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Abstract

Maturity models in the domain of IOS have been developed and used for organizational design and analysis. Nevertheless, they typically provide a heterogeneous and inconsistent picture of relevant problem spaces (e.g. Supply Chain Management, interoperability problems, etc.). This effect is aggravated by the lack of a thorough model or method for self-appraisal with respect to an organization's capabilities on technical, organizational and institutional levels to implement interorganizational processes. Our research attempts to fill this gap by constructing a maturity model for interorganizational integration that addresses the shortcomings of previous approaches. We analysed 23 maturity models in the domain of IOS to identify critical design elements for our own design process. We selected the model of Fraser et al. (2002) as our starting configuration that includes levels, characteristics, dimensions, elements and activities. From the analysis of alternative models we identified four additional design elements that we incorporated, namely class of entity, benefit, barrier and product. These extend the previously defined elements by Fraser et al. (2002).

Keywords: Maturity, Maturity model, Interorganizational systems, Design elements

1   Introduction

In today's globalized world businesses are increasingly involved in some kind of interorganizational activity ranging from basic electronic document exchange (e.g. invoices or delivery receipts) to participation in complex supply networks. B2B (Business-to-Business) functionalities have become a critical factor in enterprise systems like enterprise resource planning (ERP) systems (Carter et al., 2009).

Despite the perceived importance of growing B2B requirements within organizations the beneficial effects of interorganizational systems (IOS) (e.g. Holland 1995; Gebauer and Buxmann 2000; Christiaanse 2005) are still difficult to realize (Steinfeld et al. 2011). Impediments like uncoordinated and inconsistent integration attempts or obsolete

technologies (Lheureux et al. 2009) hinder organizations from engaging in an interorganizational relationship (e.g. Iacovou 1995; Markus 2005).

Different theoretical assumptions and models developed by academia and practitioners alike attempted to provide classification and assessment schemes for interorganizational systems (e.g. Reimers et al 2010; Williams 1997). The most prominent examples of these attempts are the so-called maturity models. In general, a maturity model "[…] consists of a sequence of maturity levels for a class of objects" (Becker et al. 2009) that outlines an evolutionary path from a bottom stage of maturity to the highest level of maturity (Paulk et al. 1993). Their overall purpose is to classify and assess the capabilities of an organization or information system in order to determine the appropriate maturity level with respect to a given set of requirements and goals.

In the domain of IOS our preliminary research identified that existing maturity models differ in various aspects like scope, model composition or method of application (Frick and Schubert 2011). In fact, this observation can be made for almost all maturity models in the domain of information systems (IS). Many maturity models lack a sound underlying theoretical approach and a holistic view of all relevant maturity issues of a domain (Mettler et al. 2010, Becker et al. 2010). Our overall research attempts to overcome these deficiencies by designing a holistic maturity model for interorganizational integration that is constructed based on a rigorous development strategy and a solid empirical base.

In our design approach we aim to reuse design elements from existing maturity models in the IOS domain. This initial premise for our first design cycle proved to be difficult to implement. We discovered many differing structural model setups in our sample of 23 IOS related maturity models that had few or no commonalities. Fraser et al. (2002) present one of the few attempts to identify basic design elements within maturity models: (a) levels, (b) a summary of characteristics of each level, (c) dimensions and (d) elements respectively activities for each dimension. Still, our initial observations identified that due to the heterogeneous character of the available maturity models these design elements differ in number, scope, domain-specific attributes etc. Therefore, our research question is the following:

Which are the suitable design elements of existing IOS related maturity models that can be reused for the development of a holistic maturity model for interorganizational integration that addresses the shortcomings of previous approaches?

The results presented in this paper reflect on the fourth phase of our longitudinal research project, namely the iterative maturity model development. This phase is part of a procedure for maturity model development adapted from Becker et al. (2009) and de Bruin et al. (2005) and encompasses several iterative design cycles within the development of the maturity model.

The following chapter provides a literature overview and a critical appraisal of maturity models in IS. Chapter 3 describes our research approach within this fourth phase of the development procedure. Chapter 4 discusses the comparative analysis of the 23 maturity models identified within the domain of IOS. The final chapter offers some concluding remarks, limitations of this work and outlines potential for future research.

2 Critical Appraisal of Maturity Models in IS

The concept of maturity models has existed in the domain of IS for several decades. Nolan's (1973) stage model was one of the first attempts to provide some kind of framework that allowed outlining the evolution of an initial stage in Enterprise Data Processing to a more mature stage. Several other authors followed this example and developed maturity models for e.g. Quality Management (Crosby, 1979), Use of ERP Systems (Holland and Light 2001) or Supply Chain Management (Lockamy and McCormack 2004). The Capability Maturity Model (CMM) has become on of the most prominent examples of a maturity model description and assessment (Paulk et al. 1996). It was developed by the Carnegie Mellon Software Engineering Institute (SEI) and comprises five stages (Initial, Repeatable, Defined, Managed and Optimizing) that organisations go through as they move from an immature to a mature understanding of business processes.

CMMs success probably led to a growth in maturity models in the domain of IS. Since 2000 the number of maturity models multiplied n-fold (Mettler and Rohner 2009). By 2005 more than 150 maturity models existed (de Bruin et al. 2005). The popularity of these models can be derived from the perceived ease-of-use as most maturity models present a rather abstract but intuitive hybrid of a model description (in terms of defining maturity levels and their evolutionary structure) and method of application (in terms of assessment methodology and improvement measures) (Mettler et al. 2010). However, academia has taken a more critical stance towards these models in recent years (e.g. de Bruin et al. 2005; Mettler and Rohner 2009; Becker et al. 2009; Pöppelbuß and Röglinger 2011). Typical, but not exhaustive, areas of critiques are: purpose of use, general model structure and model evaluation.

2.1 Purpose of Use

De Bruin et al. (2005) define the purpose of a maturity model as the structured guidance through an evolutionary progress by evaluative and comparative measures. But most organizations find themselves in a rather unique environment in terms of used IT, applied business processes or business partnerships. Therefore, model designers try to cover a broad range of organizations within their intended domain-specific user group by providing an abstract description of the maturity levels and their respective assessment criteria. Consequently, many maturity models open themselves to the critique of simplicity. Nolan's (1973) stage model was one of the first models that were subject to this kind of critical appraisal (Benbasat et al 1984; King and Kraemer 1984). The main argument about the rather simplistic construction of these models was the design of a sequential step-by-step maturity without any aspect of evolutionary change and no empirical evidence to evaluate the suggested design. Interestingly, after about 30 years of maturity model development this argument still holds for the majority of maturity models (Pöppelbuß and Röglinger 2011).

2.2 General Model Structure

The successful impact of the Capability Maturity Model (CMM) tempted authors to adapt its structural build-up to their own maturity models (Becker et al., 2010). Consequently, many maturity models in the domain of IS were classified as *CMM-like* (Fraser et al. 2002). Fraser et al. (2002) identified further model types as *Maturity Grids*

(array-like structure with level- and aspect-related statements), *Likert-like* (assessment of maturity aspects according to questionnaires) and *Hybrids* (combination of Maturity Grids and Likert-like model structure).

Yet, an overall classification of maturity models or a basic reasoning for the choice of model structure is rare. Many researchers use implicit structural definitions like Solli-Sæther and Gottschalk (2010): Maturity models typically consist of several stages that are (1) sequential within their evolutionary progress, (2) represent a hierarchical structure that cannot be reversed easily and (3) encompass a broad collection of organizational activities and structures. Mettler et al. (2010) set out to develop a complete classification framework of maturity models in the IS domain based on an analysis of 117 maturity models in IS literature. They identified three dimensions that cover all relevant aspects of a model: (1) General Model Attributes serve mainly as a descriptive part for the model's assessment, (2) the Maturity Model Design deals with conceptual issues like construction and organization of the model, (3) The Maturity Model Use covers the deployment, the suggested assessment and practicality. Each dimension encompasses a distinct set of attributes that represent a requirement or property of the maturity model.

Still, this classification scheme does not provide a categorization or even identification of necessary design elements of a maturity model. The conceptual analysis by Fraser et al. (2002) is one of the few works that takes a deeper look at the actual model structure. They identify levels, descriptors for each level, a summary of characteristics of each level, dimensions, elements respectively activities for each dimension and a description of each element respectively activity as basic design elements of maturity models. However, without a proper derivation of the authors' decision for their model structure during the design process the choice of specific design elements and consequently the overall model design seems arbitrary (Pöppelbuß and Röglinger 2011).

2.3 Model Evaluation

Maturity models are typical design artefacts (Mettler and Rohner, 2009) that have to undergo some kind of evaluation to show their utility and applicability. Subject to evaluation can be: the process of model design, the quality and/ or the components of the maturity model design product (Pöppelbuß and Röglinger, 2011).

The *process of model design* is often unclear or not documented by the authors (Becker et al. 2009). This has a negative impact on repeatability, verifiability and completeness of the overall research steps. Authors like de Bruin et al. (2005), Maier et al. (2009) and Becker et al. (2009) set out to overcome this problem by providing future authors of maturity models with generic procedure models to conduct their model design.

The *quality of the design product* is even more subject to criticism than the design process. That does not mean that there is no empirical evaluation of the proposed model but (e.g. depending on the chosen benchmark variables) there can be differing conclusions about a proven validity (e.g. King and Teo, 1997) or a failed attempt to do so (e.g. Drury, 1983). This problem becomes more apparent when the overall model design and quality criteria are more abstract.

Current research still struggles for a common composition of a "good" maturity model in terms of the appropriate *maturity model components*. Suggestions range from a

general divide into a domain reference model and assessment model (Ofner et al. 2009) to a more detailed component description like Fraser et al. (2002) proposed (cf. Chapter 2.2). Pöppelbuß and Röglinger (2011) suggest so-called general design principles as a checklist for a proper model approach that encompasses basic (basic information, definition of central constructs related to maturity respectively application domain, target-group oriented documentation), descriptive (intersubjectively verifiable criteria, target-group oriented assessment methodology) and prescriptive (improvement measures, decision calculus for selecting improvement measures, target-group oriented decision methodology) design elements. They argue that the design elements (referred to as components) and their interplay constitute the model structure and therefore have to be defined at the beginning of every design process.

3   Research Approach

Our longitude research project aims at the development of a holistic maturity model for interorganizational integration. In academia there are few procedural model development approaches that delineate important and mandatory steps. De Bruin et al.'s (2005) model e.g. focuses more on the overall model use stating the phases *Scope, Design, Populate, Test, Deploy* and *Maintain*. Becker et al. (2009) follow Hevner et al.'s (2004) design guidelines to formulate specific design requirements reflecting in the phases *Problem definition, Comparison of existing maturity models, Determination of development strategy, Iterative maturity model development, Conception of transfer and evaluation, Implementation of transfer media, Evaluation* and *Rejection of maturity model*.

We chose to adapt Becker et al.'s (2009) procedural model as it is founded on the well-established principles for design science by Hevner et al. (2004) and provides a rigorous development strategy. Our preliminary research defined the development strategy (Frick and Schubert 2011): The main goal was not to extend a given maturity model or reinvent it, but rather reusing relevant and rigorous research results from previous model designs. In order to do so we revisited the analysed maturity models (23) and applied additional analytical lenses (Fraser et al.'s (2002) design elements of maturity models and Pöppelbuß and Röglinger's (2011) Design Principles) to the initial instrument of analysis (Mettler et al.'s (2010) classification framework) and performed a comparative analysis. This time the overall goal was not to initially inform the development strategy by comparing existing models but rather to identify existing design elements within the maturity models to determine the first instance of the iterative model design process and its structural setup.

4   Design elements in IOS-related Maturity Models

The domain of IOS as a sub-domain of IS comprises a significant smaller number of maturity models. We identified 23 maturity models through a thorough literature analysis comprising a keyword-based search in electronic journal databases (ACM Digital Library, AIS Electronic Library, EBSCOhost, Emerald, IEEE Xplore, INFORMS, ScienceDirect and SpringerLink). Most favourable contexts within the IOS domain are *Supply Chain Management* (Poirier and Bauer 2000; Skjoett-Larsen et al. 2003; Folinas et al. 2004; Lockamy and McCormack 2004; Handfield and Straight 2004; Butner and Geuder 2005; Srai and Gregory 2005; McLaren 2006),

Interoperability (Clark and Jones 1999; Kasunic 2001; Tolk and Muguria 2003; Brownsword et al. 2004; Benguria and Santos 2008; Guédria et al. 2009; Gottschalk 2009) and *Service Oriented Architectures* (Bachmann et al. 2006; Söderstöm and Maier 2007; Kreger et al. 2009). Further topics include Collaboration (Magdaleno et al. 2009; Tapia et al. 2009), Virtual Organizations (Venkatraman & Henderson 1998), Process Integration (Areee et al. 2008), E-Business (McKay et al. 2000) and Interorganizational IT (Williamson 2007).

Our preliminary classification of the identified IOS-related maturity models based on Mettler et al.'s (2010) classification scheme (cf. Chapter 2) revealed a heterogeneous collection of models differing in all three dimensions (cf. Table 1) that are discussed in more detail in the following chapters.

Dimension	Model / Attribute	Aggregated analysis results of 23 IOS-related Maturity Models
General model attributes	**Source**	Authors from academia and practice
	Domain/ Topic	SCM: 7; Interoperability: 7; SOA: 3; Collaboration: 2; Virtual Organizations; Process Integration; E-Business; Interorganizational IT
	Origin	Academia: 15; Business: 5; Government: 3
	Target audience	Academia: (20); Business: 22; Government: 4
	Year of publication	1998-2009
Maturity model design	**Concept of maturity**	Object/Process/People (Technological, Organizational, Institutional Maturity)
	Composition	CMM-like: 8; Maturity Grid: 15; Likert-Like: 0; Hybrid: 0
	Reliability	Single Case Studies; Questionnaires; No empirical evaluation
	Mutability	Form/ function: 0
Maturity model use	**Method of application**	Self-Assessment: (23)
	Support of application	Assessment tool: Questionnaires, no explicit tool recommended
	Practicality of evidence	Implicit/ explicit recommendations

Table 1: Classification of 23 IOS related maturity models (based on Mettler et al. (2010))

4.1   General Model Attributes

Overall, 15 models derive from academia, 5 from practitioners and 3 from governmental institutions. Almost all analysed models follow the basic design principles defined by Pöppelbuß and Röglinger (2011) in terms of stating the prerequisites for the application

domain, the purpose of use and the intended target groups. However, few of them proceed to define the *class of entities* that are under investigation. The intended target group, such as small and medium sized enterprises (SME) or supply chains (SC) is not specified, e.g. in terms of industry sectors, company size, etc. This observation confirms the critical appraisal of simplicity (cf. Chapter 2) as many organizations are set in a rather unique environment that has to be addressed in the maturity model structure.

The missing differentiations from related maturity models support this argument even further, as the construct itself is frequently not informed by existing model approaches. Tolk and Muguria (2003) and Söderström and Maier (2007) are exceptions as they merge and build on existing maturity model designs. Unfortunately, none of the authors describe their design process or provide documentation.

4.2 Maturity Model Design

Maturity models in the domain of IOS follow a very similar simplistic pattern as IS related models, in terms of providing an abstract description of maturity levels and assessment criteria. Five of the 23 analysed models (Folinas et al. 2004; Bachmann et al. 2006; Aryee et al. 2008; Benguria and Santos 2008; Tapia 2009) do handle the critique of simplicity by a refinement of assessment criteria. They attempt to exceed the descriptive nature of the model by suggesting prescriptive activities that are supposed to lead to an improvement of the assessed maturity level. By doing so, the authors implicitly extend the classic design elements of a maturity model (cf. Fraser et al. 2002) to a point where new design elements (e.g. explicit *beneficial effects* (Williamson 2007)) enrich the overall model structure.

Moreover, Williamson (2007) adds so-called *barriers* to his model design that define certain level- and dimension-specific problems that have to be overcome in order to reach the corresponding maturity level. Thereby, he extends the classic approach of a positive formulated maturity model to a more critical stance that accounts for potential hindrances. Benguria and Santos (2008) extend their maturity model design by so-called *work products*. They help to specify the practices that are allocated to each objective and its process area. Sonic Software Corp. (2006) include a similar element with their explicit allocation of electronic data exchange standards to the model dimensions.

The classic design elements like levels or dimensions can be found in all analysed maturity models. Thus, they all meet the basic design principles of *definition of central constructs related to maturity* and *definition of central constructs related to application domain*. However, the term maturity and the maturity paths are given implicitly as the authors invoke these core definitions by defining the maturity dimensions and maturity levels for their specific domain. Underpinning *theoretical foundations for the evolution and the change process* are rarely found.

Additionally, the design principle of having *intersubjectively verifiable criteria* for each maturity level is not met. The corresponding aspects that provide the actual description of a degree of maturity are often not precise and can be mixed up with adjacent level descriptions. The identification of criteria suitable for a later assessment is hard to conduct. As expected, most of the maturity models do not define any assessment criteria and respectively no measures for improvement.

4.3 Maturity Model Use

Consequently, we found no adequate method of application that indicated a third-party or even certified assessment. We assume that at least some kind of self-assessment will be possible. At best, there are fragmented evaluation attempts that were conducted to show the applicability of a model. Benguria and Santos (2008) introduced an assessment method (Assessment Preparation, Assessment Execution, Assessment Reporting and Assessment Follow-Up). However, this is not defined more precisely. Kreger et al. (2009) mention an assessment tool that is not part of their initial maturity model. The design principle of a *target group oriented assessment methodology* including a procedure model or advice on adaption and configuration of assessment criteria is not realized in most of the models analysed.

The same statement holds for the design principle of *target group oriented decision methodology*. Again, a procedural model or advice on the concretization and adaption of improvement measures cannot be found. Most descriptions of maturity paths leading to a more mature state are either vague in their prescriptive manner or remain on a descriptive level. We found no implemented prescriptive design principles.

5 Discussion of Findings

In our attempt to develop a maturity model for interorganizational integration we analysed 23 maturity models present in the domain of IOS.

We applied three analytical lenses to our initial findings: the classification framework from Mettler et al. (2010), the definition of design elements from Fraser et al. (2002) and the design principles from Pöppelbuß and Röglinger (2011). We found that almost all maturity models follow the basic design principles by implementing the already defined design elements from Fraser et al. (2002). Nevertheless, their general design approaches oftentimes reflect rather simplistic structural setups that fail to provide any reasoning for their initial design decision. Without a proper description of the underlying design process the chosen design elements for the maturity models seem arbitrary. Consequently, we derived our model structure on basis of a previously performed comparative analysis. We identified four new design elements that extend the already existing classic design elements:

- Class of Entity: defines the organizations of a target group on a more granular level and allows for possible model configurations within the same target group

- Benefit: defines a beneficial effect depending on the related aspect and allows for deduction of assessment criterion/ criteria

- Barrier: defines a problem space for reaching a related maturity level and allows for deduction of prescriptive activities to overcome

- Product: defines a tool for realizing a related practice and allows for support of a prescriptive activity

Their overall purpose is not only to refine existing modelling approaches but also to enable a more rigorous and relevant development of a maturity model: rigour in terms of complementing procedural design approaches for maturity models, relevant in terms of providing additional evaluation criteria for a more accurate assessment. There are additional elements that do not directly inform the maturity model itself but are

important for subsequent activities like the model assessment or the evaluation of the design: *Documentation of the design process, Procedure model for assessment, Procedure model for improvement* and *Documentation of assessment tools*.

6 Limitations and Further Research

Our comparative analysis is interpretive in nature. Nevertheless, we are confident that the application of three analytical lenses on 23 maturity models provides valuable results to this emergent research area. The applicability of our extended pool of design elements will become apparent when the first iterative design cycle is completed and the initial model design is evaluated according to Hevner et al.'s (2004) design guidelines.

Our maturity model approach covers relevant IOS issues and follows a rigorous design process. Still, the identified additional design elements in our model may also be applied to maturity models in the domain of IS. Overall, the call for a more rigorous design process in terms of process documentation and design reasoning should be answered in future maturity model design projects. This call especially applies to the development of a thorough and target group oriented assessment methodology for any maturity model. Up to now, our findings indicate either missing or insufficient assessment approaches. Both the design of an assessment methodology and the corresponding assessment criteria should be in focus of future research.

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