Automotive E/E Architecture evolution and the impact on the network

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Content of this presentation

› Introduction of E/E architecture trend
› Network implication for TSN features
› Types of automotive Ethernet TSN nodes
Definitions

› 10 Mbit/s (e.g. IEEE P802.3cg 10BASE-T1) was not taken into account

› Only Ethernet was taken into account (no CAN, LIN, SerDes …)

› Arrows in drawings of communication indicate logical data flow, NOT half-duplex connections

› There is no “one common” E/E architecture among the car manufacturers
  › Every car manufacturer uses its own architecture (different number of hops & requirements)
  › But the main concept is often similar
Automotive E/E architecture
Current state and outlook

Today: Traditional architecture
- application-specific ECUs
- application-specific bus systems
- 1-to-1 communication

In development: Domain architecture
- application-specific ECUs
- functional consolidation in domain controllers
- 1-to-1, “many-to-one” communication

Tomorrow: Centralized architecture
- software-driven architecture
- centralized processing
- “all-to-some” communication
### Automotive E/E architecture

#### Characteristics

<table>
<thead>
<tr>
<th>Network topology</th>
<th>topology</th>
<th>point-to-point, star</th>
<th>point-to-point, star, ring</th>
<th>point-to-point, star, multiple rings</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of hops for a stream</td>
<td>1-2</td>
<td>2-4</td>
<td>3-6</td>
<td></td>
</tr>
<tr>
<td>link speed</td>
<td>100 Mbit/s</td>
<td>10 Mbit/s – 10 Gigabit/s</td>
<td>10 Mbit/s – 50 Gigabit/s</td>
<td></td>
</tr>
<tr>
<td>no. of Ethernet links</td>
<td>&lt; 10</td>
<td>10 - 50</td>
<td>&gt; 50</td>
<td></td>
</tr>
<tr>
<td>no. of congestion points for a stream</td>
<td>0-1</td>
<td>1-3</td>
<td>2-5</td>
<td></td>
</tr>
<tr>
<td>no. of segments (VLANs, IP-networks)</td>
<td>&lt; 8</td>
<td>&lt; 8</td>
<td>&gt; 8</td>
<td></td>
</tr>
</tbody>
</table>

*Information here is based on educated guess, no full centralized architectures are in development today yet*
### Automotive E/E architecture Characteristics

<table>
<thead>
<tr>
<th>Data characteristics</th>
<th>&lt; 8</th>
<th>&lt; 8</th>
<th>&gt; 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of different traffic classes at congestion points</td>
<td>&lt; 8</td>
<td>&lt; 8</td>
<td>&gt; 8</td>
</tr>
<tr>
<td>no. of streams at congestion points</td>
<td>&lt; 10</td>
<td>&lt; 50 at domain controller</td>
<td>&gt; 200 (at Server)</td>
</tr>
<tr>
<td>typical latency requirements</td>
<td>milliseconds (2 digits)</td>
<td>milliseconds (1-2 digits)</td>
<td>microseconds (2-3 digits)</td>
</tr>
<tr>
<td>typical target of traffic load per link</td>
<td>mid to high</td>
<td>mid</td>
<td>low (at vehicle SOP)</td>
</tr>
<tr>
<td>typical L2 frame size</td>
<td>64 Byte, 1500 Byte</td>
<td>64 Byte, 1500 Byte</td>
<td>&gt; 64 Byte (no encapsulation)</td>
</tr>
<tr>
<td>periodicity of data</td>
<td>various types</td>
<td>various types</td>
<td>various types</td>
</tr>
<tr>
<td>time synchronization requirements</td>
<td>milliseconds (1 digit)</td>
<td>milliseconds (1 digit)</td>
<td>microseconds (2-3 digits)</td>
</tr>
<tr>
<td>dynamic network configuration</td>
<td>very little</td>
<td>little</td>
<td>partially</td>
</tr>
</tbody>
</table>

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Classes of Ethernet devices
Example use case: Object detection camera in system context (simplified illus.)

Sensor (Talker)  Zone controller with Bridge  Server w. Bridges (Listener + Talker)  Zone controller with Bridge  Actuator (Listener)

Camera  X  X  X  X  Steering system

High data rate  very high data rate  very high data rate  very low data rate

One stream  many streams w. different TC  even more streams w. different TC  many streams w. different TC  one stream

TC = Traffic Class
Classes of Ethernet devices
Types of different TSN automotive implementation: Profiles?

› TSN Endpoints
  › Single port Talker/Listener
    › focus: safety relevant data processing e.g. server, antenna module
    › other:
  › Single port Talker only (back channel data is not time critical)
    › focus: safety relevant sensors for ADAS (Cameras, Radars, Lidars,...)
    › other: microphone
  › Single port Listener only (back channel data is not time critical)
    › focus: safety relevant actuators (steering, braking, display)
    › other: speaker
Classes of Ethernet devices
Types of different TSN automotive implementation: Profiles?

› TSN Bridges
  › 3-port bridge (supports ring topology)
  › access bridge (interface to outside vehicle networks)
    › focus: security
  › aggregation bridge (low port count)
  › aggregation bridge (high port count)
Classes of Ethernet devices

<table>
<thead>
<tr>
<th>Class</th>
<th>&lt; 10</th>
<th>&lt; 20</th>
<th>&gt; 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talker endpoints only</td>
<td>&lt; 10</td>
<td>&lt; 20</td>
<td>&gt; 25</td>
</tr>
<tr>
<td>Listener endpoints only</td>
<td>&lt; 5</td>
<td>&lt; 10</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>Talker/Listener endpoints</td>
<td>&lt; 5</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>3-port bridge</td>
<td>0</td>
<td>&lt; 5</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Aggregation bridge mid</td>
<td>1-2</td>
<td>&lt; 5</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Aggregation bridge high</td>
<td>0</td>
<td>&lt; 3</td>
<td>&lt; 5</td>
</tr>
</tbody>
</table>

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