30 years CANopen

In November 1994, CiA published the first version of the CAL-based application profile for industrial systems. After some improvements, this application layer and communication profile was renamed to CANopen, which was accepted as a base for many embedded and deeply embedded networks in different industries.

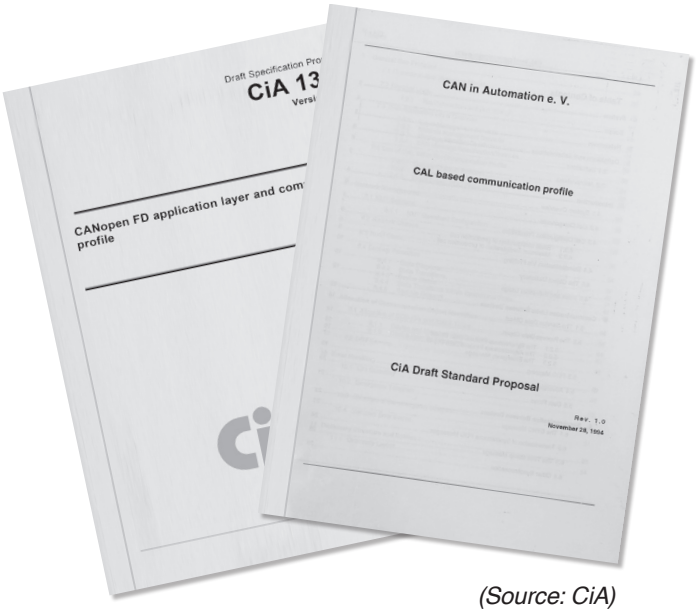
The routes go back to the project 7302, named ASPIC (Automation and Control Systems for Production Units using an Installation Bus Concept), within the Esprit (European Strategic Program on Research in Information Technology) research program. The objective was to develop control architectures and devices to enable flexible and modular combinations of existing manufacturing cell units. The researchers led by Dr. Mohammad Farsi (University of New Castle) and Stefan Reitmeier (Bosch) decided to use as a base the CiA 200 CAN Application Layer (CAL) protocol series developed by CiA. CAL was a pure application layer approach according to the OSI (open systems interconnection) model. Device interoperability was not on the CAL agenda.

The results of the ASPIC research project were handed over to CiA in summer 1994. In November 1994, CiA released version 1.0 of the CAN-based application profile for industrial systems. In January 1995, CiA published an updated version. In the same year, CiA demonstrated on its joint booth on the Hanover Fair a first production cell demonstrating the compatibility and interoperability of CANopen products developed by different companies.

New applications: From medical devices to construction machines

The most important new feature of the researchers compared with CAL was the introduction of the CANopen object dictionary. It was a well specified link between the CANopen protocol stack and the (device) profile software. It provides a unique address mechanism from both sides by means of a 16-bit index and an 8-bit subindex for process data, configuration parameters as well as diagnostic information.

First adapters were medical device makers (e.g., Philips Medical Systems) as well as construction machine manufacturers and their suppliers (e.g., Moba). Selectron, another early bird, used CANopen in several embedded machine control applications and introduced CANopen in the rolling stock industry. All these first applications complied with the version 3.0 of the CiA 301 (CANopen application layer and communication profile) specification published in 1996. KEB and Lenze were first suppliers of frequency inverters with CANopen connectivity. They implemented the CiA 402 profile for drives and motion controllers, which derived from an Interbus profile. Moog contributed a CANopen hydraulic servo, which was later used in many wind power systems for pitch control.



(Source: CiA)

CiA members have developed further CANopen-related documents. Besides the profiles for modular I/O devices (CiA 401), for drives and motion controllers (CiA 402), and for measuring devices and closed-loop controllers (CiA 404), the CiA 302 series for CANopen application layer add-on functions were released. The CiA 302 series specified among other functions an NMT "flying master" (network management) concept and other redundancy features requested by maritime electronics suppliers.

From version 3.0 to version 4.0

The last big step of CANopen CC (classic) was the release of the CiA 301 version 4.0. In this document, the Heartbeat service substituted legacy Node/life-guarding services, which were based on CAN remote frames. Also remotely requested PDO messages were not more recommended. Additionally, version 4.0 introduced the Boot-up service, which substituted the EMCY (emergency) service misused by several companies as an indication that the device has entered the NMT pre-operational state. Version 4.0 introduced in 1999 is also the base of the EN 50325-4 standard.

CiA has internally enhanced the CiA 301 document by a very few functions. The current version 4.2.0 has been released in February 2011. It is stable since this time. Of course, there are some weaknesses in the text and the modeling of communication functionality. The modeling ▷

is, from an academic point of view, not perfect. But the many successfully used CANopen networks do not care on these issues: Never change a winning team. CiA has frozen this document, so to speak.

From CANopen CC to CANopen FD

When CAN FD (flexible data rate) was launched beginning of the second decade of this century, the CANopen community developed the CiA 1301 CANopen FD application layer and communication profile specification. It overcame some of the academic weaknesses and introduced the USDO (universal service data object) services and protocols. They allow a multi- and broadcast transmission of confirmed messages accessing the CANopen object dictionary entries. Additionally, CANopen FD supports higher bit rates and message payloads up to 64 byte.

However, the acceptance of CANopen FD is slow. Still, most of the CANopen users can live with CANopen CC (classic) limitations in speed (up to 1 Mbit/s) and message payload (up to 8 byte). This may change, when there is an increasing demand on functional safety and cybersecurity.

Standardized profiles for CANopen

One of the unique features of the CANopen technology is the standardization of profile specifications. This improves the interoperability and partly exchangeability of CANopen devices on the market. CiA 402, the profile for servo controllers, stepper motors, and frequency inverters, has been internationally standardized in IEC 61800-7-201/-301 (2015). It has been mapped also to other communication technologies.

In total, CiA has released far more than 20 000 pages of profile specifications. The CiA 422 series (application profile for refuse-collecting vehicles) has been standardized in EN 16815 (2019) and the CiA 443 application profile for subsea equipment has been partly moved into an ISO standard (ISO 13628-6). There is also the DIN 14700 application profile for fire-fighting equipment (also known as FireCAN), which is based on CANopen CC. It addresses also ambulances and other rescue vehicles.

The future of CANopen

Currently, CANopen technology covers CANopen CC based on the CAN CC data link layer and CANopen FD based on the CAN FD data link layer. CANopen FD is written in a way that it can be easily adapted to the CAN XL data link layer, but this is future. It will happen, when first micro-controllers with on-chip CAN XL cores and CAN SIC (signal improvement capability) XL transceivers are available in mass production.

CiA expects also new profile specifications and improvement of existing ones. In the pipeline is a profile for manual welding and cutting equipment. There is also a standardization of greenhouse automation in preparation, where deeply embedded CANopen networks are candidates to link sensors and actuators. This application may require new profiles for specific products used in greenhouses. Also, a CANopen-based profile for body application of road- and winter-service vehicles could be a new work item. Modular (service) robots are standardized in the ISO 22900 series, which references CANopen (CiA 301 and CiA 1301). This could lead to new profiles for specific robot subsystems.

CiA specifies profiles only on demand. In minimum, three members can request a new work item. CiA office normally organizes a workshop on the new work item proposal, in order to inform as many interested parties as possible, before an CiA-official kick-off-meeting is scheduled. Also non-members (especially original equipment manufacturers) can initiate a new work item. CiA believes in the African proverb: “If you like to go fast, go alone. If you like to go far, go together.” CANopen has gone a long way and will keep walking. ◀

hz

Correction

In the September issue, we reported about Microchip’s PIC64-HPSC (high-performance spaceflight computing) processor series. Unfortunately, we wrote by mistake that these 64-bit microprocessors are equipped with two CAN CC (classic) protocol controllers. Correct is, that they do not support CAN communication. It is the PIC64-GX1000 series, which features two on-chip CAN CC ports. We apologize for this misinformation. *hz*