Guidelines for using IEEE 802.1Qcr in JASPAR's in-vehicle network ~ Why are Qav and Qbv Dominant ~

Japan Automotive Software Platform and Architecture

IEEE SA Ethernet & IP @ Automotive Technology Day

JASPAR Next Generation High-Speed Network WG
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Introduction

Software Defined Vehicle: SDV is now attracting attention.

SDV is expected to realize a new Cross-Domain UX by consolidating in-vehicle functions in a central ECU.

So, ***What exactly is SDV ?***

Does consolidating functions into the Central ECU make it an SDV?

JASPAR believes that **Zonal Architectures and Networks** are the key to realizing SDV.

This presentation discusses the state of networks in SDV.

Agenda

I. How will in-vehicle communications change ?

II. Introduction of Ethernet TSN QoS (shaping)

III. Comparison of some shaping

Trends in the Automotive Industry

The mobility industry is facing a once-in-a-century innovation.

Service Shift

MaaS

Intelligent

NFT

Manufacturing

ICE BAN

BCP

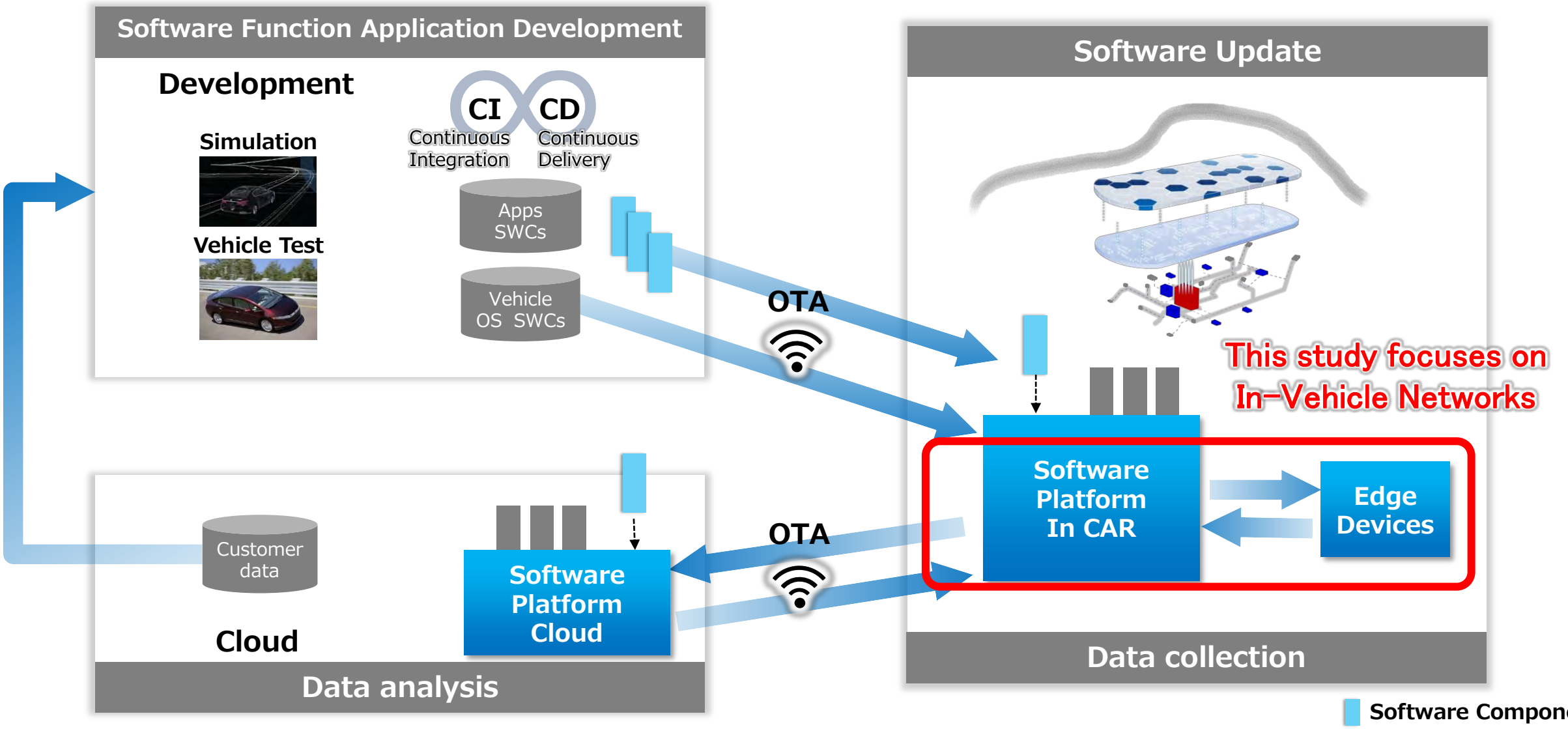
Electrification

Rulemaking

Decoupling

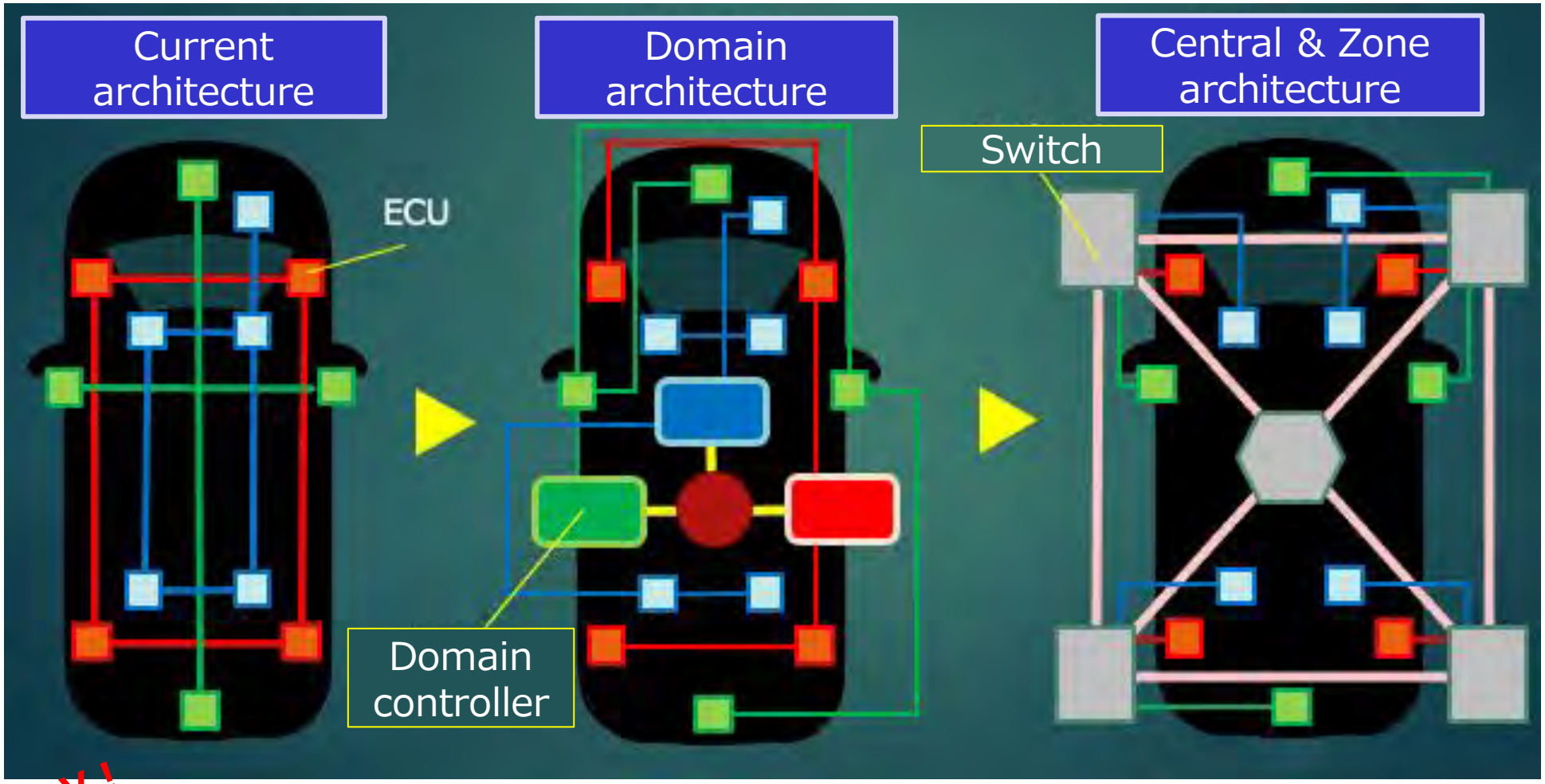
SDVs are now the center of worldwide attention.

SDV Ecosystem



Completely different data flow from conventional ones.

Innovating in-vehicle networks to realize SDV



So-called SDV !

Centralization of Services

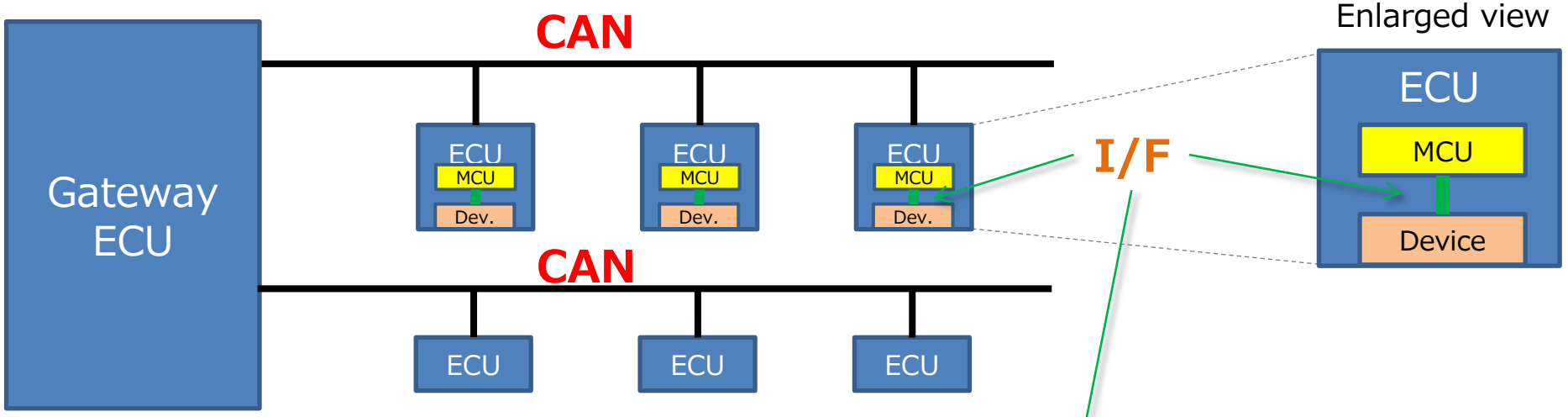
Two sides of the same coin

Also important!

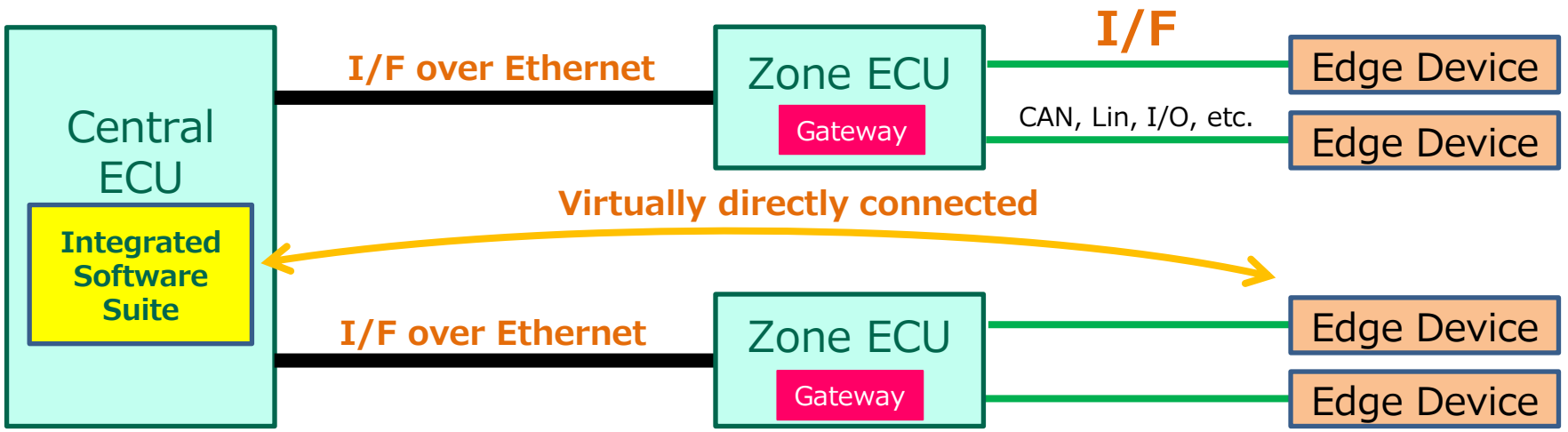
Zoning and Device Containment

Zoning and Device Containment

Conventional architecture

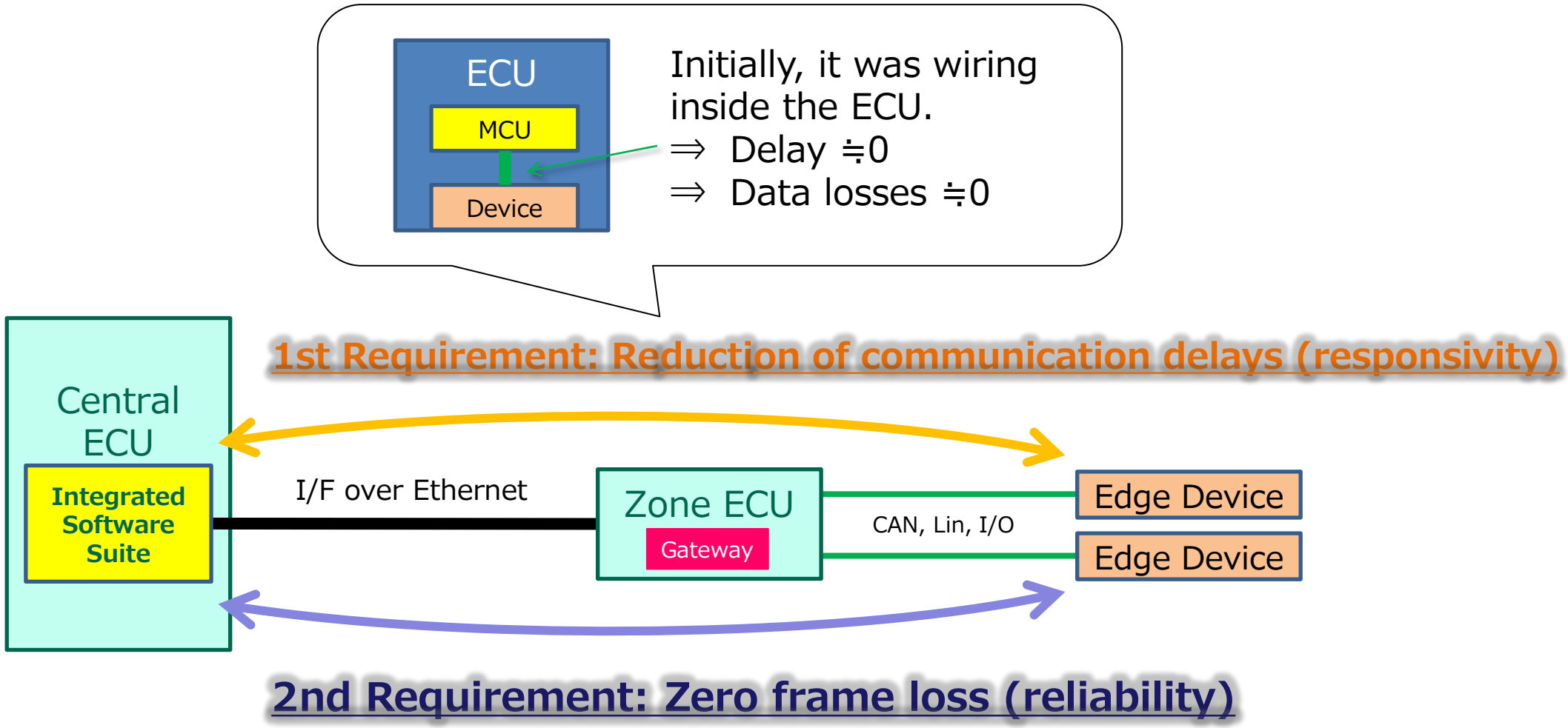


Central & Zone architecture



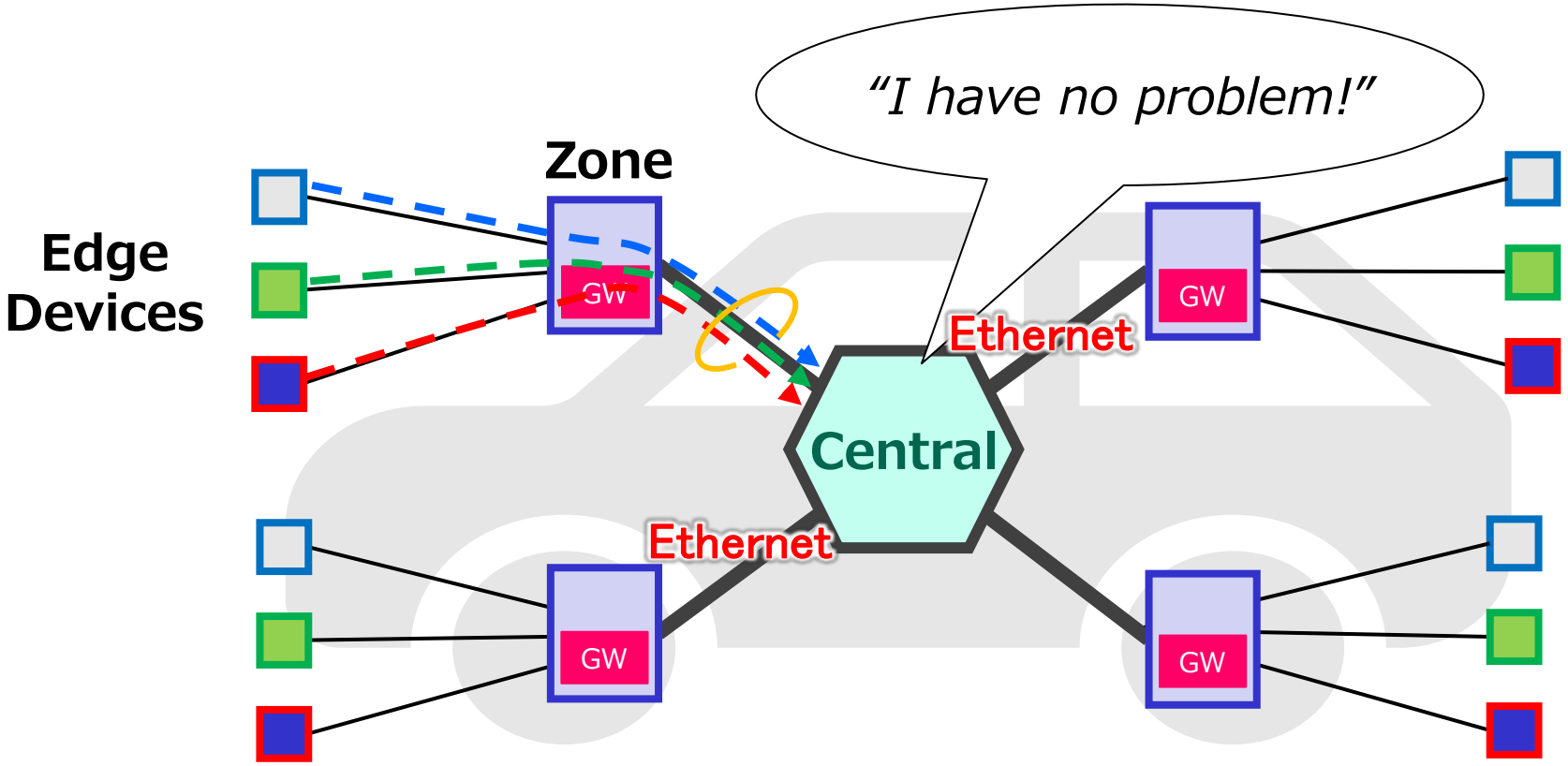
The C&Z architecture will significantly change the data transmission through channels.

Zoning and Device Containment



Quick Responsivity and High Reliability are required.

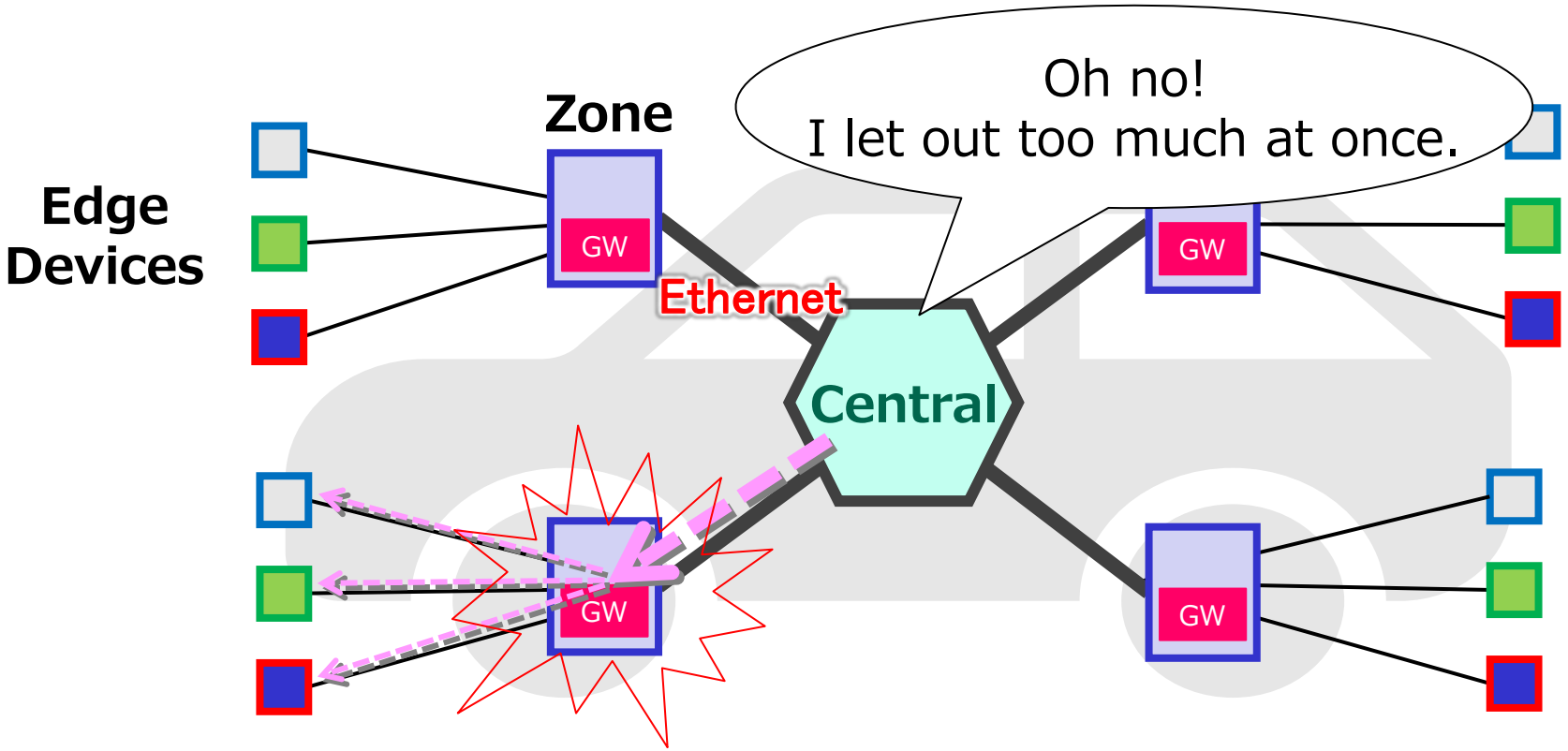
Uplink (Direction: Edge Device ⇒ Zone ⇒ Central)



Transmission of information from edge devices to the central quickly and reliably

Increase of the bandwidth to the central

Downlink (Direction: Central ⇒ Zone ⇒ Edge Device)



When the Central output exceeds the Zone processing capacity, data overflows.

The selection and design of protocols are inevitable to prevent flooding in the zone.

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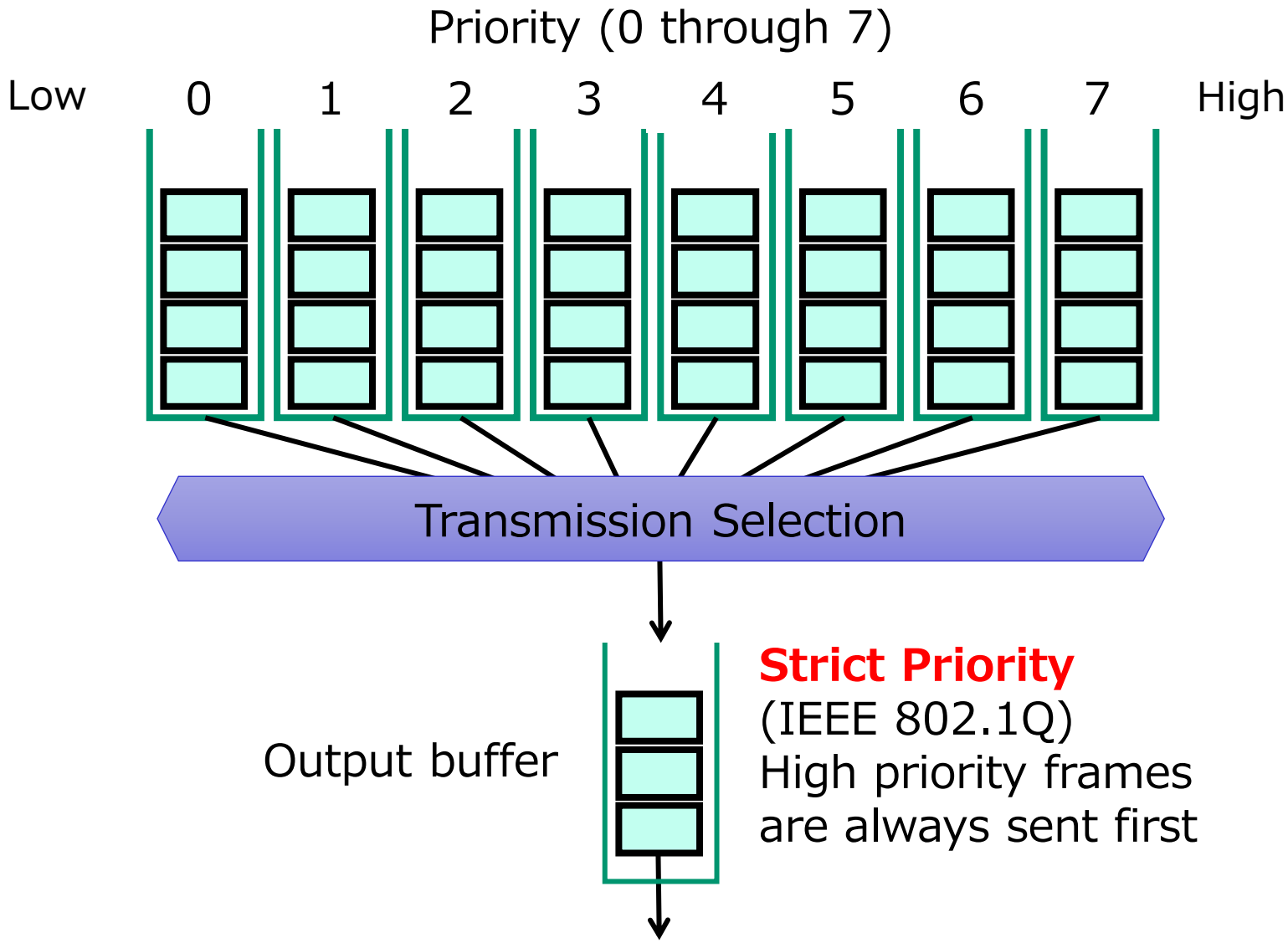
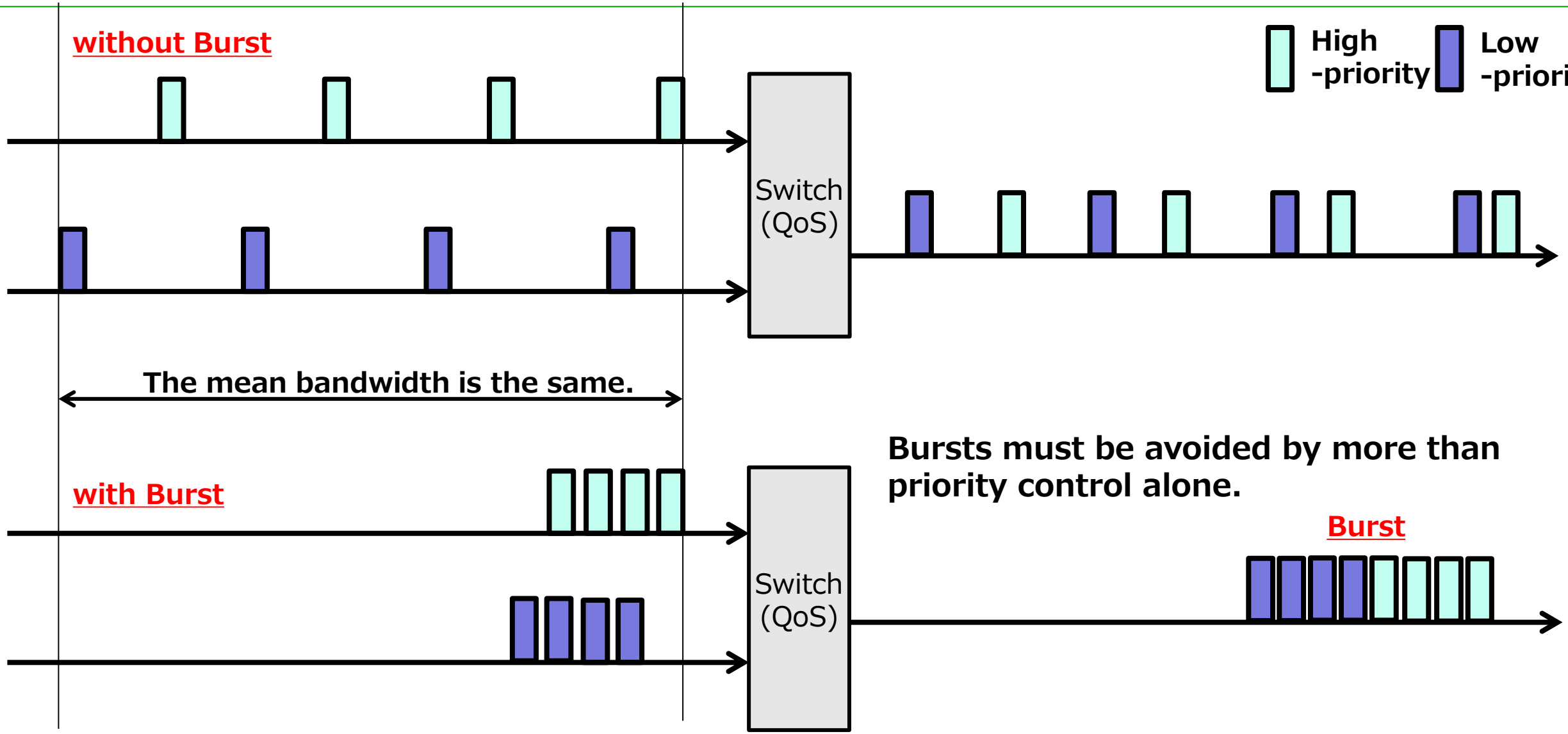
Basic Priority Control on Ethernet



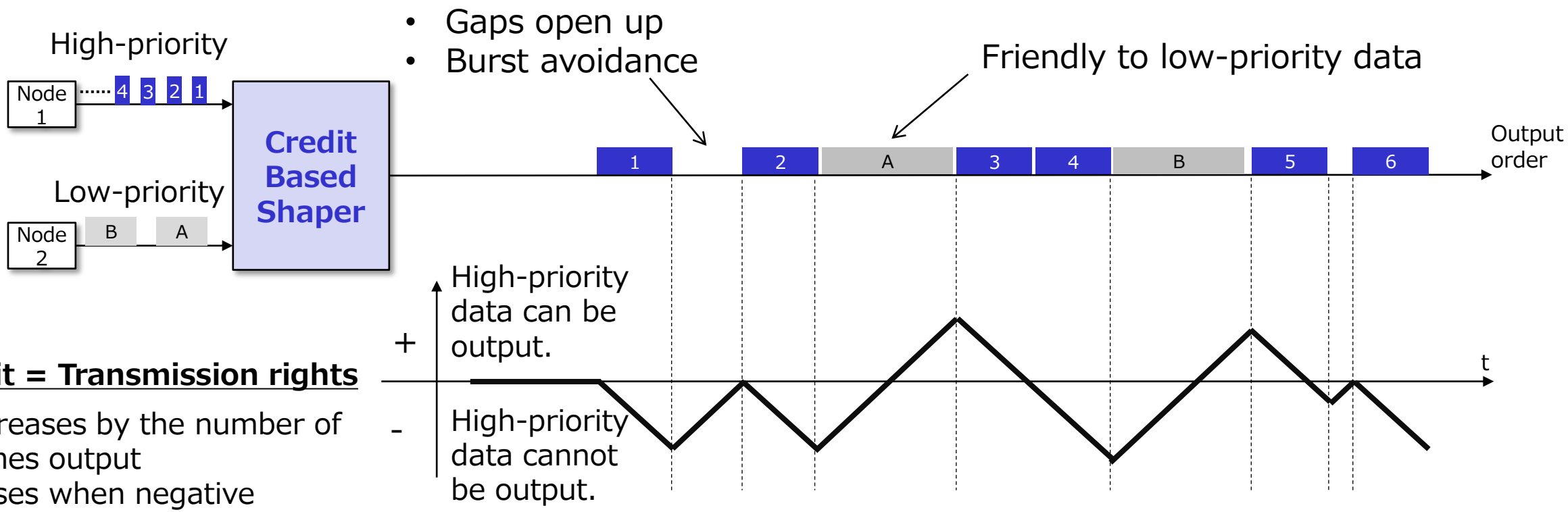
Prioritizing only high-priority data can result in bursts of traffic that can cause flooding in a zone.

Burst impact



A method of avoiding bursts (shaping) is necessary.

Outline of Credit Based Shaper (IEEE 802.1Qav)



Credit = Transmission rights

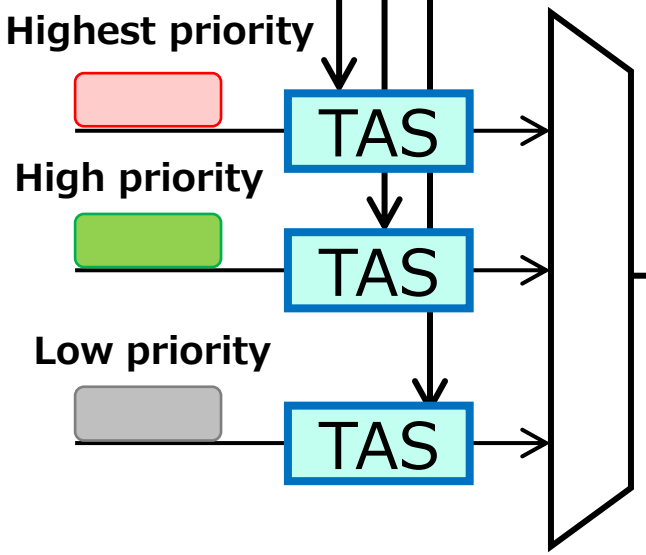
- Decreases by the number of frames output
- Pauses when negative
- Restarts output when positive

Pros:
- **Easy to implement**
- No time synchronization is required.

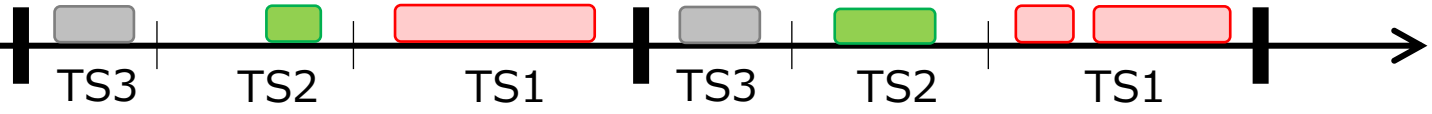
Cons:
- No precise control
- No consideration for delays

Outline of Time Aware Shaper (IEEE 802.1Qbv)

Priority	Time Slot
Highest	1
High	2
Low	3



For example, during TS1, the highest priority TAS is open, while other TAS are closed.



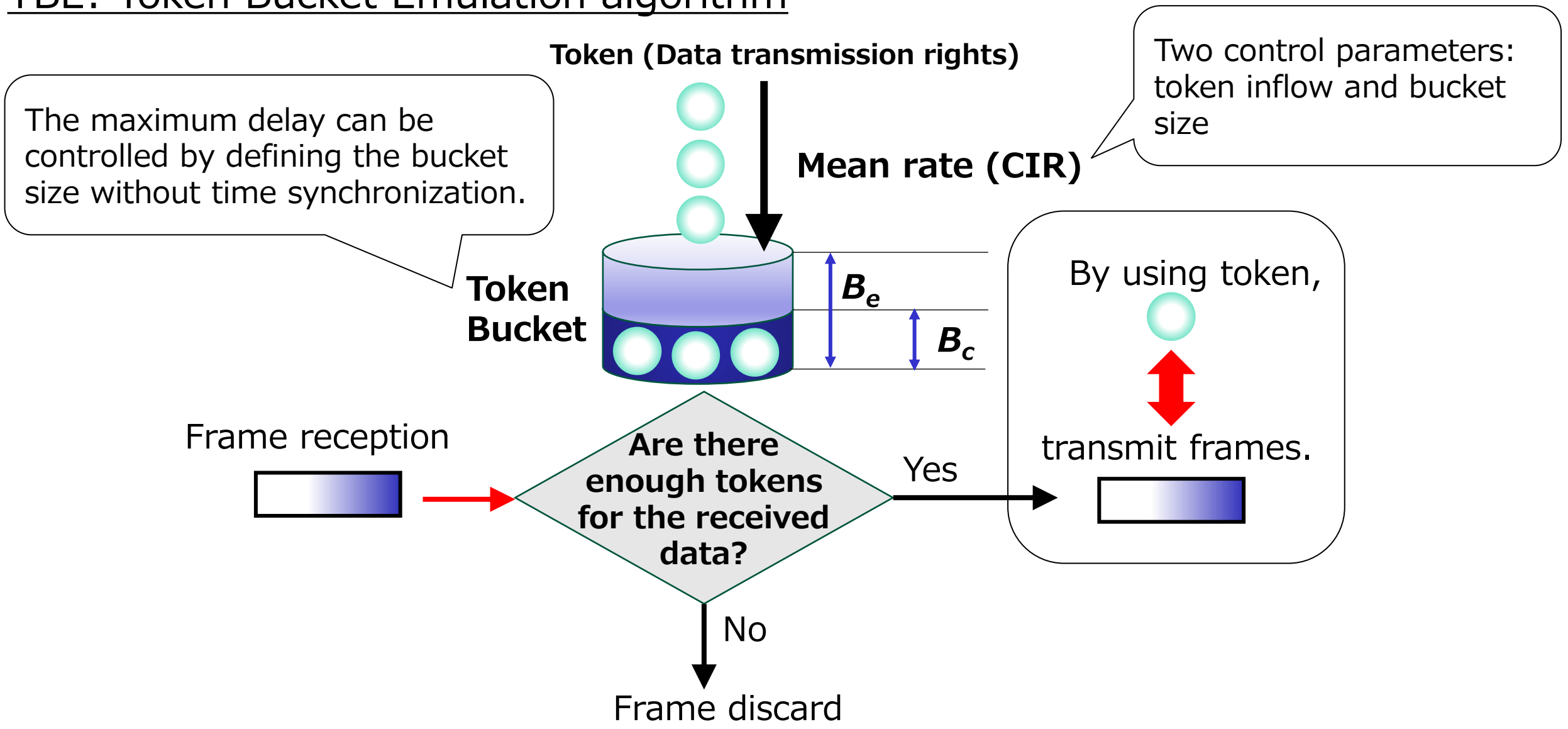
If this could be realized, ideal data transmission would be possible, but designing the schedule would be extremely difficult.

Pros:
- Precise control is available.
- Maximum delay can be guaranteed.

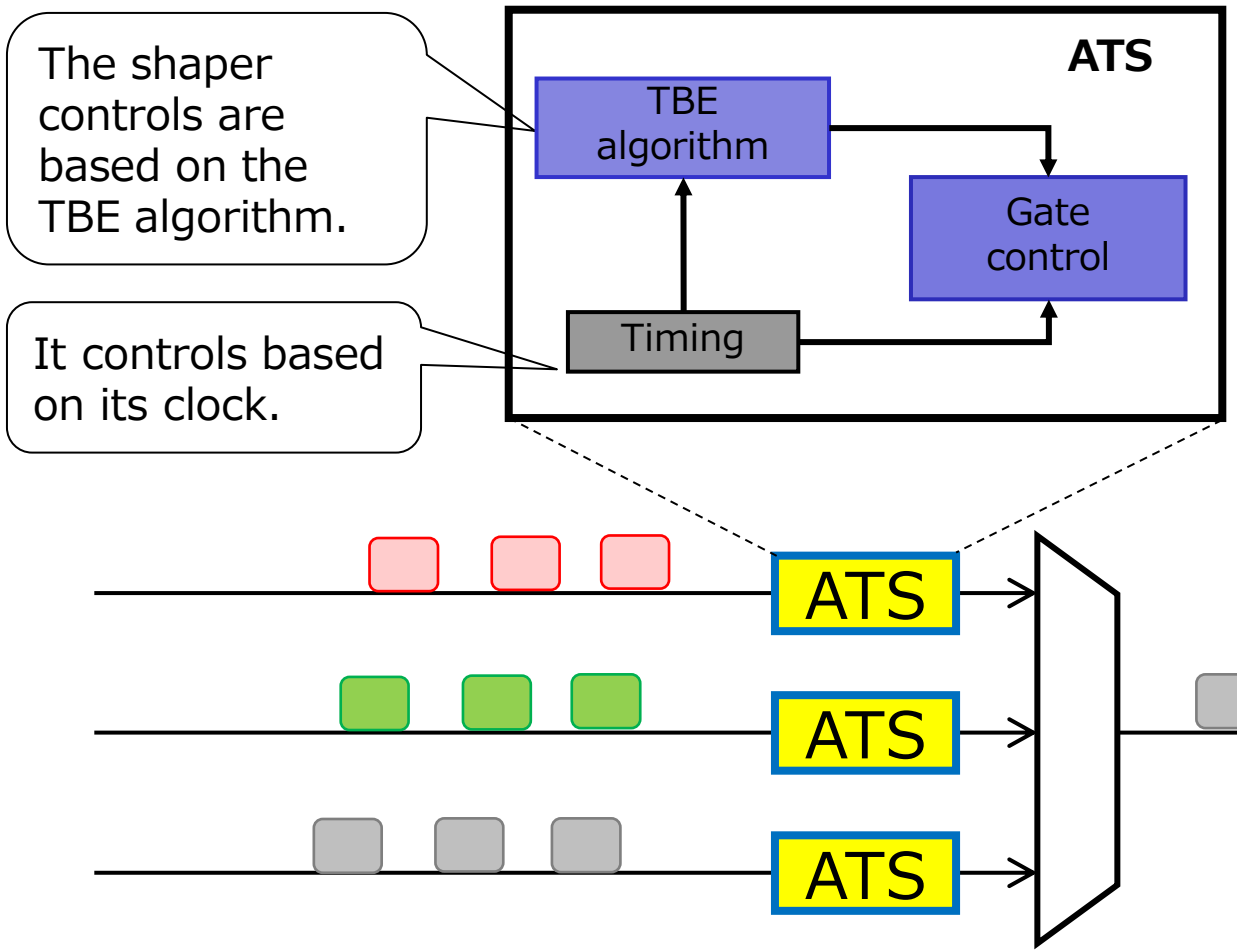
Cons:
- Complicated implementation
- Gate control schedule design is required.
- Time synchronization is mandatory.

Outline of Asynchronous Traffic Shaper (IEEE 802.1Qcr)

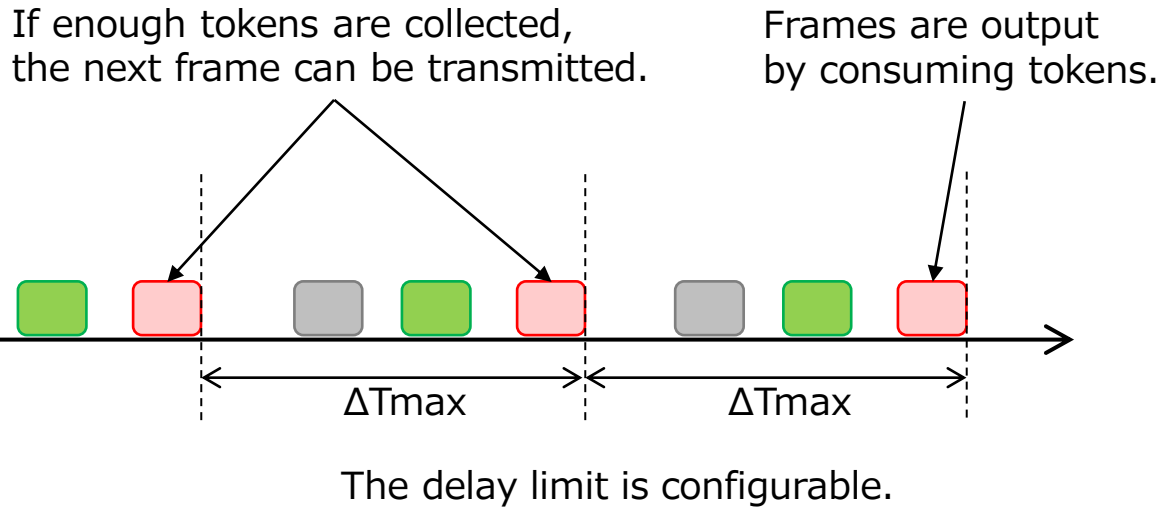
TBE: Token Bucket Emulation algorithm



Outline of Asynchronous Traffic Shaper (IEEE 802.1Qcr)



The implementation of ATS is less complicated than that of TAS and allows for more precise control than CBS.



Pros:
- The frame delay limit is configurable.
- No time synchronization is required.

Cons:
- The implementation of ATS is more complicated than that of CBS.

Comparison of Shapers

Shaper	Pros	Cons
CBS (802.1Qav)	• No time synchronization is required • One setting parameter (Credit) • Easy to implement	• Precise control is difficult. • Quality other than for high-priority frames degrades.
TAS (802.1Qbv)	• Precise control with the Gate Control List	• Each switch requires time synchronization. • Designing an optimal gate control list is difficult. • Implementation is complex.
ATS (802.1Qcr)	• No time synchronization is required. • There are only two setting parameters (token inflow and bucket size) and more precise control than CBS.	• Few switches have been implemented. • It's far less proven than CBS and TAS.

I. How will in-vehicle communications change with the shift to SDV?

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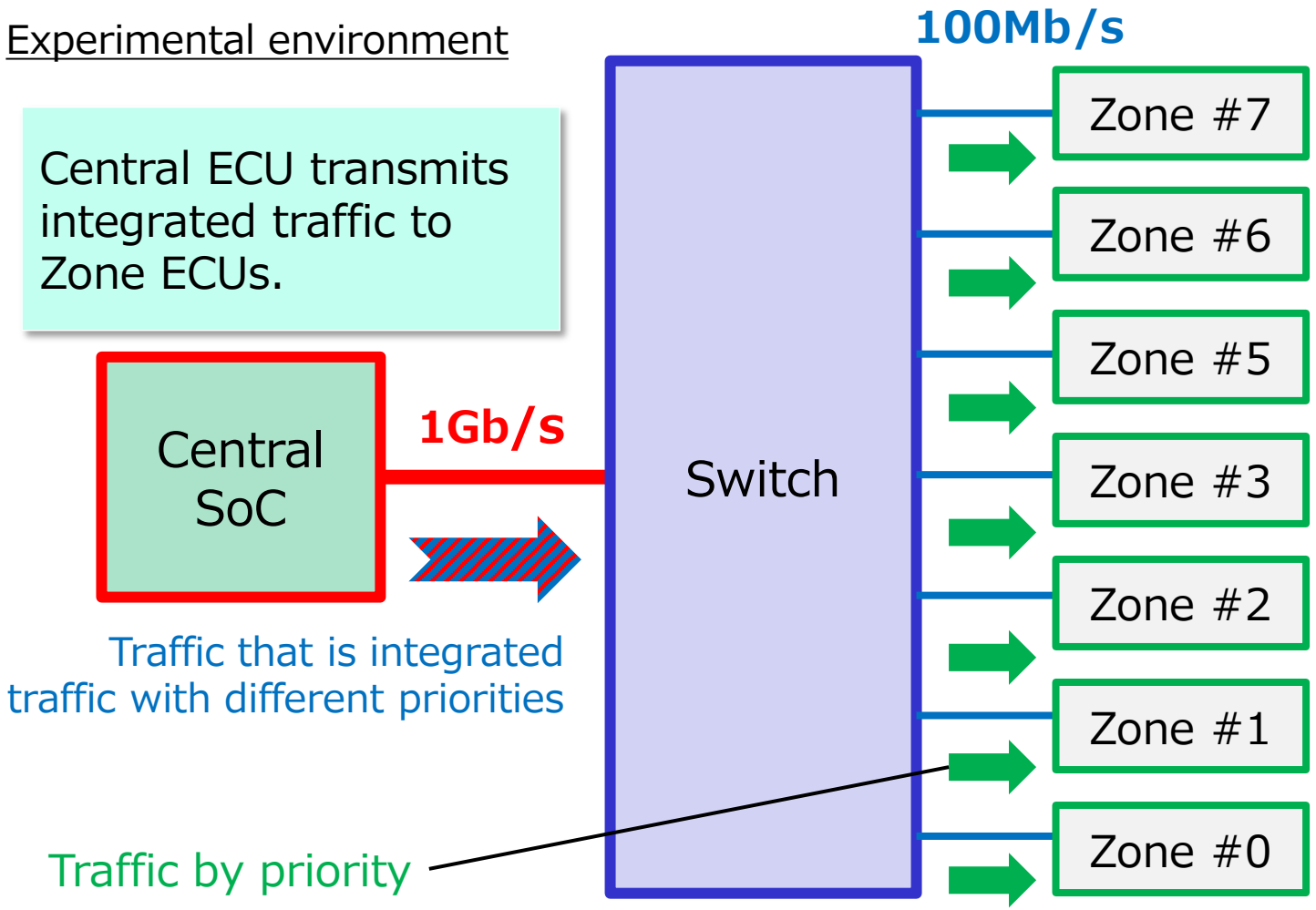
Comparison of CBS and ATS in In-Vehicle Networks

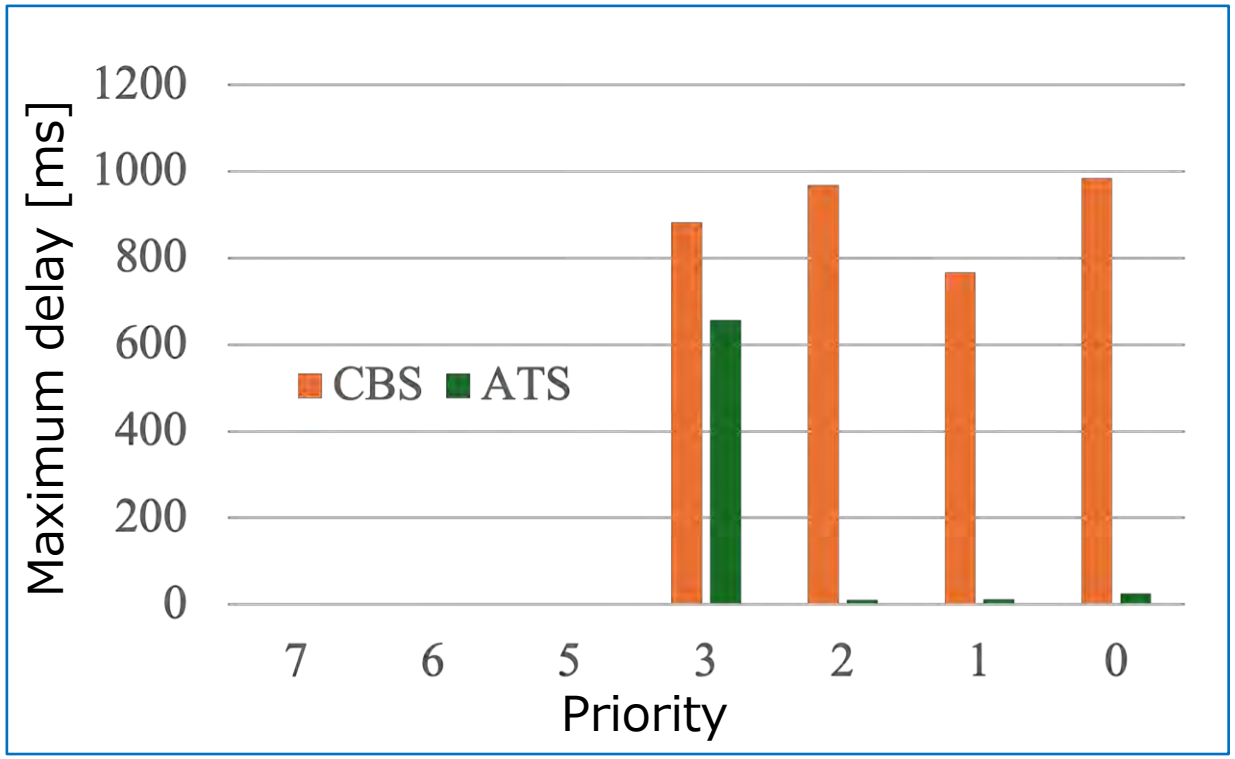
- Simulations compare the shaping effects when using CBS and ATS.
- Central ECU transmits traffic according to its priority.
- The maximum delay and frame loss rate are evaluated.

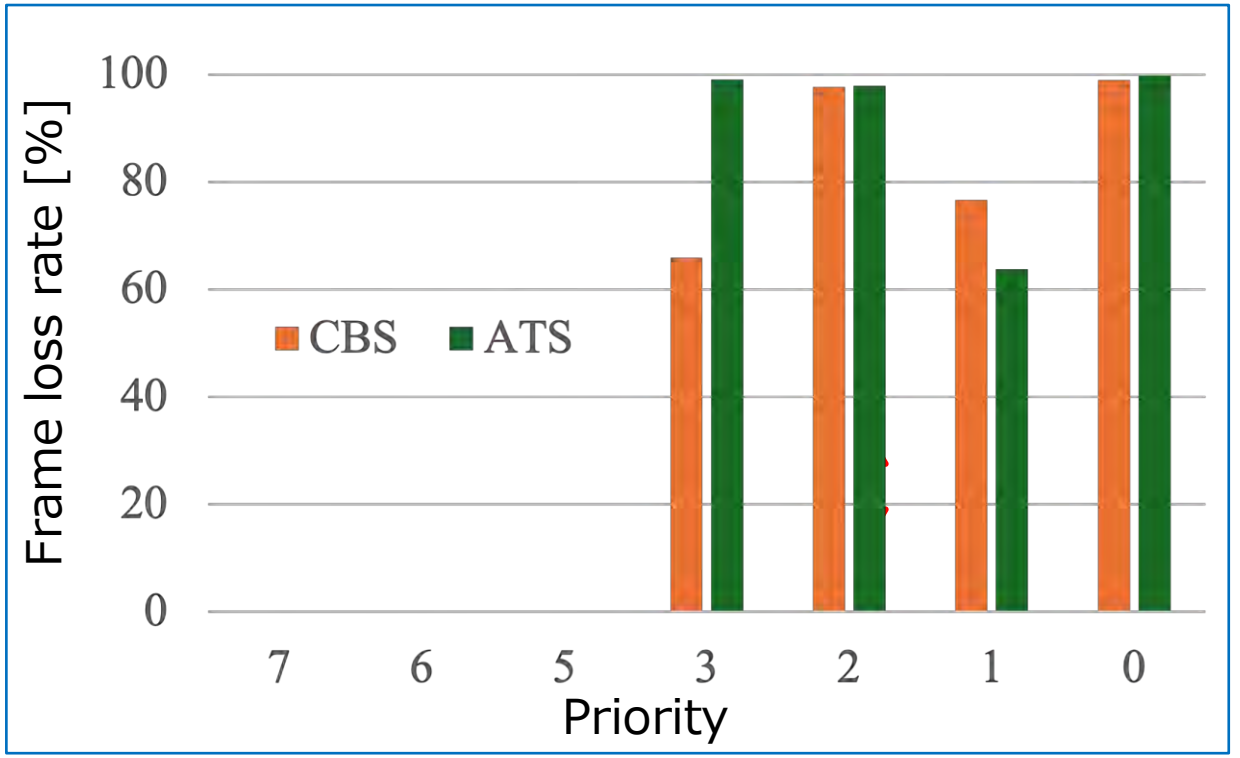
Experimental environment



- ATS and CBS are applied before queuing the output interfaces.
- ECU*n* receives traffic of priority *n*.
- The mean and variance of the transmission rate of the integrated traffic generated by the central ECU changes per priority.
- Traffic with priority 4 is omitted in this experiment because it is assumed that Frame preemption will be used.

Results of evaluation experiment



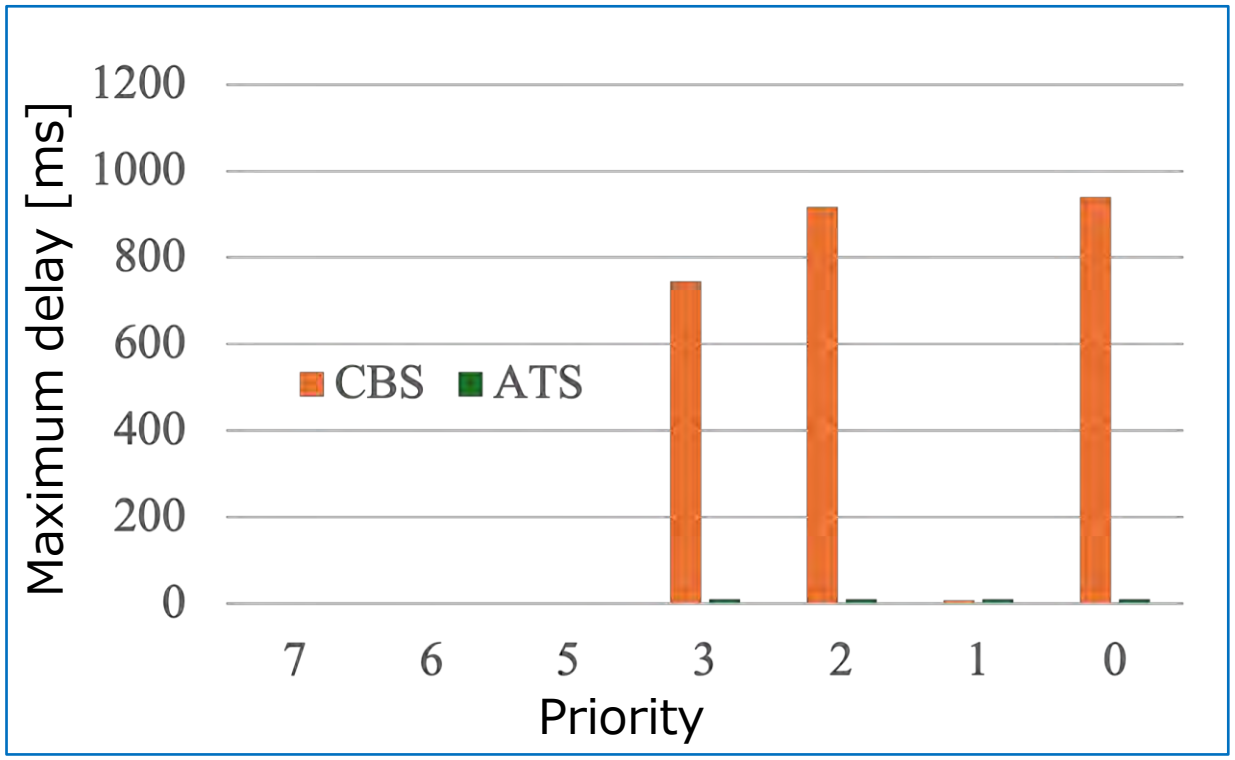


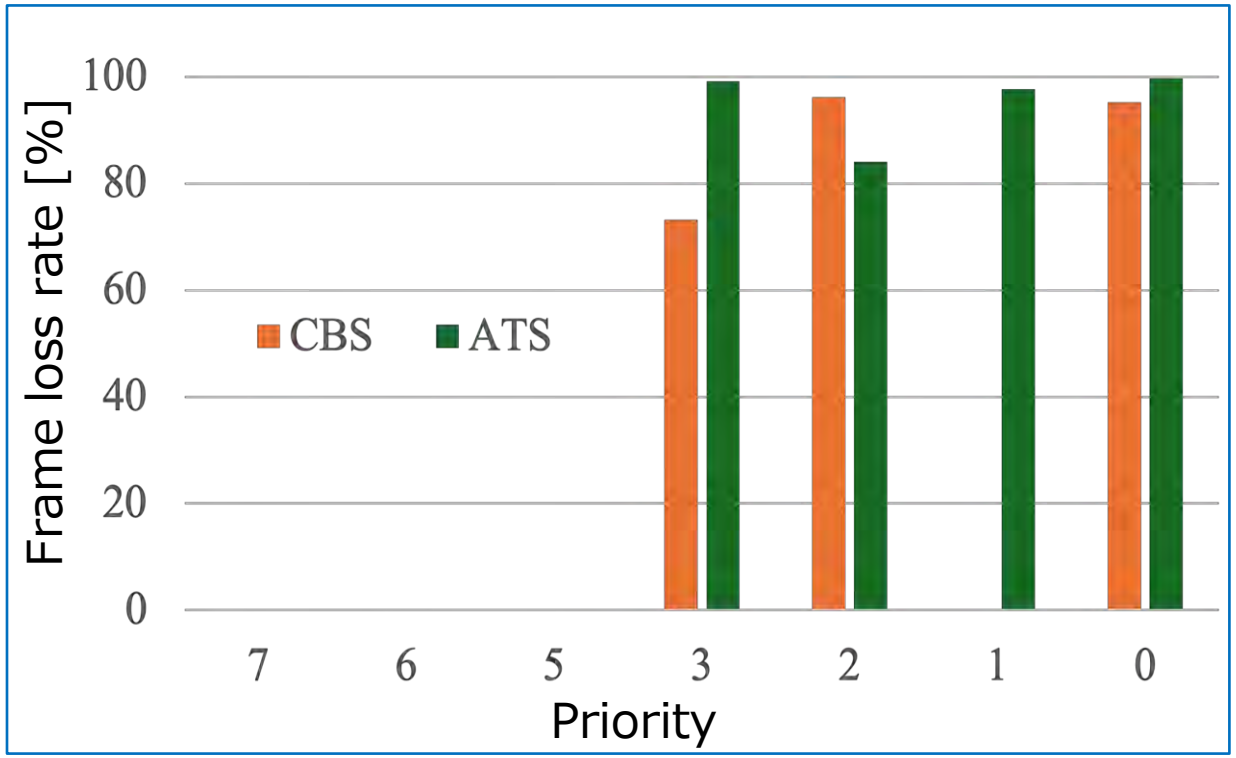
By setting Committed Burst Size, ATS can suppress the maximum delay more than CBS. Additionally, the maximum delay can be managed by adjusting the Committed Burst Size.

While ATS suppresses the maximum delay, frames that exceed the maximum residence time are discarded, resulting in more frame losses than CBS.

ATS allows the choice of an appropriate point in the trade-off between maximum delay and frame loss rate.

Results (Traffic with a lower mean sending rate but more extensive variation)





Since frames are no longer held in the token bucket due to bursts, the maximum delay can be suppressed entirely in ATS.

While ATS suppresses the maximum delay, frame loss occurs in ATS even though there was no frame loss in CBS.

・Data with a time structure, that is, data that becomes meaningless after the expiration time, should be transmitted by ATS, and ATS can manage the expiration time.
・CBS should be used for data that is more sensitive to missing data than time constraints.

Considerations on Results - JASPAR's Design Guidelines -

- The main structure is constructed based on CBS, which is easy to implement and configure.
- Selectively apply ATS to time-sensitive data

The right person in the right place

- Parameter optimization to trade off responsiveness and reliability

It is better to derive optimal values through simulation before implementing them.

・For in-vehicle networks, it was assumed that CBS (Qav) and TAS (Qbv) would be adopted, but they may be only sometimes optimal.
・The reason why we assumed CBS and TAS is just a conventional one. Therefore, we should also take the combination of ATS, which has more control variables than CBS.

Conclusions

- This study analyzed the effect on communications caused by the centralization of functions in the central ECU due to the adoption of SDVs. It clarified that SDV networks require responsiveness and reliability.
- The simulation clarified that shaping is necessary to avoid bursty (continuous) traffic to achieve both responsivity and reliability.
- Three shaping standards of IEEE 802.1TSN were qualitatively evaluated, and their relative characteristics were clarified.
- In particular, this study focused on CBS vs. ATS and evaluated the effect quantitatively and relatively.

Thank you for your attention.