The Truck Gateway Interface

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Summary

This presentation will describe the various development stages of the interface between the truck and the superstructure within the last two decades. Current problems with this interface will be explained and the requirements for an “ideal interface” will be defined. The requirements with respect to flexibility and real-time capability recommend the use of a field bus system. Reasons for choosing CANopen will be explained. This will be followed by information about the structuring of that CANopen Gateway standard, explaining also default communications and safety concept. In addition, the integration of the interface into the entire system of truck and trailer will be highlighted, special objects and mechanisms for superstructure manufacturers as well as the remaining open items. So it still needs to be clarified, which Truck manufacturers will support CANopen. They will commonly agree the mandatory objects, that will enable superstructures to develop their core functionality and modular extensions.

1. Introduction and History

In addition to the classical use of a truck for long-distance and / or distribution missions, about one-third is adjusted to special customer-specific requirements, and this is an increasing trend. In general, these customer-specific adjustments are made by the superstructure manufacturers. These are mostly small to mid-sized companies, which have focused on special applications. All, however, have one thing in common: they need an interface to the truck. The type and the extent of the required information from the vehicle and access to the vehicle vary considerably and are highly dependent on the specific application. This is nothing new and that is the way it is, the way it was and it will continue to be the case. However, trucks have undergone fundamental changes in the last 10 to 20 years. About 20 years ago there was not a trace of electronics. In the meantime legal requirements and comfort functions, which were demanded by the market, finally led to the use of complete networks of electronic systems in trucks. That are very complex systems, which reacts extremely sensitive to any changes by 3rd parties. Such vehicles provide the superstructure manufacturers with certain signals and access at defined connections. The type and extent of this interface vary depending on the vehicle manufacturer.

2. Requirements for an "Ideal Interface"

This is a non-ideal condition for all participants, but how should the "ideal interface" appear? Of course, it should be based on a digital interface. It should universally cover all requirements from the low-end to the high-end applications and ideally be integratable into the superstructure network. The following table lists and weights - separately for superstructure and truck manufacturers - the requirements for such "ideal interface". (See table 1) Physical aspects, such as the definition of standard connectors, its pin assignments and the connector locations are assumed and will not be discussed further. If one conducts a more detailed analysis, then additional limiting conditions are to be considered, especially for the integration of the superstructure control. As is the case for trucks, the complexity and the performance of the superstructure controls are increasing continually. Therefore a bus system should connect the various in- and output devices. For the use of programmable devices, the Master / Slave communication should be supported. The increasing trend to shift intelligence into peripheral devices and the increased process splitting to several programmable devices make a Multimaster bus access necessary. The bus system should encompass devices with high complexity such as supervising control units as well

Communications	Superstructure Manufacturer	Truck OEM
Clearly defined functionality's	+	+
Sufficient amount of vehicle information [1)]	+	+
Sufficient number of controls [1)]	+	+
Known and widely used protocol	+	+
Free selection of required signals	+	+
Free selection of required accesses	+	+
Message information freely definable	+	+
Communication set-up freely configurable	+	+
Suited for simple to complex applications	+	+
Clearly defined safety aspects	+	+
Independent of truck OEM	+	
Integration into the superstructure control	+	
Bus system similar to internal vehicle network(s)		+
Information similar to SAE J1939		+
Expandable / usable for the future	+	+
Low costs	+	+

Table 1: Ideal Interface between Truck and Superstructure Manufacturer

[1)] Number should cover at least 90% of all superstructure manufacturer requirements.

as the simplest and very low-priced devices like binary sensors and actors. Beside the availability of low-cost components, predefined devices and application profiles are extremely important for economic system integration. Only such profiles are the prerequisite for the use of standard devices allowing rationalisation. Further, the bus system must satisfy very high requirements for communication security in an environment, which is influenced by electromagnetic interference's. Typically 20, at maximum 30 devices, should be connectable into the network with an typical expanse about 20 to 30 meters. The bus system usage is expected mainly in process related communication. Short telegrams would be sufficient for this purpose. For special requirements, such as the transmission of configuration files, diagnosis data or things similar, the transmission of longer telegrams should also be supported. As a summary, the bus system should satisfy the following requirements:

Real-time capability	High
Transmission speed	High
Reliability and failure tolerance	High
Electromagnetic capability	High
Flexibility / configuration	High
Installation / assembly	Low
Cost effectiveness	High

These requirements are fulfilled by field buses.

3. Overview of Field bus Systems

What field bus systems are available on the market? Investigating the most conventional field bus systems
PROFIBUS
InterBus
Bitbus
CAN
indicates benefits of the CAN bus system, in particular in the area of electromagnetic capability. The additional requirements according to section 2 such as the real-time capability, transmission speed, flexibility and cost effectiveness are also fulfilled by the CAN bus system. CAN was originally developed by BOSCH especially for vehicles requirements. In the meantime, CAN is being used in a high number of non-automotive applications with great success. The sale of more than 100 million CAN transceivers impressively shows the success story of the CAN bus system.

4. CAN Standardisation

4.1. Available CAN protocols

The standardisation of CAN in accordance

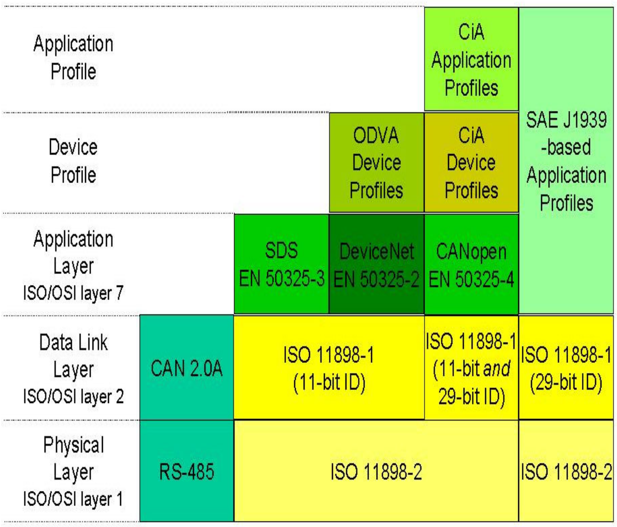

Illustration 1: CAN Standardisation

with ISO 11898 only includes the ISO/OSI[11] layers 1 and 2. The implementation of the application layer is left to the user.

He must define:
values to be transmitted including value resolution
value mapping into messages
assignment of priority and transmission parameters of messages.
This does not present any problems for closed systems. However, if CAN devices and components from various manufacturers are to be integrated into one CAN bus system, then all of the above points must be individually defined and agreed on for each implementation. This would be associated with a very high expenditure and would not be economically feasible. As already shown in table 1, an "ideal interface" between the truck and the superstructure must, on the one hand, allow a free communication set-up and, on the other hand, be highly standardised by means of device or application profiles. Various approaches have already been developed with the goal of standardising CAN communication. The conventional CAN protocols are:
SDS (Smart Distributed Systems)
Device Net
CANopen
SAE [2] J1939
The CAN protocols SDS and Device Net were developed for the automation technology. SAE J1939 was specially developed for automotive applications and CANopen focus on distributed automation technology. Nevertheless only SAE and CANopen protocol support application profiles. (see illustration 1) The SAE J1939 describes in detail the communications of various automotive systems. Thus it assures the easy exchangeability of various well defined automotive components but however provide low flexibility only. Thus CANopen only fulfils

[1] ISO/OSI – International Standards Organisation / Open Systems Interconnection

[2] SAE - Society of Automotive Engineers

the requirements on both high flexibility and application profile support.

4.2. CANopen Field Bus System

As already pointed out the CANopen field bus approach is the standardisation for distributed automation technology based on CAN. CANopen is standardised in EN 50325-4. Just shortly after its introduction, it became widely used and can be seen as the definitive standard in Europe for industrial CAN-based system solutions. The CANopen product family is based on "communication profiles”. Further highlights from the user point of view are a well defined conformance test and the electronic data sheets (EDS), which are a detailed and standardised electronic device description. All of these standardisation’s are a significant advantage compared to other bus systems. The user doesn’t have to worry about settings and compatibility problems but allows him to individually adjust all parameters. These technical prerequisites and the non manufacturer dependence of the protocol have lead to a rapid widespread use of the CANopen protocol in the various applications. This is also shown in the numerous components, development and application tools, and CANopen source code etc., which have been available from various manufacturers on the market for years.

4.3. CANopen Device Profiles - Truck Gateway WD413

The founding of the CANopen Special Interest Group (SIG) Truck Gateway was in 1998. Participants in the definition included CAN-in-Automation (CiA), all German truck manufacturers, various software and ECU manufacturers and superstructure manufacturers, which were represented by the ‘Verband für Arbeitsgeräte und Kommunaltechnik’ (VAK).

4.4. Structuring

The CANopen Truck Gateway device profile is structured as follows:

Part 1: General definitions and "default" communications
Part 2: image of ISO 11992-2 "brake and running gear"
Part 3: image of ISO 11992-3 "other than brake and running gear"
Part 4: image of ISO 11992-4 "diagnosis"
Part 5: Objects for superstructure manufacturers
Part 6: Generic SAE J1939 – CANopen Gateway
Part 7: Objects for agriculture and forestry
Part 8: Other objects

Currently CANopen 413 part 2, 3 and 5 have been approved. Thus, well over 200 CANopen objects have already been standardised. In addition, a generic SAE J1939 - CANopen Gateway is presently being discussed within the CANopen workgroup. CANopen 413 part 8 is reserved for future requirements, which cannot be assigned to other parts. One reason for this structuring was the existing ISO 11992 standard, focusing on the data exchange between the truck and the trailer(s). This provides advantages to both the truck and superstructure manufacturers. The truck manufacturer profits from the implementation since ISO 11992 and CANopen signals are identical. The superstructure manufacturer will profit since the very same CANopen objects are available in both the truck and in the trailer.

4.5. "Default" Communication

In addition to the above general statements, CANopen 413 part 1 defines "default" communication, which provide a basic functionality in the delivery condition. This was standardised according to ISO 11992 part 3 and encompasses all objects for the following ISO 11992-3 messages:
vehicle information GPM 12,13,14,15
vehicle accesses GPM 22,23,24

4.6. Safety Concept

Particular attention is drawn to an integrated safety concept for accesses to the vehicle, which was aligned to the ISO 11992 standard. Various access is assigned to a status information of "control allowed" or "control not allowed." Thus, the superstructure manufacturer is always informed in a uniform manner about the authorisation of this access. Thus, this clear separation increases the safety level for the entire combination of vehicle and superstructure and also allows for considerable rationalisation, particularly for the superstructure manufacturers.

4.7. Integration into the Entire Vehicle Truck and Trailer

A further goal is the complete integration of the CANopen interface into the entire vehicle. To achieve this, mechanisms were defined, which use existing network structures without additional wiring. This "tunnelling" mechanism is based on the reservation of special parameter group numbers (PGN) within the existing networks. This really encompasses nothing more than empty messages. The contents of the data, that is all 64-bit user data within the telegram, can be freely defined by the CANopen user. The required applications were submitted to both SAE J1939 Committee and ISO 11992 Workgroup. The mechanism is shown in illustration 2. /1/

4.8. Part 5 – Superstructure Manufacturer

After decisions were made about the basics, co-operation with the superstructure manufacturers was systematically sought. A large number of the German superstructure manufacturers from the various branches are members of the Association 'Verband für Arbeitsgeräte und Kommunaltechnik (VAK). Their overall requirements are partially covered in CANopen 413 parts 2 and 3. The remaining requirements are standardised in CANopen 413 part 5. These objects can be classified into three groups:

General Status Information:

Signals mostly simple but highly useful in practice such as:

Selected language

Parking lights, low and high beams

Etc.

<u>Additional Status Information:</u>

Two of the most important accesses for the superstructure manufacturer are the engagement of power take-offs and the limitation and/or control of the engine. ISO 11992 part 3 define two general status conditions only, which are 'engine control' and 'PTO control' allowed. CANopen 413 part 5 provide more detailed status information:

"PTO control allowed" separately for each individual PTO

Status information "engine control allowed" separate for:

requested engine speed upper limit

requested engine speed lower limit

requested engine speed

<u>Superstructure Status Information:</u>

Future developments for commercial vehicles may consider certain superstructure internal status. Certainly, only standardised information can be considered on vehicle developments. Knowing well, that the presently defined objects only represent the very beginning, the following information is already standardised:

Current consumption superstructure [A]

power consumption (net torque) superstructure [kW]

4.9. Open items

The variety of objects offers both complete new functionality's as well as significant rationalisation. In reality only specific systems may provide specific objects. For instance only an electronic display allows selecting a language or only vehicles with torque converter may inform on it's oil temperature. In same way the available signals will depend on Truck manufacturer. Consequently CANopen standard allow already yet rationalisation on 'high end' applications, where a great variety of signals is mandatory. The focus of the CANopen standard is however to satisfy both 'high end' and 'low end' applications. Therefore Truck manufacturers will commonly agree on the mandatory objects – for each part separately - independent on individual vehicle options. This mandatory functionality will then guaranteed on all vehicles from all Truck manufacturers. Additional objects will then depend on Truck manufacturer and / or individual vehicle options. After completion of all this co-ordination the superstructures may realise significant rationalisation, basing on their specific core functionality and modular extensions. To obtain that objective various steps are necessary. First it needs to be clarified, which Truck manufacturers will support CANopen on which vehicle ranges. Then manufacturers needs to investigate the available objects on the various vehicle ranges, independent on any vehicle option. Finally participating Truck manufacturers need to commonly agree the mandatory objects.

In parallel application notes will be prepared, that should easily guide and instruct the superstructure manufacturers, how the various signals should be interpreted and used.

5. Summary and outlook

My goal as the chairman of the workgroup was the development of a practice-oriented standard. I have been working at IVECO for more than six years as system integrator and prior to this I worked for almost 10 years in various testing areas. Therefore, I am very well acquainted with the various requirements from both real applications and system integration. Illustration 3 graphically shows the general goal of the CANopen Truck Gateway. /2/ The advantages are the uniform and the manufacturer-independent Gateway, which can be completely integrated into the superstructure control. The CANopen protocol is a very flexible one. Safety aspects for interfacing superstructures are already considered by specific objects. It allows the integration into the entire system of the truck and trailer(s) and thus avoids individual adjustments to the truck. The variety of the objects allows entirely new functionality's and it also creates a significant rationalisation potential. When the mandatory objects will be agreed the superstructures may define their specific core functionality and modular extensions. For further developments truck manufacturers may consider superstructure-specific status in the future. The necessary expansions of the CANopen must be jointly defined between truck and superstructure manufacturers. These expansions are necessary and are expressly desired in order to consider future requirements in a both standardised, but still flexible manner.

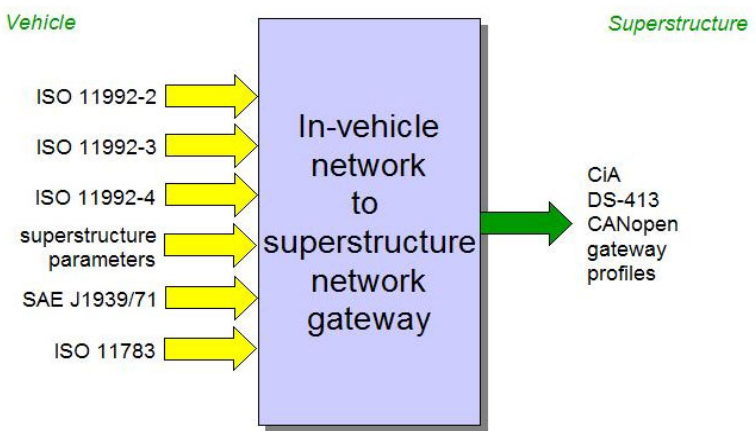

Illustration 3: Goal of CANopen Truck Gateway

6. Literature List

/1/ Peter Fellmeth, Vector Informatik GmbH
Technical Article: *CANopen Truck Gateway*, Messtech & Automation 1-2 / 2003

/2/ With the kind approval of CAN User Organisation, CAN in Automation (CiA), Erlangen

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