Automotive Gateways
Bridge & Gateway from FlexRay/CAN/LIN to AVB Networks

Razvan.Mihalache@de.bosch.com
Content

- Gateways in current/future architectures
- Main GW functions (Routing, Diagnostic, ...)
- Main principles of GW’s functionality (SW aspects, protocol aspects, AUTOSAR aspects)
- LIN/CAN/FlexRay 2 Ethernet transport mechanisms (1722a)
- GW performance aspects
- Ethernet GW/Switch in future EE architectures
Gateways in current/future architectures
Transition from Central Gateway to Backbone Arch

- **Today**
  - Central Gateway (CGW)
  - Domain Control Unit (DCU)
  - Switch (SW)

- **Mid-term**
  - CGW
  - SW

- **Long-term**
  - CGW
  - DCU
  - SW
## Characteristics of different GW types*

<table>
<thead>
<tr>
<th></th>
<th>No. of interfaces</th>
<th>No. of GWs per vehicle</th>
<th>Diagnostic interface</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central GW</td>
<td>any no. of LIN/CAN/FR</td>
<td>&lt;= 1</td>
<td>x</td>
<td>Increasing no. of itfs.</td>
</tr>
<tr>
<td>Local GW</td>
<td>1 x domain bus itf. n x subdomain bus itfs.</td>
<td>&gt;= 0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Domain GW</td>
<td>1 x domain bus itf. 1-2 x backbone itf.</td>
<td>&gt;= 0</td>
<td></td>
<td>possible</td>
</tr>
<tr>
<td>GW with integrated Switch</td>
<td>any no. of LIN/CAN/FR/Eth</td>
<td>&gt;= 0</td>
<td></td>
<td>possible</td>
</tr>
</tbody>
</table>

* From the EE architecture point of view
Main GW functions
(Routing, Diagnostic, ...
Routing Features

• Message Routing
• Packet Routing
• Signal Routing (eventually with signal processing)
• Routing with High Priority
• Different sorts of rate adaption between received and transmitted message, e.g.
  Periodic & Immediate Transmit On Change (TOC)

• Y Routing
• Diagnostic Routing
Other Gateway Functions

• Nominal-actual configuration comparison

• Diagnostic tester
  – CAN and Ethernet interface provided

• Flash function

• Message mirroring on diagnostic bus

• Network management

• OEM specific features

<table>
<thead>
<tr>
<th>Components</th>
<th>ECU_1</th>
<th>ECU_2</th>
<th>ECU_3</th>
<th>ECU_4</th>
<th>…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration</td>
<td>Nominal 1 1 0 1 …</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual</td>
<td>1 0 0 1 …</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Main principles of GW’s functionality (SW aspects, protocol aspects, AUTOSAR aspects)
State of the Art: Software Gateway in Central Processing Unit (CPU)

Source: ETAS
Notes:
IL = Interaction Layer according OSEK Comms 3.03 and AUTOSAR; adopts messages/signals to PDUs
• Message Routing performed in the PDU Router
• Signal Routing performed in AUTOSAR COM
• Signal Processing performed in Apps
LIN/CAN/FlexRay 2 Ethernet transport mechanisms (1722a)
Gateway Protocol Stack with 1722 Tunneling

Source: ETAS
### Generic Frame Format

<table>
<thead>
<tr>
<th>Ethernet header</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVTP control stream data header</td>
</tr>
<tr>
<td>Packet info</td>
</tr>
<tr>
<td>LIN/CAN/FR message 1*</td>
</tr>
<tr>
<td>...</td>
</tr>
<tr>
<td>LIN/CAN/FR message n*</td>
</tr>
</tbody>
</table>

* only messages of the same type allowed in one frame
The FlexRay PDU consists of a control stream PDU and one or more FlexRay messages.

Source: IEEE 1722a/D3
The CAN extended PDU consists of a control stream PDU and one or more CAN extended messages.
The LIN PDU consists of a control stream PDU and one or more LIN messages.
ETAS Contribution to IEEE 1722a

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cd</td>
<td>stream_id</td>
</tr>
<tr>
<td>subtype</td>
<td>avtp_timestamp</td>
</tr>
<tr>
<td>sv version</td>
<td>packet_data_length</td>
</tr>
<tr>
<td>mr</td>
<td>message_timestamp</td>
</tr>
<tr>
<td>r</td>
<td>protocol_type</td>
</tr>
<tr>
<td>tv</td>
<td>length</td>
</tr>
<tr>
<td>sequence_num</td>
<td>reserved</td>
</tr>
<tr>
<td>reserved</td>
<td>src_bus</td>
</tr>
<tr>
<td>tu</td>
<td>identifier</td>
</tr>
<tr>
<td></td>
<td>flexray_data (0-254 bytes)</td>
</tr>
<tr>
<td></td>
<td>message_timestamp</td>
</tr>
<tr>
<td></td>
<td>protocol_type</td>
</tr>
<tr>
<td></td>
<td>length</td>
</tr>
<tr>
<td></td>
<td>reserved</td>
</tr>
<tr>
<td></td>
<td>src_bus</td>
</tr>
<tr>
<td></td>
<td>identifier</td>
</tr>
<tr>
<td></td>
<td>rtr</td>
</tr>
<tr>
<td></td>
<td>can_data (0-64 bytes)</td>
</tr>
<tr>
<td></td>
<td>message_timestamp</td>
</tr>
<tr>
<td></td>
<td>protocol_type</td>
</tr>
<tr>
<td></td>
<td>reserved</td>
</tr>
<tr>
<td></td>
<td>src_bus</td>
</tr>
<tr>
<td></td>
<td>identifier</td>
</tr>
<tr>
<td></td>
<td>can_data (0-64 bytes)</td>
</tr>
<tr>
<td></td>
<td>message_timestamp</td>
</tr>
<tr>
<td></td>
<td>protocol_type</td>
</tr>
<tr>
<td></td>
<td>reserved</td>
</tr>
<tr>
<td></td>
<td>src_bus</td>
</tr>
<tr>
<td></td>
<td>identifier</td>
</tr>
<tr>
<td></td>
<td>lin_data (8 bytes)</td>
</tr>
</tbody>
</table>

Optimized Gateway Messages: The transport PDU consists of a control stream PDU and one or more LIN, CAN, FR messages

Source: ETAS
GW performance aspects
GW performance aspects

The routing performance should allow all messages received on several buses with 100% load to be loss-free transmitted on the destination interfaces (which are considered to be in ideal condition).

Latency time requirements are strongly OEM specific, e.g.:

- OEM1: $t_{\text{latency}} < 2$ ms
- OEM2: $t_{\text{latency}} < 500$ µs
- Toyota’s ultra low latency: 100µs over 5 hops, i.e. 20µs/hop

Startup time (time needed to start communication)
Ethernet GW/Switch in future EE architectures
Ethernet GW/Switch in future EE architectures

- Daisy Chain with optional redundant path
- Full Meshed redundant Backbone
- Switched Architecture CGW inspired
Gateway as possible Time Master

• TBD hope to get the permission from an OEM to insert a slide
Zone oriented architecture makes use of Ethernet backbone (which connects all main areas of the vehicle)
Inside the zone CAN/LIN networks
Ethernet AVB ensures data type convergence on backbone
Thank you!

Razvan.Mihalache@de.bosch.com