12TH INTERNATIONAL DEPENDENCY AND STRUCTURE MODELLING CONFERENCE, DSM'10
22 – 23 JULY 2010, CAMBRIDGE, UK

STRUCTURAL ANALYSIS OF REQUIREMENTS – INTERPRETATION OF STRUCTURAL CRITERIONS

Katharina G.M. Eben and Udo Lindemann
Institute of Product Development, Technische Universität München

Keywords: requirements, structural analysis, structural criterion, DSM

1 INTRODUCTION

The management of requirements is a central task in the product development process, as a successful product has to meet the entire amount of requirements originating from customer wishes, market conditions and the situation in the company. In literature many contributions can be found in the context of requirements management or engineering. This field of studies is not only of importance in one discipline as there are approaches for the management of requirements tailored specifically to product development and software engineering (Baumberger and Lindemann, 2006; Pohl, 2008). Pohl (2008) names the core steps documentation, elicitation of requirements, which are to be backed up by the validation and the continuous management of requirements. The latter is meant to be implemented permanently into the business process in order to achieve an incessant documentation of validated requirements.

The documentation or modelling of requirements is addressed differently in literature. Besides methods like for example semantic nets, object oriented modelling languages like the unified modelling language (UML) are used (Pohl, 2008). Moreover, Kusiak and Wang (1995) introduce a network model to integrate multiple perspectives on the design task – each bringing along a specific set of requirements. The software-based model is then used to compute multiple design solutions. Several approaches make use of matrix-based methods in order to model and hence to document requirements. Here is to mention the methodology of Quality Function Deployment (QFD). Therein customer requests and requirements are converted to specific product properties, which can also be understood as elemental technical requirements to the product design (Akao, 1992). Baumberger and Lindemann (2006) use the DSM (design structure matrix; Browning, 2001) and DMM (domain mapping matrix; Browning and Eppinger, 2002) to identify requirements. Starting in the DSM of components the cause for the relations between two components is investigated, as it might be representing a requirement.

Within the field of affordance based design Maier et al. (2009) use hierarchical modelling of requirements, which are expressed as negative or positive Artefact-User Affordances (AUA) and Artefact-Artefact Affordances (AAA). The affordances are analysed in an affordance structure matrix (ASM), which maps for example the affordances to components and is partly similar to a House of Quality in QFD (Akao, 1992). The affordances of a product on different levels of hierarchs are analysed regarding their amount of harmful and useful relationships between them. The aim is to gain insight on whether certain affordances or components etc. are critical.

The approaches described above use matrix-based methods to depict and analyse the dependencies between requirements and product components. They use different approaches to assess the importance of single requirements and their impact on the whole product by assigning specific values to the relations within their regarded system.

Maier et al. (2007) suggest a hierarchical requirements modelling scheme in order to capture the entire information necessary in the development process. For the purpose the requirements are linked to several other domains, e.g. components, working principles etc., in DMMs. Thereby other matrices are computed, in order to gain different perspectives on the regarded system. For example several requirements DSMs are computed using different DMMs. The results are compared concerning the gained edges in order to identify missing aspects and to attain a complete model of requirements.

These procedures afford a high effort for the analysis of the requirements' interdependencies, as on the one hand the weighted dependencies have to be discussed (Akao, 1992; Maier et al., 2009) and on the other hand a large number of matrices has to be created and compared (Maier et al., 2007).

In this paper it is proposed to conduct a structural analysis by the identification and interpretation of structural criterions. The requirements are modelled in a DSM, while the edges represent the existence of influence on other requirements. Thus, there is only the effort to fill one DSM. Moreover the importance of single nodes and edges is identified by the analysis of the criterions instead of defining attributes or weights for each relation.

The interpretation of different structural criterions can be used to identify significant requirements in a regarded system. Consequently, the definition of tasks in requirements management can be supported. Not only the quality of the requirements model can be assessed and improved by hinting at critical elements and relations, but also the classification of requirements and the evaluation of how and up to which degree changes impact the related requirements can be facilitated. The latter's aim is similar to the one followed by Clarkson et al. (2001), who address the propagation of product changes. Thereby, for each element, i.e. component, the risk induced by a change, is calculated considering the impact and likelihood resulting from that change.

Procedures for the calculation and analysis of structural criterions can be found in Lindemann et al. (2009) concerning for example the design of product architectures and in Kreimeyer (2009) concerning process management in engineering design. Regarding requirements structures Eben et al. (2010) use structural analysis to check the completeness and plausibility of requirements in control systems. Their purpose is to facilitate the elicitation of requirements on multiple layers of hierarchy. Thereby only a few structural criterions have been regarded concerning their meaning in the context of requirements.

As, only some first structural criterions have been used to support the modelling and analysis of requirements, no exhaustive list of possible interpretations of such criterions in the context of requirements has been presented in any contributions to literature. The matrix-based approaches concerning requirements all deal with building the network of requirements and how the latter are translated or realized by the components, working principles etc. The relations between the requirements are not analysed from a structural perspective. Further the contributions mentioned above aim at an integrated management and modelling of requirements, but do not cover the structural perspective within a requirements DSM. They mostly focus on requirements-components DMMs (Akao, 1992; Maier et al., 2009; Baumberger and Lindemann, 2006).

This paper proposes interpretations of structural criterions identified within a network of requirements modelled in a DSM. Thereby, existing interpretations and new found meanings of those criterions are presented in section 2. A brief example naming structural significant requirements identified during a current research project is shown in section 3.

2 STRUCTURAL ANALYSIS OF REQUIREMENTS

In order to enable the analysis of requirements matrix-based approaches have been chosen because of the success in product architecture and process planning (Browning, 2001; Browning and Eppinger, 2002; Kreimeyer, 2010). The structural analysis of requirements affords that the meaning of structural criterions – particular constellation of nodes and edges with a certain meaning according to the context of the system as defined by Kortler et al. (2010a) – is to be explored.

First steps have been made by Eben et al. (2010), who listed the possible meaning of some criterions. Their focus is the prioritisation of requirements on multiple layers of hierarchy. This list is not complete, nevertheless they allow for a structural analysis of the requirements DSM in order to test the completeness and plausibility of the gathered data (Eben et al., 2010). The importance of correct and complete data acquisition is immense, since e.g. missed or wrongly documented relations can alter the appearance of the regarded system (Biedermann, 2009).

In tables 1 and 2 structural criterions are summed up and existing and new findings regarding the latter's significance for requirements pointed out. Criterions covering single nodes are depicted in table 1, criterions for subsets of nodes in table 2.

There is a large number of different metrics, which can be computed using the criterions, see for example (Kreimeyer, 2010), but not all of them can be linked to a specific meaning concerning requirements. Thus those metrics are documented below, for which a meaning regarding the modelling requirements could be identified. In order to gather the meaning of these structural criterions, a data set of requirements for a laundry service has been analysed. The requirements have been modelled in a DSM and the structural criterions have been recognized and computed. According to this specific dataset of the laundry service, see section 3 for a more detailed description, each criterion's meaning could be derived. The results can be used to identify significant requirements within the system and may lead to possible tasks in requirements management. For example a criterion could hint at missing requirements or missing edges between them, thus an additional data acquisition would be needed.

Table 1. Structural significance of requirements – single nodes

Structural criterion	**Explanation according to Lindemann et al. (2009)**	**Meaning**
Activity	Degree of incoming to outgoing relations	The activity stands for the intensity of the requirement's influence on other requirements.
Passivity	Degree of outgoing to incoming relations	A highly passive requirement is affected by many others. It might be a source of uncertainty, e.g. concerning the probability of changes.
Criticality	Multiplication of active sum (sum of outgoing edges) and passive sum (sum of ingoing edges)	A requirement with a high criticality affects and is affected by a large number of other requirements. Because of its high importance in the system it should be given a high priority (Eben et al., 2010).
Reachable nodes	Number of nodes reached directly or via possible paths	Influence of requirement on others within the whole model or requirements, impact of its change
Articulation node	Single node linking two subsets	The requirements links otherwise independent subsets of requirements. This requirement can for example represent an important interface or interaction in the regarded system.
Start	Only outgoing relations	The requirement only influences one other directly, but it has a possible impact on various others via paths. The whole system is affected, the whole system might be affected
Leaf	Only related to one other node	The requirement only influences or is influenced by one other directly. Not necessarily the whole requirements structure is affected by the requirement.
End	Only incoming relations	The requirement is only directly influenced by one other requirement. The requirement can be changed without causing any impacts.
Isolated node	No outgoing and no incoming relations	The requirement can be regarded on its own, if no relations to others have been neglected.

Table 2. Structural significance of requirements – subsets of nodes

Structural criterion	**Explanation according to Lindemann et al. (2009)**	**Meaning**
Cluster	Subset of highly interconnected elements with few links to elements outside	Requirements forming a cluster may belong to the same class, e.g. functional requirements (Eben et al., 2010) and be highly interdependent.
Path	direct or indirect connection of two nodes by edges	Requirements connected via a path to a requirement can be affected by a change of the latter (Eben et al., 2010).
Feedback loop	two or more nodes that are interlocked sequentially by edges	Requirements connected in a cycle might form a conflict (Eben et al., 2010).

Hierarchy	sub graph represented as tree	Requirements of a lower hierarchy level may inherit the priority of higher level ones. Different lengths of paths between requirements may point at missing ones (Eben et al., 2010).
Independent subsets	Subsets of nodes not linked bay relations [Kreimeyer, 2010]	A subset of requirements having no influence on other subsets can be regarded separately, if no relations or other requirements have been neglected.
Similarity	amount of identical connections of nodes to surrounding nodes	Requirements with similar relations can be addressed at the same function or component. Or they can be summarized within a certain class of requirements.
Quantity of indirect dependencies	Number of indirect paths between two specific nodes	Two requirements – even if not directly connected – may have a high influence on each other.

3 EXAMPLE – LAUNDRY SERVICE

This section describes the results of a structural analysis of a set of requirements for a hotel laundry service. This data set has been developed within a current research project carried out in a collaborative design centre. The overall goal of the research is on the one hand to gain insight in the dependencies between all disciplines being part of innovation processes. On the other hand the collaboration between the former is examined, in order to make the processes more effective and successful. In order to capture iterations between product design (e.g. of washing machines or planning-software) or service design (e.g. of delivery of laundry) and requirements management the laundry service has been developed. Step by step, the requirements and product properties have been detailed, amended and refined in discussions and workshops (Kortler et al., 2010b). Thereby, these tasks iterated between a research institute situated in product development and a second working on information systems – the latter focuses requirements engineering within the current project.

Figure 1 shows the graph of an extract of an early version of the requirements set used to identify the meaning of structural criterions proposed in section 2. An edge in the graph stands for "requirement has influence on requirement".

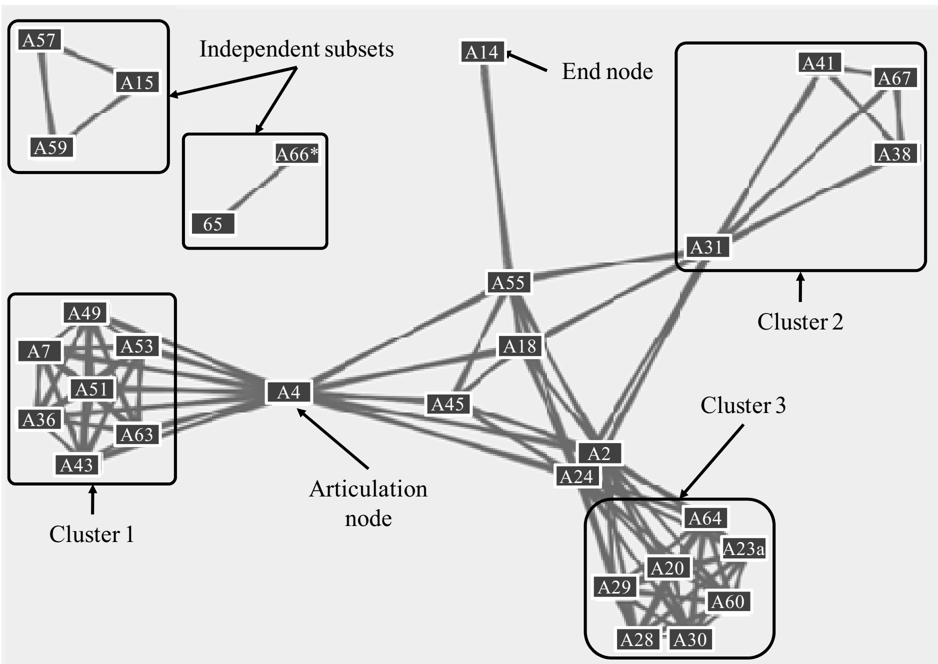


Figure 1. Example – structural criterions in a set of requirements for a hotel laundry service

The requirement A14 "payment dependent on laundry amount", as depicted in figure 1, is represented by leaf node. It is obvious, that this requirement has hardly any influence on the remaining system, as it is only dependent on the necessity of the record of stock-keeping (A55). Figure 1 depicts two independent subsets. First, there is a pair of requirements, i.e. A65 "monthly invoice" and A66* “minimum of profit margin”. Second of the requirements A57 “monthly report not containing staff data”, A59 “invoice containing VAT registration number” and A15 “monthly report to customer” form another subset. Both comprise of requirements concerning the book-keeping of the laundry service. Consequently, as both sets are closely related, links between both sets might have been missed. Thus, all these requirements have to be examined again, in order to assure that missed relations or requirements are identified. In the current case both sets are actually via an additional requirement, concerning the contents of the monthly report. The articulation node A4 “delivery in time” links cluster 1 to the rest of the requirements. Thus, it can be seen that a punctual delivery is highly dependent of the delivery times and management constraints defined in cluster 1 (A49 “delivery time towels”, A51 “delivery time of bed-linens”, A53 “delivery time complete laundry”, A36 “management of kitchen cloths”, A43 “availability of planning software” A7 “correct management of cleaning process”, and A63 “minimum amount of laundry for cost efficiency”). Moreover A4 is an important interface to the remaining requirements. In order to handle the scheduling of delivery the elements of cluster 1 have to be defined accordingly. It is to be pointed out that the requirements of cluster 1 form a consistent group of process management related items.

Cluster 2 contains requirements concerning local circumstances. On the one hand the service is only available within Munich (A67) on the other hand there are different issues concerning data management (A38 “data management via online platform”, A41 “data privacy protection hotel guests”, A31 “reassignment of personal laundry of hotel guests”). This group of requirements aims specifically to the actual application conditions and have to be regarded in combination. A change of one requirement affects all other ones. This finding also applies for cluster 3, as all its requirements cover the cleaning process specifically (A64 “maximum cost of coloured laundry detergent”, A60 “maximum water quantity per cleaning process”, A20 “environmental sustainability of detergent”, A28 “environmental sustainability of bleach”, A23a antiallergenic detergent, A30 additional bleaching of tablecloths, A29 “additional cleaning of tablecloths”).

The examples described above show how structural criterions can be interpreted and support the analysis of requirements and the decision making in requirements management.

4 CONCLUSION AND OUTLOOK

Within a current research project the dependencies of elements within innovation processes are to be modelled and analysed. For that purpose matrix-based methods have been chosen, as their success has been proven concerning the management of product architectures and processes. In innovation processes stakeholders of various disciplines have to work together. On the one hand the product architecture has to be designed and on the other hand the requirements have to be elicited and documented. In order to analyse the system of requirements, structural criterions identified in a requirements DSM have been examined regarding their meaning in this context. Interpretations – found for one structural criterion in a specific area of the laundry service model – have been reconsidered each time the same criterion has been identified afterwards. If necessary the interpretation has been adapted or enhanced. Thus, it is assured that the criterions are regarded and can be applied from different perspectives on the focused system.

These structural criterions support the identification of significant requirements. Thus, the definition of possible tasks in requirements management is facilitated. For example the analysis’ results can hint at missing requirements or relations. Moreover important groups of requirements can be identified having a high influence on each other. Consequently the impact of changes can be assessed easily by identifying structural criterions.

Although these structural criterions may be useful to analyse requirements networks, further work is necessary regarding the application to sets of requirements in contexts different to laundry services. It is to be assured that the meaning of the structural criterions is transferable to other contexts.

ACKNOWLEDGEMENTS

This research was made possible through the generous funding by the German Research Foundation (DFG) in the context of project A2 (“Modelling and analysis of discipline-spanning structural criteria and their impacts on product development processes”) within the Collaborative Research Centre 768.

REFERENCES

Akao, Y. (1992). *QFD – Quality Function Deployment,* Landsberg/Lech: Moderne Industrie.

Baumberger, C., & Lindemann, U. (2006). Requirement Oriented Process Planning and Configuration, In *Proceedings of NordDesign 2006*, August 2006.

Biedermann, W., Kreimeyer, M., & Lindemann, U. (2009). Measurement System to Improve Data Acquisition Workshops, In *Proceedings of the 11th International DSM Conference*, DSM 2009, October 2009 (pp. 119-130). Munich: Hanser.

Browning, T. R. (2001). Applying the Design Structure Matrix to System Decomposition and Integration Problems: A Review and New Directions. *IEEE Transaction on Engineering Management*, 48, 3, 292–306.

Browning, T. R., & Eppinger, S. E. (2002). Modeling Impacts of Process Architecture on Cost and Schedule Risk in Product Development. In *IEEE Transactions on Engineering Management*, 49, 4, 428 -442.

Clarkson, P. J., Simons, C., & Eckert, C. (2001). Predicting Change Propagation in Complex Design. In *ASME International Design Engineering Technical Conferences (Design Theory & Methodology Conference)*, Pittsburgh, September 2001.

Eben, K. G. M., Daniilidis, C., & Lindemann, U. (2010). Interrelating and Prioritizing Requirements on Multiple Hierarchy Levels. In *International Design Conference*, *Design 2010*, Dubrovnik, May 2010. Accepted 26 February 2010.

Kortler, S., Diepold, K. J., & Lindemann, U. (2010a). Structural Complexity Management Using Domain-Spanning Structural Criteria. In *International Design Conference*, *Design 2010*, Dubrovnik, May 2010. Accepted 26 February 2010.

Kortler, S., Helms, B., Berkovich, M., Lindemann, U. , Shea, K., Leimeister, J. M., & Krcmar, H. (2010b). Using MDM-Methods in Order to Improve Managing of iterations in Design Processes, In *Proceedings of the 12th International DSM Conference*, DSM 2010, July 2010. Munich: Hanser.

Kreimeyer, M. (2010). A Structural Measurement System for Engineering Design Processes. Munich: Dr. Hut.

Kusiak, A., & Wang, J. (1995). Dependency Analysis in Constraint Negotiation. *IEEE Transactions on Systems, Man and Cybernetics*, 25, 9, 1301-1313.

Lindemann, U., Maurer, M., & Braun, T. (2009). *Structural Complexity Management – An Approach for the Field of Product Design*. Berlin: Springer.

Maier, J. R. A., Mocko, G., & Fadel, G. M. (2009). Hierarchichal Affordance Modeling. In *International Conference on Engineering Design, ICED '09, Vol. 5,* Stanford, August 2009 (pp. 397-404).

Maier, J. R. A., Ezhilan, T., Fadel, G. M., Summers, J. D., & Mocko, G. (2007). A Hierarchical Requirements Modeling Scheme to Support Engineering Innovation. In *International Conference on Engineering Design, ICED '07, Vol. 5,* Paris, August 2007.

Pohl, K. (2008). *Requirements Engineering – Grundlagen, Prinzipien, Techniken*, 2nd edition, Heidelberg: depunkt.verlag.

Contact: Katharina G. M. Eben
Technische Universität München
Institute of Product Development
Boltzmannstrasse 15
86748 Garching
Germany
0049.89.289.15132
0049.89.289.15144
katharina.eben@pe.mw.tum.de
www.pe.mw.tum.de

Structural Analysis of Requirements – Interpretation of Structural Criterions

Katharina G.M. Eben
Udo Lindemann

Institute of Product Development
Technische Universität München

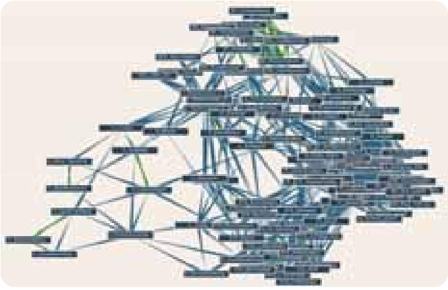
Technische Universität München UNIVERSITY OF CAMBRIDGE

Outline

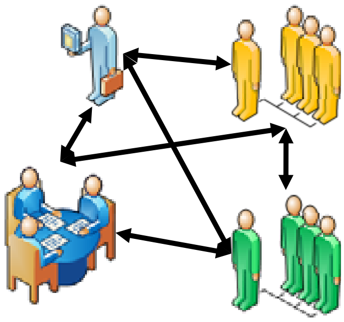
- Motivation
- Requirements Management and matrix-based approaches
- Structural Analysis of Requirements DSM
- Structural Criterions
  - Overview of interpretations
  - Application to example – Hotel Laundry Service
- Summary and Outlook

Motivation

- Rising complexity of products
  - Fast changing market demands
  - Rapidly evolving technologies



- Involvement of various stakeholders in development process
  - Customers
  - Multiple perspectives within enterprises



- Requirements management – support to handle these aspects

Requirements Management and Matrix-Based Approaches

- Procedures for the calculation and analysis of structural criterions
  - design of product architectures (Lindemann et al., 2009)
  - process management in engineering design (Kreimeyer, 2009)

- Existing matrix-based approaches for requirements management deal with:
  - building the network of requirements
  - Linking of requirements to components, working principles etc. (Akao, 1992; Maier et al., 2009; Baumberger and Lindemann, 2006).
  - do not cover the structural perspective within a requirements DSM. They mostly focus on requirements-components DMMs

- No exhaustive list of possible interpretations of criterions to support analysis of requirements networks

Akao, Y. (1992). QFD – Quality Function Deployment, Landsberg/Lech: Moderne Industrie.
Baumberger, C., & Lindemann, U. (2006). Requirement oriented process planning and configuration, In Proceedings of NordDesign 2006, August 2006.
Lindemann, U., Maurer, M., & Braun, T. (2009). *Structural Complexity Management – An Approach for the Field of Product Design*. Berlin: Springer.
Kreimeyer, M. (2010). *A Structural Measurement System for Engineering Design Processes*. Munich: Dr. Hut 2010.

Structural Analysis of Requirements DSM

- Requirements modelled in a DSM
- Edges represent the existence of influence on other requirements
- Structural analysis
- Interpretation of structural criterions

→ Support of definition of tasks in requirements management
  - Assessment and Improvement of quality of the requirements model
  - Identification of significant and critical elements and relations
  - Support of also the classification of requirements
  - Support of evaluation of impact of changes

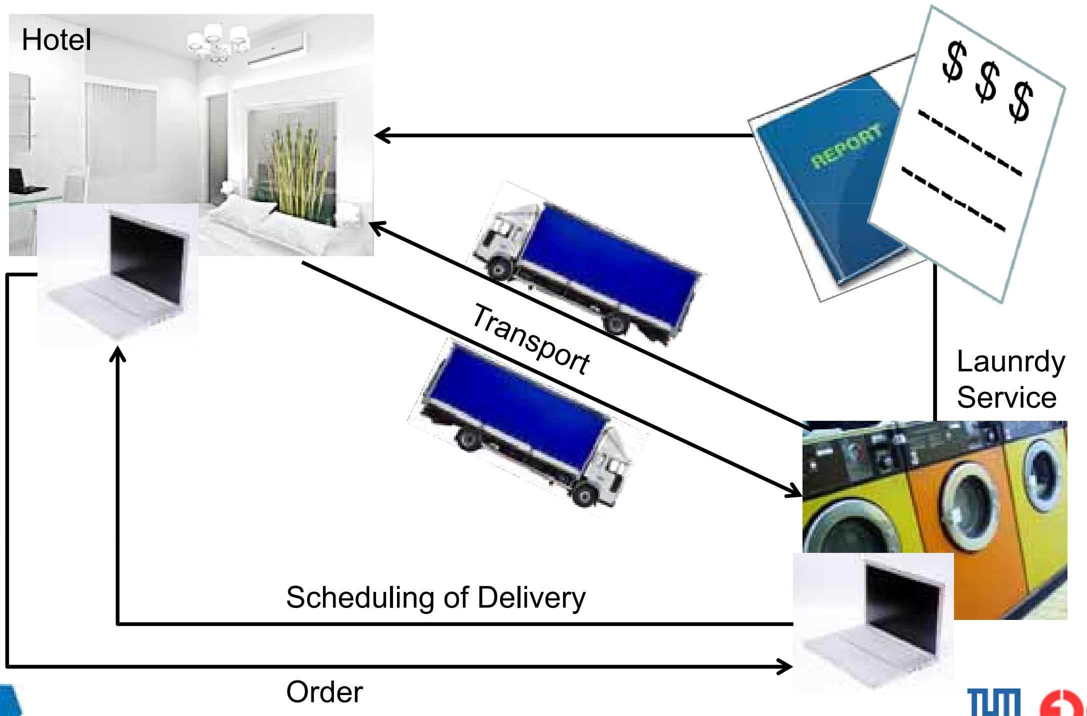
BY MODELLING DEPENDENCIES MANAGING COMPLEXITY

Structural Criterions - Overview

Structural criterion	Explanation according to Lindemann et al. (2009)	Structural significance of requirements – single nodes – meaning
Activity	Degree of incoming to outgoing relations	The activity stands for the intensity of the requirement's influence on other requirements.
Passivity	Degree of outgoing to incoming relations	A highly passive requirement is affected by many others. It might be a source of uncertainty, e.g. concerning the probability of changes.
Criticality	Multiplication of active sum (sum of outgoing edges) and passive sum (sum of ingoing edges)	A requirement with a high criticality affects and is affected by a large number of other requirements. Because of its high importance in the system it should be given a high priority (Eben et al., 2010).
Reachable nodes	Number of nodes reached directly or via possible paths	Influence of requirement on others within the whole model or requirements, impact of its change
Articulation node	Single node linking two subsets	The requirements links otherwise independent subsets of requirements. This requirement can for example represent an important interface or interaction in the regarded system.
Start	Only outgoing relations	The requirement only influences one other directly, but it has a possible impact on various others via paths. The whole system is affected, the whole system might be affected
Leaf	Only related to one other node	The requirement only influences or is influenced by one other directly. Not necessarily the whole requirements structure is affected by the requirement.
End	Only incoming relations	The requirement is only directly influenced by one other requirement. The requirement can be changed without causing any impacts.
Isolated node	No outgoing and no incoming relations	The requirement can be regarded on its own, if no relations to others have been neglected.

Structural criterion	Explanation according to Lindemann et al. (2009)	Structural significance of requirements – subsets of nodes – meaning
Cluster	Subset of highly interconnected elements with few links to elements outside	Requirements forming a cluster may belong to the same class, e.g. functional requirements (Eben et al., 2010) and be highly interdependent.
Path	direct or indirect connection of two nodes by edges	Requirements connected via a path to a requirement can be affected by a change of the latter (Eben et al., 2010).
Feedback loop	two or more nodes that are interlocked sequentially by edges	Requirements connected in a cycle might form a conflict (Eben et al., 2010).
Hierarchy	sub graph represented as tree	Requirements of a lower hierarchy level may inherit the priority of higher level ones. Different lengths of paths between requirements may point at missing ones (Eben et al., 2010).
Independent subsets	Subsets of nodes not linked bay relations (Kreimeyer, 2010)	A subset of requirements having no influence on other subsets can be regarded separately, if no relations or other requirements have been neglected.
Similarity	amount of identical connections of nodes to surrounding nodes	Requirements with similar relations can be addressed at the same function or component. Or they can be summarized within a certain class of requirements.
Quantity of indirect dependencies	Number of indirect paths between two specific nodes	Two requirements – even if not directly connected – may have a high influence on each other.

Set-up of Example – Hotel Laundry Service



Laundry Service - Interpretation of Structural Criterions

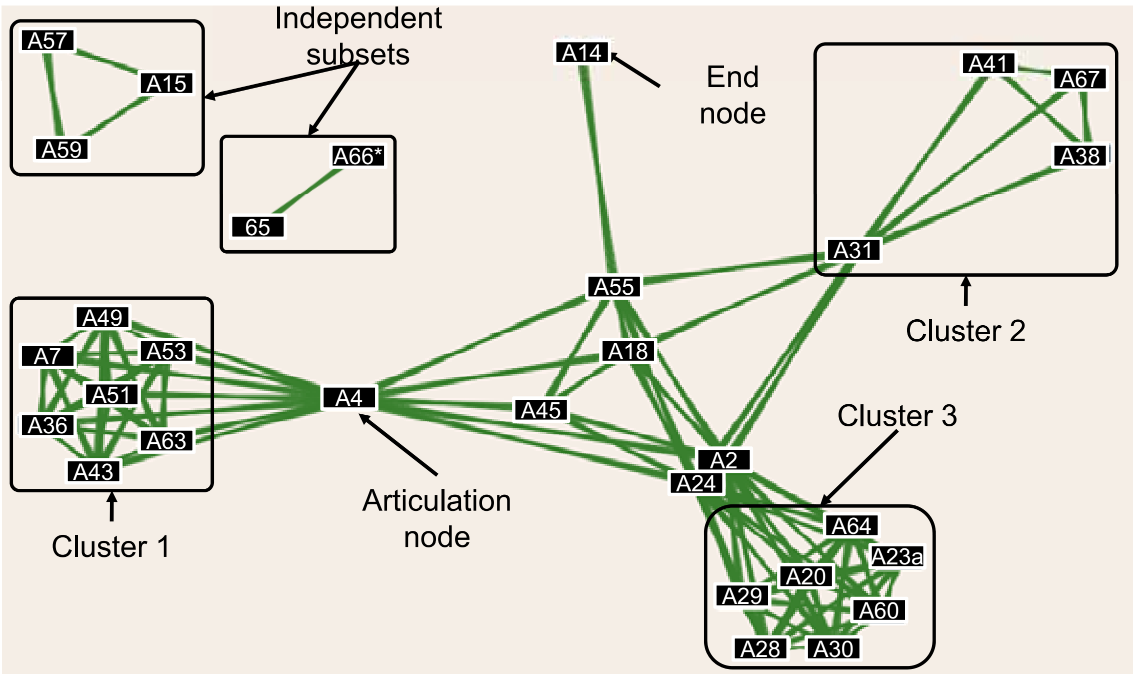
		A2	A4	A7	A14	A15	A18	A20	A23a	A24	A28	A30	A29	A31	A36	A38	A41	A45	A43	A51	A53	A49	A59	A60	A55	A57	A65	A66*	A63	A64	A67
A2	clean laundry		1				1	1	1	1	1	1	1	1				1						1	1					1	
A4	delivery in time	1		1			1			1					1			1	1	1	1	1			1				1		
A7	correct management of cleaning process		1												1				1	1	1	1							1		
A14	payment dependant on laundry amount																								1						
A15	monthly report																						1			1					
A18	manageable packages for delivery	1	1							1				1				1							1						
A20	environmental sustainability of detergent	1							1	1	1	1	1											1						1	
A23a	antiallergenic detergent	1						1		1	1	1	1											1						1	
A24	no damage of silk laundry	1	1				1																							1	
A28	environmental sustainability of bleach	1																												1	
A30	additional bleaching of tablecloths	1						1	1	1	1		1											1						1	
A29	additional cleaning of tablecloths	1						1	1	1	1	1												1						1	
A31	reassignment of personal laundry of hotel guests	1					1			1						1	1								1						1
A36	management of kitchen towels		1	1															1	1	1	1							1		
A38	data management via online platform													1			1														1
A41	data privacy protection hotel guests													1		1															1
A45	storing facilities for clean laundry	1	1				1			1															1						
A43	availability of planning software		1	1											1					1	1	1							1		
A51	delivery time of bed-linens		1	1											1				1		1	1							1		
A53	delivery time complete laundry		1	1											1				1	1		1							1		
A49	delivery time towels		1	1											1				1	1	1								1		
A59	VAT Registration Number in invoice					1																				1					
A60	maximum water quantity per cleaning process	1						1	1	1	1	1	1																	1	
A55	record of stock keeping	1	1		1		1			1				1				1													
A57	monthly report without staff data					1																	1								
A65	monthly invoice																											1			
A66*	minimum of profit margin																										1				
A63	minimum amount of laundry for cost efficiency		1	1											1				1	1	1	1									
A64	maximum cost of coloured laundry detergent	1						1	1	1	1	1	1											1							
A67	service only within Munich													1		1	1														

requirement has influence on requirement

Laundry Service - Interpretation of Structural Criterions

A2	clean laundry	A41	data privacy protection hotel guests
A4	delivery in time	A45	storing facilities for clean laundry
A7	correct management of cleaning process	A43	availability of planning software
A14	payment dependent on laundry amount	A51	delivery time of bed-linens
A15	monthly report	A53	delivery time complete laundry
A18	manageable packages for delivery	A49	delivery time towels
A20	environmental sustainability of detergent	A59	VAT Registration Number in invoice
A23a	antiallergenic detergent	A60	maximum water quantity per cleaning process
A24	no damage of silk laundry	A55	record of stock keeping
A28	environmental sustainability of bleach	A57	monthly report without staff data
A30	additional bleaching of tablecloths	A65	monthly invoice
A29	additional cleaning of tablecloths	A66*	minimum of profit margin
A31	reassignment of personal laundry of hotel guests	A63	minimum amount of laundry for cost efficiency
A36	management of kitchen towels	A64	maximum cost of detergent for coloured laundry
A38	data management via online platform	A67	service only within Munich

Laundry Service - Interpretation of Structural Criterions



BY MODELLING DEPENDENCIES MANAGING COMPLEXITY

Laundry Service - Interpretation of Structural Criterions

- Leaf Node – A14 "payment dependent on laundry amount"
  → hardly influencing remaining system, only dependent on A55
- Independent subsets – A65-A66* and A57-A59-A15
  – Requirements concerning book-keeping of the laundry service
  → missing relation to requirement of the contents of the monthly report
- Articulation node – A4 "delivery in time"
  – linking cluster 1 to remaining requirements
  → important interface – handling of scheduling of delivery dependent on definition of cluster 1
- Cluster 1 – delivery times and management constraints
- Cluster 2 – local circumstances
- Cluster 3 – cleaning process

BY MODELLING DEPENDENCIES MANAGING COMPLEXITY

Laundry Service – Requirements with High Criticality

Crit.	No.	Requirement		Crit.	No.	Requirement
				49	A7	correct management of cleaning process
169	A2	clean laundry		49	A31	reassignment of personal laundry of hotel guests
169	A24	no damage of silk laundry		49	A36	management of kitchen towels
144	A4	delivery in time		49	A43	availability of planning software
64	A20	environmental sustainability of detergent		49	A51	delivery time of bed-linens
64	A23a	antiallergenic detergent		49	A53	delivery time complete laundry
64	A28	environmental sustainability of bleach		49	A49	delivery time towels
64	A30	additional bleaching of tablecloths		49	A55	record of stock keeping
64	A29	additional cleaning of tablecloths		49	A63	minimum amount of laundry for cost efficiency
64	A60	maximum water quantity per cleaning process		36	A18	manageable packages for delivery
64	A64	maximum cost of coloured laundry detergent		25	A45	storing facilities for clean laundry

Summary and Outlook

Summary

- Analysis of requirements network
  - Identification of structural criterions
  - Interpretation of meaning of criterions concerning requirements
- Use of data set – Laundry Service
- Structural criterions – support of
  - Identification of significant requirements
  - Definition of possible tasks in requirements management
  - Estimation of impact of changes

Further work

- Application of structural analysis in context different to laundry service
- Examination of transferability of structural criterions to other contexts