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Model-Based Validation of Automotive Infotainment Functions Using Reference Models

Annette Paulić, Marc Zeller, Gereon Weiß, Dirk Eilers
Fraunhofer Institute for Communication Systems ESK
Hansastrasse 32, 80686 München, Germany
{annette.paulic, marc.zeller, gereon.weiss, dirk.eilers}@esk.fraunhofer.de

Abstract
As the complexity of automobile infotainment systems increases, also the development and validation of these systems is getting more complex and time-consuming. However, the quality of infotainment systems still has to be guaranteed. In order to reduce time and costs when developing infotainment systems in cars, Fraunhofer ESK explored new concepts for the validation of infotainment systems using model-based techniques. Thereby, so-called reference models are created as executable specifications. These models can be reused for validation. This enables an automation of the validation process.

1 Introduction

Infotainment and multimedia applications are increasingly important buying criteria when purchasing a new car. The current standard for automobile infotainment systems is the Media Oriented Systems Transport (MOST) network technology [4]. The MOST protocol lets passengers enjoy sophisticated infotainment applications in the vehicle by networking all of the multimedia components distributed throughout the car. A major challenge for automobile manufacturers and suppliers in the development of infotainment systems is the increasing complexity and interaction of automotive infotainment functions. The quality of these systems must be ensured as the functionality grows constantly while the software development costs must be driven down continuously. One approach that has proven successful here is model-based software development. In this work, we developed and realized new concepts for the model-based validation of infotainment functions. So-called reference models are introduced as executable specifications and reused in the development process for the validation of infotainment systems. Fraunhofer ESK is developing methods and concepts for the model-based validation of infotainment functions based exemplary on the MOST protocol. In this work, reference models are derived from specification models in order to validate infotainment functions.

In section 2, we give an overview how model-based design of infotainment functions is currently done. The model-based validation of these infotainment functions is described in section 3. In section 4, we introduce the new validation methodology. Finally, section 5 concludes with a critical discussion of the developed concepts.

2 Model-based Design of Infotainment Functions

Following the success of model-based development tools, the creation of specifications and initial prototypes as executable models is becoming more and more common. For

this purpose, models for numerous infotainment applications – so-called MOST function blocks – are being developed with UML-based [7] CASE tools like Rational Rhapsody [3] by IBM. Existing frameworks like MODENA [2], for instance, can be used to connect UML models to the physical MOST network bus. Thereby, it is possible to test communication interfaces of infotainment functions based purely on such models [1]. The sequences defined in the MOST protocol specification [6] (such as Figure 1) are the basis for creating the so-called *specification models*, which are executable models of the MOST function blocks.

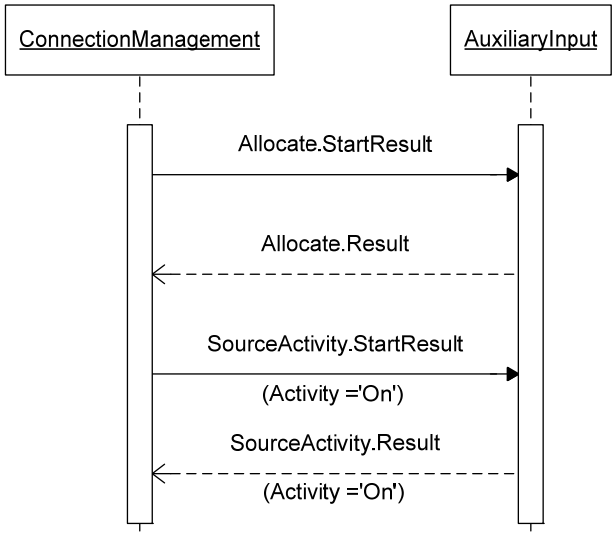

Figure 1 Example of a specified sequence for a successful startup of an Auxiliary Input [6]

Specification models depict the functional specification of an application to be implemented in series production. For instance, Figure 2 displays an exemplary specification model of the Auxiliary Input function block [5] created with Rational Rhapsody. Prototypes modeled in this fashion are utilized to test the infotainment functions in real future environments and as result possess a high degree of maturity. In addition, specification models can be employed to generate production code for infotainment ECUs in the automobile. In order to test adherence to the specification, the behavior of the specification model has to be compared with the behavior of the implemented MOST function block.

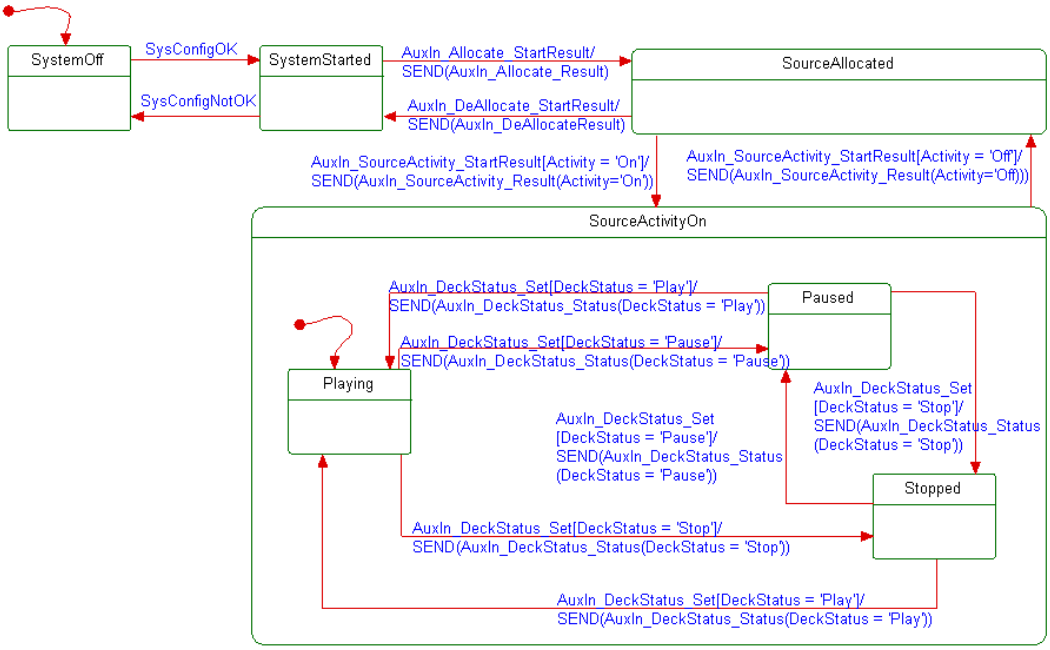

Figure 2 Example of the specification model for the Auxiliary Input Function Block [5]

3 Model-based Validation of Infotainment Functions

The objective of the validation is to identify deviations from the specified communication behavior. For doing so, the accuracy of the message sequences at the MOST interface is tested. To determine if there is a deviation from the defined behavior, a nominal/actual analysis is carried out to compare the MOST messages sent from the implemented function block with the message sequences in the specification. Existing models for the MOST function blocks are reused to validate an implemented function for minimizing the effort of the model-based validation in the design process. Therefore, a so-called *validation model* generated from the existing specification model provides the defined MOST sequences (target messages). In Figure 3 the transformation from a specification model to a validation model for the sequence specified in Figure 1 is illustrated. During this transformation new states are added to the validation model. So-called 'OutOfSync' states are used to synchronize the model with the implemented MOST function block. If a deviation of the specified behavior is detected, the currently active state of the model does not match the actual state of the implemented MOST function block. In order to re-synchronize the model with the function block the 'OutOfSync' state is activated. With the next message that can be assigned to a transition the correct state can be activated. 'Validation states' (highlighted in grey in Figure 3) are needed, in order to check both the messages received and sent by the regarded function block.

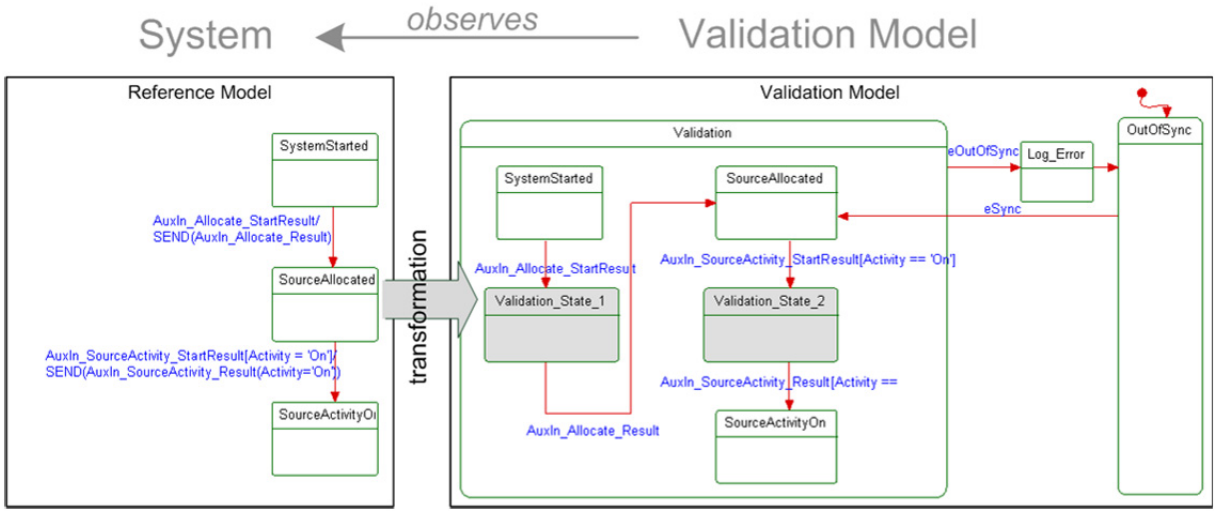

Figure 3 Validation model of the AuxiliaryInput Function Block [5]

By using this model transformation, the existing information in the specification model is preserved and utilized for the validation. The actual messages are compared to the messages sent from the implemented infotainment function (target messages). This new method permits the validation of previously-captured MOST message traces and implemented functions while the automated tests are being carried out.

4 New Validation Methodology

The model-based validation methodology developed by Fraunhofer ESK lets developers check the implemented infotainment functions against the corresponding specification and reliably detect deviations at the MOST interface. The required validation models can be produced in an automated fashion. The foundation of this new method is the function definitions and the existing specification model for the MOST function block. By reusing the specification model for validity checks, the effort required to develop specific validation models for automobile manufacturers and suppliers is eliminated. This approach also automates the validation of infotainment functions, which accelerates the design process. Through this also the quality of software for automobile infotainment systems can be improved. The concept for the automated generation of validation models also led to new guidelines for improved development of specification models for infotainment functions. The final result of this work is the creation of a new method for specifying and validating the communication behavior of ECUs.

5 Discussions

The concepts for the model-based validation of infotainment functions in the automobile illustrate how model-based methods can be employed across the various phases of development. The information from existing models can be reused for various tasks such as code generation, validation or testing. The conversion of the models for these specific tasks is automated. However, the validation models can only be used to validate the control flow of a MOST function block so far. In order to be able to include data flow in the validation additional work is in progress. When generating a validation model from a specification model, some modeling guidelines for creating the specification model have to be followed. Nevertheless, certain elements of the generated validation model cannot be presented graphically by tool constraints. But as the generated validation model does not have to be adapted manually, that does not pose a problem. Thus, the introduced methodology is a promising approach for an improved validation of automotive infotainment functions.

6 References

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