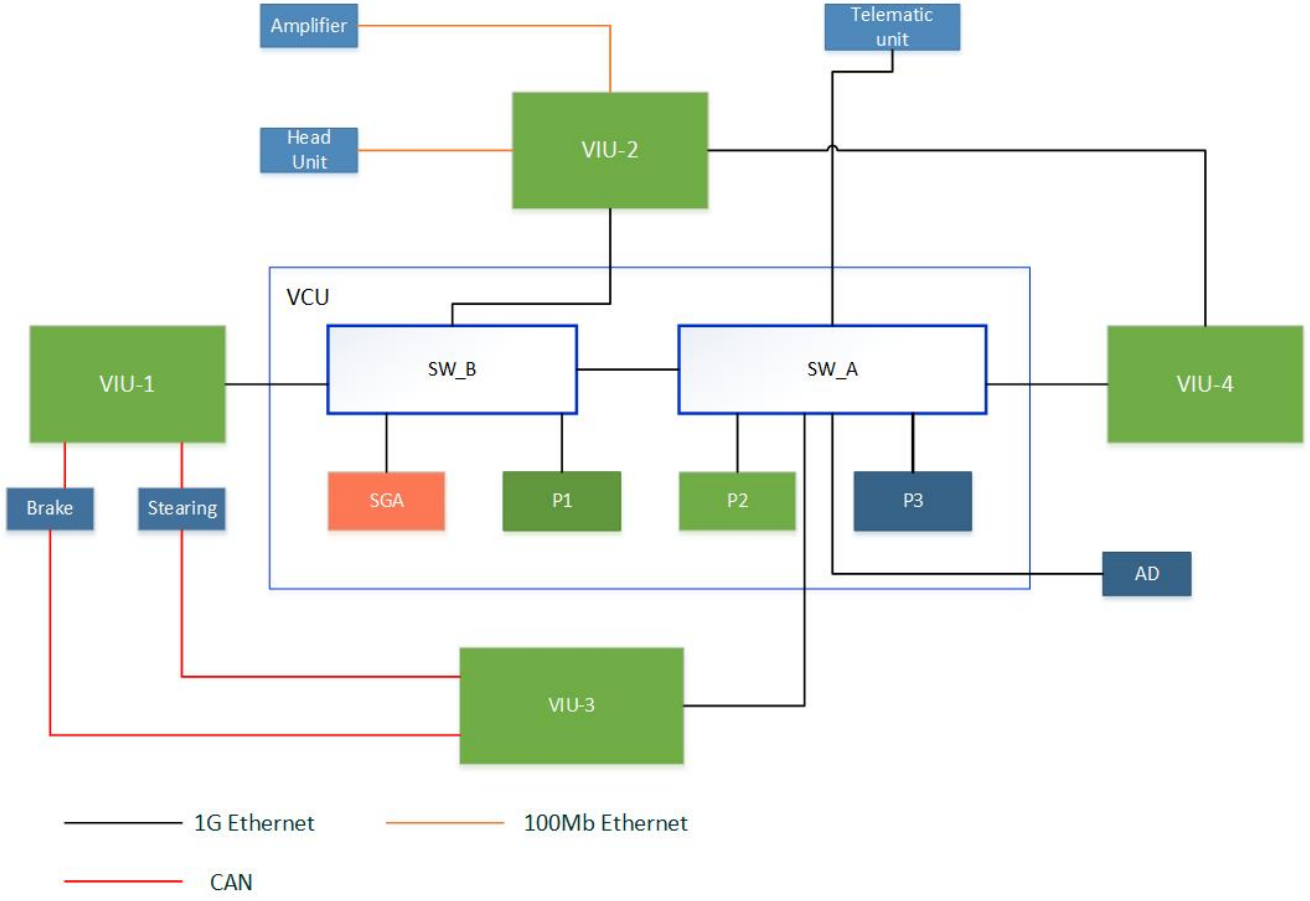


TSN simulator



Network topology

VIU: Vehicle Integration Unit
SW_A, **SW_B**: Ethernet Switch Module
P1, **P2**, **P3**: Processor
AD: Autonomous Driving Module
SGA: Security Gateway Module



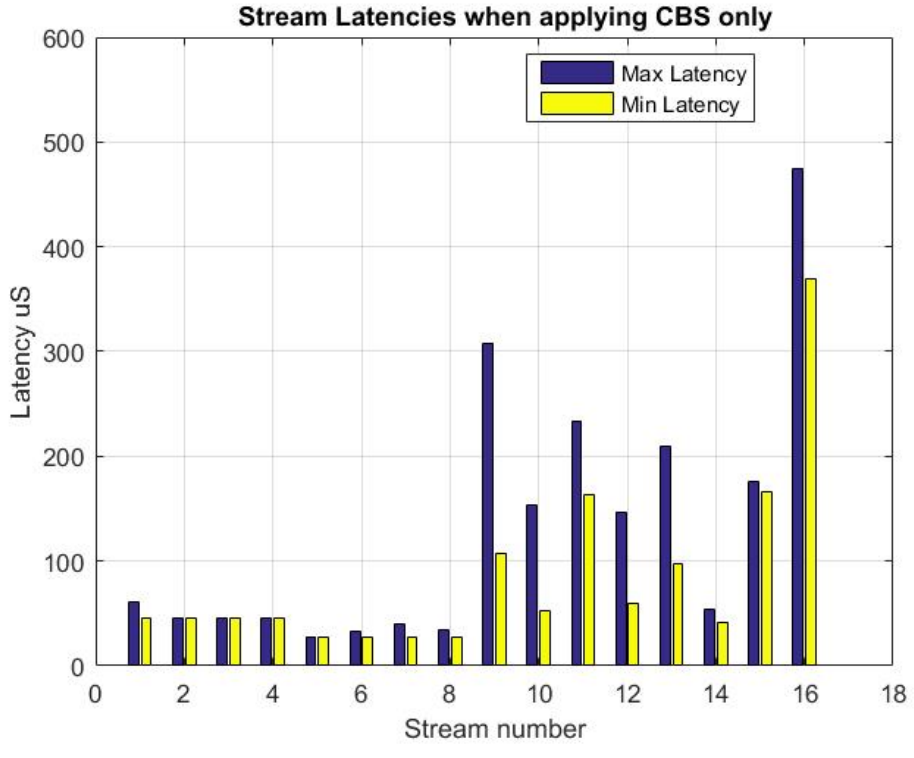
Scenario_AVB (TSN)

CT: Control Traffic (sent via UDP protocol)
AVB_A (**B**,**C**): AVB traffic class A, B or C
BE: Best Effort traffic
***** : broadcast

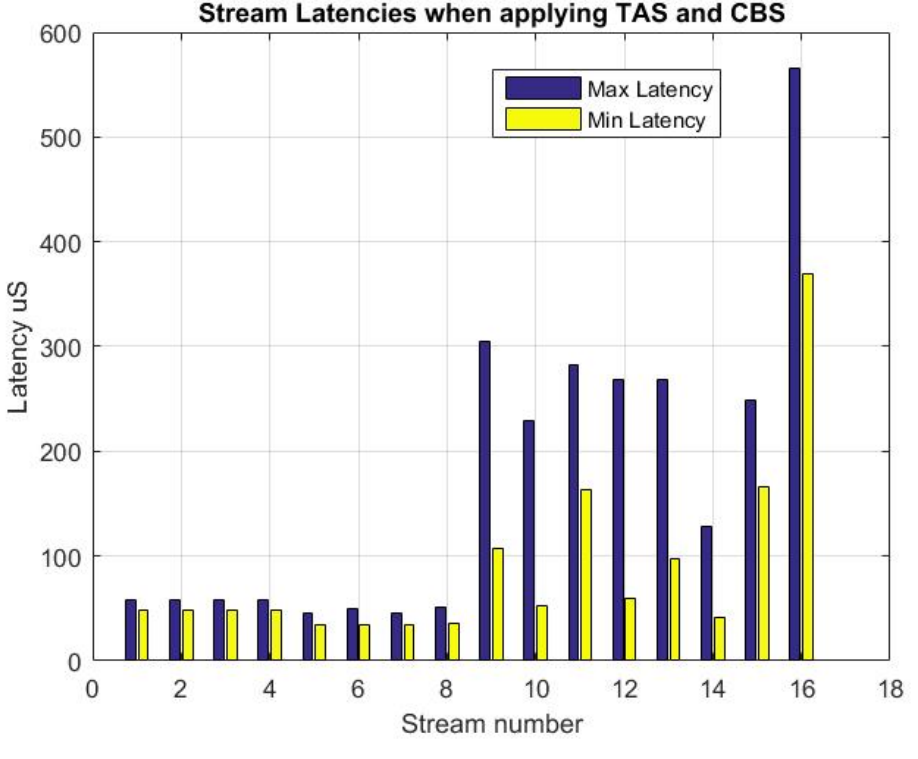
Stream ID	Talker	Listener	Traffic class	Payload	Header	Interval
1	VIU-2	SGA	CT (CDT)	1171	42 (66)	500
2	SGA	VIU-2	CT (CDT)	1171	42 (66)	500
3	VIU-1	P1	CT (CDT)	1171	42 (66)	500
4	P1	VIU-1	CT (CDT)	1171	42 (66)	500
5	VIU-3	P3	CT (CDT)	600	42 (66)	500
6	P3	VIU-3	CT (CDT)	600	42 (66)	500
7	VIU-3	P2	CT (CDT)	600	42 (66)	500
8	P2	VIU-3	CT (CDT)	600	42 (66)	500
9 (*)	Amplifier	Head Unit	AVB_A	360	74	125
10 (*)	Amplifier	SGA	AVB_A	360	74	125
11	Head Unit	Amplifier	AVB_A	600	74	125
12	Amplifier	SGA	AVB_C	432	74	1333
13	SGA	Amplifier	AVB_C	312	74	1333
14	AD	P2	AVB_B	1434	66	256
15	Tele-Unit	SGA	BE	1480	42	Poisson
16	Tele-Unit	Head Unit	BE	1480	42	Poisson

Comparative results & discussion

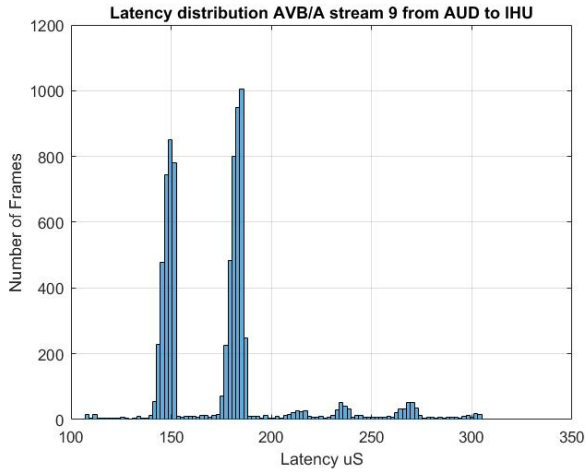
- AVB & strict priority (CT_period=500µs)

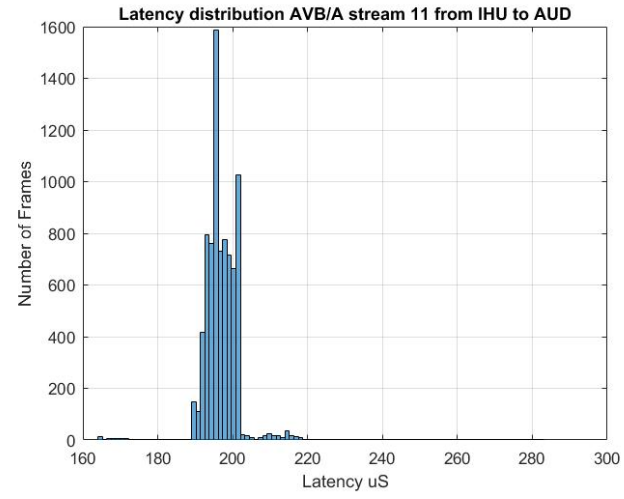


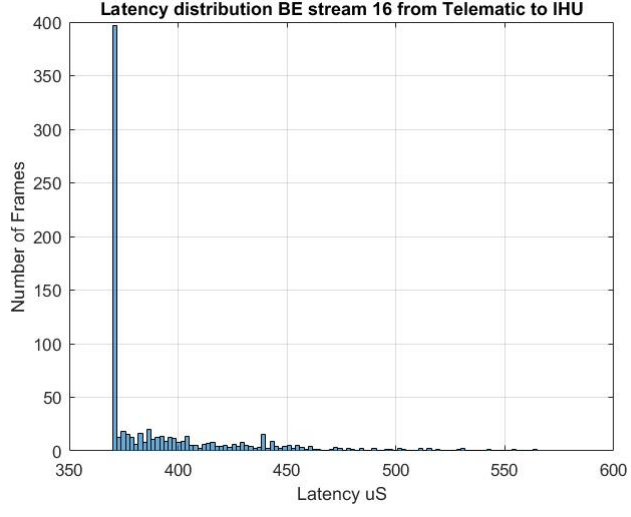
- *Applying TAS (CDT_period=500µs; TAS_interval = 500µs*

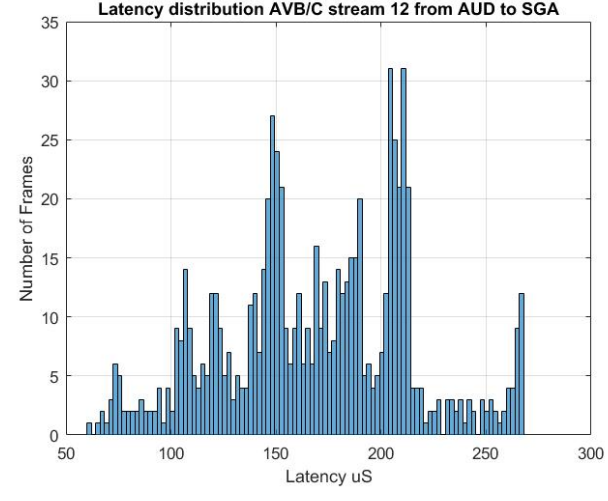


Delay distributio









discussion

- Using TAS does not obviously gain the performance
  - In our specific scenario
  - When bandwidth utilization is moderate
- With AVB and Credit Based Shaper
  - We can achieve similar performance as with TAS
  - No dependence to reserved network time slots
  - “Bottlenecks” of the network are the links between processors and the switches inside VCU
- A simple and flexible solution
  - Applying simple traffic policing for all traffic queues to
    - Limiting ingress rate and burst size
    - Defining memory partition used for ingress buffering
  - Apply CBS for each traffic class (queue) for each port (including control traffic)


Thank you
for your
attention