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Integration of external functions in CAN-based in-vehicle networks

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abstract

First the concept of the CAN-based in-vehicle network for the next generation of Mercedes-Benz trucks is introduced. This implies the connection of different systems, as e.g. engine- and braking-controller. A special characteristic of this information-network is the structure, where the components are combined in functional groups, which are connected via gateways, and organised in several hierarchical levels.

Emphasis is put on concepts to the integration of external electric/electronic functions in the in-vehicle network. This will be shown on the interfaces to external systems such as bodyshell-electronics (e.g. concrete-mixer) and trailer-electronics (braking and non-braking applications), and on the data transmission via telephone ore satellite-communication for other services (e.g. vehicle pool management, emergency calls, remote-diagnosis and so on). The current position of this integration is illustrated by some examples.

At the end of the discourse the question of standardisation is considered critically, and the consequences for the relationship in information exchange between car manufacturer, trailer and body manufacturer and suppliers for electronic systems are discussed.

In-vehicle network

Why do we need networks in trucks

With the next generation of electronic control units, however, an important leap forward will be achieved as far as data exchange/communication is concerned. The various control units will make use of data and information provided by others to a progressively larger extent , in order to

- display a greater variety of functions
- avoid multiple scanning and processing
- render every-day functions more efficient and accurate.

We expect that in the next generation of heavy commercial vehicles the following systems will operate/be controlled electronically

- dashboard
- engine control
- transmission control
- electronic brake system
- retarder
- chassis control
- on board computer (service, electric system control)

The system-inherent functions will be complemented by so-called coupling functions, which are based on the synergic cooperation of two or more of the systems stated above. Examples are shown in table 1.

functions	***communication between***
display, information, warning	respective control unit, instrument
ASR (reduction of drive torque)	ASR-control unit, engine control unit
electronic drive control (EAS)	engine, clutch, transmission control
brake management	service brake, retarder, engine brake
dynamic handling control	engine, clutch, brake control
diagnosis (on board)	respective control unit, instrument
anti-theft lock	control unit, engine control

Table 1: coupling-functions

The Mercedes-Benz truck concept for in-vehicle network

The Mercedes-Benz truck concept for in-vehicle network, which is called Integrated Electronic System (IES), is based on the following vehicle-system-model.

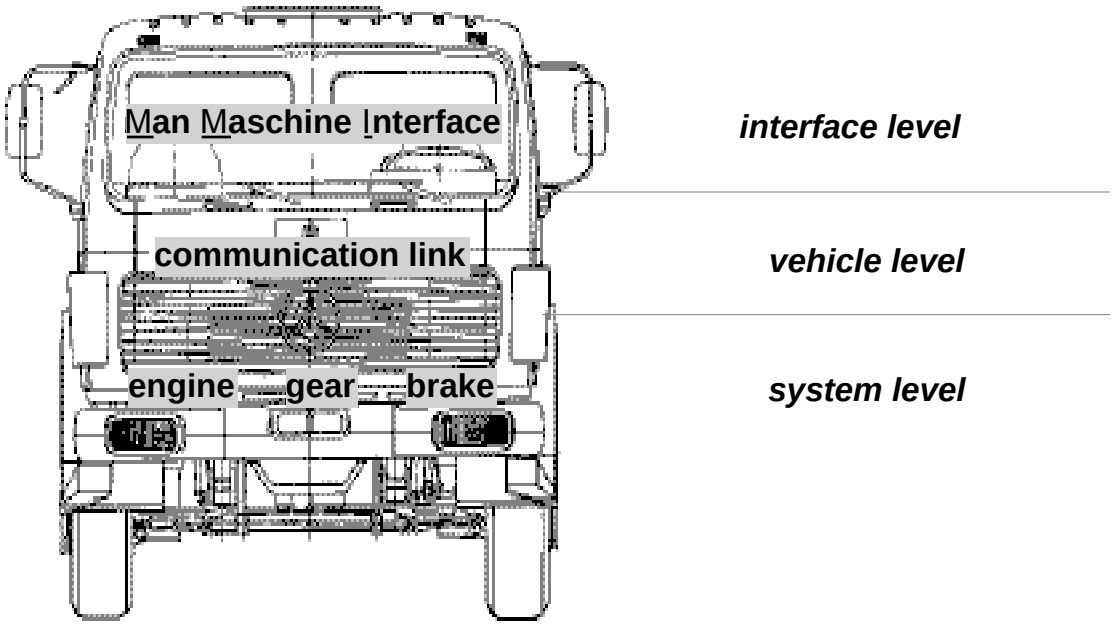

Figure 1: vehicle-system-model

In the system-level (bottom of figure 1) the basic systems like engine, gear, brakes etc. are located. All systems in this level are independent and self-assure.

The vehicle-level links the basic systems together with themselves and with the upper interface-level, by connecting them for communication. Here the coupling-functions (see table 1) are located.

In the upper third, there is the environment- (driver-) oriented interface level. Its task is for example the Man-Machine-Interface (MMI), which is represented by the dashboard and switches. The interfaces to external systems are also located here.

Based on this model, the concept for the in-vehicle network becomes the following, more detailed, structure.

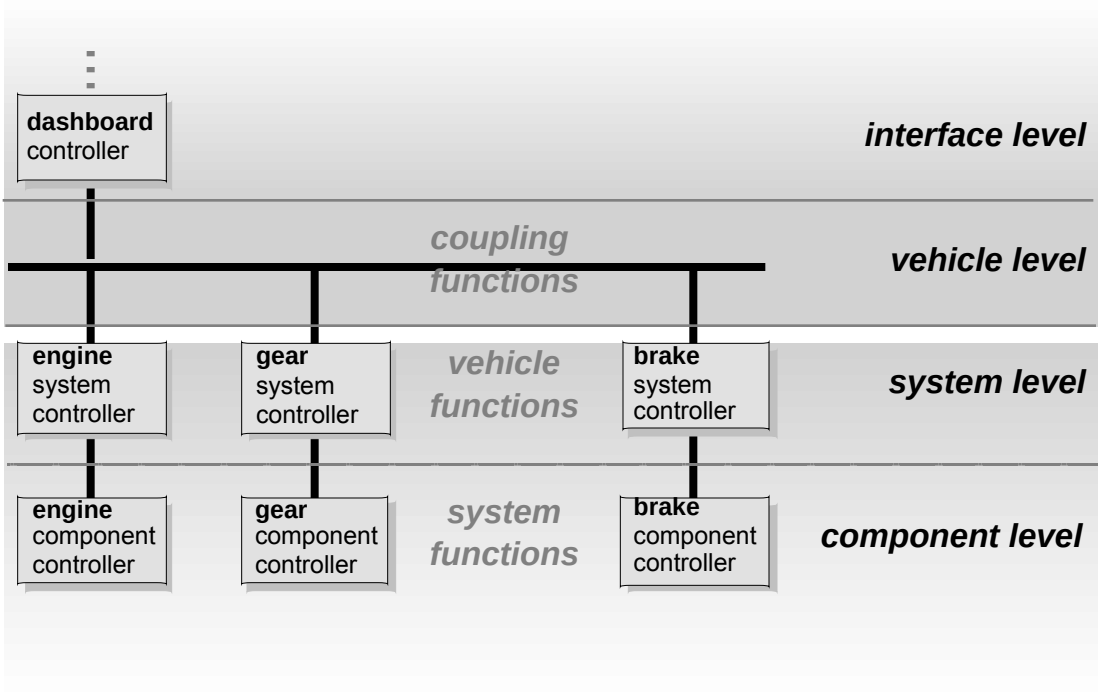

Figure 2: Integrated Electronic System - structure

The system level again is separated into two sublevels. The systems-level mainly embodys the signalprocessing part with the realisation of the vehicle-oriented functions e.g. cruise-control etc.. This small part of electronics could be placed in the cabin. So it does not need to be waterproof, or as shock-resistant and working at high temperature like the electronics in the components-level, which are located at the systems (like engine, gearbox, ..) directly. They are containing mainly the system-oriented functions (like revolution-control and overheat-protection for the engine), the power-electronics and the I/O for the sensors and actors.

The link between this two sublevels (system- and component-electronics) is done for each system separately by a low-speed CAN with the physical layer

Again it should be pointed out, that each of the systems (engine, gear, brake, ...) is independent and self-assure. So each system function itself, and thus also the vehicle function ‘driving’ could be done at a high level of safety, reliability and availability.

The vehicle-level is built by a communication link between all electronic systems of system-level and interface-level. This is done by a high-speed CAN according to ISO 11898. The tasks of this level are the vehicle-functions which need more than one system to work. These are for example driver information, ASR, braking-management (including engine-brake, exhaust-brake, retarders). We call them coupling-functions (see table 1). It is very important, that a total break-down of this level does not affect the base functions of the truck (they are all realised in the system-level) - so driving, steering and braking is still possible.

The interface-level contains not only the MMI, but also the interfaces to all external electronic functions (see next paragraph). The one shown in figure 2 is off-board diagnosis, which uses the dashboard-electronics as gateway.

Interface(s) to external electronic functions

This electronic system will have the following communication interfaces to the "external world" (besides the off-board diagnosis:

- integration of body and trailer/semitrailer (displays and control)
- integration of external bases such as fleet (remote diagnosis, ...)
- environment (traffic guidance, automatic toll charging, ...)
- and other services (emergency call, location determination, ...)

The Mercedes-Benz concept for integration of external functions

In the Integrated Electronic System (IES) of Mercedes-Benz trucks, the integration of external electronic functions is done via the interface-level. The external electronic systems, e.g. electronic trailer braking, are connected via

gateways to the high-speed CAN in the vehicel-level, and therefore they can exchange information with all other electronic systems in the truck (e.g. dashboard etc.), see figure below.

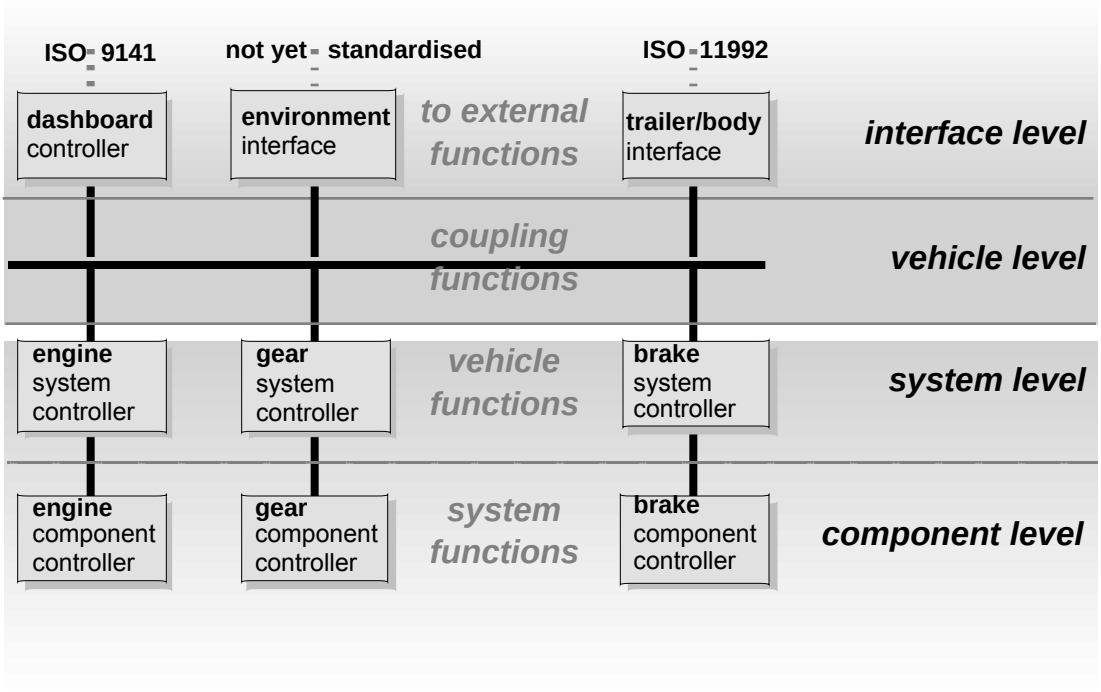

Figure 3: integration of external electronic functions in IES

Today at Mercedes-Benz there are four more gateways (besides MMI) to external electronic systems in preparation for the next truck-generation:

- off-board diagnosis (according to ISO 9141)
- electronic trailer braking (according to ISO 11992-1 and 2)
- non-braking, electronic trailer systems (according to ISO 11992-1 and 3)
- body electronics (physical layer according to ISO 11992-1)
- radio communication for e.g. remote diagnosis (not yet standardised)

All this external systems could be optional, but their integration must be forseen in the functional concept of in-vehicle electronics.

Standardisation

As regards network systems and allocation of functions, always the question of standardisation of interfaces arises. A determination/standardization of physical parameters such as the transfer medium, driver characteristics, protocol and data representation (ISO-OSI Layer 1 and 2) is desirable.

A differenciation is however necessary in the case of higher services:

a) *within the vehicle*: neither a rigid determination of the scope of functions nor the implementing and allocation of functions must take place since openness and flexibility of the implementing of functions mean a competitive edge; *(that is the main reason not to use SAE J1939);*

b) *externally*: standardization of the interfaces to the trailer/semitrailer is indispensable (see ISO WD11992) - every tractor must be designed to tow any trailer.

So the Mercedes-Benz IES-concept uses the following existing or coming standards for serial data communication:

- ISO 11898 for in-vehicle high-speed CAN
- ISO 11992-1 for in-vehicle low-speed CAN
- ISO 9141 for off-board diagnosis
- ISO 11992-1, 2 and 3 for all CAN-interfaces to external electronic devices

It should be clear, that for the integration of external functions not only the data-exchange has to be standardised, but also the functions (data-content) must be specified (as for example in ISO 11992-2 and 3).

Consequences for manufacturers and suppliers

Although there is a tendency towards system suppliers, the system integrating functions (coupling and cross functions) require more communication and coordination between vehicle manufacturers and suppliers, and also among the suppliers themselves, because not all systems are provided by one supplier alone. On the one hand, the definition, development and testing of control unit interfaces (hardware and function (software)) require more communication, and on the other hand network thinking is expected of all parties interested in development - because this is the only way to implement network structures and systems.

The allocation of the so-called coupling and cross functions to a whole range of systems and control units makes it indispensable for the overall system leadership to lie with by the vehicle manufacturer now and in the future.

Conclusion

It has been shown a concept for all in-vehicle-electronic functions (not only drivetrain) for the next generation of Mercedes-Benz trucks. This concept includes the integration of external functions as far as they could be seen today. In case of the modular structured concept, and the use of ISO standards in every external interface definition, even future integration of new developed functions could be done very easy.