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Standardization of an Open Platform for Distributed Automotive Real-Time Systems OSEK / VDX

OSEK/VDX is a joint project of the automotive industry. It aims at an industry standard for an open-ended architecture for distributed control units in vehicles. This paper briefly summarises the current state of OSEK/VDX.

INTRODUCTION

It is generally known that there is an increasing trend towards a distributed architecture for automotive electronics. A distributed architecture may comprise different electronic control units (ECU) as well as autonomous intelligent sensors and actuators connected by a communication link through equivalent network interfaces (1). Networking is the basis for new top-down control ap-proaches, which provide higher performance, more comfort, a higher sa-fety level and less exhaust emission for today's automobiles [2]. Exam-ples are traction control, vehicle dynamic control and electronic tor-que control. These applications are independent of local ECU platforms.

From a more abstract point of view at least three application independent tasks can be identified. First, the operating system providing the execution environment for the functions or tasks that are assigned to a control unit. Second, the communication software for the exchange of data within and between control units. And third, the network management that has to guarantee the safe operation of safety-relevant distributed systems by determining and monitoring of the configuration. [3]

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A standardisation of interfaces and protocols of these application independent tasks, i.e. operating system, communication and network management, seems to be well suited to support the portability and reusability of application software. Thus, several advantages of the standardisation can be expected, e.g.:

- significant reduction of development costs and time,
- enhancement of the software quality,
- ability for integration of software modules from different suppliers into one micro-controller.

The expected advantages and the common consideration that the areas of standardisation are not competition relevant for the OSEK/VDX partners were the decisive factor for starting the OSEK/VDX project. [4]

This paper presents the current state of the OSEK/VDX project. After a look on the history of OSEK/VDX, a brief introduction into the specifications of the three areas operating system, communication and network management and an overview of existing implementations is given. For a detailed description we refer to the proceedings of the first OSEK/VDX workshop that also include the OSEK/VDX specification [5]. The certification procedure of OSEK/VDX implementations is currently in development, so we describes the objectives and tasks of certification. Finally, the objectives for the next two years and the organisation structure of OSEK/VDX are presented.

OSEK/VDX HISTORY

In May 1993 OSEK has been founded as a joint project in the German automotive industry aiming at an industry standard for an open-ended architecture for distributed control units in vehicles. OSEK is an abbreviation for the German term "Offene Systeme und deren Schnittstellen für die Elektronik im Kraftfahrzeug" (English "Open Systems and the Corresponding Interfaces for Automotive Electronics"). Initial project partners were BMW, Bosch, Daimler-Benz, Opel, Siemens, VW and the IIIT of the University of Karlsruhe as co-ordinator. The French car manufacturers Peugot and Renault joined OSEK in 1994 introducing their VDX-approach (Vehicle Distributed eXecutive) which is a similar project within the French automotive industry. At the first workshop on October 1995 the OSEK/VDX group presented the results of the harmonised specification between OSEK and VDX [5].

The open architecture introduced by OSEK/VDX comprises the three areas (s. figure 1):

- operating system (real-time executive for ECU software and basis for the other OSEK/VDX modules)
- communication (Data exchange within and between Control Units)

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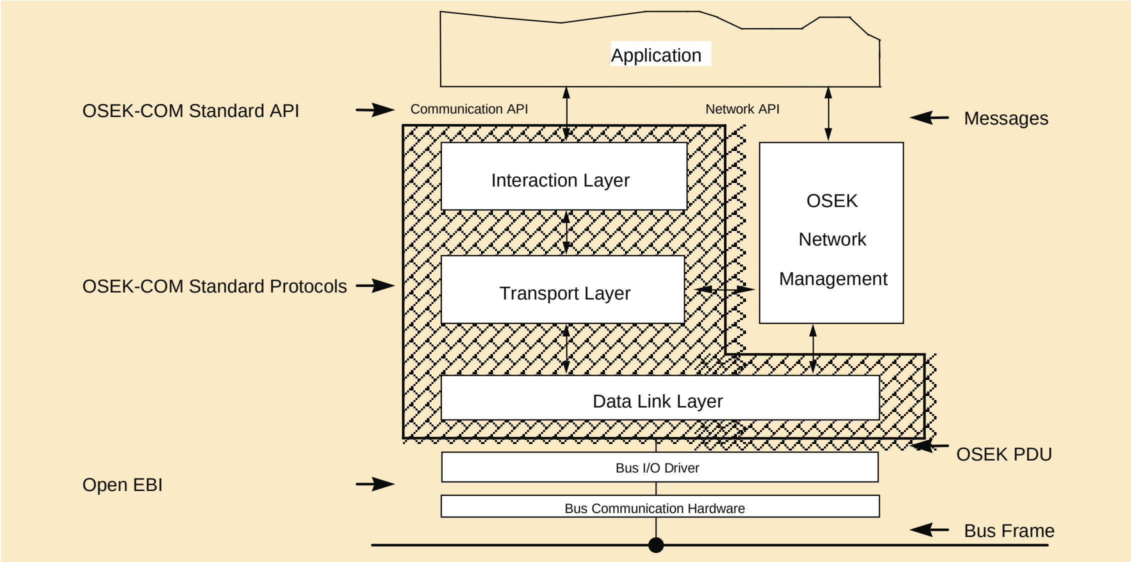

Figure 1. Layered Model of OSEK/VDX

- network management (Configuration determination and monitoring).

A structured and modular software implementation based on standardised interfaces and protocols as proposed by OSEK/VDX is a necessary condition for the portability and extendibility, and thus the reusability of existing software. Functional extendibility means the integration of new application functions into a single control unit together with other application functions. Portation of application is the transfer of application functions from one hardware platform to another one with only minor modifications , e.g. portation of existing application software to the next product generation of an ECU. Moreover, extendibility and portability should be independent of the supplier of application functions, i.e. a "co-habitation" of software from different suppliers must be possible. It shall be remarked that OSEK/VDX does not prescribe the implementation of OSEK/VDX modules, i.e. different ECUs may have the same OSEK/VDX interfaces, but different implementations, depending on the hardware architecture and the performance required.

Specific requirements for the OSEK/VDX modules arise in the application context of software development for automotive control units. Requirements such as reliability, real-time capability, and cost sensitivity are addressed by the following features:

- All OSEK/VDX modules are configured and scaled statically.
- To fit the various requirements of the application and system capabilities (e.g. processor, network, memory), each OSEK/VDX module provides an upward compatible set of conformance classes. The conformance classes differ in the number of services provided and in their capabilities.
- The specifications of the OSEK/VDX modules support implementations capable of running on ROM, i.e. the code may be executed from Read-Only-Memory.
- The specifications of the OSEK/VDX modules provide a predictable and documented behaviour to enable implementations, which meet automotive real-time requirements.

OPERATING SYSTEM

The specification of the OSEK/VDX operating system provides a pool of services and processing mechanisms. The operating system serves as a basis for the controlled real-time execution of concurrent application programs and provides their environment on a processor.

The architecture of the OSEK/VDX operating system distinguishes three processing levels: interrupt level, level for operating systems activities and task level (see figure 2). The interrupt level is assigned the highest processing priority. At this level interrupt service routines are executed in preference to the lower processing levels. Interrupts may call a restricted number of operating system services. The processing level for the execution of operating system services has a priority ranking immediately below that of the interrupt level. The task level on which the application software is executed has the lowest processing priority. Tasks are executed (non-, full- or mixed-preemptive) ac-cording to their user assigned priority. For reasons of the required memory, a distinction is made between the management of tasks with and without waiting states (Extended / Basic Tasks). Basic tasks, which are not able to wait normally require less RAM. The run time context refers to resources which are occupied at the beginning of execution time and are re-leased again once the task is finished.

In addition to the management of the three processing levels, operating system services are provided for the following functionality:

- Task management, i.e. activation and termination of tasks, management of task states and task switches.
- Event management for task synchronisation.
- Resource management which is used to coordi-

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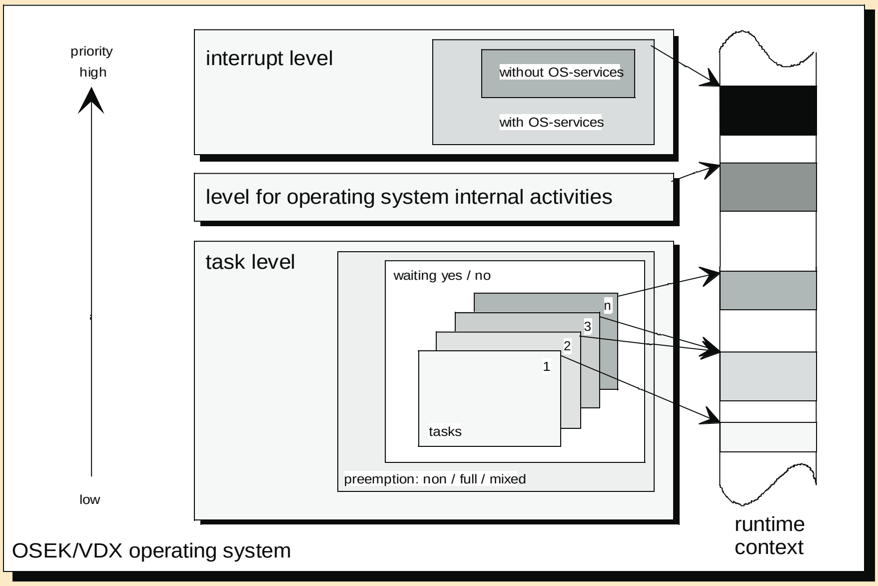

Figure 2. Execution levels of the OSEK/VDX operating system

nate concurrent accesses of several tasks to shared resources, e.g. memory or hardware areas. It is based on the priority ceiling protocol. [6]

- Counter and alarms, a two-level concept for the use of recurring events like periodic interrupt of timers, interrupts of sensors, etc. Recurring events can be registra-ted by counters. These counters serve as a basis for an alarm mechanism that is offered to the application software.
- Error treatment: Mechanisms supporting the user in case of error occurrences.

COMMUNICATION

All communication of application tasks takes place by exchange of messages that are stored in message object.

The specification of OSEK/VDX Communication provides interfaces and protocols for the internal communication within a vehicle. This in-vehicle communication comprises the communication between and within linked ECUs, and the communication between ECUs and peripherals.

The general positioning of the OSEK-COM system within the OSEK architecture is represented in figure 1. It shows the interface of OSEK-COM with the application, with the OSEK network management, and with the hardware communication bus.

OSEK-COM is organised in layers, including the Interaction Layer, the Transport Layer, and the Data Link Layer. The Interaction Layer provides the communication services of the API to the application. The Transport Layer provides the mechanisms for the segmentation and/or acknowledgement of messages. The Data Link Layer provides the functionality for the transmission and reception of OSEK Protocol Data units (OSEK frames).

All communication of application tasks takes place by exchange of messages that are stored in message object. Therefore OSEK/VDX communication introduces the so called message concept that distinct two kinds of messages: state messages and event messages. A state message represents the current value of a system variable, e.g. engine temperature, wheel speed, etc. State messages are not buffered but overwritten with their actual values. The receive operation reads the state message value. Thereby the message data is not consumed. In contrast, an event message contains an event information, e.g. "engine temperature exceeds a certain limit". Event messages are buffered with the send operation and consumed with a receive operation.

In order to hide the difference between internal and network communication from the application, uniform services with identical interfaces for both kinds of communication are provided. Therefore the implementation model shown in figure 3 is introduced. The services and the message objects for local communication are provided as an integral part of the Interaction Layer.

A separate module for network communication performs the transfer of messages over the network. This module is made up by tasks which uses the local communication services like application tasks. For each message that is transferred over the network a local message object is created within each station of the involved communication partners. The network communication module ensures that messages transmitted within stations are sent via the network, if there exists a receiver in another station. At the receiver stations it ensures that the corresponding message objects are updated accordingly.

The main advantages arising by the use of OSEK/VDX communication services are:

- Data consistency is ensured, i.e. prevention of conflicts by simultaneous access of concurrent tasks to the same data.

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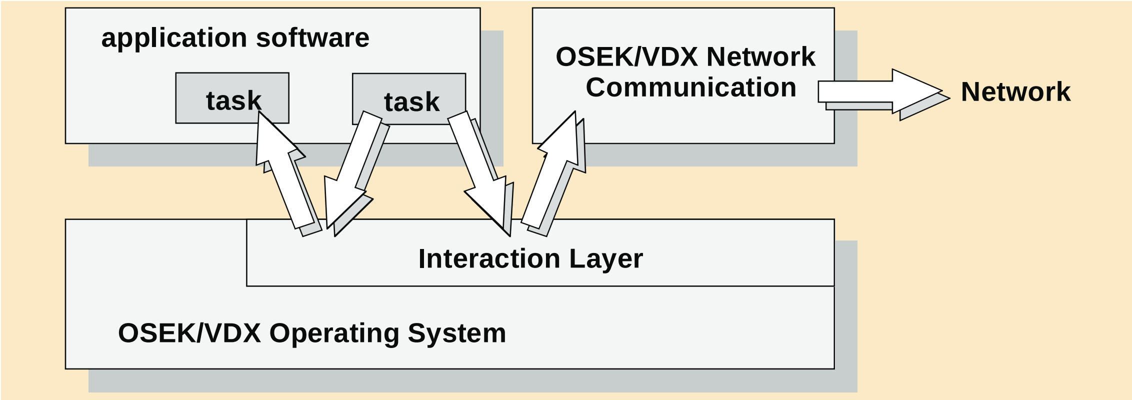

Figure 3. Implementation model of OSEK/VDX Communication

- Portability is supported, if only OSEK/VDX communication services are used for inter-task communication, the application can be assigned to any ECU.
- The layered architecture of OSEK/VDX communication (Fig. 1) makes the major part of the communication software independent of the underlying communication protocol (CAN, VAN, ABUS, etc.) and communication hardware. In combination with the introduced implementation model the portability of the communication software itself becomes possible.

NETWORK MANAGEMENT

Architectures of automotive systems are currently changing from a number of local, more or less isolated electronics to a functionally integrated distributed system which is linked by a network. Networking serves as a basis for new distributed control functions that are independent of local ECU platforms. As a consequence of networking, the local station behaviour influences and depends on the global station behaviour, and vice versa. These mutual influences and dependencies often require network wide negotiated management. In order to guarantee the reliability and safety of a distributed system, the OSEK/VDX network management gives support for several of such management tasks, e.g.:

- initialisation of the network communication, e.g. protocol circuit,
- provision and monitoring of the network configuration
- management of local and global operating modes of stations and the network,
- support of diagnosis.

The basic concept of OSEK/VDX network management is monitoring of the networked stations. Two alternative monitoring mechanisms are offered: direct and indirect station monitoring. Direct monitoring is done by a dedicated communication of the network management. Therefore the network management of each station broadcasts its own alive-message in a synchronised manner and receives the alive-messages of all other stations. The synchronisation of the alive-messages is done by use of a logical ring along which the alive-messages are sent. The indirect station monitoring is done by listening to specific messages of the application communication. The reception of a message is interpreted as alive-message.

Figure 4 shows the motivation of monitoring. The applications A, B, C are all distributed among the three stations. Each application needs the presence of all its sub-functions in the network as a necessary condition to ensure its functionality. As this condition must be fulfilled during the whole runtime of the application a function monitoring is required. This function monitoring can be realised by using the station monitoring of the network management, if the mapping of

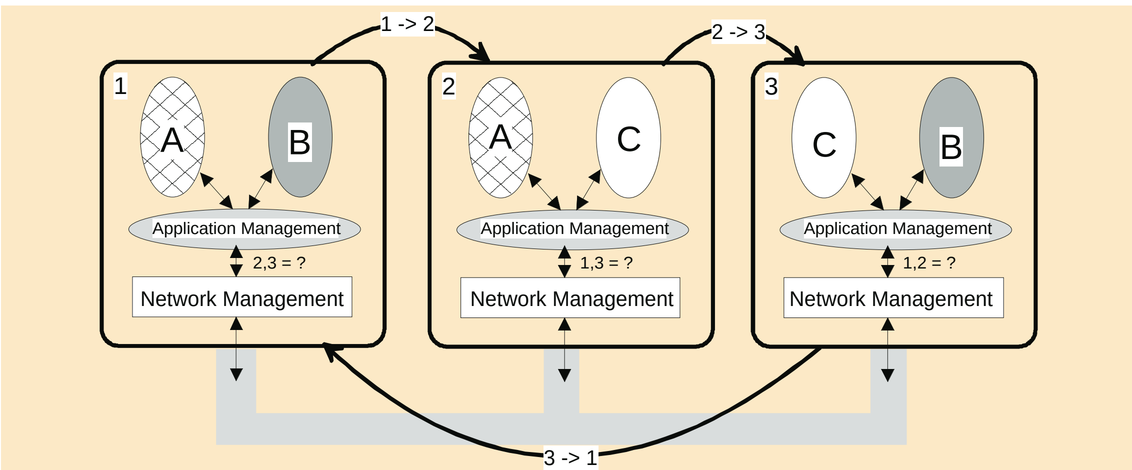

Figure 4. Station Monitoring

function to stations is given.

IMPLEMENTATIONS

This section tries to give a brief overview of the state concerning implementations of the three OSEK/VDX modules that currently exist or are in development. The overview does not demand to be complete, because all OSEK/VDX partners currently develop implementations of the three OSEK/VDX modules within pilot projects. Thus, the number of implementations continuously increases.

The OSEK/VDX operating system is the area where currently the most efforts for implementations are on the way. This is not surprising, as the OSEK/VDX operating system is not so far from existing real-time operating system. So, an adaptation of existing real-time operating systems to the specification of the OSEK/VDX operating systems seems to be relatively easy. Implementations available are a PC implementation from ATM Computer GmbH and the operating system ERCOS from ETAS GmbH which is closely compatible. Daimler Benz and GSI/Tecsi (VDX operating system) currently adapt their already used operating systems to the specification of OSEK/VDX operating system.

In the areas communication and network management currently no complete implementations are available, but several OSEK/VDX partners are in development of it. However, Bosch has successfully implemented several parts of the OSEK/VDX communication which are already used in ECUs for serial production cars. Siemens has developed a generic communication software that is nearly OSEK/VDX compatible and is used for all new CAN-based motor management systems. Renault developed SDL models for the verification of specifications of communication and network mana-gement. Daimler Benz is doing a pilot implementation of the network management which is planed to be ap-plied in series production cars in 1998.

CERTIFICATION

OSEK/VDX aims to become an industry standard in the automotive community. Therefore it is mandatory to establish a rule that allows to determine unambiguously if a proposed OSEK/VDX implementation is compliant with the standard, and thus to avoid the emergence of self-proclaimed OSEK/VDX components. To overcome this important job, the OSEK/ VDX steering committee installed a project group certification. The main tasks of this project group are:

- specification of the certification procedure (tools, reference models, test plans);
- definition of performance criteria and their measurement methods, i.e. for each OSEK/VDX implementation a performance data sheet is requested;
- creation and organisation of the certification authority.

At present Certification will be done under the European ESPRIT project MODISTARC. The consortium includes industrial companies that bring to the MODISTARC project the required expertise. The participation of mayor end-users will guarantee the conformance of the project results with the industry needs. Including equipment suppliers in the project is a guarantee for a representative work.

OBJECTIVES AND ORGANISATIONAL STRUCTURE

The first phase of OSEK/VDX has been successfully completed with the presentation of the elaborated specifications at the workshop in October 1995. The objectives for the next phase are:

- propagation of OSEK/VDX to become a quasi-

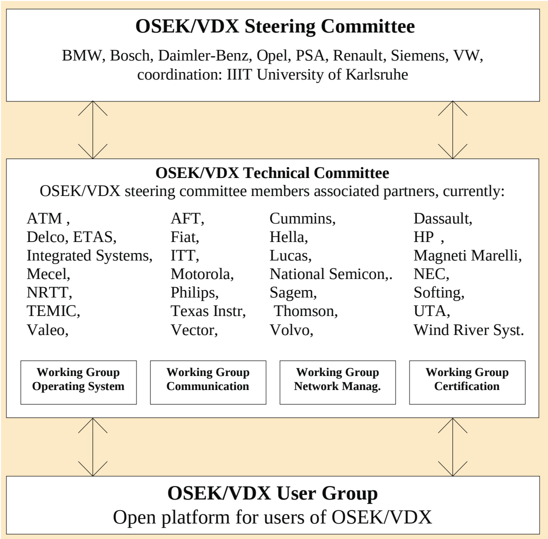

Figure 5. Organisational structure

standard.

- elaboration of specification, version 2.0 for the areas operating system, communication and network management based on experiences with existing implementations;
- elaboration of a certification procedure;
- organisation of the 2nd Workshop for presentation of OSEK/VDX related pilot projects;
- introduction of OSEK/VDX in series production cars planed for 2000 - 2002.

In order to achieve these goals the OSEK/VDX group opened the project for the integration of new associated partners after the first workshop on October 1995 workshop. This expansion of the OSEK/VDX group necessitates a new organisational structure which comes up to the expectations of the initial OSEK/VDX partners as well as of the new associated partners. These are on the one hand that the steering committee should not be enlarged to keep it capable of acting and to preserve the standardisation effort. On the other hand, the new partners should have as many rights for co-determination in technical aspects as possible. For this reason the steering committee installed the organisational structure presented in figure 5 that meets both interests. It consists of a steering committee, a technical committee with subordinated project groups for operating system, communication and network management, and a user group.

The steering committee is formed by the initial OSEK/VDX partners. In order to preserve the standardisation effort, the steering committee remains the instance for final decisions on all technical and financial aspects regarding OSEK/VDX. Up to now, a situation that required to force such a final decision happened only once. In practice, decisions have been prepared in the respective working groups.

Beyond that, the steering committee is responsible for the overall project organisation and co-ordination (e.g. assignment of working group leaders and of the technical committee co-ordinator), for granting of licences to other companies, and for the external representation of OSEK/VDX (e.g. publications). It decides on membership eligibility for new members of the technical committee by majority vote. And if necessary, e.g. on hindering of standardisation effort, the steering committee may censure technical committee members.

The participation in the technical committee offers the associated partners to actively co-operate in OSEK/VDX. Currently the technical committee is formed by the initial OSEK/VDX partners and 23 associated partners from different industries related to automotive electronics, i.e. car manufacturers, automotive suppliers, semi-conductor industries and software companies. Obviously, OSEK/VDX is open for the integration for additional associated partners.

The technical committee organises and co-ordinates the working groups and elaborates in co-operation with it preliminary specifications for the four areas operating system, communication, network management and certification. Status reports on the progress of this work are to be presented at the steering committee meetings as basis for decisions.

Technical committee members oblige on delegation of one representative to the meeting of the technical committee, and on delegation of representatives to at least on working group. A consistent representation at the meetings is necessary for efficiency.

At the moment four working groups are installed for the areas operating system, communication, network management and certification. They are formed by representatives of the member companies of the technical committee. Their task is the elaboration of preliminary specifications of the respective area. Moreover, the working groups are a platform for the exchange of experiences with existing OSEK/VDX implementations. Status reports are to be presented at the meetings of the technical committee.

The user group is planed as a platform for the exchange of experiences for users of OSEK/VDX. Therefore further workshops shall be organised.

CONCLUSION

The OSEK/VDX project is an excellent example of an efficient and successful co-operation within the automotive industry of different countries. The elaborated specifications of the application independent tasks operating system, communication and network management seem to be a sufficient basis for the development of portable and reusable application software. This is not at least emphasised by the great interest within the automotive community. Nevertheless, lot of work remains to be done to achieve an industrial standard, but with active co-operation of all partners under the described lean organisational structure the aimed objectives seem to be achievable. Thus, the use of OSEK/VDX in ECUs of series production cars may become possible in the beginning of the next millenium.

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