A study of Ethernet TSN profile based on JASPAR's automotive use cases

Japan Automotive Software Platform and Architecture

JASPAR Next Generation High-Speed Network WG

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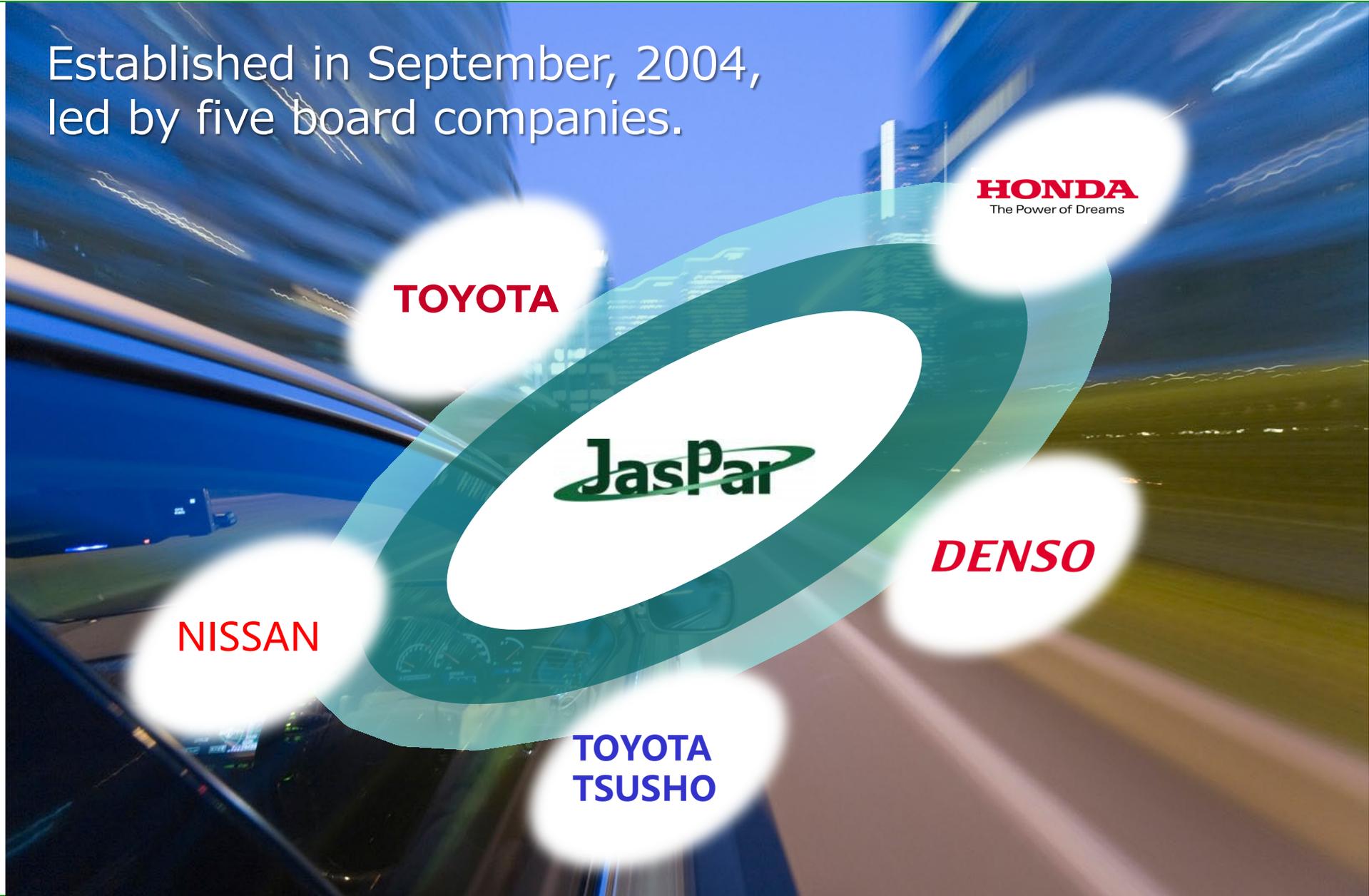
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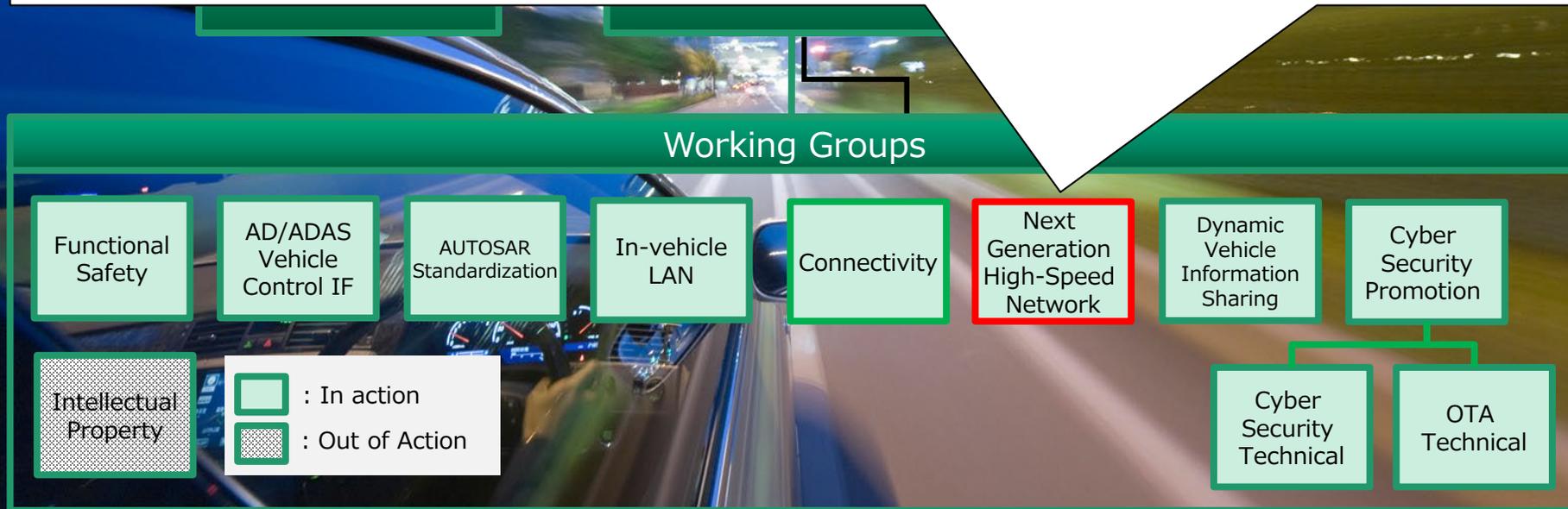6. Conclusions

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Introduction: About JASPAR

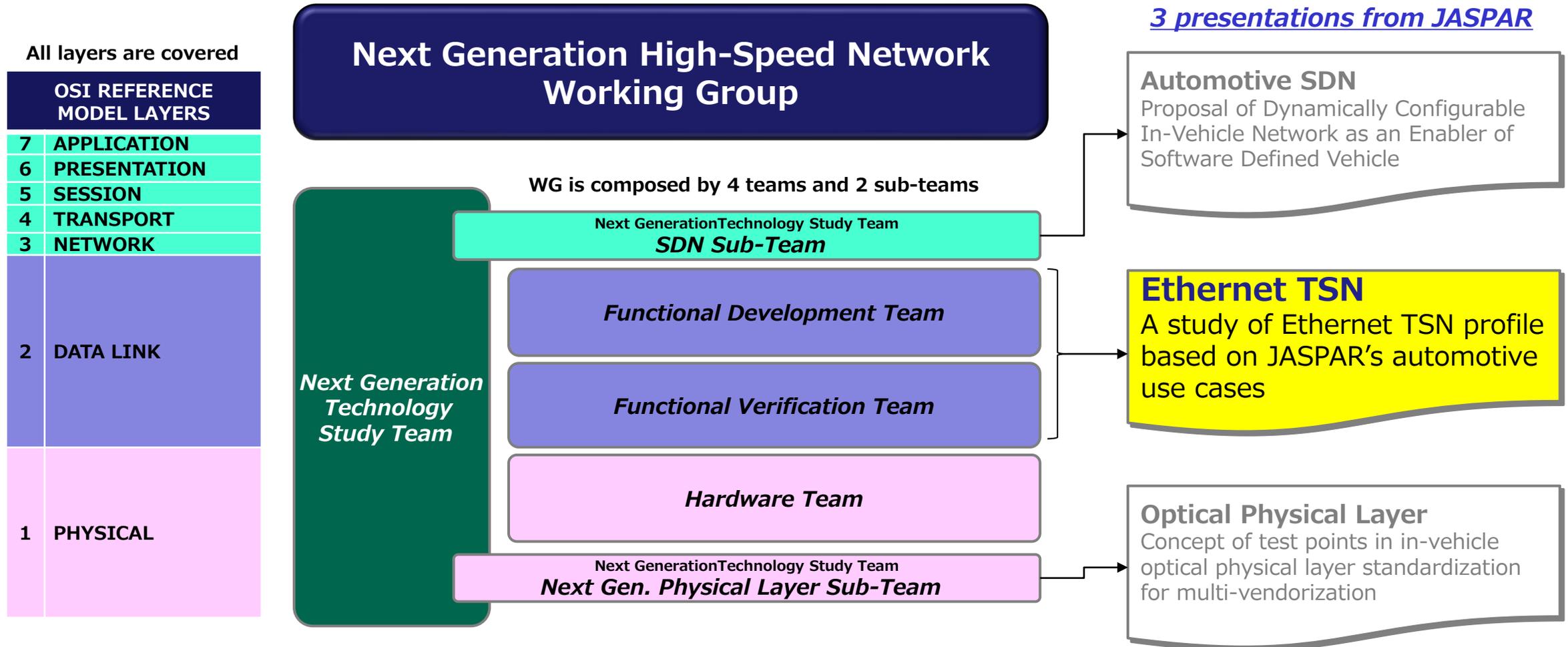Established in September, 2004,
led by five board companies.

HONDA
The Power of Dreams

TOYOTA

JasPar

DENSO

NISSAN

TOYOTA
TSUSHO

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Next Generation High-Speed Network Working Group

To define standard specification of high reliability technology of in-vehicle high-speed networks with an eye focused on control system applications, and to define vehicle requirements/problem extraction and solution method of Automotive SDN (Software Defined Networking), Automotive TSN, 10Gb/s class Ethernet and SerDes.

Working Groups

Functional Safety	AD/ADAS Vehicle Control IF	AUTOSAR Standardization	In-vehicle LAN	Connectivity	Next Generation High-Speed Network	Dynamic Vehicle Information Sharing	Cyber Security Promotion

Intellectual Property

: In action

: Out of Action

Cyber Security Technical

OTA Technical

Introduction: 3 presentations from JASPAR

All layers are covered

	OSI REFERENCE MODEL LAYERS
7	APPLICATION
6	PRESENTATION
5	SESSION
4	TRANSPORT
3	NETWORK
2	DATA LINK
1	PHYSICAL

Next Generation High-Speed Network Working Group

Next Generation Technology Study Team

WG is composed by 4 teams and 2 sub-teams

Next GenerationTechnology Study Team
SDN Sub-Team

Functional Development Team

Functional Verification Team

Hardware Team

Next GenerationTechnology Study Team
Next Gen. Physical Layer Sub-Team

Team Composition of Next Gen. High-Speed Network WG

3 presentations from JASPAR

Automotive SDN
Proposal of Dynamically Configurable In-Vehicle Network as an Enabler of Software Defined Vehicle

Ethernet TSN
A study of Ethernet TSN profile based on JASPAR's automotive use cases

Optical Physical Layer
Concept of test points in in-vehicle optical physical layer standardization for multi-vendorization

Background: Ethernet TSN Profiles

	Transport	Synchroni-zation	Stream Reservation	Quality of Service	Redundancy	Security
AVB **802.1BA** AVB Profile	1722-2011 Media Transport Protocol	802.1AS-2011 gPTP	802.1Qat SRP	802.1Qav Credit Based Shaper	–	802.1X 802.1Xbx 802.1Xck Network Access
TSN **802.1DG**	1722-2016 Adds CAN, FlexRay, Lin	802.1AS-2020 Redundant gPTP	802.1Qcc Enhanced SRP 802.1Qca Path Control& Reservation	802.1Qbv Time Aware Shaper 802.1Qbu &802.3br Preemption 802.1Qch Cyclic Queue Forwarding 802.1Qcr Asynchronous Shaping	802.1CB Frame Replication & Elimination 802.1AS-2020 Redundant gPTP	802.1Qci Policing 802.1AE MACSec

TSN Profile for Automotive In-Vehicle Ethernet Communications

IEEE P802.1DG Base Profile

TSN is a collection of many standards: **Tool Box**
Selection and use of TSN tools: **Profile**
We must standardize a **profile for automotive**.

IEEE P802.1DG is standardizing profiles for automotive in-vehicle Ethernet.

Background: JASPAR's contribution to date for IEEE P802.1DG

2018 ... 2019 2020 2021 2022 **Now**

TSN Profiling

Contribution for IEEE P802.1DG

Liaison Approved !!
July 2019

Use Cases Requirements
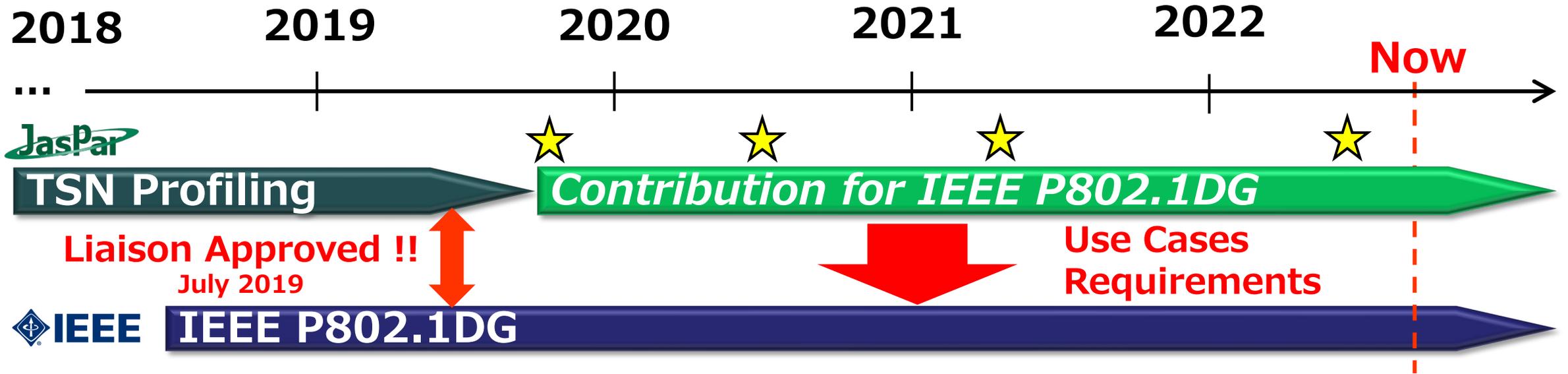
IEEE P802.1DG

- To avoid the double standards of TSN profile, JASPAR has established a liaison with IEEE 802.1 WG from 2019.
- JASPAR has been studying many use cases of Ethernet-based in-vehicle networks with IEEE 802.1TSN.

Contribution to IEEE P802.1DG is JASPAR's mission.

Objectives

IEEE P802.1DG Profiles (Draft1.4)

TSN features		Reference
PSFP	Per-Stream Filtering and Policing	802.1Q-2018 clause 8.6.5.1
FQTSS	Forwarding and Queuing Enhancements for time-sensitive streams	802.1Q-2018 clause 34
gPTP	Timing and Synchronization	802.1AS
FRER	Frame Replication and Elimination for Reliability	802.1CB
TAS	Scheduled Traffic	802.1Q-2018 clause 8.6.8.4 and Annex Q
CQF	Cyclic Queuing and Forwarding	802.1Q-2018 Annex T
ATS	Asynchronous Traffic Shaping	802.1Qcr-2020
FP	Frame Preemption	802.1Q-2018 clauses 6.7.2 and 8.6.8

Base profile
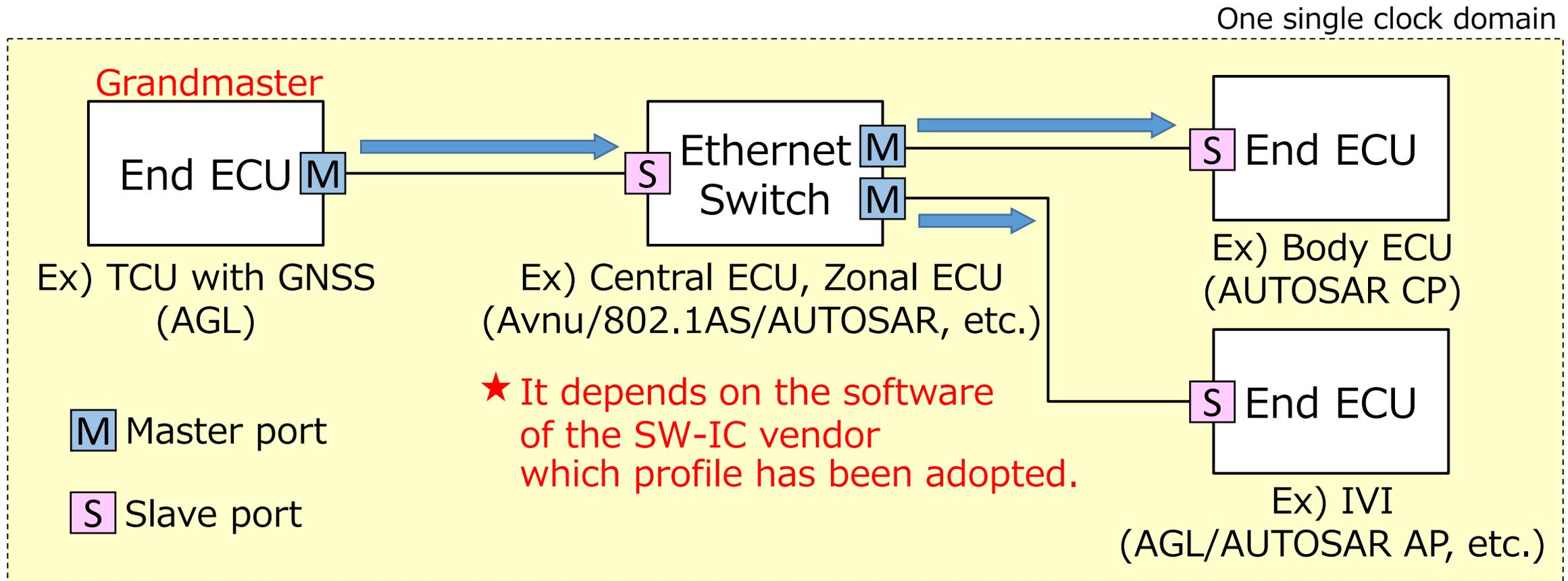
Extended profile

Today's target

★ How the profiles should be applied to actual use cases is under consideration.

According to JASPAR's use cases, we discuss Time Synchronization, which will be included in the Base profile.

4. A study of Ethernet TSN Profile

- JASPAR's automotive use case
- Differences in existing profiles for time synchronization
- Analysis and solutions
- Policy of JASPAR Profile

JASPAR's automotive use case

One single clock domain

Grandmaster

End ECU [M] ──→ [S] Ethernet Switch [M] ──→ [S] End ECU

[M] ──→ [S] End ECU

Ex) TCU with GNSS
(AGL)

Ex) Central ECU, Zonal ECU
(Avnu/802.1AS/AUTOSAR, etc.)

Ex) Body ECU
(AUTOSAR CP)

[M] Master port

[S] Slave port

★ It depends on the software
of the SW-IC vendor
which profile has been adopted.

Ex) IVI
(AGL/AUTOSAR AP, etc.)

JASPAR assumes that the time synchronization under an environment where various communication software is used together on the same time-synchronization domain.

AGL : Automotive Grade Linux
CP : Classic Platform
AP : Adaptive Platform
ECU : Electronic Control Unit
TCU : Telematics Control Unit
IVI : In-Vehicle Infotainment

JASPAR's automotive use case ~Problem of coexistence of SWs

In-vehicle comm. SWs and corresponding profiles

Communication Software	Time synchronization profile
AUTOSAR CP	AUTOSAR
AUTOSAR AP	AVnu Profile / AUTOSAR / etc.
Linux (AGL)	AVnu Profile
SW-IC Software	AVnu Profile / AUTOSAR / etc.

Major profiles, such as AVnu, AUTOSAR, and IEEE P802.1DG, are based on IEEE 1588 and IEEE 802.1AS.

➡ These profiles are not the same as each other.

<Origin of Profile of Time Synchronization>

IEEE 1588-2008
Version 2.0

Update

IEEE 1588-2019
Version 2.1

IEEE 802.1AS-2011

Derivative

IEEE 802.1BA-2011
AVB Automotive Profile

IEEE 802.1AS-2020

IEEE P802.1DG
TSN Automotive Profile

AVnu Automotive
Profile V1.6

AUTOSAR
R21-11

If the profiles for automotive are not consolidated, ECUs based on various profiles will be used together.

We would like to **expect IEEE P802.1DG**, which is standardizing automotive TSN profiles, **to bridge gaps** between standards that have already been issued and implemented.
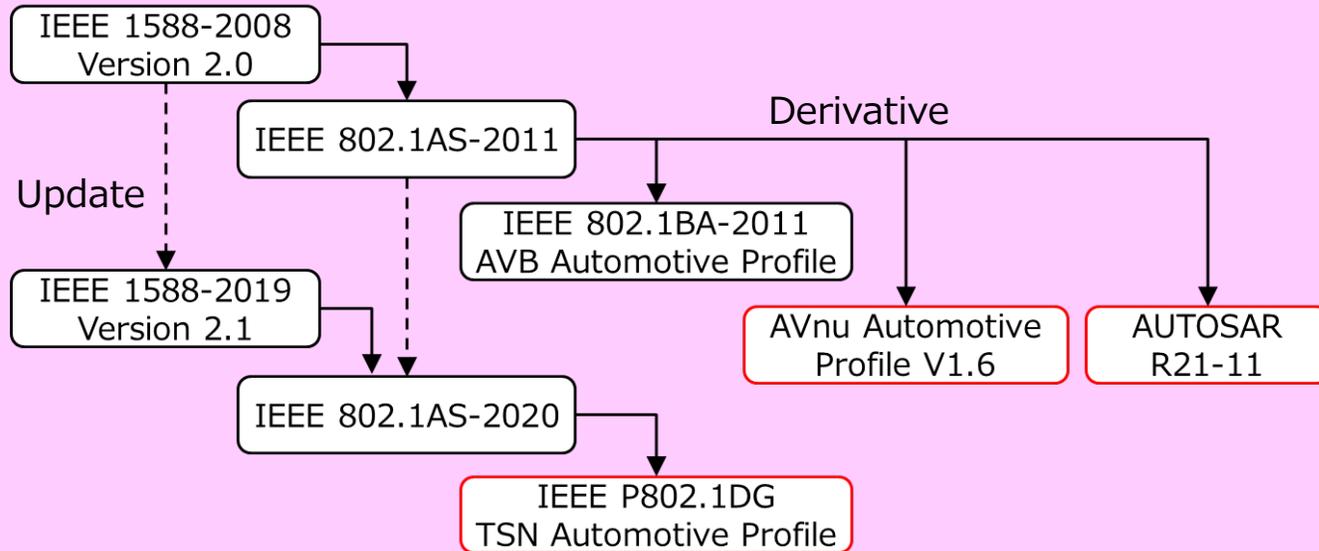
We must consider the coexistence of ECUs which meet various profiles.

Differences in existing profiles for time synchronization (JASPAR's analyses)

Item	P802.1DG (D1.4)	802.1AS (Standard)	Avnu (v1.6)	AUTOSAR
Use of BMCA	Not used	Optional	Yes/Not used	Not used
Use of Announce message	Yes	Yes	Yes/Not used	Not used
Use of Signaling message	Undefined	Yes	Yes	Not used
Use of Pdelay message	Yes	Yes	Yes	Measurement is optional
Sync message format	2-Step	2-Step/1-Step	2-Step	2-Step
Multiple time domains	Yes	Yes	No	Yes (non-Std.)
Use of VLAN and priority	Undefined	Not used	Not used	Optional
…	…			…

1st analysis (rows: Use of BMCA, Use of Announce message, Use of Signaling message)

2nd analysis (row: Multiple time domains)

There are some differences between profiles regarding time synchronization.

Details of the differences and the resulting problems are shown in the following slides.
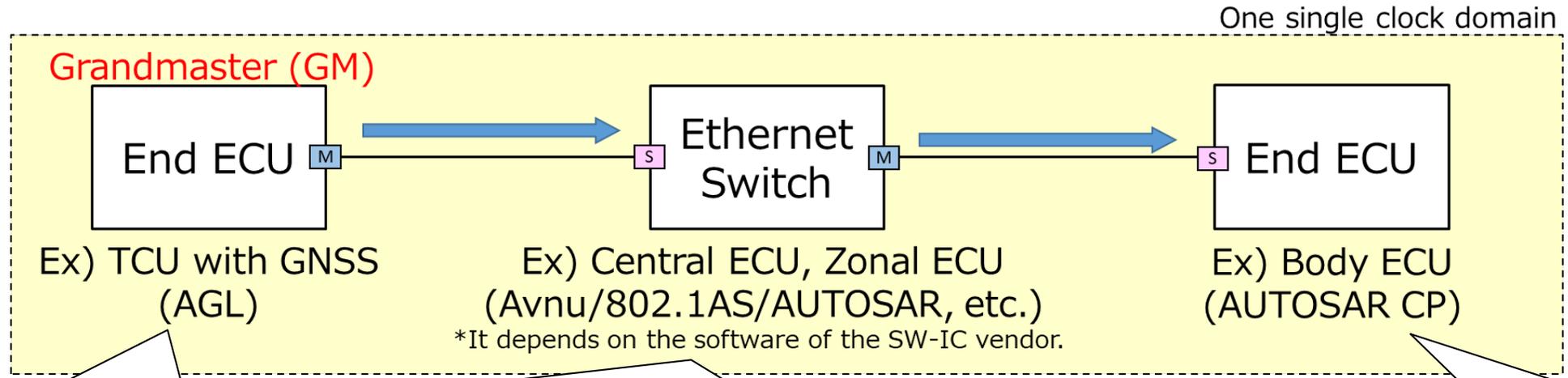
1st analysis (BMCA, announce message, signaling message)

Item	P802.1DG	802.1AS	AVnu	AUTOSAR
Use of BMCA	**Not used**	Yes	Yes/**Not used**	**Not used**
Use of Announce message	Yes	Yes	Yes/Not used	Not used
Use of Signaling message	Undefined	Yes	Yes	Not used

- **None** of P802.1DG, AVnu, and AUTOSAR **assume the use of BMCA** now.
  ⬅ Since an in-vehicle network is assumed to be a closed one for the present, it is not necessary to elect the best Grandmaster clock, which is decided uniquely.

- P802.1DG (D1.4) adopts the announce message while AVnu and AUTOSAR don't. (Even if AVnu and AUTOSAR receive it, they ignore it.)
  (But P802.1DG may make it optional in the future.)

- Moreover, the adoption of the signaling message differs by profile.

> **The difference in the adoption of Announce/Signaling messages hinders the interconnectivity.**

1st analysis (BMCA, announce message, signaling message)

One single clock domain

Grandmaster (GM)

End ECU [M] ➡ [S] Ethernet Switch [M] ➡ [S] End ECU

Ex) TCU with GNSS (AGL)

Ex) Central ECU, Zonal ECU (Avnu/802.1AS/AUTOSAR, etc.)
*It depends on the software of the SW-IC vendor.

Ex) Body ECU (AUTOSAR CP)

TCU notifies itself as GM by announce message.

A switch cannot select a profile to comply.
(A switch cannot decide whether to propagate or drop.)

End ECU ignores announce messages.

Examples of solution

Static configuration can be merits for the automotive case.
Ex.) Improvement of Startup performance
     Mitigation of the security risk

- **<u>Static configuration</u>** (Master/Slave, topology, etc.)
  ➡ Announce messages and signaling messages will be unnecessary.

- Amendment to 802.1AS/1588: **<u>No Announce mode</u>**, etc.
  ➡ The interoperability can be guaranteed.

We will raise the issue to IEEE P802.1DG.

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2nd analysis (Multiple time domains)

Item	P802.1DG	802.1AS	AVnu	AUTOSAR
Multiple time domains	**Yes**	No (2011) Yes (2020)	No	**Yes (non-Std.)**

- Both P802.1DG and AUTOSAR support multiple time domains. However, the specifications slightly **differ from each other**.

⬅ AUTOSAR implemented it before the standardization of IEEE 802.1AS-2020.

<Example of the difference> (Parameter values)

Item	P802.1DG/802.1AS(2020)	AUTOSAR
versionPTP	2.1	2.0
domainNumber	0..255 (uint8)	0..15 (uint8)

P802.1DG can distinguish AS and AUTOSAR but AUTOSAR cannot.

AUTOSAR supports multiple domain networks by an internal parameter (MessageCompliance).
This requires defining time domains statically and sharing them with the other ECUs in each domain.

Since the two profiles differ from each other much, interoperability cannot be guaranteed.

2nd analysis (Multiple time domains)

Case study: Interoperability between P802.1DG and AUTOSAR
 <Approach> We consider to migrate multiple domains specification of AUTOSAR to that of IEEE 802.1AS-2020.

Item	P802.1DG/ 802.1AS(2020)	AUTOSAR	Case study (Assuming AUTOSAR migraded to AS-2020)
versionPTP	2.1	2.0	2.0 ➡ 2.1 Devices cannot distinguish AUTOSAR profile and IEEE 802.1AS-2020 by "versionPTP."
domainNumber	0..undefined/ 0..255(uint8)	0..15 (uint8)	When "MessageCompliance" is TRUE, multiple domains can be operated based on AS-2020. 0..15 (unit8) ➡ 0..255 (unit8)
			When "MessageCompliance" is FALSE, backward compatibility to existing AUTOSAR specifications should be considered. P802.1DG should decide to keep 0..15 or change to 0..255.

This approach can realize the interoperability between IEEE P802.1DG and AUTOSAR but limit the use of the extended format of AUTOSAR.

2nd analysis (Multiple time domains)

- ## What does AUTOSAR consider this issue?
  - The migration of IEEE 802.1AS-2020 is **under expert discussion** in AUTOSAR.
  - The migration will not be reflected in the upcoming release (R22-11);
    it will be reflected in a release later than R23-11.

  - Moreover, AUTOSAR defines 'Requirements on Time Synchronization,' which **supports CAN, FlexRay and Ethernet**, we have to consider the conformance with the requirements.

AUTOSAR™ **JasPar**

Press Release

May 2022

AUTOSAR and JASPAR announce collaboration in strengthening standardization in the field of Automotive and Future Intelligent Mobility

AUTOSAR™ and JASPAR have signed a Memorandum of Understanding (MoU) to enhance many years of successful collaboration, further expand synergies between the two organizations, and drive standardization in the field of Automotive and Future Intelligent Mobility. This joint technical collaboration between AUTOSAR and JASPAR is intended to coordinate common requirements and developments.

JASPAR signed MOU with AUTOSAR to promote collaborative activities.

JASPAR keeps an eye on the standardization of AUTOSAR profile while cooperating with AUTOSAR.

Consideration policy of profile for time synchronization

- JASPAR continues to study in-vehicle profiles from the following point of view.

  > - How to realize the **coexistence** of current time-synchronized networks with the ones based on IEEE P802.1DG

  - What should we consider **coexistence**?
    - Which is better for many devices which were implemented according to different profiles to work on <u>the same network</u> or <u>separate networks</u>?
      - We evaluate the mutual interference between an implementation based on one profile and that on the other profiles.
      - We will study JASPAR's profile as an overall solution for existing profiles.

Consideration policy of profile for time synchronization

< A profile for the time synchronization under consideration in JASPAR >

Item	P802.1DG (D1.4)	AVnu	AUTOSAR	JASPAR Profile
Use of BMCA	Not used	Yes/Not used	Not used	Not used
Use of Announce message	Yes	Yes/Not used	Not used	Not used
Use of Signaling message	Undefined	Yes	Not used	Not used
Use of Pdelay message	Yes	Yes	Measurement is optional	Yes
Sync message format	2-Step	2-Step	2-Step	2-Step
Multiple time domains	Yes	No	Yes (non-Std.)	No
Use of VLAN and priority	Undefined	Not used	Optional	Not used
…	…		…	

We hope that the specification defined in IEEE P802.1DG will bridge the gap.

- How can we adapt Ethernet TSN to Ethernet networks which are based on AUTOSAR specifications?

  - Ex.) We want to add Ethernet TSN functions to an Ethernet network with AUTOSAR-based time synchronization to realize ADAS functions.

    - Prerequisites and **their corresponding issues**
      - There already exists a network for time synchronization based on AUTOSAR.
        - It is difficult to change the specification of the time synchronization network from AUTOSAR to the other to add new functions.
      - We want to realize Ethernet TSN while utilizing the existing network.
        - As we have already shown, there are many issues caused by the differences in profile.
      - Although we recognize the issues, there is no doubt about the usefulness of Ethernet TSN in the ADAS functional area, etc. Therefore, we want to realize practical use as soon as possible.
        - We strongly expect P802.1DG activities to solve the gap between profiles by some means.

Future works

TSN features		Reference
PSFP	Per-Stream Filtering and Policing	802.1Q-2018 clause 8.6.5.1
FQTSS	Forwarding and Queuing Enhancements for time-sensitive streams	802.1Q-2018 clause 34
gPTP	Timing and Synchronization	802.1AS
FRER	Frame Replication and Elimination for Reliability	802.1CB
TAS	Scheduled Traffic	802.1Q-2018 clause 8.6.8.4 and Annex Q
CQF	Cyclic Queuing and Forwarding	802.1Q-2018 Annex T
ATS	Asynchronous Traffic Shaping	802.1Qcr-2020
FP	Frame Preemption	802.1Q-2018 clauses 6.7.2 and 8.6.8

Base profile

Extended profile

Today's target

- Although this presentation showed our study of profiles for time synchronization, JASPAR is discussing the other ones including the Base profile of IEEE P802.1DG.

  The details of the profiles discussed by JASPAR are published on the JASPAR website.
  JASPAR standard document: ST-HN-8 "TSN Profiles for In-Vehicle-Ethernet Ver.3.0"

- We are studying a TSN Profile for Automotive SDN, which will be one of the future use cases.

We will continue to contribute to IEEE P802.1DG by studying of TSN Automotive Profile.

Conclusions

- According to JASPAR's use case, there expect to be many devices based on various time synchronization profiles on the same clock domain.

- Since the profiles for time synchronization of IEEE P802.1DG, AVnu, AUTOSAR, and so on differ from each other, we have a problem with interoperability.

- JASPAR will continue to study the coexistence of devices with various profiles while respecting the existing time synchronization profiles.

- JASPAR is studying profiles for TSN functions other than time synchronization and will continue to contribute to P802.1DG in the future.

- Although AUTOSAR is the base for in-vehicle networks, IEEE P802.1DG's Profile will be essential. JASPAR, which has a liaison with both IEEE P802.1DG and AUTOSAR, wants to serve as a bridge between them and contribute to standardization.

Thank you for your kind attention.