Harmonization of TSN parameter modelling with automotive design flows

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Introduction
Network on vehicle

- Variable topology
- Different domains connected by Ethernet links
- High utilization on central/backbone links
## Mixed traffic profile

<table>
<thead>
<tr>
<th>Use cases</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>- Timely behavior is critical (bounded low latency and jitter)</td>
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<tr>
<td></td>
<td>- Delivery must be guaranteed</td>
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<td></td>
<td>- Configuration must be validated by design</td>
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<tr>
<td><strong>Streaming</strong></td>
<td>- Timely behavior is important (bounded latency and jitter)</td>
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<tr>
<td></td>
<td>- Delivery must satisfy a QoS</td>
</tr>
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<td></td>
<td>- Configuration must be validated by design</td>
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<tr>
<td><strong>Best-effort</strong></td>
<td>- No time guarantees needed</td>
</tr>
<tr>
<td></td>
<td>- No guarantees for delivery</td>
</tr>
<tr>
<td></td>
<td>- No configuration required</td>
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</tbody>
</table>
IEEE 802.1 Time Sensitive Networking (TSN)

- Adds real-time capabilities to switched Ethernet

<table>
<thead>
<tr>
<th>TIME SYNCHRONIZATION</th>
<th>LATENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.1AS: Time Synchronization</td>
<td>IEEE 802.1Qav: Credit Based Shaper</td>
</tr>
<tr>
<td>P802.1AS-Rev: Time Synchronization Redundancy</td>
<td>IEEE 802.1Qbu: Frame Preemption</td>
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<tr>
<td></td>
<td>IEEE 802.1Qbv: Scheduled Traffic</td>
</tr>
<tr>
<td></td>
<td>IEEE 802.1Qch: Cyclic Queuing and Forwarding</td>
</tr>
<tr>
<td></td>
<td>P802.1Qcr: Asynchronous Time Shaping</td>
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</tbody>
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<thead>
<tr>
<th>RELIABILITY</th>
<th>MANAGEMENT</th>
</tr>
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<tbody>
<tr>
<td>IEEE 802.1CB: Frame Replication and Elimination</td>
<td>IEEE 802.1Qat: Stream Reservation Protocol</td>
</tr>
<tr>
<td>IEEE 802.1Qca: Path Control</td>
<td>IEEE 802.1Qcc: Network Management</td>
</tr>
<tr>
<td>IEEE 802.1Qci: Per-Stream Filtering and Policing</td>
<td>IEEE 802.1Qcp: YANG Data Model</td>
</tr>
<tr>
<td>P802.1AS-Rev: Time Synchronization Redundancy</td>
<td>P802.1CS: Link-local Reservation Protocol</td>
</tr>
</tbody>
</table>
First steps towards a TSN Automotive Profile
(PAR expected to be approved in Nov)

TSN Automotive Profile has the following benefits:
• TSN Customers: easier specification of requirements
• TSN Vendors: easier implementations
IEEE 802.1 TSN Approach to Configuration
Configuration models (IEEE 802.1Qcc)

Distributed model:
- Configuration decisions are made locally in every node
→ In automotive: dynamic behavior replaced by a centralized static configuration

Centralized model:
- Configuration decisions are made in the CNC (Centralized Network Configuration)
- CNC has a global view of the network
- CNC can be located outside the vehicle (in a backend network) or inside as a trusted node
- CNC can reconfigure the network during operation time
Configuration Entities are called *Managed objects*

Managed objects:

- specify configurable parameters of TSN mechanisms ➔ modeled using YANG (Modelling Language)
- can be read and modified using configuration protocols ➔ Definition of protocols not part of TSN
- used for static and dynamic configuration

- Examples:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE 802.1AS</td>
<td>initialLogSyncInterval</td>
<td>Initial value of the of synchronization messages.</td>
</tr>
<tr>
<td>IEEE 802.1Qci</td>
<td>AdminControlList</td>
<td>Administrative version of the gate control list (ingress).</td>
</tr>
<tr>
<td>IEEE 802.1 Qbv</td>
<td>AdminControlList</td>
<td>Administrative version of the gate control list (egress).</td>
</tr>
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</table>
Configuration: YANG Data Models

Ongoing effort to model the TSN managed objects with YANG

https://github.com/YangModels/yang/tree/master/standard/ieee/802.1/draft

Advantages of YANG:

• Human readable, and easy to learn representation
• Hierarchical configuration data models
• Formal constraints for configuration validation
• Well defined versioning rules

• Instantiations of the model can be encoded in XML or JSON
IEEE 802.1 Time Sensitive Networking (TSN)

Configuration workflow

1. Static and dynamic configuration information are provided to the CNC
2. The CNC generates new configuration
3. New configuration is distributed to network devices using a transport protocol
AUTOSAR modules and its ecosystem are well established in the industry

1. Static configuration is provided to a network configuration tool in arxml format
2. The Network configuration tool produces device specific configuration
3. Configuration is flashed to the ECU
Static configuration

- Initial configuration produced during the design process
- Upon a user request, a configuration update takes years
Dynamic configuration

Option 1:
- User request is handled by the CNC in the back-end → Configuration update takes hours
Dynamic configuration

Option 2:
• User request is handled by the CNC in the vehicle → Configuration update takes seconds!
Proposed Harmonization of TSN and Automotive Configuration Approaches
1. Static and dynamic configuration information is provided to the CNC (→ configuration information can be general network configuration and/or TSN specific)

2. The CNC generates new configuration

3. New configuration is distributed to ECUs using a transport protocol
Efforts needed

Parameters:
- Incorporate TSN parameters to existing network configuration tools
- Automotive specific parameters needed in/for the CNC

Interfaces:
- Automotive standardization activities to consider harmonization with YANG data models
- CNC to merge general network configuration and TSN specific configuration

Transport protocol:
- A transport protocol should be defined / chosen, considering security aspects
Conclusions

Automotive design flows
• Well established for static configuration
• Upcoming need for dynamic reconfiguration

TSN standards
• Satisfy automotive requirements (automotive profile on the making)
• Already defines dynamic reconfiguration process

Automotive - TSN harmonization
• Will align OEMs requirements with Tier1s configuration and Tier2s features
• And facilitate the use of TSN in automotive networks…
  → thus providing an already established process for dynamic reconfiguration
<table>
<thead>
<tr>
<th>Vienna, Austria (Headquarters)</th>
<th>Germany</th>
<th>USA</th>
<th>Japan</th>
<th>China</th>
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</thead>
<tbody>
<tr>
<td>Phone +43 1 585 65 38-5000</td>
<td>Phone +49 841 88 56 47-0</td>
<td>Phone +1 978 933 7979</td>
<td>Phone +81 52 485 5898</td>
<td>Phone +86 21 5015 2925-0</td>
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