DB Netz

High-quality interface specifications with SysML modeling

This article describes an approach that leads to a detailed interface specification in clearly defined steps, starting with a coarse view on the system. The approach has been developed by Berner & Mattner based on numerous technical discussions with railway engineering experts of Deutsche Bahn. In the meantime, the procedure has become a standard in the project NeuPro of DB Netz. It is especially suitable for creating high-quality specifications in the complex environment of railway engineering. Due to its clear structure, the approach is also applicable for large projects with a large team of specifiers.

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Railway network operators are increasingly facing the challenge of integrating subsystems supplied by different manufacturers. Currently, there are no detailed specifications for many interfaces which the manufacturers could use as an orientation. As a result, overall systems are normally ordered from a single manufacturer. Within the project NeuPro, DB Netz follows the objective of achieving higher flexibility by creating standardized interface specifications. Berner & Mattner has developed an interface specification approach in order to support this goal. The approach is based on modeling with SysML (Systems Modeling Language).

Approach

The approach is divided up into two phases: The modeling of the domain level and the modeling of the technical level. The interface modeling process is visualized graphically in the activity diagram (figure 1).

The domain level provides a functional, logical and abstract view of the requirements, independent of particular solution concepts. Solution-focused requirements, such as physical, electrical or software-related descriptions, are covered at technical level. Tasks carried out at domain level are referred to as the *analysis phase* in systems engineering.

The technical level uses a technical solution concept to implement domain level requirements. In systems engin-

eering, this phase is referred to as the *design phase*.

Activities at domain level

At the beginning, it has to be determined which of the subsystems of the overall signaling system are involved in the interface communication (below referred to as *interface end points*) and which of the subsystems are important regarding the interface to be specified. This is referred to as the *interface context* (interface environment). SysML applies a block definition diagram for this purpose. It shows the static structure of elements (in SysML: *blocks*) and their relation to one other (*associations*). Subsequently, the interface definition determines which functionality is executed on which subsystem of the interface context and which of these functionalities require communication via the interface. In SysML, use cases reflect the functionality of a subsystem as services which a subsystem offers to another subsystem or a person (*actors*).

After defining the interface context, the interface-relevant use cases have to be identified and modeled in a use case diagram (figure 2). A use case consists of a sequence of actions executed in changing order by the subsystem and the actor who is applying the use case. The activity diagram of SysML models this sequence of alternating actions between actor and subsystem. It is determined in detail which sub-functionality is executed on which subsystem and in what sequence.

Once the use case sequences have been worked out and the functional distribution among the subsystems has been fixed, the next step is the functional interface specification, based on sequence diagrams (figure 3). The necessary communication via the interface with functional information (commands and messages) is determined for standard workflows (successful process flow of a use case without faults) of the developed activity diagrams. Sequence diagrams are suitable for visualizing the interaction of several selected communication scenarios, but not for completely describing all processes. Therefore, a new diagram type comes into play: Statecharts for subsystems of interface end points now also cover and model all exceptional cases. In this way, the interface description is very

Figure 1

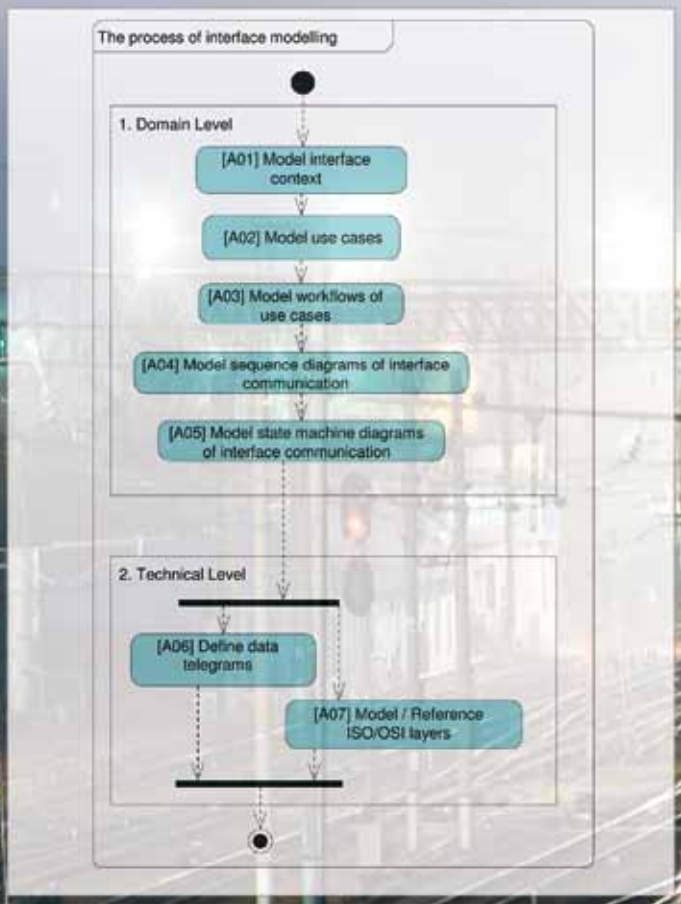
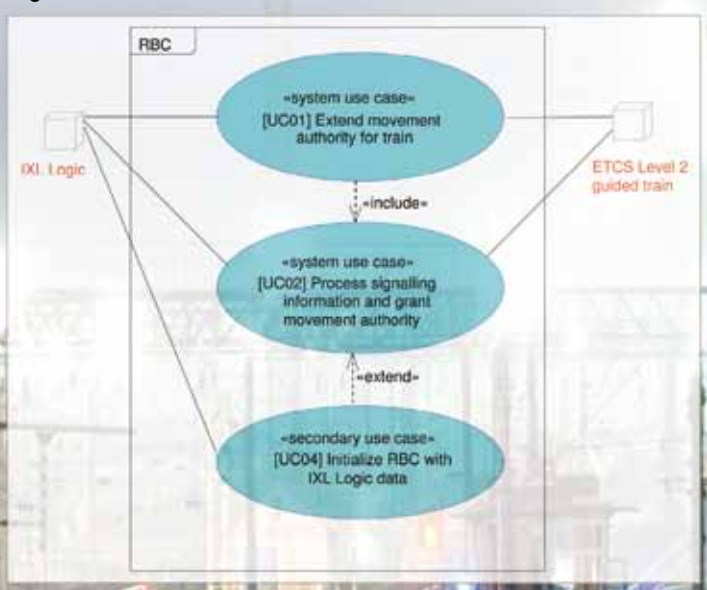


Figure 2



complete at domain level. At last, statecharts offer execution and simulation options in order to enable further optimization and requirement testing.

Activities at technical level

The final step is the description of the specific technical implementation. At first, the ISO/OSI layers are described. If industry protocols and standards are applied such as Ethernet and TCP/IP, it is sufficient to refer to their specification. Finally, the technical data telegrams are defined, including the description of their bytes and bits as well as their value ranges and meanings.

SysML process of Berner & Mattner

The process for developing interface specifications is part of a comprehensive process. It is developed by Berner & Mattner for modeling and developing railway systems with SysML.

The entire process

> is based on the procedure models SYSMOD (Systems Modeling Process) and OOSEM (Object-Oriented Systems Engineering Method)

> implements the concept System of Systems (SoS)

> defines a model structure (implemented with SysML packages)

> supports the modeling of variants

> integrates the phases of the RAMS life cycle

> supports three presentation levels of railway requirements (operational, domain and technical level)

> is easier to understand due to limitation of the number of used SysML model elements, compulsory modeling guidelines, integration and preference of railway terms as well as presentation in German language as far as possible

The modeling of interface specifications can be integrated seamlessly and redundancy-free into the overall SysML signaling system model. The modeling of the operational level is not necessary for creating interface specifications and is thus not being referred to.

Benefit of SysML modeling:

> More precise requirements

> Improved completeness

> Higher accuracy

> Easier to understand

Berner & Mattner has been using SysML in many projects with very good results. One of these projects is NeuPro of DB Netz.

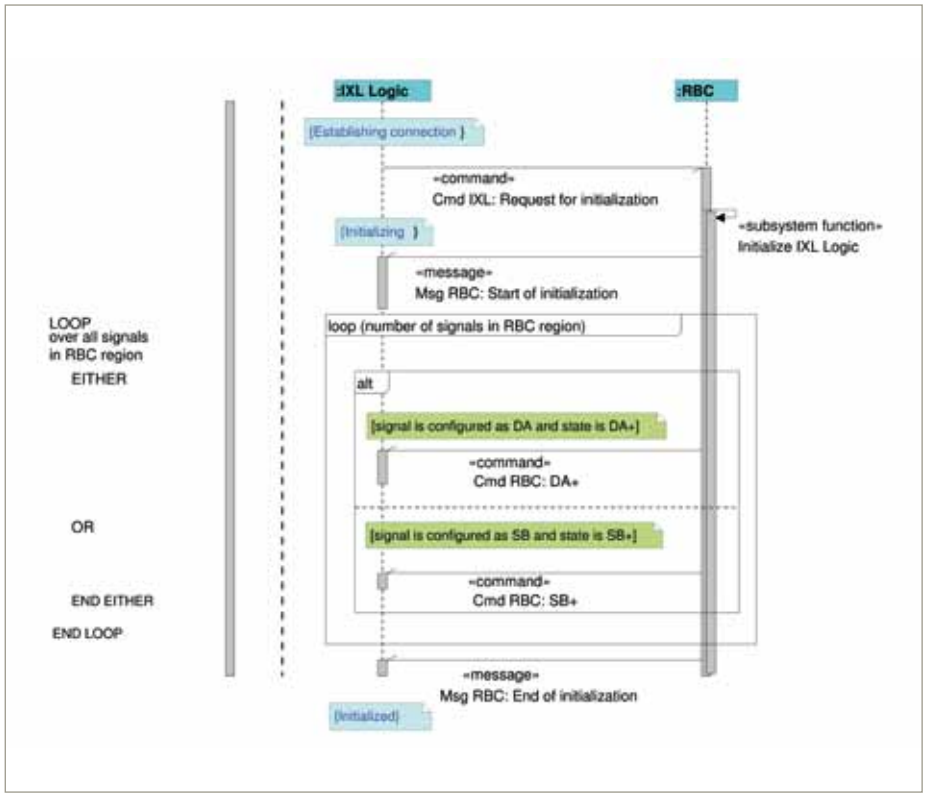


Figure 3: IXL logic initialization - sequence diagram