Overview of TSN use cases

Japan
Automotive
Software
Platform
and
Architecture

2019.11.14

Takumi Nomura (Honda)
Hideki Gotoh (Toyota)
Yoshihiro Ito
(Nagoya Institute of Technology)

Objective

- Provide use case study examples to create the Automotive Profile.
  - ✓ Create use cases We are here
  - ✓ Extract Requirements
  - ✓ Profiling

	Use cases from JASPAR
UC1	Connected-Car with 5G network
UC2	Functional Safety
UC3	Real-time communication
UC4	Security
UC5	In-Vehicle Traffic Types

UC1. Connected-Car with 5G network

- We recommend to investigate the requirement for In-Vehicle Network as a part of End-2-End (E2E) system for Connected-Car with 5G network.

- Use cases for Connected-Car with 5G network should be carefully discussed in 802.1DG because 5G network continues dynamically evolving and requires the updatability and upgradability of In-Vehicle Network which should be able to support additional new service applications after market.

- Use cases for Connected-Car will use the sophisticated network performance of 5G network as a part of E2E system from ECU to Server in Cloud.
  5G network includes the specification of eMMB and URLLC which can enable attractive E2E service applications if there is no bottleneck part of In-Vehicle Network.

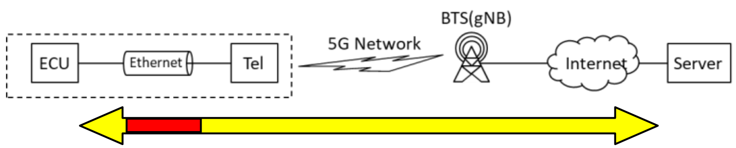
	Data rate (5G Network)	Latency (5G Network)	Reliability (5G Network)
5G (Sub 6GHz)	Depends on Category	< 1ms	99.999 %

Specification of 5G Network

eMMB: enhanced Mobile Broadband
URLLC: Ultra Reliable Low Latency Communications

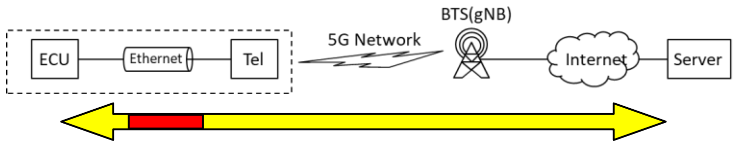
UC1. Connected-Car with 5G network

- **High data rate** of 5G Network should be kept on all part of E2E system to avoid the bottleneck of low data rate so that In-Vehicle Network should have the same capability of High data rate.
- **Latency** is cumulative total of the latencies of all part so that we need to know them completely in order to define the requirement of latency for In-Vehicle Network part.
- **Reliability** is the total multiplication value of the reliability of all part so that we need also to know the reliability of each part.



Scenario	Max-allowed E2E Latency	Reliability	User experienced Data rate
ITS Infrastructure backhaul	30ms	99.999%	10Mbps

Use case defined in 3GPP TS 22.261 V15.8.0 (2019-09) (Rel.15) " 7. Performance Requirements "



Scenario	User experienced Data rate
5 Dense Urban	DL: 300Mbps UL: 50Mbps
6 Broadcast like service	DL: 200Mbps UL: n/a
8 High Speed Vehicle	DL: 50Mbps UL: 25Mbps
(Ref) 3 Indoor hotspot (*1)	DL: 1Gbps UL: 500Mbps

*1 : Not vehicle relevant use case, but can be hotspot in vehicle

Requirements defined for In-Vehicle Network (Ethernet) (Draft)

5G Scenario for Vehicle	Latency	Reliability	User experienced Data rate
ITS Infrastructure backhaul 5 Dense Urban	?? ms	100% ? with redundant NW?	DL: 300Mbps UL: 50Mbps

UC2. Functional Safety

- Application of TSN standards for Functional Safety

We analyzed TSN standards from the “failure modes” of communication analyzed in functional safety (ISO 26262-5:2018) perspective.

Considered effective combinations of TSN standards for functional safety.

Extracts from ISO 26262-5:2018, Annex D, TableD.1 – Analyzed failure modes

Element	Analyzed failure modes
Data transmission	Loss of communication peer
	Message corruption
	Message unacceptable delay
	Message loss
	Unintended message repetition
	Incorrect sequencing of message
	Message insertion
	Message masquerading
	Message incorrect addressing

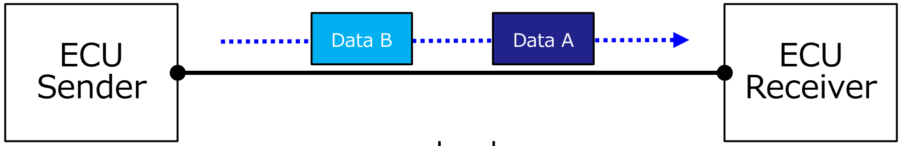
Summary example

Analyzed failure modes	Application of TSN standards for Functional Safety		
	good	NOT good	Notes
Loss of communication peer	–	–	
Message corruption	–	**802.1AS**	**・Requires mechanisms such as CRC（FCS) - Add CRC function (optional)**
Message unacceptable delay	802.1CB	–	
Message loss	802.1CB	–	
Unintended message repetition	–	–	
Incorrect sequencing of message	–	–	
Message insertion	–	–	
Message masquerading	–	–	
Message incorrect addressing	–	–	

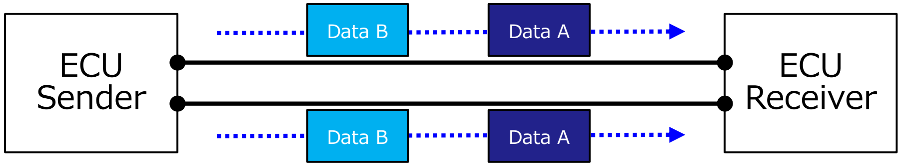
Appendix: Application of 802.1CB for Functional Safety

- Extracts from ISO 26262-5:2018, Annex D, TableD.6－Communication Bus

Safety mechanism/ measure	Typical diagnostic coverage considered achievable	Notes
Complete hardware redundancy	High	Common mode failures can reduce diagnostic coverage
Transmission redundancy	Medium	Depends on type of redundancy. Effective only against transient faults

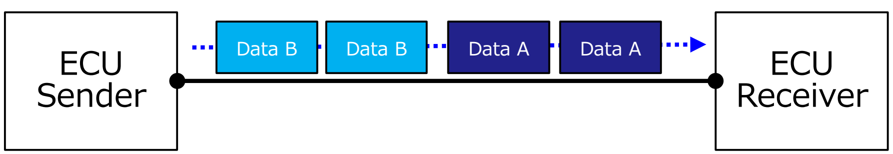


non redundancy



Complete hardware redundancy

Aim:
To detect failures during the communication by comparing the signals on two buses.
Description:
The bus is duplicated and the additional lines are used to detect failures.



Transmission redundancy

Aim:
To detect transient failures in bus communication.
Description:
The information is transferred several times in sequence.

802.1CB may be able to achieve **High/Medium diagnostic coverage**.
Considering application of TSN standards for Functional Safety.

UC3. Real-time communication

Use Case: FlexRay features

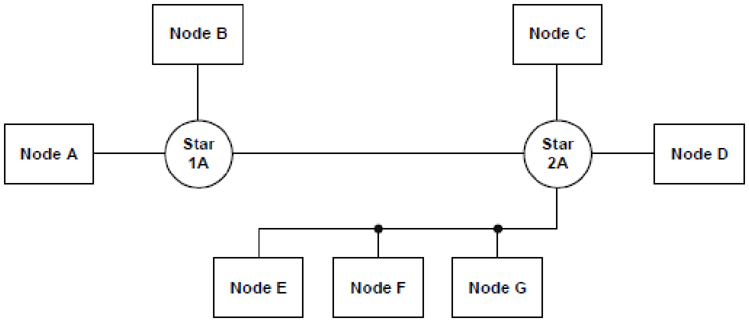


Figure 10 — Single channel hybrid example

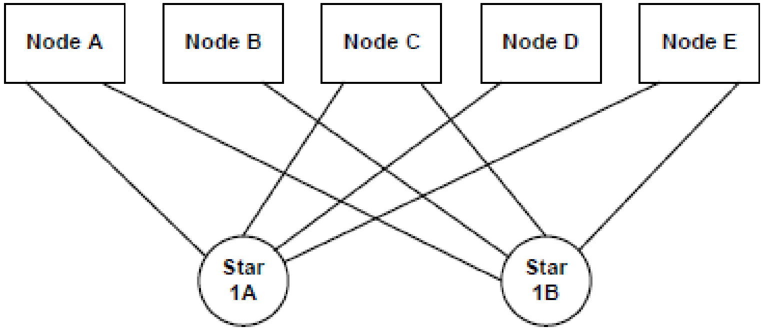


Figure 7 — Dual channel single star configuration

Referenced from ISO 174580-2:2013

Requirement:

R x.1	Requirements to enable FlexRay like functionality
R x.2	
R x.3	
R x.4	
R x.5	

Useful 802.1 mechanisms:

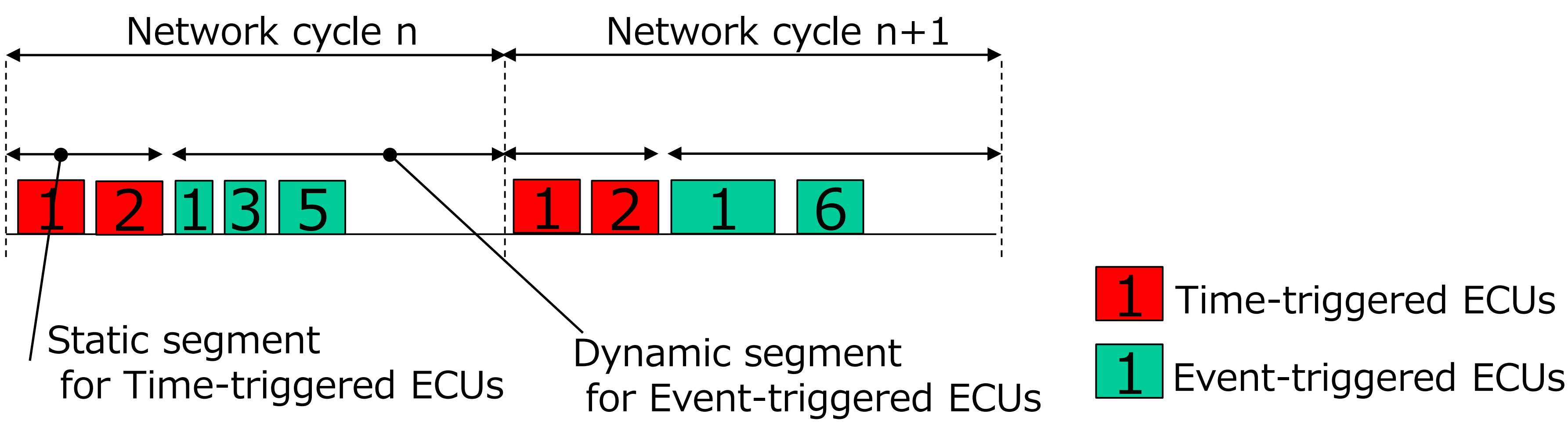
TSN protocols/subset proposals to realize above requirements

UC3. Real-time communication

Useful aspects of TSN (under discussion)

Requirement	Function	Standard
Periodic traffic Bounded low latency	Clock synchronization	802.1AS
	Scheduled traffic	802.1Q 8.6.8.4 : Qbv
Traffic classification	TCP/IP-based stream identification	802.1 CBdb
	Ingress Policing	802.1Q 8.6.5.1 : Qci
Configuration		802.1Qcc, 802.1ABcu etc.

Example of traffic scheduling

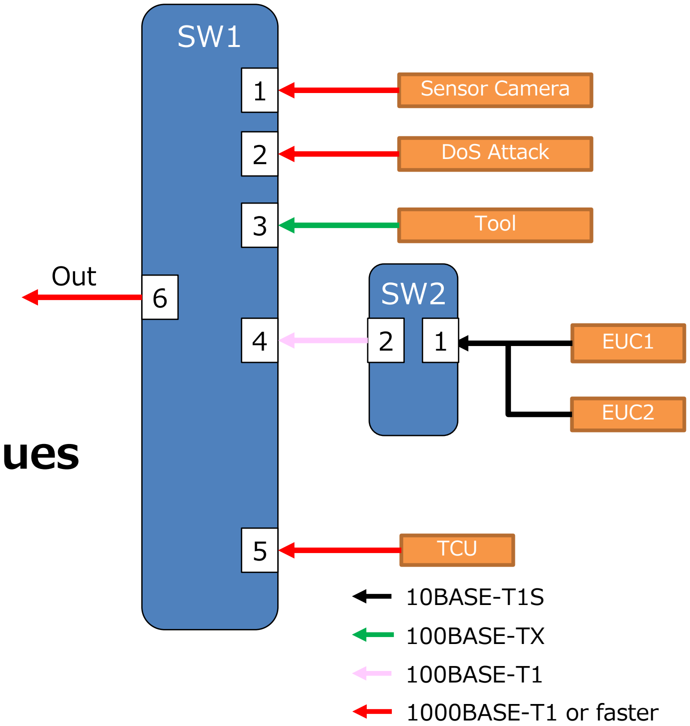


JasPar

- **Goal**
  1. Define an IVN profile which can provide protection of high priority traffic
  2. Ensure low latency with this IVN profile for ECUs communication(Scheduled Traffic) against DDoS attacks
  3. Detect DDoS attacks immediately and protect the IVN and ECUs from them

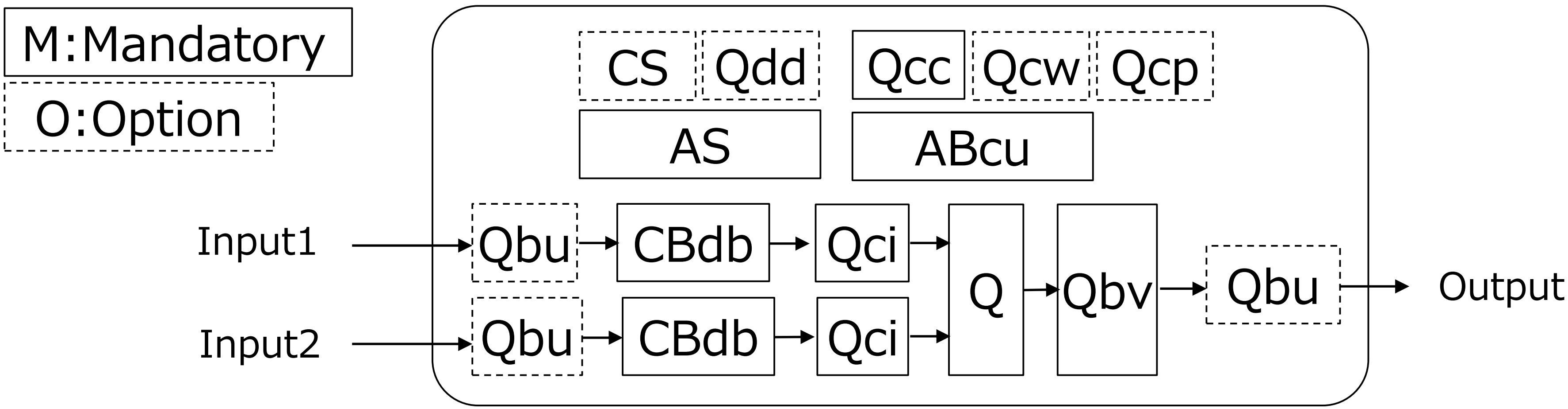
- **Potential Security Issues**
  1. DDoS attacks bring bandwidth exhaustion and disturbances to traffic prioritization on switch
  2. IVN is exposed to unauthorized access due to Brute-force attack

- **Example approach of using Qci to Security Issues**
  1. Block misbehaving streams by Per-Stream Filtering and Policing
  2. Detect unknown nodes or streams by Per-Stream Filtering and Policing
  3. Protect high-priority traffic from DDoS attacks and keep low latency



Example IVN in this use case

Appendix : Definition the TSN model



Switch structure model

TSN Function (1/2)

Function	Standard	Convention
Clock synchronization	802.1AS	M
Preemption	802.1Q 6.7.2	O: 802.1Qbu
Ingress Policing	802.1Q 8.6.5.1	M: 802.1Qci
VLAN	802.1Q 6.9	M
Transmission selection control	802.1Q 8.6.8	M
Scheduled traffic	802.1Q 8.6.8.4	M: 802.1Qbv
Extended Stream identification	802.1CBdb	M

TSN Function (2/2)

Function	Standard	Convention
Link-local registration Protocol	P 802.1CS	O
Resource allocation protocol	P 802.1Qdd	O
YANG for Qbv, Qbu, Qci	P 802.1Qcw	O
YANG for Bridge	802.1Qcp	O
LLDP Neighbor discovery	P 802.1ABcu	M
Centralized configuration	802.1Qcc	M

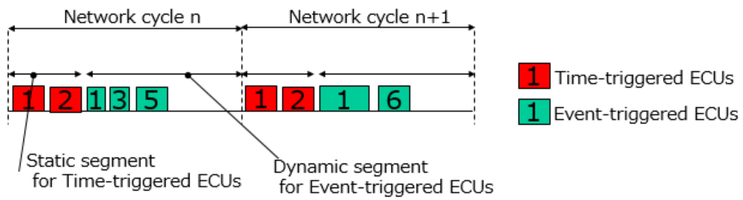
Appendix: Example of TSN model for Real Time

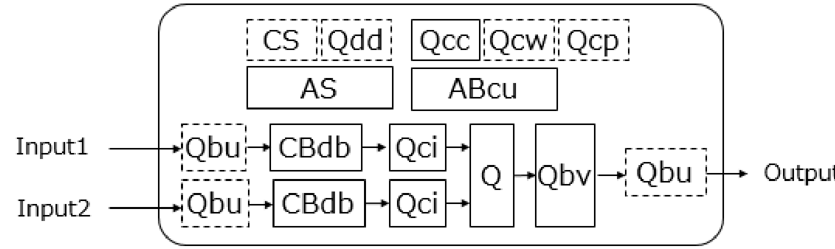
UC3. Real-time communication

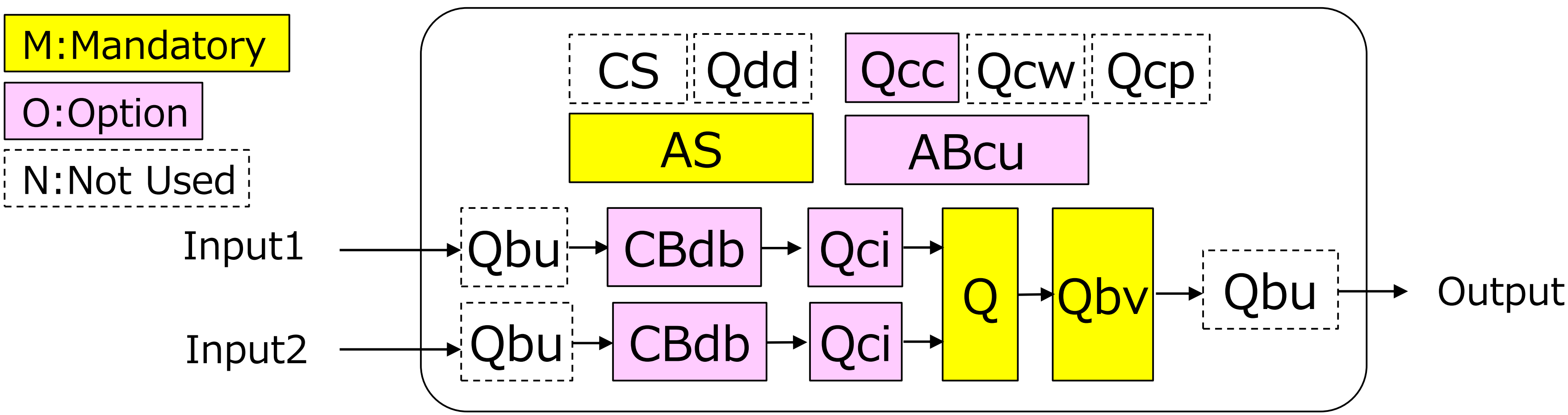
Useful aspects of TSN

Requirement	Function	Standard
Periodic traffic Bounded low latency	Clock synchronization	802.1AS
	Scheduled traffic	802.1Q 8.6.8.4 : Qbv
Traffic classification	TCP/IP-based stream identification	802.1 CBdb
	Ingress Policing	802.1Q 8.6.5.1 : Qci
Configuration		802.1Qcc, 802.1ABcu etc.

Example of traffic scheduling







Describe the Profile like a "Coloring" for easy understanding

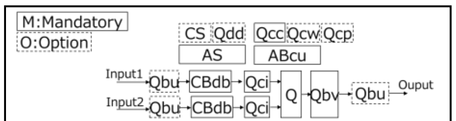
UC5. In-Vehicle Traffic Types

- Add a supplement to Auto Use Case 04 of「dg-pannell-automotive-use-cases-0719-v04.pdf」

Need for consideration of higher layer protocols (L3-L7)

Traffic Type	Period	Guarantee[4]	Tolerance to Loss[5]	Frame Size	Criticality	L2	L3	L4	L5~L7
Safety-relevant Control: see 3.4.1.2	<= 20ms	Deadline based Reserved w/Latency < 1ms	No	64 bytes	High		IP	UDP	See next slide
Safety-relevant Media: see 3.4.1.3	<= 10ms	Bandwidth based Reserved w/Latency < 1ms	No	64 to max frame size[6] (w/1500 data bytes)	High		IP	UDP	
Network Control: see 3.4.1.4	50ms to 1s	Sporadic Highest priority Non-Reserved	Yes	64 to 512[7] bytes	High		IP OSPF	None, UDP	
Event: see 3.4.1.5	N/A	Sporadic 2nd Highest priority Non-Reserved	Yes	64 to max frame size (w/1500 data bytes)	Medium		IP	TCP, UDP	
Safety-irrelevant Control see 3.4.1.6	< 200ms	Bandwidth based Reserved w/Latency < 50ms	Yes	64 bytes	Medium		IP	UDP	
Safety irrelevant Media: see 3.4.1.7	Defined by the media type	Bandwidth based Reserved w/Latency < 300ms	Yes	64 to max frame size (w/1500 data bytes)	Medium		IP	UDP	
Best Effort: see 3.4.1.8	N/A	None	Yes	64 to max frame size (w/1500 data bytes)	Low		IP ARP	TCP, UDP, None	

Requirement from Application / Service



Example) Switch structure

TSN Funciton (1/2)

Function	Standard	Convention
Clock synchronization	802.1AS	M
Preemption	802.1Q 6.7.2	O: 802.1Qbu
Ingress Policing	802.1Q 8.6.5.1	M: 802.1Qci
VLAN	802.1Q 6.9	M
Transmission selection control	802.1Q 8.6.8	M
Scheduled traffic	802.1Q 8.6.8.4	M: 802.1Qbv
Extended Stream identification	802.1CBdb	M

TSN Function (2/2)

Function	Standard	Convention
Link-local registration Protocol	P 802.1CS	O
Resource allocation protocol	P 802.1Qdd	O
YANG for Qbv, Qbu, Qci	P 802.1Qcw	O
YANG for Bridge	802.1Qcp	O
LLDP Neighbor discovery	P 802.1ABcu	M
Centralized configuration	802.1Qcc	M

L2 Colum shows in diagram of TSN functions.

Add protocol example

The traffic type MUST be decided according to the L3 / L4 protocols

UC5. In-Vehicle Traffic Types

An Example of Application-based Categorization
(Just a concept model without correctness)

L5-L7	Latency	Reliability	L4	Traffic type
HTTP	< 1s	N/A	TCP	Best Effort
NFS	< 200ms	99.99%	UDP	Safety-irrelevant media
			TCP	Best Effort
SNMP	< 1s	N/A	UDP	Different by management information
FTP	< 1s	N/A	TCP	Best Effort
TFTP	< 1s	99.999%	UDP	Safety-irrelevant media
SSH	< 500ms	N/A	TCP	Safety-irrelevant control
Application-A (for Safety)	< 10ms	99.999%	UDP	Safety-relevant control
Application-B (for no-safety)	< 1s	99.99%	TCP	Best Effort

Thank You