SFB 768

A Traceable Way from Scenarios to Concrete Product-Service-System Adaptions

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INNOVATIVE PRODUCTS ARE CHALLENGING

In order to maintain their own competitiveness companies are forced to develop future-oriented and technologically advanced products. This is currently often solved by the intensive integration of products and services into so-called product-service systems. In the industrial practice these are mostly existing products which are further developed and extended by additional features and services. The development of innovative and commercially successful offerings is challenging. These systems must meet future requirements in a rapidly changing environment. There are a lot of environmental context factors influencing the system and its success. Strategic planning is essential, but at the same time decisions are made in early phases with high uncertainty and consequences over the entire lifecycle. These decisions are often untraceable and based on subjective assessments, so they could lead to bad decisions that endanger the system's success.

COMBINING FORECASTING AND STRUCTURAL MODELING AS DECISION SUPPORT

Subproject C2 of the SFB 768 tackles this challenge and develops a systematic and traceable way to support decisions in product-service-system planning. Future situations are forecasted and connected with a structural model of a reference system (i.e. previous system). So decisions have an objective basis and could be traced in two directions: back to the forecasted aspects and forward to the system elements.

Since in industrial practice quantitative data mostly lacks in context of forecasts and qualitative forecasts are well suited for event or trend prognosis, qualitative forecasting methods seem well-suited. An established qualitative forecasting method is the scenario planning. In context of our research, it builds the basis for forecasting future situations. This includes upcoming events and technologies, future applications or general developments in the system's context. These scenarios are translated, combined and summed up into use cases that describe concrete future situation and integrate the contextual influences (figure 1 - left). Due to the high ratio of adaptation developments in industry, engineers can build up on a reference system. Hence, the future-oriented use cases are linked with the requirements of the reference system. This builds the connection between the planning and the engineering perspective. The engineering perspective is represented according to typical systems engineering. The system is broken down from requirements over functions to components (Figure 1 – middle). In case of product-service-systems Kammerl (2017) developed a structural model that includes the service elements on all levels in addition to the product perspective (figure 1 – right: function, process, resource). This structural model enables traceability in the system structure from the requirements to all system elements. The model is designed as a graph-based network of nodes (system elements) and connecting edges that represent mutual influences. To meet the increased interdisciplinary character of product-service-systems the organizational perspective was added to identify involved organizational units. Through the link between the use cases and the requirements, a traceable connection between the planning perspective (scenarios) and the engineering perspective (system elements) is realized. This traceability supports decision-making in the planning phase, because effects of forecasted situations on system level could be better assessed on an objective basis. The structural modeling allows to trace the propagation of use cases in the system and identify affected system elements.

APPLICATION

This method was applied in several industrial situations. All typical application situations have in common that a planning process was initiated to adapt an existing system to future situations. The case study of a public pedelec sharing system, which was conducted in cooperation with a company from the public transport sector lasted one year. First, scenarios and use cases for three planning horizons were developed. Overall there were nine scenarios and five prioritized use cases. An exemplary use case in a medium term planning horizon was that the pedelecs should better suit tourist demands. This use case was connected to all system requirements concerning the usability of the charging system in the structural model. An exemplary affected requirement was the self-retracting charging cable. The future charging process should be self-explanatory with a minimum of interaction steps. Based on the graph-based structural model of the reference bike system all potentially affected system elements (i.e. functions, processes and components) and organizational responsibilities could be identified automatically.

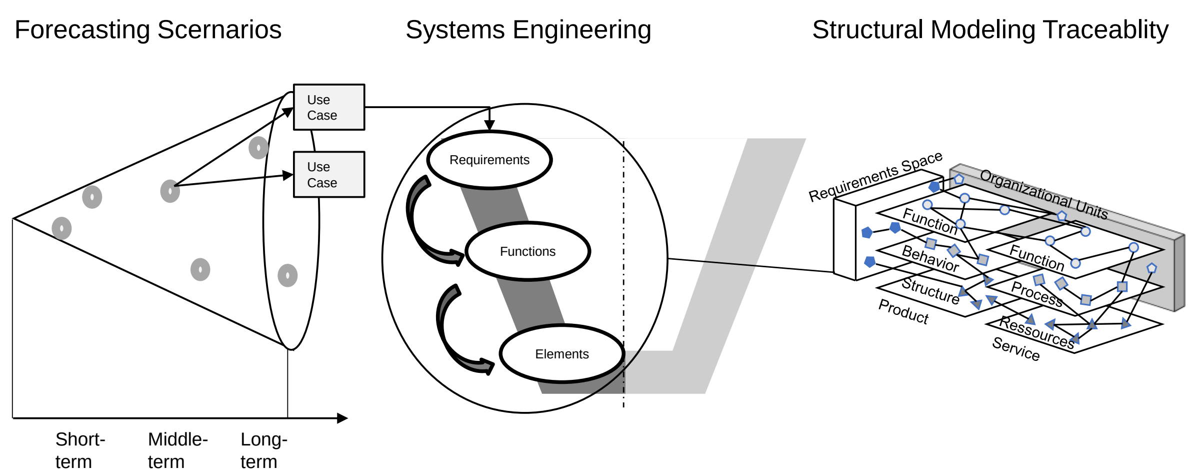

Figure 1 – From forecasting to structural modelling of the system as decision support

Therefore, the model and the analyses were implemented in a software support. Otherwise the analyses would be too complex. Components (i.e. charging station), functions (i.e. ensure energy supply), and responsible persons (i.e. specialist power unit) were identified. As result of the entire study, analyses over all use cases were summed up in a management summary that covers the requirements, its forecasted change, the affected structural elements, and the responsible domains. Based on this clear representation potential effects of the implementation of future use cases are traceable and decision-making is supported in early planning phases. Nevertheless, these analyses and representation build only the basis for expert-based decision-making.

CHANCES

Depending on the application, the method has various benefits and chances. Basically, the structural modeling improves the system understanding and the knowledge about interaction of different system elements. The method objectifies decision-making and as a result of the existing knowledge on future requirements changes, it helps to prevent unexpected or critical design changes in the late phase of development. Based on the connection of forecasts and the structural model emerging environmental influences could be prioritized due to their potential influence on the system. Hence, critical future aspects could be identified and a strategy for the development department could be derived with core aspects for future developments. Particularly the transition from traditional product design towards product-service-system design is an interesting aspect in terms of this research, because there are often existing products that should be adapted to product-service-system business. In future research the degree of automation of the analyses will be increased and additional aspects such as cost or risk analyses will be integrated to enhance a holistic decision-making.

Further publications:

Weidmann, D.; Seibel, F.; Becerril, L.; Kattner, N.; Lehr, J.; Mörtl, M.; Lindemann, U.: Integration of Scenarios in Product-Service System development - Combining Scenarios, Use Cases and Requirements Traceability. IEEE International Conference on Industrial Engineering and Engineering Management (IEEM 2018), 2018.

Weidmann, D.; Stenger, M.; Mörtl, M.: Future Oriented Planning of Product-Service Systems. Lecture Notes in Electrical Engineering, Springer Nature Singapore Pte Ltd., 2018, 299-310.

Kammerl, D.: Modellbasierte Planung von Produkt-Service-Systemen. Dissertation, 2017

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