Mapping of J1939 to CAN FD

CiA members have mapped SAE's J1939 application profile to the CAN FD data link layer. The related CiA 602-2 specification will be released soon.

The J1939-21 application layer specifies how to use the CAN-ID and the protocol that transmits the Parameter Groups (PG). The PGs and the single parameters are described in SAE J1939-71. Traditionally, the J1939 application profile is mapped to the Classical Extended Frame Format (CEFF) data link layer protocol using the 29-bit CAN-ID.

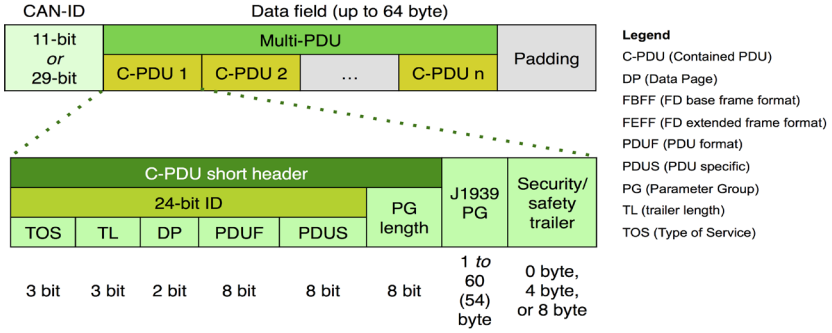

Figure 1: The Multi-PDU as defined in CiA 602-2 can be mapped into 11-bit as well as 29-bit CAN FD messages; the J1939 C-PDU contains one Parameter Group and a 32-bit header compliant with Autosar

Some European OEMs (original equipment manufacturer) of trucks need more bandwidth on their CAN-based in-vehicle networks. Additionally, they require higher throughput when downloading software or uploading diagnostic data. For this reason, some CiA members have started to specify the mapping of J1939 messages to CAN FD. It is intended to run the communication at higher bit-rates (e.g. 2 Mbit/s) and to use the extended payload of up to 64 byte.

Another requirement of the OEMs is the compatibility to Autosar. In order to allow a simple mapping of PGs as defined in J1939-71, a Multi-PDU (process data unit) is used in the CiA 602-2 specification. Such a Multi-PDU can comprise several C-PDUs (Contained PDU). The C-PDU combines a PG and a 4-byte (short) header as described in Autosar. A legacy PG is always 8 byte long. This means you can map in maximum five traditional PGs into one 64-byte CAN FD data frame considering the header. In the future, there may also be shorter and longer PGs, which gives the user more mapping flexibility. Of course this approach is a compromise. It requires some protocol overhead: 4 byte per C-PDU.

FD Base Frame Format (FBFF) as well as FD Extended Frame Format (FEFF) messages are supported. The 11-bit CAN-ID has the benefit that the "slow" arbitration phase is as short as possible. In both approaches, the CAN-ID contains the J1939 source address (SA). The J1939 PDU format and the PDU specific are part of the Autosar PDU short header. Consequently, ECUs (electronic control unit) need to parse all messages. Normally, CAN acceptance hardware filters cannot be used.

Besides the J1939-21 information (PDUF and PDUS), the C-PDU header also comprises a 3-bit Type of Services (TOS) field, a 3-bit information about the optional safety/security "trailer", and an 8-bit PG length indication (necessary, when other than 8-byte PGs are used). With this information, the receiver can interpret the received C-PDU.

The 11-bit CAN-ID provides the 8-bit SA and the 3-bit Protocol Indicator (PI). The PI distinguishes between Multi-PDU container (Autosar compliant), Autosar CAN-NM (network management), SAE address claiming, XCP (extended calibration protocol), J1939 TP connection management (TP.CM), J1939 TP data transfer (TP.DT), and TP extended addressing functional as well as physical (both are defined in ISO 15765-2). The usage of 29-bit CAN-IDs is specified, too. However, this would eat some bandwidth due to the longer arbitration phase (about 20 bit-times not considering stuff-bits). For this approach, CiA needs to request dedicated PDU 1s and PDU 2s from SAE, which is still on the "to do" list.

The usage of a security/safety trailer is indicated by the 3-bit TL (trailer length) sub-field. There may be no trailer, either a security or a safety trailer (32 bit or 64 bit), or a combined security/safety trailer (32 bit + 32 bit). These are placeholders, because the definition of security and safety protocols is not in the scope of CiA 602-2.

The mapping of the BAM or CMDT protocols as specified in J1939-21 into CEFF messages will not be changed, meaning the DLC (data length code) is always 8. The ▷

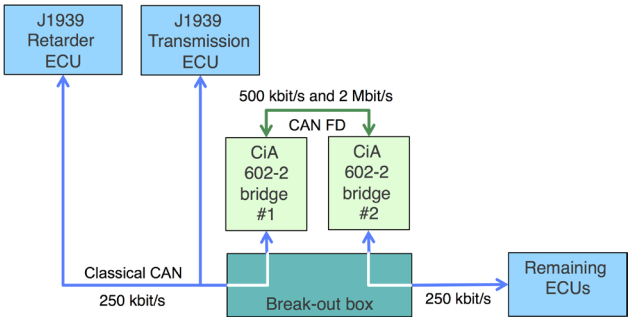

Figure 2: Test set-up for the proof of concept

mapping of these protocols to FBFF and FEFF messages is under development. The idea is to extend the TP.DT frame to 64 byte using 63 byte for the payload and one byte for a sequence counter. The total message size would be 16065 byte (255 x 63 byte).

Proof of concept

The concept of CiA 602-2 has been proofed by Vector and ZF. They simulated a traditional truck communication between ECUs. They opened the simulated J1939 network, introduced a simulated CiA 602-2 network using 500 kbit/s in the arbitration phase and 2 Mbit/s in the data-phase. The two bridges mapped the received J1939 messages into Multi-PDUs and sent them on the CAN FD network and vice versa. The time waiting on J1939 messages was increased in order to optimize the mapping of C-PDUs. This improved the achieved protocol efficiency, because most of the CAN FD messages used the maximum possible payload. On the other hand, when waiting to long, there was some time-outs on the application level.

This straightforward implementation is not really optimized by any means. It is just based on existing J1939 application software. The simulation was compared with the results in a real truck: The J1939 network was opened, two CAN FD bridges introduced, which communicated via a real CAN FD network. The results were the same as the simulated ones. There was a throughput win of about 80 %. The busload decreased from above 50 % to less than 10 %. Of course, not just the data-phase speed was increased to 2 Mbit/s, the arbitration bit-rate was also doubled (from 250 kbit/s to 500 kbit/s). Optimization regarding the periodic transmission, the length of PGs, and the usage of Change-of-State triggering can additionally decrease the busload.

Summary and outlook

The CiA 602-2 specification will be released soon as a Draft Standard Proposal (DSP). It can be used with unchanged J1939 application software, just adding a small bridge program mapping the PGs into Multi-PDUs. Additionally, the CiA 602-2 protocol stack can also accelerate the download of application software and calibration data as well as the uploading of diagnostic information. The CiA 602-2 protocols can also be used for other J1939-based solutions such as Isobus (ISO 11783 series) and NMEA 2000 (IEC 61162-3). In the "CAN 2020" seminars (free-of-charge for CiA members), they are a topic, too. ◀

Author

Holger Zeltwanger
CAN in Automation
headquarters@can-cia.org
www.can-cia.org