Future of CAN networking in VW's passenger cars

VW has established the Car.Software unit. It is not only responsible for the software development as the name suggests, but also for the in-vehicle networking. CAN is an important communication technology for future VW cars.

CAN was, is, and will be one of the most important communication technologies used in VW's passenger cars. Historically, the Volkswagen (VW) Group was the inventor of the A-Bus, competing against Classical CAN, in the late 80ties. After the automotive industry decided to use jointly the OEM-independent (original equipment manufacturer) CAN protocol, originally developed by Bosch, VW was and is highly committed to CAN, internationally standardized in the ISO 11898 series. VW is even one of the early CAN FD supporters, and initiated the development of the CAN XL protocol, the third CAN protocol generation.

Carsten Schanze from Volkswagen stated in his iCC 2020 keynote (the conference has been postponed to June 2021, due to the Covid-19 pandemic) that the Golf models are the carriers of new communication technologies: "The Golf was established in 1974 and, until today, more than 35 million vehicles are sold. The requirements for future CAN networks respectively future architectures will be found by looking into the CAN networks of the Golf generations." In the first three Golf generations no CAN network was implemented at all. CAN communication started with the fourth generation of the Golf in 1998 with two CAN networks.

Nowadays, there is the trend to substitute even some LIN networks by CAN networks. "This change is done due to diagnosis requirements," explained Schanze. "The introduction of Ethernet-based communication technologies, e.g. 100Base-T1, in control units shifts the CAN control units one level down. CAN control units are mainly used as sensor respectively actor control units." Furthermore, security reasons necessitate transmitting

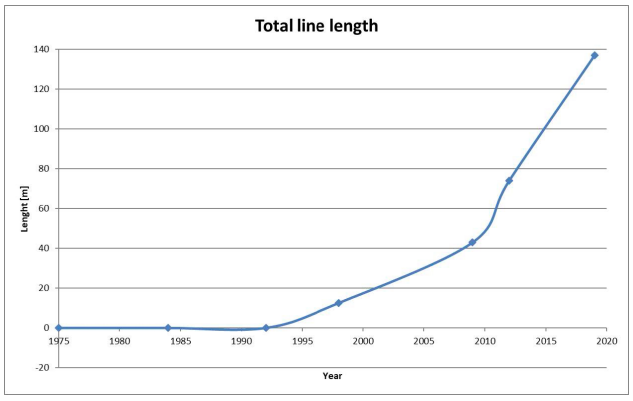

Figure 1: Total network length in Golf cars, which needs to be reduced in future vehicles to save weight (Source: VW)

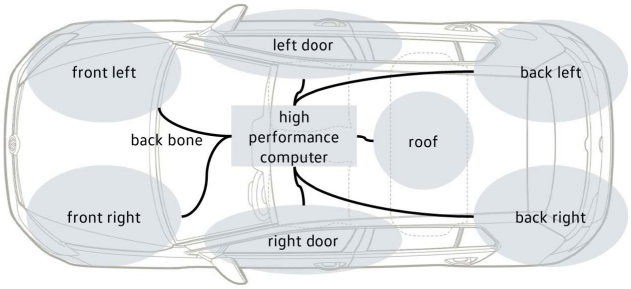

Figure 2: Zone networking architecture example (Source: VW)

a signature for certain ECUs (electronic control units). In order to reduce the effort of generating such a signature, messages are merged, so that just one signature is needed instead of multiple once for shorter messages. This leads to messages with larger data fields. This is, why VW proposed the CAN XL protocol with payloads up to 2 048 byte. Additionally, this allows an easy integration in a TCP/IP-based environment using Ethernet-based networks as backbone between different zone control sub-systems with deeply embedded networks.

Carsten Schanze provided in his iCC paper the following future requirements, deriving from an analysis of the past and present in-vehicle networking:

- Clean-up of the wiring harness, in order to reduce the weight, to gain space, and to ensure the signal integrity;
- More scalability, in order to get more bandwidth and to get sufficient payload length.

"The vision for the future is to reduce the different architectures: 'One architecture fits all', stated Schanze. "Zone architectures will solve the first requirement to reduce the weight and gain space for the packaging of control units and the layout of the wire harness. The requirements for the bandwidth are increasing from the senor/actor level to the high performance computer."

The introduction of zones offers an additional possibility of scaling. As today, the number of ECUs and the bit-rate are scalable. "Furthermore, the number of zones in the car and the communication technology of backbone networks are scalable," Schanze added. "A good approach of a communication technology for such an architecture seems to be CAN XL." The CAN XL protocol offers a data-field that is able to transmit TCP/IP segments. CAN XL-connected ECUs can be used in a multi-drop topology. The bit-rate of the CAN XL communication is scalable until a net bit-rate of more than 10 Mbit/s. CAN XL can run on high-speed ▷

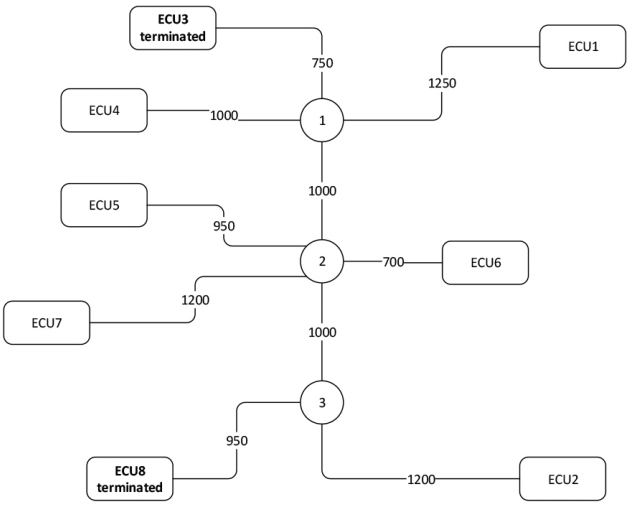

Figure 3: Possible CAN XL topology (Source: VW)

CAN physical interfaces as specified in ISO 11898-2:2016, CAN SIC interfaces as specified in CiA 601-4 as well as CAN XL SIC interfaces as specified in CiA 610-3 (under development). Of course, the CAN XL payload is also scalable from 1 byte to 2 048 byte.

VW plans to use in its next generation of in-vehicle networks CAN FD substituting all legacy Classical CAN networks and CAN XL networks. Carsten Schanze concluded: “The change to zone architectures will straighten the topology to reduce the total line length and thereby the weight.” The needed bandwidth is provided by CAN FD in conjunction with CAN SIC transceivers respectively CAN XL using CAN XL SIC transceivers. The CAN FD (up to 64 byte) and CAN XL (up to 2 048 byte) payloads are larger as the Classical CAN payload (up to 8 byte). Both CAN FD SIC and CAN XL SIC transceivers feature signal improvement capability, so that the settle time after a bit change is reduced.

Committed to open source approaches

“Open source is becoming increasingly important for software development – and could help Volkswagen make progress on its way from a pure car manufacturer to a car and software provider.” That is Oliver Hartkopp's mission.

Figure 4: Oliver Hartkopp, VW’s open source missioner and one of the SocketCAN developers: “Technology, strategy, processes – Open Source is a huge topic. My job is to anchor it at Volkswagen.” (Source: VW)

Volkswagen's Car.Software unit

Dirk Hilgenberg leads the Car.Software organization (Source: VW)

Starting beginning of 2020, the Car.Software organization operates as an in-dependent business unit. As a VW Group company, it centralizes the associates and subsidiaries that develop car software and software for the digital ecosystems. Initially, around 3 000 experts from the software-related associates and subsidiaries are grouped together in this unit. The focus of the Car.Software organization is on developing common software for all brands and markets at the VW Group. This is primarily about the VW.OS automotive operating system and the connectivity with the Volkswagen automotive cloud. In addition, the Car.Software organization will consolidate the technological platform solutions for data-driven business models and innovations at the Group. One other task is the development of future in-vehicle network architectures. This includes CAN FD and CAN XL networks.

Investments of more than seven billion euros are planned for these tasks by 2025. The Car.Software unit brings together international expertise. It has its organizational base in Ingolstadt and, with its subsidiaries, has other sites in Germany including in Berlin, Stuttgart, Wolfsburg, and, in the future, Munich. In addition, the Car.Software unit has locations in Europe, as well as in China, the United States, Israel, and India. By 2025, more than 10 000 employees will work in this business unit.

Dirk Hilgenberg manages the Car.Software organization. He graduated in physics. In 1999, he began his career as General Manager Plant IT Operation at BMW UK Manufacturing Ltd. In 2017, Hilgenberg was appointed Senior Vice President Manufacturing Engineering at the BMW Group in Munich. He is now the CEO of the Car.Software unit.

Oliver Hartkopp is well-known in the CAN community, because he is one of the fathers of the SocketCAN open source Linux software driver. A couple of years ago, he had a lot to do with building prototypes. In order to be able to access the CAN (Controller Area Network) network-based steering solutions, Volkswagen always purchased new systems from new suppliers. For Hartkopp this was incomprehensible. He researched the open source community, consulted with a colleague, and in 2003 began programming an extension for the Linux operating system himself, with which it is now possible to access the CAN network via standardized interfaces – regardless of the CAN hardware used. In 2006, Volkswagen published SocketCAN as open source. By the way, this Linux driver does not only run on the test vehicle on display and in automotive development departments within and outside the VW Group: some fish trawlers on the Atlantic, heavy-duty cranes in the port of Hamburg, the Cern nuclear research facility in Geneva, and a scientific institute in Novosibirsk also use the software, which had its origins in VW Group research.

Since 2008, Oliver Hartkopp is responsible for more than 6 000 lines of code in the Linux kernel – the "core" of the Linux operating system. In addition, the Car.Software unit and the use of open source will make Volkswagen a much more attractive employer for software developers. "If we go from 'We buy everything' to 'We do more ourselves', we will automatically attract more people who are familiar with software," said Hartkopp, Volkswagen's open source preacher. "I also think it's really exciting about my job that I can be a pioneer in shaping this new culture here at Volkswagen." He organizes workshops, gives training courses for developers together with the legal department, is often in contact with colleagues from the Group's brands via Skype conferences, and gives lectures about open source: "I'm kind of a missioner." He is now part of the new Car.Software organization. ◀

Holger Zeltwanger