Future of CAN from the prospective of an OEM

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The future of CAN is linked to the future of architectures in vehicles. This article considers the future of architecture from a physical layer point of view, too. The requirements for future architectures will developed by analyzing the past and the present.

The carrier for new communication technologies at Volkswagen is the Golf. The Golf was established in 1974 and, until today, more than 35 million vehicles are sold. The requirements for future CAN networks resp. future architectures will be found by looking into the CAN networks of the Golf generations.

What forms the CAN

Before opening the history books of the networking department, the understanding of an OEM "what forms the CAN" is summarized. After several discussions three keywords are named:

- Flexibility,
- Cost-efficiency and
- Controllability.

The term flexibility includes scalability and the layout of the control unit. It is easy, to scale CAN networks by adding or deleting control units. The scalability of the bit rate is illustrated in figure 1. It is possible to adapt the bit rate to the complexity, e.g. size, of the topology.

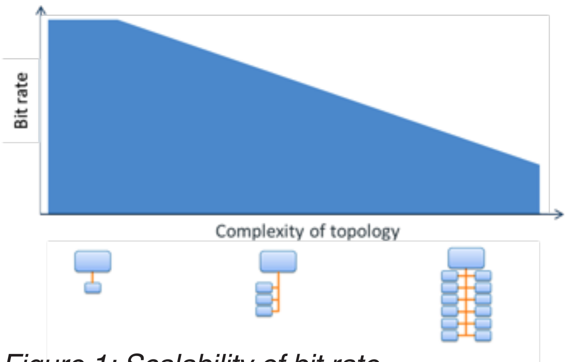

Figure 1: Scalability of bit rate

Due to the size of the CAN interface compared to the control unit, the designer has certain grade of freedom to place the CAN interface on the circuit board.

Cost-efficiency is self-explanatory. The following interface devices are considered:

- CAN controller,
- CAN transceiver,
- Common mode choke and
- Termination resistors.

The last keyword controllability is best described by citing a colleague "Almost everybody is able to access and read the CAN!".

The past

The first three generations of the Golf have no CAN networked control units at all. CAN networking started with the fourth generation of the Golf in 1998 with two CAN networks, see figure 2.

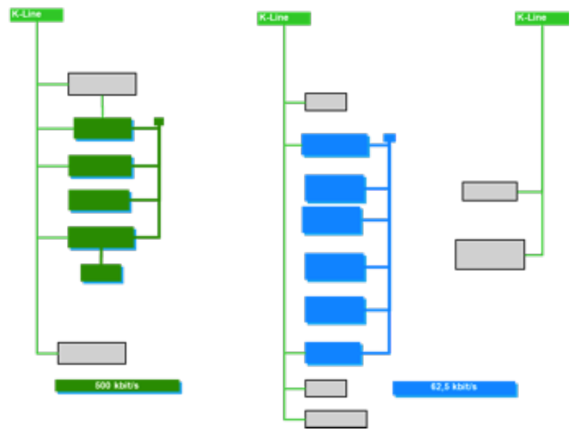

Figure 2: CAN architecture of Golf 4

Figure 3: CAN architecture of Golf 7

Both the number of CAN networks and the number of control units increases over time as shown in figure 2 and figure 3. In 2003 Volkswagen introduces a central gateway as separate control unit to improve the data exchange among the CAN networks.

The existing CAN networks resp. CAN topologies per vehicle are analyzed regarding the “total” bit rate and the total line length.

To calculate the “total” bit rate of all CAN networks the net bit rate of the control units are added. E.g. for the Golf 4 there are five control units with a net bit rate of 393 kbit/s (gross bit rate 500 kbit/s) and six control units with 51 kbit/s (gross bit rate 62,5 kbit/s). The calculation is five times 393 kbit/s plus six times 51 kbit/s and results in 2271 kbit/s.

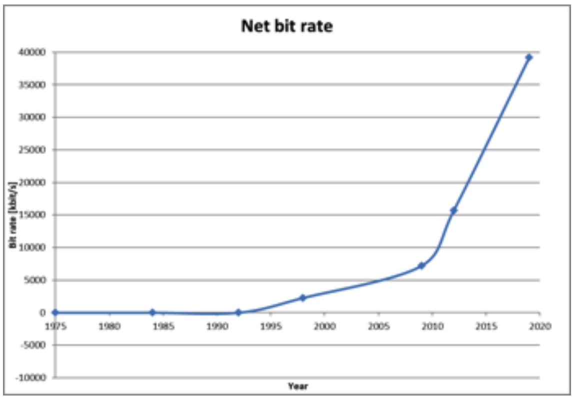

Figure 4: Development of the bit rate

The total line length results by adding all line sections of the CAN topologies.

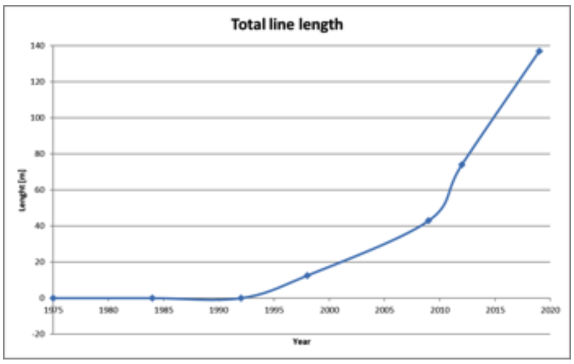

Figure 5: Development of the total line length

It is noticeable that the total line length increase comparable with the increase of the bit rate.

A good guess of what is expectable shows figure 6 with the total line length applied to the net bit rate.

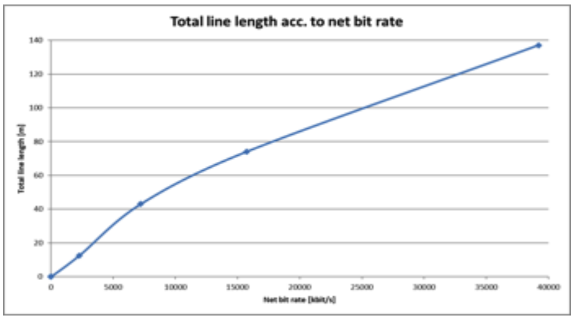

Figure 6: Development of the total line length according the net bit rate

The future increase of bit rates will be absorbed by new automotive communication technologies (e.g. CAN FD SIC, CAN XL).

Today, the networks are organized in functional domains. This implies a huge effort in the wire harness, if control units of one network are packaged in the whole vehicle. By extrapolating the curve of figure 6, a net bit rate of 65.000 kbit/s (step from Golf 7 to Golf 8) leads to a total line length of more than 200 m.

The increase of the total line length leads to higher weight and challenges for the packaging of control units and the layout of the wire harness. The impact of the total line length on the signal integrity has to be considered, too. If the size of the topology exceed a certain limit, the bandwidth has to be decreased. Otherwise an additional technology is needed to improve the signal, e.g. to reduce the settle time of the edge dominant to recessive.

The present

Today there is the trend to change the communication technology LIN in some control units to CAN. This change is done due to diagnosis requirements.

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 resp. actor control units.

Furthermore security reasons necessitates to transfer a signature for certain control units. To reduces the effort of generating such a signature, messages are merged, so that the signature shall be generated once for the merged message instead of serval times for the single messages. This leads to messages with larger data fields.

The future

From the analysis of the past and the present the following requirements derive:

- Clean-up of the wire harness, to
  - reduce the weight,
  - gain space and
  - to ensure the signal integrity.
- More scalability, to satisfy
  - the bandwidth and
  - data length requirements.

The vision for the future is to reduce the different architectures: “One architecture fits all”.

Zone architectures, see figure 7, 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.

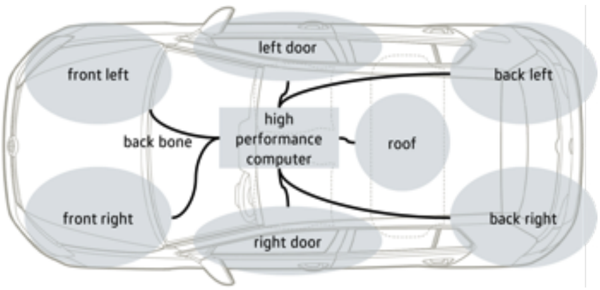

Figure 7: Zone architecture

Zone architectures are organized in zones instead of functional domains, as the name implies. Each zone is arrange at a zone gateway. This zone gateway is a control unit with high performance and standard equipped. The zone gateway communicates via a back bone with a central high performance computer.

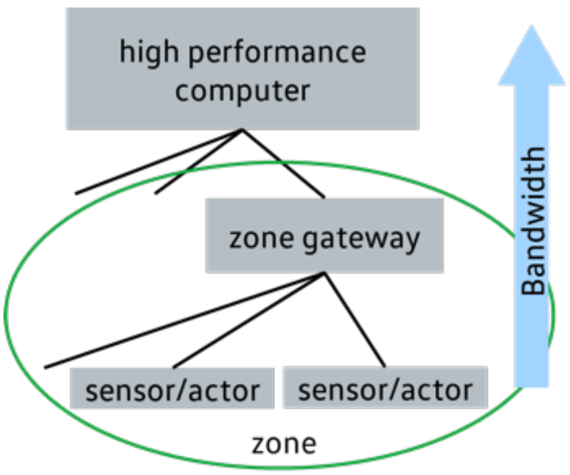

Figure 8: Zone structure

The structure of a zone is shown in figure 8. The requirements for the bandwidth is 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 control units and the bit rate is scalable. Furthermore the number of zones in the vehicle and the communication technology of back bone are scalable.

A good approach of a communication technology for such an architecture seems CAN XL. The CAN XL protocol offers a data field that enables to transmit IP frames. CAN XL control units 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. Table 1 gives an overview about the combinations of a CAN XL controller with different CAN transceiver.

Table 1: Scalability of CAN XL

Technology	CAN XL			
Max. DLC [byte]	2048			
Transceiver	HS CAN	CAN FD	CAN FD SIC	CAN XL
Max. bit rate [kbit/s]	500	2000	5000	10000

The numbers of table 1 are valid for an The numbers of table 1 are valid for an automotive topology with eight control units and a total line length of l=10 m, see figure 9.

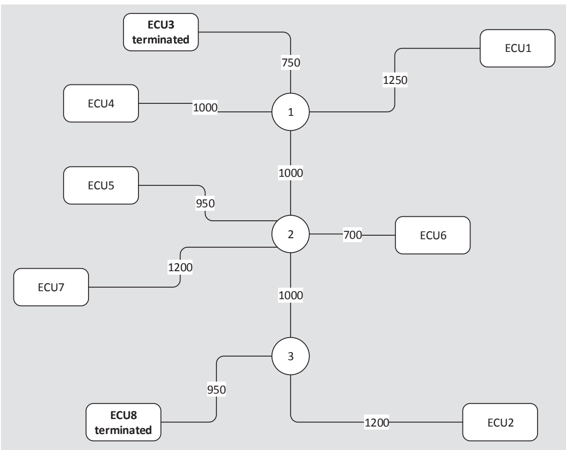

Figure 9: CAN XL topology

An estimation in comparison to figure 6 is shown in figure 10.

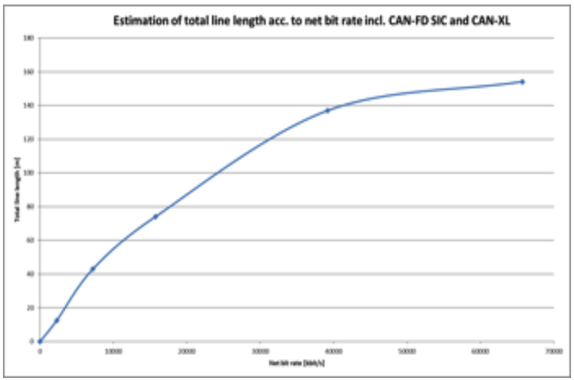

Figure 10: Development of the total line length according the net bit rate including CAN-FD SIC and CAN XL

The calculation is based on the same total number of control units as for the Golf 8. Four control units communicate with CAN-FD SIC (2712 kbit/s net bit rate) and two control units communicate with CAN XL (10 Mbit/s net bit rate).

Conclusion

The analysis of the situation in the past and today leads to following requirements:

- Clean-up of the wire harness, to
  - reduce the weight,
  - gain space and
  - to ensure the signal integrity.
- More scalability, to satisfy
  - the bandwidth and
  - data length requirements.
- Signal improvement.

These requirements will solved in the future by

- changing from domain oriented architectures to zone architectures and
- introducing CAN-FD SIC and CAN XL.

The change to zone architectures will straightened the topology to reduce the total line length and thereby the weight. The needed bandwidth will be provided by CAN-FD SIC resp. CAN XL. The data length for CAN-FD SIC resp. CAN XL are larger as for high speed CAN, at which the maximum data length for CAN-FD SIC is limited to 64 byte. The maximum data length for CAN XL is 2048 byte. Both CAN-FD SIC and CAN XL have a signal improvement capability, so that the settle time after a bit change is reduced.

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