Quo Vadis SAE J1939 Standardization

Due to new application layer requirements, SAE is continuing to develop the J1939 standard, which is primarily used to network powertrains in commercial vehicles. However, optimizations and extensions are being made in the other communication layers as well, right up to the physical transmission layer. This article summarizes the current state of discussions within the SAE J1939 working committee, such as the planned introduction of the 500 kbit physical transmission layer and changes to network management. Moreover, it also explains ongoing efforts to standardize J1939 in AUTOSAR Release 4 and WWH-OBD diagnostics.

Based on the CAN bus (High-Speed CAN per ISO 11898), the SAE J1939 standard is used primarily to network the powertrain and chassis in commercial vehicles. The protocol creates a uniform foundation for communication between the electronic ECUs and operates by the plug-and-play principle. The J1939 standard is an active standard that currently consists of 19 documents (Figure 1). The responsible SAE subcommittees generally meet four times a year to decide on changes and further developments. The current versions of the documents may be purchased either individually or together as a package in so-called “JPaks” from the SAE website [1].

More Bandwidth

For years now, the maximum 250 kbit bandwidth specified in the standard has forced commercial vehicle developers to work at the limits of performance [2]. From a communication perspective, development of the 500 kbit data transport layer is a long overdue step. European commercial vehicle producers in particular are seeking a final decision in the near future. The specification will be released in a separate document, J1939-14, and its key aspects are:

> Twice the baudrate, 500 kbit instead of 250 kbit
> Use of shielded and unshielded cable as defined in [2] and [3] is still possible.
> Topology is essentially a bus that has branch lines with a max. length of one meter. To connect diagnostic tools, a branch line (from the diagnostic socket to the diagnostic tool) with a length of 5 meters may sometimes be used.
> The bus is terminated at both ends with a characteristic impedance of 120 Ohm. Up to 30 nodes are possible.

The specification for the diagnostic plug [4] was adapted to 500 kbit operation. In addition, a new “Type II” diagnostic socket is being used in the vehicle which has a green color coding, and its connector keying prevents use of the pre-
vius 250 kbit “Type I” diagnostic plug. A “Type II” plug is compatible with a “Type I” socket. Another change is that the “Type II” diagnostic socket defines pins previously used for SAE J1708/J1587 as reserved. Consequently, a J1708/J1587 network can no longer be addressed via a “Type II” diagnostic plug.

**SAE Gets Serious about Dynamics**

Changes are also being made in the area of Network Management [5]. For a long time now, the J1939 committee has been deliberating over ways to handle the short supply of permanently assigned ECU addresses. This is especially problematic for manufacturers of sensors with a direct bus connection. The number of new devices is growing rapidly due to heightened exhaust emissions requirements and the addition of assistance systems. Many alternatives were proposed but then rejected. They ranged from a dedicated network for sensors to implementation of a new protocol – e.g. by using previously reserved data pages. Meanwhile, the fact was that SAE has not assigned any more new addresses. That was an unsatisfactory situation for ECU suppliers. Often, they did not know whether their product designs would have lasting value. In the latest version of Network Management, SAE recommends implementing “Address Arbitrary Capable” ECUs. These ECUs are able to compute their own addresses based on the momentary vehicle configuration – and indeed at runtime.

Essentially, this approach aims to utilize the mechanism of dynamic address allocation that has always existed in the commercial vehicle field, but has never really been implemented or used before.

In conjunction with Network Management, the newly added Name Management should be mentioned for the sake of completeness. This is a standardized interface for changing specific components of the 64 bit device name. This might be necessary if the relevant function or measurement parameter is derived from the device name. So, the device name can be used to identify the position of an exhaust gas temperature sensor – upstream or downstream of the catalytic converter, on the right or left side of a dual-flow exhaust system. Changes can be made to multiple ECUs in sequence and activated at a specific point in time. This could be helpful, for example, in a case where multiple ECUs of a network need to be assigned a new function simultaneously.

These changes in Network Management are supported in Version 7.5 of Vector’s CANalyzer J1939 analysis tool and its CANoe J1939 development and test tool.

**AUTOSAR and J1939 Come Closer Together**

The introduction of AUTOSAR in the passenger car industry is ramping up quickly. Yet, there is also interest in exploiting the benefits of AUTOSAR in commercial vehicle and the agricultural machine markets. However, the special requirements of these markets have not been a focus in the development of AUTOSAR. Therefore, the AUTOSAR versions released so far have very limited potential in these markets. In particular, the requirements of SAE J1939 cannot be mapped to the current AUTOSAR concept, or only in a very limited way.

In Table 1, the status of important documents is illustrated. These documents are intended to be a reference for further discussions. The SAE J1939 standardization activities are still in progress and might be subject to changes. Therefore, this document may not reflect the latest information.

**Table 1: Status of SAE J1939 Documents**

<table>
<thead>
<tr>
<th>Document</th>
<th>Status</th>
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<tbody>
<tr>
<td>J1939</td>
<td>Recommended Serial Control and Communications Vehicle Network</td>
<td>Released status Feb. 2009 with contents through Feb. 2009</td>
</tr>
<tr>
<td>J1939-01</td>
<td>Recommended Practice for Control and Communication Network for On-Highway Equipment</td>
<td>Released status September 2003</td>
</tr>
<tr>
<td>J1939-02</td>
<td>Agricultural and Forestry Off-Road Machinery Control and Communication Network</td>
<td>Released status August 2006</td>
</tr>
<tr>
<td>J1939-03</td>
<td>On-Board Diagnostics Implementation Guide</td>
<td>Released status December 2008</td>
</tr>
<tr>
<td>J1939-05</td>
<td>Marine Torque Drive and Inboard Spark-Ignition Engine On-Board Diagnostics Implementation Guide</td>
<td>Released status February 2008</td>
</tr>
<tr>
<td>J1939-11</td>
<td>Physical Layer, 250 kbit/s, Twisted Shielded Pair</td>
<td>Released status September 2006</td>
</tr>
<tr>
<td>J1939-13</td>
<td>Off-Diagnostic Connector</td>
<td>Released status September 2006</td>
</tr>
<tr>
<td>J1939-14</td>
<td>Physical Layer – 500 kbit/s</td>
<td>Not yet released</td>
</tr>
<tr>
<td>J1939-15</td>
<td>Reduced Physical Layer: 250 kbit/s, Un-Shielded Twisted Pair (UTP)</td>
<td>Released status August 2008</td>
</tr>
<tr>
<td>J1939-30</td>
<td>Network Layer</td>
<td>Released status May 2010</td>
</tr>
<tr>
<td>J1939-13</td>
<td>Application Layer – Diagnostics</td>
<td>Released status February 2010</td>
</tr>
<tr>
<td>J1939-14</td>
<td>Application – Configurable Messaging</td>
<td>Released status November 2004</td>
</tr>
<tr>
<td>J1939-15</td>
<td>Application Layer – Generation Sets and Industrial</td>
<td>Released status June 2007</td>
</tr>
<tr>
<td>J1939-80</td>
<td>Network Management</td>
<td>Released status May 2003</td>
</tr>
<tr>
<td>J1939-42</td>
<td>Compliance – Trucks and Bus</td>
<td>Released status August 2008</td>
</tr>
<tr>
<td>J1939-86</td>
<td>On-Board Diagnostics Compliance Test Cases for Heavy Duty Components and Vehicles</td>
<td>Released status December 2008</td>
</tr>
</tbody>
</table>

**Figure 1: Status of SAE J1939 Documents (Status in September 2010)**
When all nodes of a J1939 network are known, and node addresses are already defined at the time of configuration, it is relatively easy to map J1939 PGs to AUTOSAR. In case of such a static network, the ECU addresses are fixed. Therefore source and destination addresses are fixed, and so it is possible to work with static identifiers. To transmit data that is longer than the 8 bytes available in a CAN frame, J1939-21 specifies two transport protocol (TP) variants. They are the Broadcast Announce Message (BAM) variant and Connection Mode Data Transfer (CMDT; also known as RTS/CTS) variant. Both of them are already defined in AUTOSAR Release 4.0 and have been available since December 2009. Therefore, AUTOSAR Release 4.0 already covers the requirements of many European commercial vehicle producers. More in-depth support of J1939 requirements is planned for the end of 2012 in AUTOSAR Release 4.1. The target group here includes European and some North American commercial vehicle OEMs.

The primary extended features being added to AUTOSAR:
- Support of multiple messages with the same layout (the same Parameter Group)
- Network management per SAE J1939/81 without dynamic NM, i.e. without AAC (Arbitrary Address Capable)
- Responses to a request message
- Support for diagnostic services
- On-board diagnostics (WWH-OBD) via J1939

Together with large European commercial vehicle OEMs Vector actively participates in efforts to specify these J1939 extensions for AUTOSAR. Today, Vector already offers an AUTOSAR solution with a J1939 extension based on AUTOSAR Release 4.0 (Figure 3). It will soon be used in production at one large European commercial vehicle OEM. The extension for AUTOSAR Release 4.1 is currently in the development stage.

The "static" approach of AUTOSAR stands in contrast to the "dynamic" behavior of J1939. The AUTOSAR architecture only allows fixed CAN identifiers, i.e. there is a fixed allocation between precisely one CAN identifier and one message layout. In contrast to this, a J1939 specific message layout is only allocated to a specific part of the identifier, known as the Parameter Group (PG). Some of the other components of the 29-bit identifier are dynamic and not defined at the time of configuration. Such a dynamic identifier can be modeled in AUTOSAR by creating a separate static identifier for each combination of priority, source address (SA) and destination address (DA) that can occur in a network (Figure 2).
Commercial Vehicle Diagnostics Using WWH-OBD

On-board diagnostics (OBD) is a diagnostic system standardized by ISO; one of its applications is to monitor systems related to exhaust emissions control. Over the course of time, regional standards were derived from this standard (e.g. ISO15031), which have now been merged again into WWH-OBD (World-Wide-Harmonized On-Board-Diagnostics). This standard was initiated by the United Nations and documented in its Global Technical Regulation 5 (GTR 5). ISO 27145 represents the technical implementation of GTR 5. It establishes technical constraints for WWH-OBD. WWH-OBD initially targets the commercial vehicle market, but eventually it should be extended to other vehicle industries as well. ISO 27145 consists of six parts (Figure 4). The current document status is a “Draft International Standard” (DIS), and a final version is anticipated by the end of 2011. The first step was to establish requirements for emissions control and diagnostic communications. This involved specifying the vehicle-side implementation, data access and OBD data. At this time, regional authorities are still defining limit and threshold values; harmonization will not occur until a later point in time.

For on-board diagnostics in commercial vehicles, the two CAN-based protocols “Diagnostics on CAN” (ISO 15765-4) and J1939-73 are widely being used today (Figure 5). To enable a cost-effective transition to WWH-OBD, diagnostics over CAN will continue to be used at first. For the long term, diagnostics over the Internet Protocol (DoIP) should also be possible which would enable access that is either wired over Ethernet or wireless.

Different than in the current OBD-II standard, WWH-OBD only utilizes services already defined as ISO 14229 “Unified Diagnostic Services” (UDS). No additional OBD-specific services are needed. Specifically, WWH-OBD requires support of the UDS services shown in the figure (Figure 6). Effective at the beginning of 2014, all newly registered heavy-duty commercial vehicles must conform to Euro VI standards, and so they must have WWH-OBD diagnostic capability. Developments involving new types of vehicles must fulfill standards one year earlier by 1-1-2013.

UDS diagnostic services can be implemented with CAN-based communication software that also supports J1939, which is available from Vector and is practice-proven in many production implementations. Recently, a production-ready AUTOSAR solution has also become available for implementing WWH-OBD diagnostics via UDS. The described developments in the J1939 field show how the standard continues to be adapted to current requirements on a regular basis. The transfer, extension and modification of concepts from passenger car technology aim to make the development of J1939 ECUs more cost-effective.

Vector, with its many years of networking expertise, is making a contribution by actively participating in standardization committees. In turn, developers of commercial vehicle electronics benefit from early implementation of new standards in embedded software and development tools.
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Literature:
[3] SAE, J1939-11, Physical Layer, 250K bits/s, Twisted Shielded Pair
[5] SAE, J1939-13, Off-Board Diagnostic Connector

Links:
Homepage Vector: www.vector.com
Solutions for J1939: www.vector.com/j1939
Solutions for AUTOSAR: www.vector.com/autosar
Product Information CANoe J1939:
www.vector.com/vi_canoe_j1939_en.html
Product Information CANbedded J1939:
www.vector.com/vi_canbedded_j1939_en.html

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