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Interactive visualization to support stakeholders in transdisciplinary environments within innovation processes

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Introduction

Various cyclical factors, e.g. planning and development cycles, change management processes or even cause changes in organizational structures and teams, influence innovation processes and increase complexity. Moreover, customer requirement changes or new product and production technologies affect these processes. As a result, many stakeholders from different disciplines need to efficiently work together in transdisciplinary teams within the innovation processes to successfully reach their project goals. Particularly, in the development of modern product service systems (PSS), the effort of communication and coordination within these transdisciplinary teams is increasing and handling of such complex processes becomes the crucial factor of success.

However, the stakeholders of the different disciplines have a quite different understanding of the processes based on their specific views and individual requirements. They have individual mental models about the innovation process based on their specific knowledge and experience. Additionally, the different disciplines use their own tools and terminologies, as well as their own domain specific languages and models with different levels of abstraction to describe their processes. The multitude of disciplines and stakeholders involved in the innovation process results in a complex heterogeneous model landscape with a variety of heterogeneous, discipline-specific models - e.g., requirements models, engineering models, as well as analysis models - with dependencies, overlaps and information flows between each other. Within the innovation process, a common understanding between all stakeholders is required. Difficulties in communication and comprehension often result from different underlying individual mental models between the stakeholders.

In order to solve these problems, we offer an interactive cross-discipline visualization approach to reduce the complexity by visualizing cross-model dependencies under consideration of the context and the individual task of the stakeholder within the innovation process [1]. The visualization of cross-model dependencies in a complex system such as the cross-discipline cooperation of stakeholders in the innovation process increase the transparency of the system and improve the understanding of dependencies in order to support the stakeholder in decision-making in this complex transdisciplinary environment.

The challenges of this subproject of the CRC 768 *firstly* is the investigation of model dependencies through interviews and workshops to

find dependencies and interconnections between the different models used within the different disciplines. *Secondly*, implementation of an integrative interactive visualization approach to visualize these dependencies and, *thirdly,* the evaluation by means of use-cases for an application example.

Investigation of Cross-disciplinary Model Dependencies

Cross-disciplinary model dependencies are not anchored on an abstract level but on a detailed level between the models and across abstraction levels (Figure 1, correspondent link). The recognition of these dependencies is the basis for the evolution of a common understanding in the innovation process.

To visualize cross-model dependencies, we first needed to gather the dependencies. We used semi-structured interviews with all involved stakeholder or "model providers" within the innovation process (inside the CRC 768) to collect the individual understanding of each participant's own models.

Furthermore, we collected the own understanding of the stakeholder regarding the interaction of the own discipline-specific model and its interconnection with other models on a detail level. The result of these interviews was a model map with model dependencies based on the individual understanding of the stakeholders involved.

In a further step, we extended and refined the model dependencies using focus groups. Each focus group represented a use case/action goal and included all stakeholders involved in this use case (change management, inconsistency management, knowledge management and stakeholder integration). Within the focus groups, the representatives of the different action goals/use cases discussed the model dependencies. The result of these focus groups is a model map, validated for each of the four action goals/use cases and reflects the team mental model of the use case/action goal.

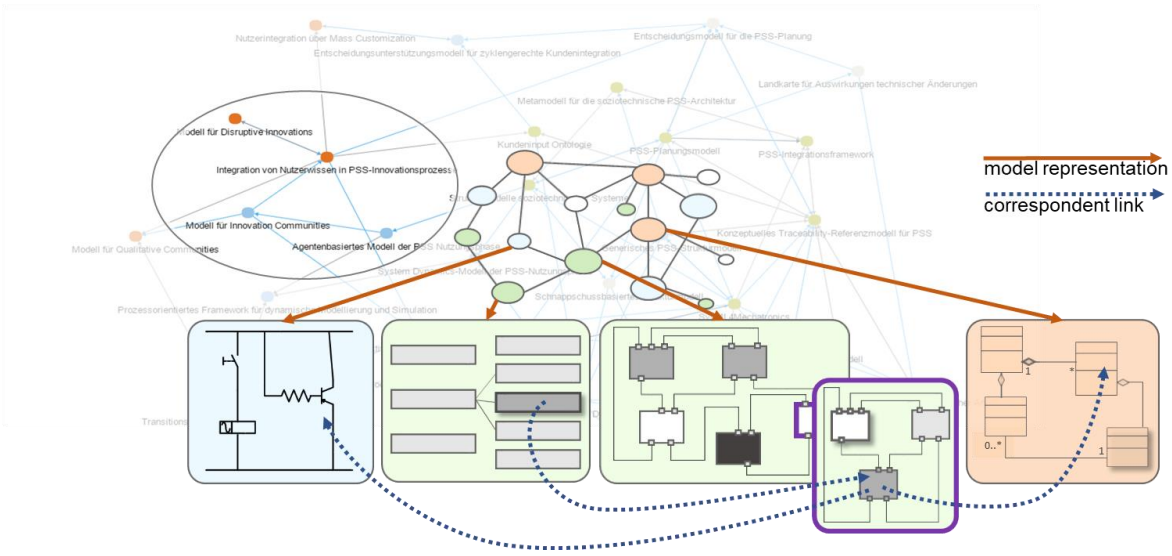

Figure 1 Cross-model dependencies in a transdisciplinary innovation process

Interactive Visualization of Model Dependencies

The challenge in developing an interactive visualization within a transdisciplinary environment is to find a representation form that is easy to understand for all involved stakeholders. This is important in order to achieve a common understanding of the presented cross-model dependencies within the innovation process. However, as especially industry models can contain thousands of entities, mechanisms to enhance comprehensibility are mandatory. Consequently, some sort of information filtering, aggregation and/or abstraction is required for our visualization approach. To meet these requirements, we initially presented all involved models and its dependencies on an abstract level using a 3D graph. Based on the theory of Shneiderman (Visual Information Seeking Mantra - overview, zoom, filtering, details on demand) [2] the complexity can be reduced by means of filter mechanisms and the visualization can be adapted to certain action goals/use cases. For the visualization of the dependencies on the detail level, we also chosen a graph-based visualization. According to the Focus+Context principle [3], we displayed both views - abstract view and detail view – in a split window. The presented links in this visualization represent the information flows between the involved models and increase the understanding of the interrelations across model boundaries. However, due to the complexity of real industry models, it does not make sense to display the models in their entirety. Therefore, in a first step, only the entities with links to entities from other models and their neighboring entities need to be visible for better orientation. Depending on the user's task, the user can freely arrange the nodes in the view by moving or scaling, which increases the information retrieval.

In a next step, we will use our prototypical implementation to evaluate the usability and the benefit of the introduced approach by means of real industrial application.

[1] Pantförder, D., Vollenweider, E., Leitner, F.: Interactive visualization of model dependencies in a transdisciplinary environment. In: 14th IFAC/IFIP/IFORS/IEA Symposium on Analysis, Design, and Evaluation of Human-Machine Systems (HMS), Tallinn, 2019 (accepted paper)

[2] Shneiderman, B.: *The eyes have it: A task by data type taxonomy for information visualizations*. Visual Languages, Proceedings, IEEE Symposium on, 1996, 336-343

[3] Card, S.K., Mackinlay, J.D., Shneiderman, B. (Eds.): *Readings in Information Visualization: Using Vision to Think*, 1999, 1-34, Morgan Kaufmann Publishers, San Francisco

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