Future Vehicle Software Architectures

Electronics and software are the foundation of new vehicle functions and are thus a key competitive factor. This development sheds light on two important trends in automotive engineering:

1. An increasing variety of functions and features
2. A growing amount of vehicle software in automotive systems

These new functions can be found in a number of systems such as:

- Active driving safety and driver assistance systems
- New powertrain concepts that lead to functions such as motor controls for hybrid engines
- Equipment and convenience features such as new infotainment functions

The operating characteristics and features of modern vehicles are leading to significantly more complex automotive systems and software architectures. This is also evident in new functions such as driver assistance systems, which rely on access to different vehicle domains, be it powertrain or infotainment systems. This trend has greatly increased the degree of networking within these domains and is thus driving the demand for more sophisticated communication capabilities. Another factor behind the increased system complexity is the growing variety of functions that result from a wider selection of customer equipment options.

In response to these trends, automotive system and software architectures must evolve in order to satisfy new requirements such as flexibility, energy efficiency and robustness.
Adaptive electrical/electronic (E/E) systems

Today’s luxury-class cars contain between 80 and 100 electronic control units (ECU) — or embedded computers — which are responsible for activating vehicle functions via software. In current automotive system architectures such as AUTOSAR, these functions are statically allocated to specific ECUs.

Because the number of ECUs for integrating new functions cannot be increased at will, new concepts are required that will allow more flexible mapping of functions to the ECUs. In addition, a growing number of functions, such as adaptive cruise control during traffic congestion, will rely directly on driving situations. Achieving a high degree of resource efficiency in this environment calls for new dynamic concepts. At the same time vehicle software must adhere to the high level of quality demanded by the automotive industry.

With the goal of creating automotive system and software architectures that can satisfy these requirements, Fraunhofer ESK researchers are actively working on self-adaptive E/E system concepts. This new approach demonstrates several advantages over current technology:

1. Improved resource efficiency
   Better use of the existing hardware resources can be achieved through adaptive activation and deactivation of the software-based functions in specific driving situations. Energy consumption is reduced as a result.

2. Increased reliability without sacrificing efficiency
   The development of reliable software systems requires extensive effort. Self-adaptive systems provide more robustness without the need for additional hardware redundancy. To cite one example, a faulty ECU could be compensated for by migrating the functions to other ECUs, thus making the E/E system more fault tolerant.

3. Maintenance and expandability
   Replacing automotive components or retrofitting/upgrading a vehicle with aftermarket products or consumer devices is simplified because adaptive software systems can dynamically adjust to new system conditions at runtime.

Runtime environment and design method

To enable the implementation of an adaptive automotive E/E system, Fraunhofer ESK is conducting research into a runtime environment based on the AUTOSAR standard, as well as a new design methodology.

The approach to developing adaptive software systems is based on two pillars: an iterative, model-based design based on a after a specific extension of the EAST-ADL2 architecture description language and the use of virtual system prototyping with the ERNEST simulator.

Fraunhofer ESK is also developing mechanisms that will permit the automotive software system to efficiently and reliably adapt at runtime. This can be achieved by activating and deactivating certain features or migrating individual software-based functions to other ECUs. Therefore, the requirements, which are defined in the design of the adaptive E/E system, must be satisfied at runtime in order to ensure proper system behavior at any point in time.

Fraunhofer ESK offers customers advice and support during the design and verification of adaptive automobile E/E systems, such as assessing automobile software and function architectures. This involves working on tools to support the development and validation of more energy-efficient automobile systems such as AUTOSAR mode management, partial networking and the generation and validation of modes and transitions (so called action lists). Moreover, Fraunhofer ESK offers its customers engineering solutions designed for the implementation of adaptive systems used in safety-relevant applications, such as the efficient verification of constraints for runtime optimization.