3rd generation of the CAN data link layer

Since a couple of years, the automotive industry substitutes Classical CAN by means of CAN FD, which is internationally standardized in ISO 11898-1:2015. In parallel, the CAN community develops the next generation of the CAN data link layer protocol: CAN XL.

The complete article is published in the December issue of the CAN Newsletter magazine 2020. This is just an excerpt.

Since December 2018, the CAN in Automation (CiA) special interest group (SIG) CAN XL is specifying the CAN XL protocol features. In the meantime, the SIG CAN XL has additionally established three task forces (TF): the TF CAN XL physical layer, the TF CAN XL higher layer, and the TF CAN XL security. Relevant topics are discussed in the respective TFs (task forces). The CiA 610 document series and the CiA 611 document series will include the CAN XL relevant specifications.

The SIC CAN XL develops directly the specification of the CAN XL data link layer, which will be released as CiA 610-1 document: CAN XL specification and test plans – Part 1: Data link layer and physical signaling. After two-years intensive discussion, the CAN XL data link layer protocol specification is recently technically stable and will be released in beginning of 2021 as CiA document. As the next step, the ISO standardization will be started.

This article introduces briefly the CAN XL data link layer protocol, namely to answer the question, what is CAN XL. Have in mind that the CiA 610-1 document is still under development. Therefore, the final CiA 601-1 document could have differences compared to the content in this article – even if the probability is very low.

The CAN XL data link layer protocol has the following key features:

- Large data field with up to 2 048 byte
- Higher-layer management information
- Improved reliability by means of two CRC fields

### OSI data link layer protocol data unit (PDU)

<table>
<thead>
<tr>
<th>SOF</th>
<th>Arbitration</th>
<th>Control</th>
<th>Data (field)</th>
<th>CRC</th>
<th>ACK</th>
<th>EOF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15 bit</td>
<td>81 bit</td>
<td>1 to 2048 byte</td>
<td>36 bit</td>
<td>6 bit</td>
<td>7 bit</td>
</tr>
</tbody>
</table>

CAN XL MAC frame fields (Source: CiA)

### LLC and MAC sub-layers

Similar to Ethernet, the CAN standard (ISO 11898 series) specifies two data link sub-layers:

- Logical link control (LLC): It acts as a sub-layer between the OSI network layer and the media access control (MAC) sub-layer.
- Media access control (MAC): It is responsible for moving frames from the LLC sub-layer to the PMA (physical media attachment) sub-layer and protects the transmission by means of stuff-bits, CRC fields, etc.

The LLC frame structure shall contain all content needed for all CAN frame formats and types, including the selection of a specific CAN frame format. In the interaction between LLC and MAC, the content of that part of the LLC frame that are not used for the selected CAN frame format shall be ignored. Figure 1 shows the LLC frame format specified in CiA 610-1. The LLC frame supports all three CAN protocol generations: Classical CAN, CAN FD, and CAN XL. The fields of the LLC frame that are used by CAN XL are highlighted green.

### Priority and addressing

In Classical CAN and CAN FD, the CAN-ID field (11 bit or 29 bit) is used for both arbitration and addressing purposes. In CAN XL these functions are separated. The CAN XL protocol separates the priority functions (11-bit ID) and the addressing (32-bit acceptance field).

- 11-bit priority ID sub-field: This field provides the uniquely assigned priority of the CAN XL data frame.
32-bit acceptance field: This field can contain node address or content indication information like a message ID.

<table>
<thead>
<tr>
<th>Priority ID</th>
<th>RRS</th>
<th>IDE</th>
<th>FDF</th>
<th>XLF</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 bit</td>
<td>1 bit</td>
<td>1 bit</td>
<td>1 bit</td>
<td>1 bit</td>
</tr>
</tbody>
</table>

**Service data unit type (SDT)**

The SDT is a feature that is usable for higher-layer protocols. The 8-bit SDT indicates the used next OSI layer protocol. It is an embedded (OSI) layer management information as described in ISO 7498-4:1998 and is similar to the Ethertype field in the Ethernet frame. CiA 611-1 specifies the SDT values and the corresponding usage to unfold the power of this field. The first version of CiA 611-1, that is planned to be released in the next months, will specify SDT values for:

- Content-based addressing (i.e. use of message IDs)
- Node addressing
- Nodes tunneling of Ethernet frames
- Classical CAN and CAN FD data frames

**Virtual CAN network ID (VCID)**

The 8-bit VCID field allows running up to 256 logical networks on one single CAN XL physical network segment. This will allow to use many protocols in parallel, on the same physical CAN network. This field is also an embedded (OSI) layer management information as described in ISO 7498-4:1998.

**Optional DLL security**

The CAN XL TF security would specify the CADsec data link layer security protocol. The SEC bit in the control field indicates, if this CAN XL data frame uses the CADsec protocol. The CADsec protocol features a header with cipher control information, the CAN secure channel ID, and a freshness value. The 16-byte trailer contains the authentication tag.

**MAC frame in XL format**

The MAC sub-layer comprises the functions and rules related to encapsulation/de-encapsulation of the transmitted/received data, error detection as well as signaling, and management of the medium access. There is just one single CAN XL MAC frame format, called CAN XL frame format XLFF. The frame has a variable length and can hold 1 byte to 2 048 byte in the data field, while the data length can change in one-byte steps. On transmission, an LLC frame is converted into a MAC frame. On reception, a MAC frame is converted into an LLC frame. MAC frames in XL format are composed of seven different bit fields as shown in figure 2. In figure 2, 3, 4, and 5 the fields marked in green are automatically added by the MAC sub-layer, and the grey fields are provided by the LLC frame.

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