Identifying the Quality of E-Commerce Reference Models

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ABSTRACT

The development of information and communication systems, in particular e-commerce systems, is a complex and time intensive task. The development process can be simplified by using reference models. Many reference models for the electronic commerce, such as the model for electronic markets by SCHMID & LINDEMANN (1997) and the OBJECT MANAGEMENT GROUP reference model are known. However, they tend to concentrate on specific aspects of the problem and give insufficient attention to all aspects of good model quality. A number of requirements are important in constructing a reference model as the quality of the construction invariably impacts the quality of the final model. To determine the quality of a reference model and its construction process an analysis scheme was designed and tested in a case study with a German standardization institution. The practical application of the analysis scheme reveals deficiencies and strengths in some reference modelling processes.

General Terms

E-Commerce Reference Models

Keywords

E-Commerce, Reference Model, Process Analysis, Quality Criteria

1. INTRODUCTION

The implementation of information and communication systems within a company is an always present task. The new generation of information and communication systems focusses on electronic commerce, for instance on electronic marketplaces, online billing, webservices and support of the electronic supply chain. The handling of very complex but regularly occurring questions can be supported by reference models. They contain knowledge gained in years of work and project experience. The usage of reference models offers, besides a raise in quality, a risk, cost and time reduction. Quite a lot reference models for electronic commerce are known, for instance the *reference model for electronic marketplaces by Kollmann*, the *model for electronic markets by Schmid and Lindemann* and the *Object Management Group reference model*. But all those models focus on specific points of customer requirements. None of the models pays attention to all customer requirements. On the other hand at the present time many companies start to develop own reference models as well. Those reference models are developed more or less through user consensus and barely using scientific knowledge. This can lead to a situation were the reference models fit very well for a few customers but not for all of them. But the quality of the development process has a strong impact on the quality of the model. So developing reference models for electronic commerce just by acknowledging the requirements of influential user or customers can result in a low quality of the models which are not used and which will not be accepted by the users.

This article introduces a theoretical based analysis scheme to examine the quality of reference modelling processes. It describes the relation between the requirements for reference models and sub processes of the reference modelling process. In a case study the scheme will be applied to identify the quality of an e-commerce integration process which can be found on a marketplace or on peer-to-peer networks between buyers and sellers, customers and suppliers. The defined processes in e-commerce represent reference models for the engineers of the models as well as for the customers.

2. REFERENCE MODELLING

Reference modelling is a special field of the information systems (re-)engineering and pursues content and methodical aspects of the development and implementation of reference models [29, 23].

A reference model is defined as a model, which supports the modelling and optimization of business processes [22]. Therefore these models can be seen as an advice or recommendation for forming an organization. They provide enterprises with an initial process engineering solution. Reference

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Table 1: Requirements for reference models

Requirements of Reference Models	Description
Universal Validity	Potential usability for derivation of individual models; based upon the completeness, adaptability and usability of the reference model
Completeness	Orientation on a methodical frame; integration of all necessary structures, processes and data
Adaptability	Possibility to adapt the reference model to different situations
Extendibility	Possibility to extend the reference model, for instance new processes
Usability	Supporting the derivation of individual models; reference model has to be detailed enough to be implemented
Re-usability	Re-use of knowledge "stored" in the reference model
Acceptance	Willingness to accept external solutions

models can be constructed in two ways:

- Best practice approach
- Theoretical knowledge approach

The development based upon real-world situations gathers the best practice knowledge in an industry, whereas the theoretical development of reference models relies on knowledge about a specific issue [20].

To analyze and evaluate the construction process of a reference model theoretical experiences have to be taken into consideration. Scientific papers of Schütte [25], Schlagheck [23], Becker et al. [3] and Remmert [20] have already had a big impact on the development of the field of reference modelling.

This theoretical basis allows the derivation of seven requirements as illustrated in table 1. These requirements represent the characteristics of reference models.

As seen in the table the requirements consciously focus on technical characteristics of reference models. These technical aspects are more likely to measure than "soft" factors with psychological background, i. e. fears, needs or wants of the users. Nevertheless, they play an important role in the quality of a reference model and are part of the interpretation of the results.

3. E-COMMERCE REFERENCE MODELS

E-Commerce is the ability to perform exchanges of goods, services, assets and money, using electronic tools and techniques [1]. The electronic commerce enables the spreading of modern information technologies. It is characterized by a high dynamic development and a high complexity designing and implementing information systems. The evolution of e-commerce in the past years led to various ambitions to develop reference models very quickly. Those models are developed under special foci and are not able to cover the requirements on reference models derived in chapter 2. To illustrate this lack four reference models for e-commerce have been chosen. They have gained recognition by their frequent application in science and references in literature. The in the following briefly explained models are:

- OMG Electronic Commerce Reference Model
- Reference Model for Electronic Marketplaces by Kollmann
- Reference Model for Electronic Markets by Schmid & Lindemann

The evaluation of the reference models, as illustrated in figure 1, is derived on the basis of arguments as well as substantiated in studies. The requirements on reference models are represented by squares. The models are illustrated as ellipse, whereas a requirement is considered to be fulfilled as soon as the ellipse intersects the square.

The OMG (Object Management Group) **Reference Model for electronic commerce** has been developed by the OMG Electronic Commerce Domain Task Force (EC-DTF). It describes a high-level object-oriented framework specifying the requirements for electronic commerce systems designed in accordance with the OMG's Object Management Architecture. The architecture provides a similar multi-layer interpretability framework. Functional requirements which are related to each other are grouped into facilities. These facilities are categorized into market infrastructure, commerce facilities, and low level services [26].

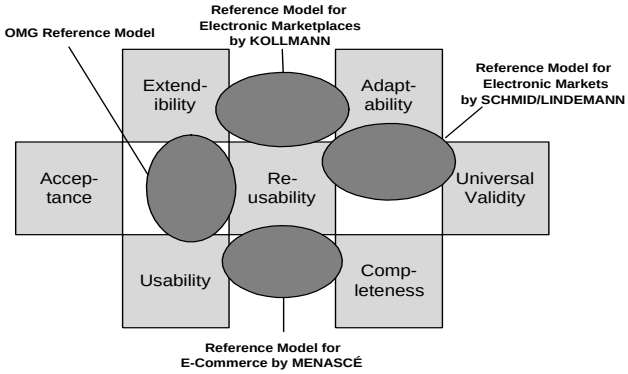

Figure 1: Fulfillment of the Requirements

The emphasis of this model is the supply with an interpretability of different solutions, instead of a single unified solution for all market participants. The focus of the OMG reference model lies on technical aspects. The *completeness* of the model which would contain aspects of the management as well is not given.

The **Model for Electronic Marketplaces** by Kollmann was introduced in 2000. He criticizes the missing attention

for the connection between supply, demand and the intermediary and the communication between these parties. He identifies three kinds of electronic trade: electronic supply hierarchy, electronic demand hierarchy, electronic market, whereas the electronic market is run by an intermediary. These parties form the so called strategic triangle whereas the coordination of the trade over the marketplace and the definition of the transactions is realized by the intermediary [13].

The model of KOLLMANN gives a very broad description of the structure of electronic marketplaces and focusses on the strategic triangle. The depiction is very general and lacks a specified reflection of structures. Likewise market transactions are not reflected in the reference model as well. Hence, the support for the design of a marketplace is rarely given as the *completeness* as well as the *general validity* of the reference model is not fully available.

SCHMID and LINDEMANN introduced a **reference model for electronic markets** in 1997. Several changes have been made, yet the basis remains unchanged. The objective of the model is the continuous transaction handling. Therefore the model is divided into a horizontal and a vertical dimension. Vertically the business view, the implementation view, the transaction view and the infrastructure view are distinguished. Horizontally the reference model discriminates between an information, agreement and settlement phase whereas the information phase was divided into knowledge and intention phase in 1999. Although the reference model is very complex it rather gives a rough description of an electronic market than a scheme how to build an electronic market. Thus it can be considered as a framework for research but not for the implementation of an electronic market. Hence, it is not *usable* without modification and a more detailed description of the components [24, 14].

The **Reference Model for designing E-Commerce Systems** was introduced by MENASCÉ. It provides a basis for the understanding and discussion of e-commerce issues. Therefore it is divided in three submodels: the business level model, the customer behavior model and the IT resource model. Thus, the model focusses on the offer of a company within the e-commerce, the customer utilisation and the interaction with an e-commerce site and the essential IT resources [17].

Whereas the OMG reference model is rather concentrated on the technological view the other ones are describing the administrative view. All three reference models lack the fulfillment of certain requirements. Mostly the *completeness*, *general validity* and *usability* are not fully given as the degree of abstraction is very high together with a merely concentration on specific aspects of a market place. Only the reference model by MENASCÉ is discussing different aspects of e-commerce which are the business, the customer behavior and the information technology resources. This underlines the need for quality management to reveal deficits. As the figure shows the most common fulfilled requirements are the *re-usability*, the *extendibility* and the *adaptability* because all models have a high degree of abstraction and are likely to be modified without any changes of the concept.

The case study gives an example for an e-commerce reference model which is examined to evaluate the quality of the model and its construction process in practice.

4. DERIVING AN ANALYSIS SCHEME

Neither scientific approaches nor the ambitions in practice have made effort to measure the quality of the engineering process of reference models. For implementing the qualitative analysis an evaluation framework needs to be developed. This allows the user-oriented measurement of the engineering process on the basis of specific characteristics.

The description of the engineering steps combined with the customer orientated "Quality Function Deployment" leads to the development of an analysis scheme which is used to analyze the quality of the reference model engineering process in practice.

4.1 Subprocesses

The requirements on reference models refer to necessary characteristics extracted from theoretical works by SCHÜTTE [25], SCHLAGHECK [23], BECKER ET AL. [3] and REMMERT [20]. Thus the engineering steps are derived from the introduced procedural models. The results of this discussion are seven subprocesses, which determine the engineering process of reference models:

- Problem definition
- Requirement analysis
- Information gathering
- Setting conventions
- Documentation
- Construction
- Evaluation

4.2 Quality Function Deployment

The Quality Function Deployment guides the production process of goods from the development to the optimization ensuring the customer focus [12]. The highest priority is to develop goods and services which meet the expectations of the customers [19].

The core of the Quality Function Deployment is the House of Quality, as depicted in figure 2 ([12, 9]). Customers and design requirements are related to each other. Therefore it supplements an organized development process [12, 9].

The vertical dimension of the House of Quality describes the requirements of customers towards the product. To explore these preferences suitable information has to be collected, i. e. by market research or results of recent investigations [8]. The requirements are rated depending on their importance for the customers [9]. The next step is the evaluation of the product by the customer to identify deficits as well as potentials [12]. The horizontal dimension formulates the requirements for the design of the production process. They

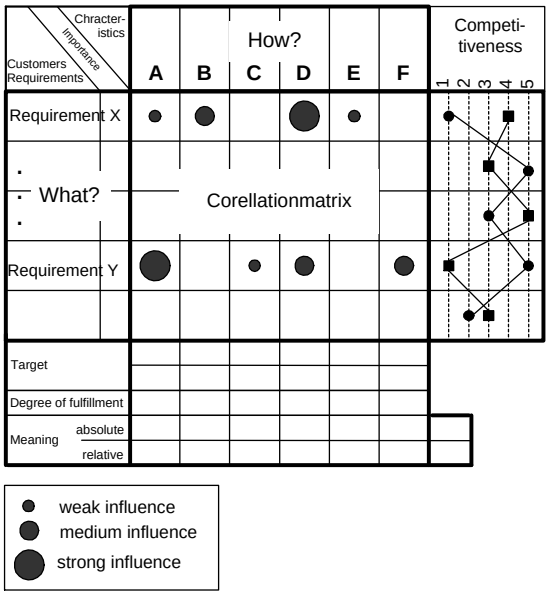

Figure 2: House of Quality [9, 10]

contribute to the fulfillment of the customer requirements in a certain intensity. This influence is symbolized through circles of different size. A small circle represents a weak influence whereas a large circle indicates a high influence.

4.3 The analysis scheme

The subprocesses of reference modelling support the fulfillment of the customer requirements. This coherency is illustrated in figure 3. The horizontal dimension focusses on the subprocesses itself, which are representing the requirements for the engineering process. The vertical dimension concentrates on the customer requirements on reference models.

The users of reference models have to evaluate the importance of each requirement (R_i). Moreover, they have to estimate in how far the reference model meets their expectations by defining the degree of fulfillment. These information indicate discrepancies between the importance and the fulfillment of the customer requirements. It emphasizes once more the costumer focus of the analysis.

The example illustrated in figure 3 shows that the requirement *completeness* is evaluated with a high importance (5) whereas the degree if fulfillment is low (2). It is to scrutinize, which subprocesses have an impact on the *completeness* of the reference model.

The influence of the subprocesses (S_j) on the realization of the customer requirements has to be determined by the engineers of the reference model. This influence is measured on a scale similar to the House of Qualities:

0 No Influence
1 Weak Influence
3 Medium Influence
9 Strong Influence

Regarding the example the discrepancy between the importance of a requirement and its fulfillment can be assessed by examining the activities, which influence the *completeness* of the reference model.

As the matrix shows, the subprocess problem definition (9) as well as the evaluation of the model (9) have a big influence on the *completeness*. The gathering of information has a medium influence since it was evaluated with 3. The other subprocesses occupy a low or no influence (influence ≤ 1).

For a cumulated observation of the influences which the subprocesses have on the requirements the analysis scheme needs to be extended (figure 4) to include the following components:

1. Realization of Characteristics

2. Influence of the subprocesses on the engineering process

3. Relative influence of the subprocesses on the engineering process

The realization of characteristics supports the measurability of the subprocesses. A detailed analysis of the subprocesses leads to characteristics which are directly measurable. A characteristic is a dichotomous variable {yes, no}. For instance, the subprocess *gathering information* is specified by the following characteristics:

- Enquiry of users of reference models
- Enquiry of cognoscenti
- Usage of conference proceedings
- Usage of theoretical based knowledge
- Market research
- Usage of existing enterprise (reference) models

The realization of characteristics is determined as:

$$RoC_{S_j} = \frac{Characteristics_{yes}}{Number\,of\,Characteristics_{S_j}} \qquad (1)$$

To determine the quality of the reference modelling process a ratio is defined. Ratios reduce the complexity of dependencies and relations of enterprise procedures and compress them to one value [28]. The ratio (Q_{RM}) for the engineering process of reference models is used to compare the construction quality of a variety of reference models.

To determine the quality key ratio the influences of the subprocesses on the engineering process have to be known. This influence is relativized with the importance of each customer requirement. Thus, the influence of a subprocess is the column sum of the importance of each requirement multiplied with the influence of the subprocess on this requirement.

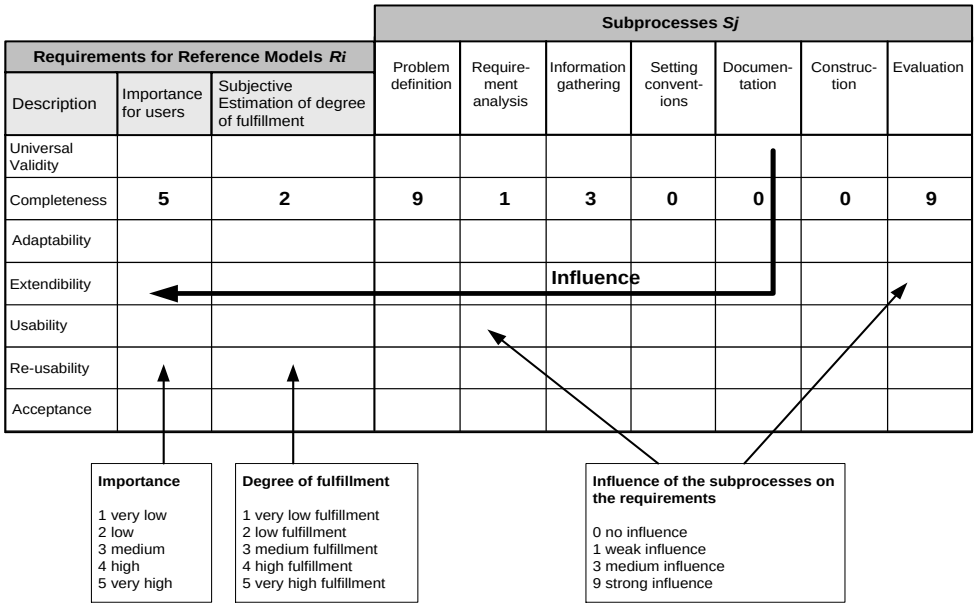

Figure 3: Analysis Scheme

The example shows, that the influence of the *problem definition* (9) on the engineering process is determined with $5 \cdot 9 = 45$. The relative influence is derived from that.

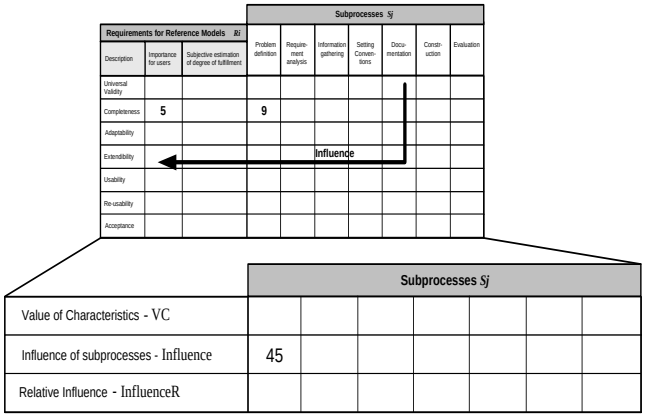

Figure 4: Extended Analysis Scheme

Using the realization of characteristics (RoC_{S_j}) as well as the relative influence of all subprocesses the quality ratio Q_{RM} is calculated as:

$$Q_{RM} = \sum_{j=1}^{7} (RoC_{S_j} \cdot InfluenceR_{S_j}) \qquad (2)$$

The quality key ratio constitutes an instrument for the evaluation of the quality of a reference model engineering process. As it is hardly possible to judge over the quality of a reference model by one figure the dependencies within the analysis scheme need to be interpreted.

5. CASE STUDY

In March 2004 the analysis scheme was implemented in a practical application. In cooperation with a German standardization institution the scheme had to be applied to an e-commerce integration process. The German institution is responsible for the definition of e-commerce standards for European companies such as Kraft Food, Nestl and Metro AG. The standards are also used for the procurement and distribution processes between small and medium-sized enterprises.

The analyzed e-commerce process describes the integration of logistic service providers into the supply chain. The reference process consists of three basis modules which define the responsibilities between the industry, the retailer and the service provider who supplies with transport as well as warehouse services. These modules are:

- Purchase order processing
- Transport activities
- Warehouse activities

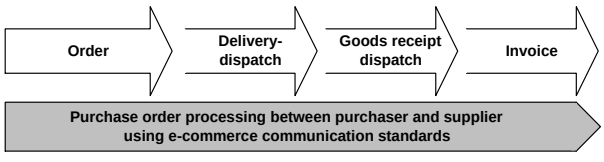

Figure 5: Module 1 - Purchase order processing

The basis modules are extracted from an analysis of depending business processes and are specified through basis processes which allow the derivation of scenarios by combining the modules. Figure 5 shows the simplified module of the

purchase order processing with communication standards. The transaction of information is realized with standardized message profiles containing fields for necessary and optional data. Based on a functional concept the actors within the distribution process are considered to be sender and recipient of the messages. In the derived scenarios the functional concept is replaced by specific terms defining the parties of the transaction. So different process variants in practice can be reproduced, e. g. transport and warehouse activities are provided by the same service provider or these two activities are split between two providers which then need an additional communication process whereas the documents are defined by the reference model.

Doing the analysis the institution acted as an engineer of reference models and few selected customers representing the users of reference models were interviewed. Standardized questionnaires as well as interviews for the validation of the information were used to acquire the data for the matrix.[1]

The following section introduces the results of the application of the analysis scheme on the e-commerce process describing the integration of a logistic service provider in the distribution process. The interpretation is supported by profile and portfolio techniques [2]. The profile technique visualises the existing data as well as the succeeded evaluation of the reference model and prepares it for a comparison. The orderly reproduction enables the recognition of strengths and weaknesses of the reference model.

5.1 Importance of customer requirements and their degree of fulfillment

One aspect of the analysis scheme is occupied with the importance of the seven requirements from the customers' point of view and additionally focusses on the degree of the fulfillment of these requirements. Figure 6 reflects this issue.

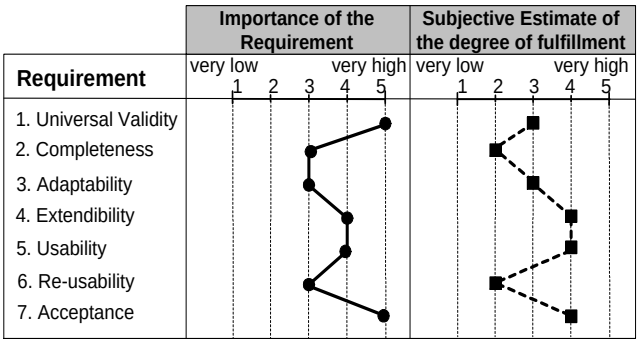

Figure 6: Relation between the importance and the requirement's degree of fulfillment

The analysis has shown that the requirements *universal validity* and *acceptance* are of high importance (5) for the users. Yet, the examination shows that the *universal validity* is rated with a medium degree of fulfillment (3).

A medium importance (3) was named for the requirements *completeness*, *adaptability* and *re-useability*, whereas the *completeness* and *re-useability* are supported by the reference model with a low degree (2). The low degree of fulfillment implies first hints for an optimization of the reference model engineering process. Yet, the effort of optimization should be in relation with the importance of the customer requirements. As far as a requirement is of low or medium importance the effort for a high degree of fulfillment should be shifted to requirements with higher importance.

The isolated exploration of the users' and engineers' points of view neglects the influence of the subprocesses on the requirements mentioned for reference models. The combination of both views and the derivation of strategies to raise customer satisfaction are the essence of the following discussion. Hence, the subprocesses as well as the requirements are conjointly depicted in figure 7.

The reflection of the value of the influence of a subprocess on the belonging requirement is realized by circles within the scheme, as it has already been introduced by the Quality Function Deployment approach.

5.2 Influence of the subprocesses on the requirements

As shown in figure 7 the *completeness* of the reference model is strongly influenced (big circles) by a number of subprocesses. Likewise the *universal validity* as well as the *acceptance* can be modified by three subprocesses. However, the requirement of *adaptability*, *extendibility* and *re-usability* (small circles) can only be influenced to a low degree.

For the requirement of *acceptance* a very high importance was detected (see figure 6). As the degree of fulfillment is low high potentials of influence for the engineers are disclosed. The users' satisfaction is therefore raised by a modification of the subprocesses *problem definition*, *requirement analysis* and *information gathering*.

The improvement of the *usability* of the reference model is supported by the subprocesses *requirement analysis* and *documentation*. These two processes fulfill a large number of required characteristics which is reflected in the positive assessment of the requirement.

The fundamental characteristics of a reference model namely the *adaptability* and *extendibility* can only be influenced through the engineering process to a minor degree. Nevertheless as these requirements are essential process requirements the whole engineering process is to scrutinize. Especially the formulated engineering steps point out potentials for optimization and supplementation.

[1]Regarding the enterpriser's wish for anonymity the confidentiality of the company was assured.

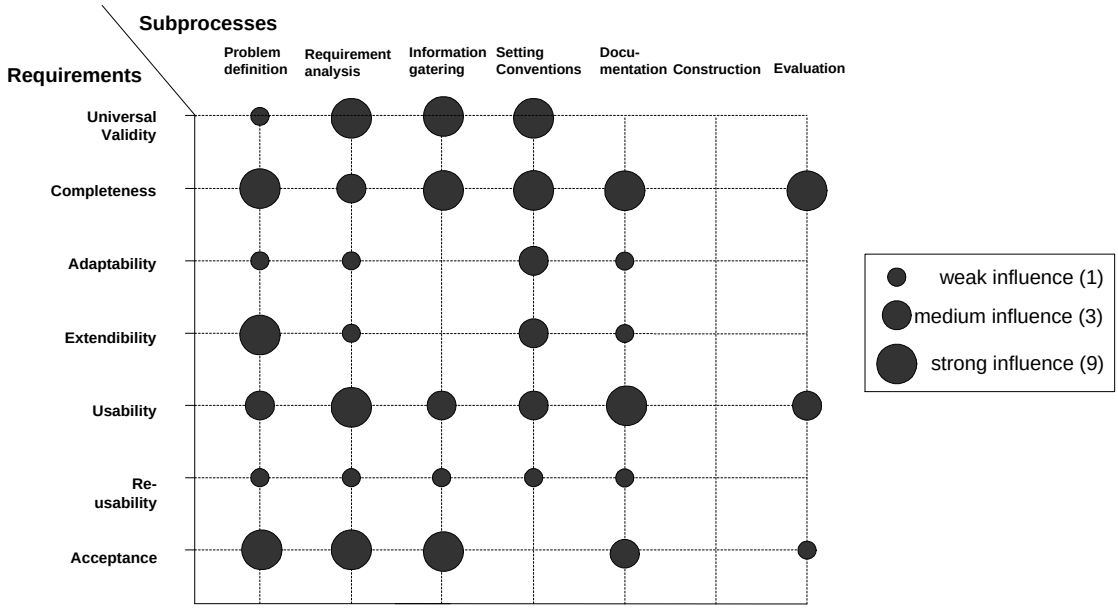

Figure 7: Influence of the subprocesses on the requirements

6. CONCLUSIONS

E-Commerce reference models support the developers of electronic commerce processes or systems like marketplaces. Using these models time and costs can be saved and the quality of the final system can be raised. In the field of reference modelling first steps are done but a solution which takes note of all customer requirements cannot be found. This lag is important because the quality of the final reference models depends on the fulfillment of these requirements. The requirements can be identified in the final models as well as on the construction process of the model. The goal of reference models constructors' should be models with the ability of high quality results.

The interpretation of the information gathered by the case study using the profile and portfolio technique reveals that the *universal validity* as well as the *acceptance* of the reference model are very important requirements for the customers. Because of the management influence the cognitive factors have more importance than technical requirements such as the *adaptability* and *re-usability* of the reference model. The analysis of the subprocess clarifies that especially the initial phase of the project has a very strong influence on the quality of the reference model since the problem definition, the requirement analysis and the gathering of information provide a basis for further steps. This has already been recognized by the engineers of reference models. Yet, the attention paid to the problem definition and the gathering of information is assessed as low compared to the other subprocesses. Particularly the comprehension of secondary literature in the subprocess problem definition as well as a more detailed description of the business content is advised.

The interpretation of the relation between the requirements on reference models and the subprocesses shows that the two requirements with the highest importance for the users can be strongly influenced. The *completeness* of the reference model is the requirement which can be influenced most and hence contributes considerably to the quality of the reference model. Assuming the requirements are equally important, all requirements can, however, be derived from the *completeness* of the reference model.

In comparison with the theoretical e-commerce reference models the practical model covers the requirements *extendibility*, *usability* and *acceptance*. The other requirements are not involved and so it cannot be seen as a complete reference model. A combination of the model by Schmid & Lindemann and the practical model integrates the most requirements and would present a mixture of a scientific developed model and experiences in practice.

The construction of E-Commerce reference models which guarantees high qualified solutions is still a challenge for the constructor. Only with the knowledge of the electronic commerce and the knowledge of scientific work on reference models as well as of the construction processes of them, they can be developed, accepted and used worldwide and therefore to satisfy customers' needs.

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