The role of CAN in ECU communication

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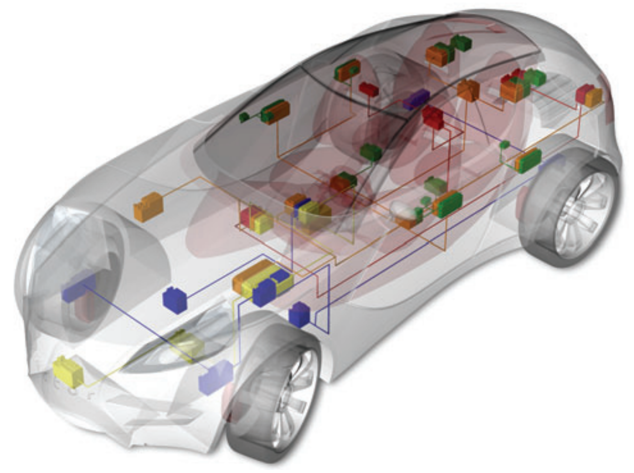
The immense innovative potential of electronics - and its associated abilities to make car driving safer, more comfortable, economical and environmentally friendly – has caused the automobile to undergone a genuine electronification that started in the 1970s and gained momentum in the 1980s. Above all, this is due to the networking of electronic components, which is a prerequisite to greater functionality and consequently a greater range of performance. In order to reduce the cabling effort and also the costs, the weight and the need for space that come with increasing networking, the vehicle manufacturers have long since decided upon serial data transmission. In addition to the serial bus system CAN, LIN and Most (Media Oriented System Transport) have been established in vehicles within a very short time. In Fall 2006, BMW will introduce its new X5 as the first production vehicle with FlexRay, a bus system specially designed for use in time-critical and safety-critical applications.

The Controller Area Network (CAN), which was standardized internationally in 1992, is without a doubt the most-used serial bus system, which can be used several times even within a single vehicle: a slow CAN bus system for the networking of comfort ECUs with a maximum transmission rate of 125 Kbit/s (CAN fault-tolerant) and a fast CAN bus system for networking ECUs for the drive and chassis with a maximum transmission rate of 1 Mbit/s (CAN high-speed). CAN offers extraordinarily high transmission security. An important contribution is made by the differential signal transmission and the cooperation of five error detection mechanisms (among others bit monitoring, form check, cyclic redundancy check), which are handled by the CAN controllers.



LIN (Local Interconnected Network) is used for cost-effective and easy data transmission in the sensor/actuator area. The data rate is limited to just 20 Kbit/s, but this is completely sufficient for transmission of non-critical sensor and actuator signals.

For real time-critical applications, there is a need for a bus system that is independent of the bus load, guarantees hard real time. Real time-critical systems are often also safety-critical systems. FlexRay is the solution here: with a maximum data rate of 20 Mbit/s and based on a guaranteed equidistant data transmission, FlexRay ensures deterministic time relationships. A second communication channel enables redundant data transmission. If the data on one channel is disturbed, it is still available via the second channel.

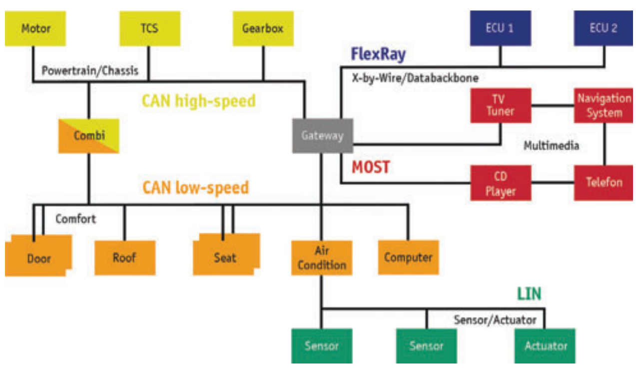


Fig. 2: Networking of modern vehicles with serial bus systems

Infotainment devices such as navigation, radio, and telephone require a relatively high bandwidth since not just control but also video and audio signals are transmitted. Therefore, Most is used for multimedia networking in vehicles. Most makes available a relatively large bandwidth: with a sampling frequency of 48 KHz approx. 23 Mbit/s for the transmission of bit streams and 768 Kbit/s for the transmission of control signals. For networking CAN, LIN, FlexRay, and Most, Vector supports the vehicle manufacturers and suppliers with a comprehensive tool chain and software components. The users of the CANoe tool benefit, for example, during the whole development process from practical functions for model creation, simulation, function tests, diagnostics, and analysis. The following options and protocols are available for CANoe and can be combined as desired: CAN, LIN, FlexRay, Most, CANopen, SAE J1939, SAE J1587, NMEA2000, and ISO11783. Tools for the development, calibration, and diagnosis of vehicle ECUs complete Vector's extensive offerings. For the development process of electronic systems, the company offers a tool environment in addition to consulting assistance. ▶

The future of CAN

Table 1: Summary of the serial bus systems CAN, LIN, and FlexRay

	CAN	LIN	FlexRay
Architecture	Multi-master	Master-slave	Multi-master
Time behavior	Not deterministic	Deterministic	Deterministic
Bandwidth	1 MBit/sec	20 KBit/sec	20 MBit/sec
Bus access	At random and priority-controlled	Controlled by schedule	Controlled by schedule
Addressing	Messages	Messages	Messages
Use bytes per frame	8	8	254
Medium	Two-wire line	Single-wire line	Two-wire line, fiber optic line
Topology	Line, star	Line	Line, star

Electronic systems are taking over a broad spectrum of different tasks in automobiles. To couple the systems, various bus systems have established themselves. Table 1 shows a summary of the serial bus systems CAN, LIN, and FlexRay and their essential properties. CAN offers very high data security with relatively low costs and is therefore predestined for use in the drive and comfort areas. Based on its still more cost-effective and easy communication architecture, LIN is very well-suited as a sub bus. FlexRay is the best selection where the concern is quick, deterministic, and secure data transmission. Most serves as a multimedia bus for the exchange of audio/visual data between infotainment devices. CAN will continue to be used in the future in the powertrain, chassis and convenience application areas. Today some well-equipped automobiles already have more than 70 different ECUs. Hardly any new CAN nodes will be added, however, since the trend among automotive OEMs is to increasingly bundle functions in central ECUs. FlexRay will gain additional significance since with it; it's possible to realize time and security-critical applications as well as data-intensive applications. Thanks to the increasing number of intelligent sensors and actuators, LIN will also play a more significant role in the future.

The enormous variety of operating systems, embedded software, microcontrollers and software components from various producers substantially increases the integration effort in distributed electronic architectures. For this reason a number of prominent automobile producers and suppliers have defined an "Automotive Open System Architecture" (Autosar). Since its inception most automotive OEMs, many large suppliers and tool specialists have joined Autosar and participate more or less intensively in its activities.

The goal is to establish a de-facto standard for all six functional domains (drivetrain, chassis, safety, telematics, human machine interface and body/convenience functions). The architectures of software and hardware components developed for this purpose will be uniform. Competition would be based primar- ▶

ily on different implementations of functions. With interchangeability come many freedoms. Examples include the simple scalability of the software for different vehicles and platforms, the freely configurable distribution of functions in the networks and the trouble free ability to combine modules from different manufacturers. The hardware is also highly compatible and has the character of being "off the shelf" products. Other important aspects to be considered are future electronics safety requirements, repair and maintenance over the entire product life cycle, and the capability of software updates and upgrades throughout the life of the automobile.

In the run-time environment Autosar relies on decoupling of the application from the hardware and base software to enable special library functions. This is achieved by specifying interfaces and their communication mechanisms. In May 2006, the Autosar development partnership published a first set of the major results of its first development phase. The specifications are results of the first three years of development work in the partnership. In May 2005, 31 Base Software (BSW) modules were specified with release 1.0. The subsequent implementation phase and validation phase (Validator 1) validated the functional capabilities of the modules and the concept. By May 2006, 42 of the 46 BSW specifications were already published, among them the RTE (Runtime Environment). To date, 99 documents, formats and models have been completed, of which 94 have been published. The specifications are currently undergoing another test phase (Validator 2) to be completed this fall. The first full release 2.1, which would also include the methodology specification, is scheduled for the end of 2006 [1].

Integration of CAN in Autosar

The CAN communication services are a group of modules for vehicle network communications with CAN. They provide a uniform interface to the CAN network, hiding protocol and message properties from the application. Autosar COM and Diagnostic Communication Manager provide uniform communication mechanisms for the application, both are bus technology independent. The PDU router allows direct routing of Process Data Units from one bus to another. In addition, within Autosar COM a signal-based gateway is included in order to route single signals from one communication system to another.

The network management is split in a bus-independent and bus-dependent part. If CAN is replaced by FlexRay, the Generic NM remains the same. By introducing a CAN interface the PDU router does not care about the fact whether the CAN controller is a part of the embedded controller or an external device. By replacing the CAN-dependent modules by LIN- or FlexRay modules the CAN communication stack can be transformed to the LIN or FlexRay communication stack.

The memory services given as the NVRAM-Manager provide a uniform access of the applications to non-volatile data. It abstracts memory from location and properties. Further on it provides mechanisms for non-volatile data management like saving, loading, checksum protection and verification or reliable storage. The memory hardware abstraction (below the memory services) abstracts from the location of the peripheral memory devices (on-chip or on-board) and the ECU hardware. E.g. the EEPROM interface and the Flash hardware should be accessible via an equal mechanism. The memory drivers are accessed via memory specific abstraction/emulation modules (e.g. EEPROM Abstraction). By emulating an EEPROM interface and Flash hardware units a common access via Memory Hardware Abstraction to both types of hardware is enabled. Both examples CAN communication stack and memory stack show a high degree of modularization to achieve an optimum on modularization and reuse of infrastructure software for very different use cases [2].

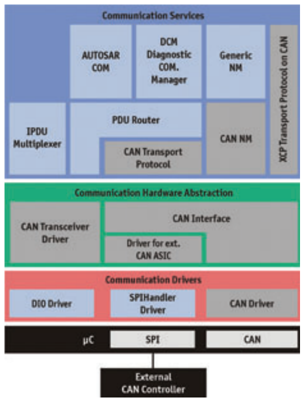


Fig. 4: Autosar architecture of the CAN communication stack

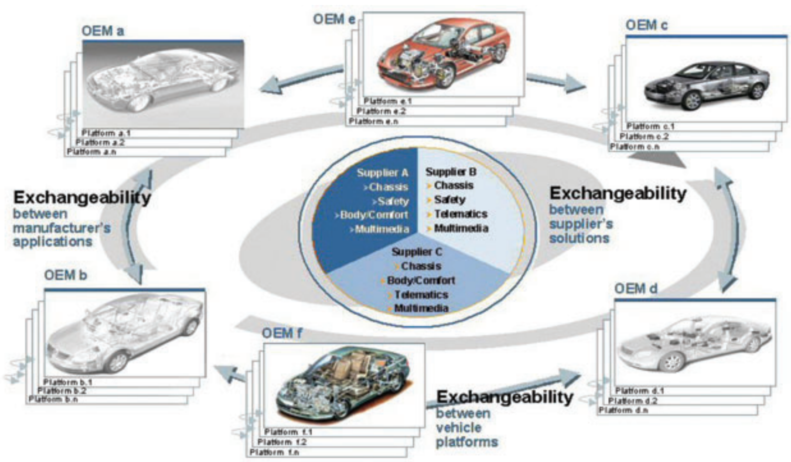


Fig. 3: The Autosar vision – Making complex E/E systems manageable by standardized architectures and interfaces

Development platform for Autosar

For all of the design steps needed to develop Autosar-conform software Vector offers a solution: From structured conceptual design of Autosar software components and their distribution among ECUs to defining communication and ECU configuration. Besides base software components for network communication and operating systems based on the Osek standard, Vector also supplies the entire core and a runtime environment based on the Autosar specification for a large number of different microcontrollers and their individual devices. Besides supporting specific target hardware platforms, the CANoe network development tool is also supported as a PC experimenting platform. Combined with Vector's DaVinci tool suite the user gets a platform for reliable development of Autosar-conform ECUs.

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References

[1] Weber, T.: Vector Autosar Conference July 2006, „The Overvalue of Autosar for OEM purposes"

[2] 7th Euroforum conference „Software in the vehicle" May 2006, „Autosar – Current results and preparation for exploitation"