9 Product design application

Following the explanations in Chapter 8, the application of basic analysis criteria to intra-domain networks helps identify structured constellations and provides knowledge about structural characteristics. This can help users improve system understanding and predict system behavior. Changes to a system can also be better planned, because probable change propagations become visible. Practical measures of system structures need to consider provided analysis criteria in combination, as the isolated application of a single criterion can be misleading in the interpretation.

With the analysis results on hand, the next step in the structural complexity management is to apply the findings to a practical product design application. The compilation of a structure manual is initially presented in this chapter. This manual is meant for situations where an existing system structure (e.g., the structural layout of change dependencies within product components) can not be generally redesigned, but frequent requests for system adaptation have to be implemented. In this case, developers require, for example, information about possible change impact due to planned adaptations. The knowledge about strongly or weakly interlinked areas of the structure permits the prediction of an adaptation effort that has to be expected (and considered in related resource planning). Specific structural subsets can prohibit any changes to elements, because the resulting change impact, and therefore adaptations to further elements, becomes too extensive to be executed efficiently. For example, a change to the central frame of an automobile will probably impact a multitude of other components. Therefore, developers can decide not to allow changes to the frame, if adaptation time and costs would be unacceptable. Additionally, some subsets can indicate the most suitable system elements for conducting product changes, as resulting change adaptations remain minimal and can be controlled by developers. Thus, changes can be quickly implemented at low cost. A structure manual can provide a scenario when the main layout of a system structure (e.g., for a product’s change dependencies) exists as a standard base, and customer-specific variants have to be derived. In these cases the general structure remains, but developers need to know about probable consequences for the specifically created product due to these adaptations.

Whereas a structure manual focuses on improving the interaction with existing system structures and their required specific adaptations, the fundamental optimization of a system structure represents the second practical application to be considered. Structural optimization is helpful when a fundamental system structure has to be redesigned in order to better meet the requirements. Once an optimized
system structure is settled, it can be used to create a structure manual, which then supports developers in the creation of specific system variants. For applying system optimization two methods are presented in this chapter. First, the tearing approach is detailed, which represents a DSM-based structure optimization meant for improving process structures. Afterwards, the structural pareto analysis is presented, which allows dependencies with significant impact on the occurrence of selected basic analysis criteria to be determined.

9.1 Structure manual

The structure manual can support communication in development teams, especially if people from different disciplines are integrated. The provision of visualized networks that clarify system dependencies can help developers understand impact chains resulting from their own system interactions. If developers cause change adaptations beyond their scope of responsibility, a structure manual describing the domain-spanning dependencies (e.g., connecting knowledge domains of two experts) can be especially helpful. Experts are normally well informed about the direct dependencies concerning their own subsystem; however, far-reaching impact chains are difficult to detect in complex systems. If a disturbing impact occurs in a design discipline (e.g., software) different from the initiating system change (e.g., mechanical components), it might remain hidden, if both disciplines are the responsibility of different developers. In terms of reliable product design, it is useful to systematically analyze possible consequences (for example, as it is supported by the FMEA\textsuperscript{27} methodology), even if a specific impact chain does not produce a negative impact in a specific single discipline or system subset.

The structure manual can also provide information about opportunities and restrictions for product adaptations. If several possible adaptations can alternatively fulfill a specific product requirement, developers can choose the most appropriate one by balancing required efforts.

A structure manual is comprised of selected information about the occurrence of basic analysis criteria for further interpretation. Results of methodical analyses are systematically presented and facilitate the planning and tracing of system adaptations as well as their resulting impact. These methodical analyses are described below. Table 9-1 lists the methods together with a short explanation and an exemplary application scenario. Further explications of the methods are provided in the Appendix.

The feed-forward-analysis depicts possible chains of change impact that originate from the adaptation of one specific node in a system. This represents an extension to the impact check list explained below, because the direct surrounding of a specific node, as well as sequences of dependencies, is considered. Because of the large amount of such dependency chains in practical applications, it is nearly

\textsuperscript{27} FMEA: Failure Mode and Effect Analysis