PACIS 2001 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

12-31-2001

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Abstract

Process modeling can be regarded as the currently most popular form of conceptual modeling. Research evidence illustrates how process modeling is applied across the different information system life cycle phases for a range of different applications, such as configuration of Enterprise Systems, workflow management, or software development. However, a detailed discussion of critical factors of the quality of process models is still missing. This paper proposes a framework consisting of six quality factors, which is derived from a comprehensive literature review. It then presents in a case study, a utility provider, who had designed various business process models for the selection of an Enterprise System. The paper summarizes potential means of conducting a successful process modeling initiative and evaluates the described modeling approach within the Guidelines of Modeling (GoM) framework. An outlook shows the potential lessons learnt, and concludes with insights to the next phases of this study.

Keywords

Process modeling, process management, conceptual modeling, modeling methodology, modeling tool, Guidelines of Modeling

1. Introduction

After the industrial revolution, with the influence of existing concepts as those of Henry Ford and Frederick Taylor, a "function oriented" approach, in which individuals concentrated only on one specific task, was the dominating organizational principle. The assumption was that a focus on specific functions lead to mass cost reduction effects and efficiency improvements. This perspective did work at the beginning, as it was easier to train mostly unqualified employees to do one small aspect of a bigger task. It involved very low degrees of investment and clearly defined simple individual processes (Kirchmer, 1998, Hammer and Champy, 1993). However, as the business arena started to evolve dynamically, weaknesses of this perspective began to hinder organizations from acting competitively. Increased interfaces reduced flexibility and influenced the probability of error to be high.

In response to this, Hammer and Champy (1993) proposed the "Business Process Re-engineering" (BPR) concept, which was further re-inforced by other contemporary theories as 'Process Innovation' (Davenport, 1993), Total Quality management (TQM), Time-based management, and value based performance measurements (Green and Rosemann, 2000a). Instead of individual employees being responsible for isolated functions, groups became responsible for a whole "process".

A 'process' is defined by Green and Rosemann (2000a, p.2) as "a self contained, temporal and logical order (parallel or serial) of those activities, that are executed for the transformation of a business object with the goal of accomplishing a given task". A process is simply a structured, measured set of activities designed to produce a specific output for a particular customer or market. It has a specific order of activities across time and place, with a beginning and an end and clearly identified inputs and outputs with a structure of action (Davenport, 1993 p.5; Bancroft, 1996).

This approach to business improvement, with its potential to achieve dramatic improvements in business performance has proved to be critical to the survival of contemporary firms (Craig and Yetton, 1994; Larsen and Myers, 1998). Organizations that have embraced the concepts of process management, have experienced how significant gains can be achieved from putting process issues first and technology issues second (Bartholomew, 1999; Evans, 1994). Various publications identify how process modeling is applied for process oriented management approaches (Becker et al., 1997; Rosemann, 2000; Curtis et al., 1992; Scheer, 1998a, 1998b).

Becker et al. (1997, p.2) define a process model as "the image of the logical and temporal order of functions performed on a process object" and state that they are the "foundation for the operationalization of process oriented approaches". Curtis et al. (1992) define a process model as an "abstract description of an actual or proposed process that represents selected process elements (components of a process - functional, behavioral, organizational, informational representation), that are considered important to the purpose of the model and can be enacted by a human or a machine" (Curtis et al., 1992, p.76). In other words, a 'process model' is a special information model that focuses on the order of activities within a business transaction. Process models can be used as a pure documentation of the present situation ('as-is' modeling) or to describe a new reality ('to-be' modeling).

A number of applications of process modeling have been identified in the literature, describing how process modeling can be used; as a means of cognitive support to make business logic more understandable; for documentation; for communication across different stakeholders; to reduce the required effort for obtaining the targeted status - by using best practice models; and as a means of simulation and benchmarking (Sarker and Lee, 1999; Scheer and Habermann, 2000; Scheer and Hars, 1992; Rosemann, 1998, 2000; Davenport, 1993; Carr and Johansson, 1995; Kettinger and Teng, 1997). A number of general frameworks for effective modeling approaches have been proposed. They are, however, focused on data modeling (Moody and Shanks, 1994, 1997; Batini et al., 1992) or address general issues related to conceptual modeling (Lindland et al., 1994; Krogstie et al., 1995; Pohl 1993).

This paper analyses a specific framework for process models; the 'Guidelines of Modeling (GoM)', which was designed based on the theory of semiotics. It evaluates a process modeling project conducted within one of the leading utility companies in Australia, based on the GoM framework's underlying concepts. The paper firstly, discusses the framework, secondly, introduces the case describing the overall project within which the process modeling activities were conducted, then introduces the modeling approach, and finally, evaluates the approach based on the findings extracted from the literature. It ends with analyzing the strengths and weaknesses of this approach and summarizing the potential lessons learnt.

2. The Guidelines of Modeling Framework

The aim of the Guidelines of Modeling (GoM) framework is the development of specific design recommendations, thus, with its application, increases the quality of models beyond the fulfillment of mere syntactic rules. It describes the critical factors that determine the quality of a model and has been derived from the three main parts of semiotics; syntax, semantics and pragmatics. These guidelines have integrated the concepts of a range of other modeling frameworks that aim to structure different qualitative criteria for conceptual models (Lindland et al., 1994; Krogstie et al., 1995; Moody and Shanks, 1994; Pohl, 1993). The GoM have the following objectives:

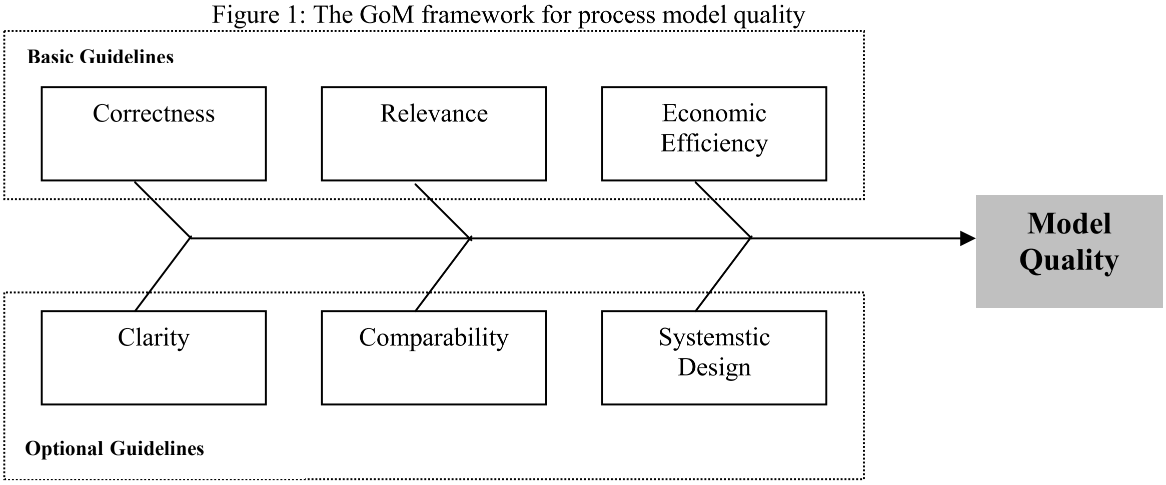
(1) To help design complexity-reduced models of a part of the real world

(2) To design relevant models, and

(3) To make sure that the modeling approach is consistent and economically efficient

(Rosemann, 1998; Becker et al., 1997; Scheer, 1998b)

Figure 1: The GoM framework for process model quality



Rosemann (1998)

As figure 1 depicts, the framework consists of six guidelines (correctness, relevance, economic efficiency, clarity, comparability and systematic design) which are further classified in to "basic" guidelines (which are essential) and "optional" guidelines (which are desirable, additional features).

'Correctness' comprises of two dimensions; (1) 'syntactic correctness' in the means of correct use of the modeling language as specified in the underlying meta model and (2) 'semantic correctness' in the sense of how well the model describes the structure and behavior of the real world) (Krogstie et al., 1995; Rosemann, 1998; Becker et al., 1997). **'Relevance'** is achieved when the model includes all important elements and relationships of the extract of the real world (external relevance) and if the model only includes elements and relationships that are of importance for the individual purpose (Rosemann, 1998; Becker et al., 1997). **'Economic efficiency'** describes feasibility (Lindland et al., 1994) and can be seen as a constraint for all other guidelines. Following this criteria, other criteria should be only achieved to a level, where the further benefits equal the further required efforts. Thus, for example, only feasible syntactic correctness, and not absolute syntactic correctness is the objective. While these three criteria describe the necessary features for model quality, the following three factors are optional.

'Clarity' is subjective in nature and looks at the perspectives required to make the model understood by the model user. It covers the criteria pragmatics within semiotics. A model reaches clarity if it is graphically and conceptually readable and as self-explanatory as possible (Batini et al., 1985; Rosemann, 1998; Becker et al., 1997). The **'Comparability'** guideline demands the identical application of all other guidelines (*e.g.* layout and naming conventions) to all models (Rosemann, 1998; Becker et al., 1997). Finally, the guideline of **'Systematic design'** aims at deriving well-defined relationships with other models belonging to other views (*e.g.* Entity Relationship diagrams, organizational charts) (Rosemann, 1998; Becker et al., 1997). Table 1 summarizes various potential means of achieving these guidelines, which have been extracted from a range of related literature.

Table 1: Potential means of reaching the Guidelines of Modeling

GUIDELINE	POTENTIAL MEANS OF REACHING THE GUIDELINE		
	MEAN(S)	STUDY	AREA
***Semantic* correctness**	- Clearly defined domains and scopes	Lindland et al. (1994) Rosemann et al. (2000)	Conceptual modeling Process modeling
	- Internal and external feed back loops	Evans (1994) Lindland et al. (1994) Rosemann (2000)	Business process reengineering Conceptual modeling Process modeling
	- Try to capture the 'soft' issues related to the processes	Rosemann (1998) Green and Rosemann (2000a)	Process modeling Ontological studies
***Syntactic* correctness**	- Document Meta model	Rosemann (1998) Nissen et al. (1996) Rosemann and zur Mühlen (1997)	Process modeling Data modeling Work flow modeling

	- Use a tool for automatic syntactic checks	Lindland et al. (1994) Curtis et al. (1992)	Conceptual modeling Process modeling
Relevance	- Have sufficient constructs in the meta-model to represent the elements of the real world	Rosemann (1998) Green (1997)	Process modeling Information modeling
	- Continuous feedback loops	Rosemann (1998) Moody and Shanks (1997)	Process modeling Data modeling
Economic efficiency	- Process scope definitions and clear objectives and targets	Rosemann et al. (2000) Grover et al. (1995) Murphy and Staples (1998) Hammer and Champy (1993) Holland et al. (1995)	Process modeling Business Process Reengineering Business Process Reengineering Business Process Reengineering Business Process Reengineering
	- Use of business frameworks	Rosemann (2000)	Process modeling
	- Select only relevant users to participate in feedback loops	Lindland et al. (1994) Moody and Shanks (1997)	Conceptual modeling Data modeling
	- Re-use of models	Rosemann (1998)	Process modeling
	- Use of reference models	Rosemann (1998) Scheer and Harbermann (2000)	Process modeling Process modeling
	- Use of state of art-modeling tools	Rosemann (1998) Scheer (1998a,b) Holland et al. (1999) Kettinger and Teng (1993) Davenport (1993)	Process modeling Process modeling Business Process Reengineering Business Process Reengineering Business Process Reengineering
Clarity	- Defined levels of model abstractions *(and constructs within each abstraction level)*	Lindland et al. (1994) Rosemann (1998)	Conceptual modeling Process modeling
	- Structured layout conventions	Rosemann (1998) Batini et al. (1985)	Process modeling Conceptual modeling

	- Develop support documentation	Scheer (2000)	Process modeling
	- Link external objectives to model *(when further information is required)*	Rosemann (1998) Scheer and Harbermann (2000) Scheer (1998)	Process modeling Process modeling Process modeling
	- Use a tool that follows prespecified layout standards	Lindland et al. (1994) Batini et al. (1985)	Conceptual modeling Conceptual modeling
Comparability	- Layout conventions	Rosemann (1998) Batini et al. (1985)	Process modeling Conceptual modeling
	- Conduct consistency checks among modeling team members	Rosemann et al. (2000)	Process modeling
	- Clearly defined naming conventions	Rosemann (1998)	Process modeling
	- Use a tool that supports automatic consistency checks	Lindland et al. (1994) Curtis et al. (1992)	Conceptual modeling Process modeling
Systematic design	- Involve the relevant participants to justify how the software integrate, with the process activities	Moody and Shanks (1997)	Data modeling
	- Develop a Meta model, that enables to integrate different views	Rosemann (1998) Rosemann and zur Mühlen (1998)	Process modeling Workflow modeling
	- Use a tool that supports multiple views	Rosemann (1998)	Process models

3. Introducing the Case Study

The case organization (referred to as *'Utility1'*) is a dynamic, national utility company employing over 270 people Australia wide, with a portfolio comprising coal-fired, hydro-electric, gas, wind, solar and biomass power generation**.** The company is broadening its core businesses and, with a focus on developing long-term community and business partnerships, aims to grow through new projects that demonstrate economic, social and environmental benefits.

The organization's continuous growth, perceived vulnerability with the existing software systems and the desire to exploit new opportunities, shed light on a need for change. This resulted in a 'Business optimization' project, which was lead by a special corporate team (here after referred to as the 'Project team').

The overall project was initiated with the vision to 'provide optimal business solutions; to bring together the way people work and the available technologies in order to support the company's future vision and strategic direction'. The objectives of the project were to:

- Make people become aware of the company's current business processes at a conceptual level and hence develop a broader understanding of its business systems and processes.
- Allow people to utilize software appropriately, resulting in them carrying out work more effectively and efficiently, in addition to the organization's information requirements being met.
- Reduce the amount of time spent by people within the organization;
    - performing operational processing activities (including the keying and rekeying of data, improving and exporting of data),
    - searching for information,
    - analyzing the operational information,
    - generating and disseminating operational reports.
- Reduce the organization's level of exposure in relation to various risks associated with software, by identifying and delivering an alternative software solution.
- Develop in-house expertise to provide support for the organization's business system, and facilitation of ongoing identification and development of system and process improvements.
- Deliver the project on time and on budget,

The project team; (1) ensured the overriding approach to the project to be dynamic, (2) promoted ownership (through - open communication; involvement and genuine participation; skills development; and training and support), (3) maintained and enhanced relationships (i.e. with teams and individuals) and (4) improved business processes and work practices (by documenting, publishing, monitoring, reviewing, improving and evolving them). This team used process modeling (to which they refer to as "process mapping") as the primary methodological approach to achieve these tasks.

In order to identify the areas to concentrate on, a high-level business portfolio of the organization was documented and summarized. All the technological elements (primary software and hardware components) that currently existed within each of these sub-business areas were identified, documented and summarized.

The project team derived the project's scope based on this preliminary review of the business's core processes, identifying areas of possible vulnerability and/or potential for change. The present software and hardware used to support these business areas, together with other potential applications were thoroughly analyzed by the project team. The overall tasks planned for the project were as follows;

1. The project objectives, scope and time frame (including key milestones) were first agreed upon *(completed).*
2. Process mapping was used to understand, and then determine the extent to which the corporation's business processes could be improved through software or non-software related solutions *(completed).*
3. The appropriateness of the organization's current software solutions is essential, taking into account in particular the organizations growth and future direction, current risk management issues, existing and emerging technologies and the business issues to be addressed *(in progress).*
4. A business case will be prepared at the end of this project phase, which will include recommendations for an optimal business solution.

The remainder of this paper describes how process modeling has been conducted and applied to date, to support the objectives of this business engineering project at *Utility1*.

4. The Modeling Approach

Process modeling within the context of this project was defined as 'The identification and understanding of the firm's current business model from a process perspective, and the technologies that currently support these processes'. The objectives of the modeling activities were to aid obtain the project goals by developing an awareness and shared understanding of the company's current business processes and their attributes. The process modeling scope was defined; (1) to include the business view of the primary and supporting business processes in the 'construction' and 'production' business areas and, (2) to identify the current software and hardware components that supported these business areas.

4.1 The Modeling Methodology

A modeling methodology can be described as a detailed set of instructions that specify and guide the modeling process and its outcomes (Scheer and Harbermann, 2000). It includes activities such as the definition of the model architecture and model quality assurance (Bancroft, 1996; Hammer and Champy, 1993; Rosemann, 1998).

The business portfolio developed to decide and define the scope of the project had been used as the platform to position the individual process models on. Level one models (the first level of abstraction) were designed to describe the core processes within these business areas. The project team and key *Utility1* personnel conducted one-to-one and group discussions to derive the information of this level. The second level of models was derived by a similar manner to describe the process inputs, outputs and their transformation of the individual activities of the first level models in more detail. These models were developed only occasionally when an activity depicted in the first level needed to be further decomposed and elaborated. The completed models were then reviewed by the project team and relevant documentation developed and published. A range of one-to-one and group discussion sessions was held with the project team and further *Utility1* personnel (mainly the process owners) to identify potential process improvements. Finally, these findings were documented and reported to the project sponsor.

4.2 Modeling Language and Tool

The modeling language includes the set of syntax or grammar rules that the modelers' abide with during the development of the models. The modeling team at *Utility1* had derived their very own set of grammar rules, which were derived from a literature review and an analysis of modeling principles implemented by popular modeling tools. Furthermore, *Utility1* developed and used a color template to differentiate software and hardware technologies used within the various processes. The individual activities within the process models were then color coded according to this template.

The project team did not use a special process modeling tool. Instead, the models were drawn and maintained with Microsoft-Word. A responsible member of the project team justified this decision stating that 'We mainly wanted to understand our business activities, what went on in the organization, properly. We did not see the need to utilize any expensive state-of-the-art process modeling tool, which usually also requires a considerably steep learning curve. This method was very cost effective and efficient as it was easy to use, interpret and understand'.

4.3 Evaluation of the overall Process Modeling Approach

This section uses the Guidelines of Modeling to identify the strengths and weaknesses of *Utility1's* modeling approach. Table 2 identifies the overall degree of use of each guideline within *Utility1's* modeling approach and summarizes how some of the instructions, identified in past studies, have been applied in this project.

Table 2: Degree of guideline application and means applied by the company to derive them

GUIDELINE	DEGREE OF EXISTENCE	*POTENTIAL MEANS OF REACHING THE GUIDELINE	
		Used	**Description**
Semantic correctness	*Strong Existence*	Yes	Clearly defined domains and scopes
		Yes	Internal and external feed back loops
		No	Try to capture the 'soft' issues related to the processes
Syntactic correctness	*Weak Existence*	No	Document Meta model
		No	Use a tool for automatic syntactic checks
Relevance	*Weak existence*	No	Have sufficient constructs in the meta-model to represent the elements of the real world
		Yes	Continuous feedback loops
Economic efficiency	*Weak existence*	Yes	Process scope definitions and clear objectives and targets
		Yes	Use of business frameworks

		Yes	Select only relevant users to participate in feedback loops
		Yes	Re-use of models
		No	Use of reference models
		No	Use of state of art modeling tools
Clarity	*Strong existence*	Yes	Defined levels of model abstractions *(and constructs within each abstraction level)*
		Yes	Structured layout conventions
		Yes	Develop support documentation
		No	Link external objectives to model *(when further information is required)*
		No	Use a tool that follows pre-specified layout standards
Comparability	*Weak existence*	Yes	Layout conventions
		Yes	Conduct consistency checks among modeling team members
		No	Clearly defined naming conventions
		No	Use a tool that supports automatic consistency checks
Systematic design	*Weak existence*	Yes	Involve the relevant participants to justify how the software integrate, with the process activities
		No	Develop a Meta model, that enables to integrate different views
		No	Use a tool that supports multiple views

* Extracted from literature, see Table 1.

The models developed by *Utility1's* modeling team can arguably said to be **semantically correct.** The models had passed through a number of feedback and evaluation loops involving the modelers and users to justify if they depicted the true meaning of the real world.

The designed models conform to the relatively few underlying rules of the modeling technique. Thus, they can technically be regarded as **syntactically correct.** However, these rules were not supported by any meta model**.** A meta model contains 'meta information'; information about itself describing the notation, syntax and grammar in detail. Thus there was no real framework to check the models' syntax with.

The models simply identify (1) what goes into the process (the inputs, classified by input types), (2) what comes out of the process (the outputs) and (3) the activities that perform these transformation (color coded to depict the supporting applications). However, this limited representation of information in the models may indicate a lack of **relevance**, a quality factor also identified in many studies on the quality of information models as completeness (Batini et al., 1992; Moody and Shanks, 1998). A critical point is that the models do not indicate 'who' performs the activities. Furthermore, weaknesses and suggestions for improvement are not clearly assigned to the relevant parts of the model.

The decision to maintain only this degree of information within the models may have been adopted by the designers as a means of fulfilling the **economic efficiency** guideline - being able to fulfill the overall purpose of the modeling initiative while maintaining a balance between cost and benefits. The modeling tool (Microsoft-Word) used at *Utility1* can arguably have had a negative impact in obtaining economic efficiency. The absence of many useful features such as automatic syntactic checks, automatic consistency checks, hyperlinks to external objects, ability to follow pre-specified layout standards, filtering, animation, ability to integrate with existing CASE tools (Lindland et al., 1994; Curtis et al., 1992; Batini et al., 1985; Scheer, 1998a, 1998b; Rosemann, 1998; Holland et al., 1999) would have been an inhibitor for the efficient development, maintenance and use of the models. The models literally had to be redrawn, each time an insertion, deletion or modification of a model element took place, creating an immense maintenance problem. Nevertheless, the tool was easy-to-use, with (1) a user friendly interface, (2) that the modelers and model users were already very well exposed and used to. These are two essential factors that should exist within business re-engineering support tools (Sarker and Lee, 1999; Stedman, 1998). The strong existence of these features helped to overcome the effects of not having the state-of-art process modeling tool features (introduced above), and thus, contributed to the economic efficiency within the developed models.

Layout conventions were defined and applied consistently throughout all models, which supported the graphical and conceptual readability; the **clarity,** of the models. However, standard and detailed naming conventions were not strictly applied. Thus, reducing the clarity across the models.

This lack of comprehensiveness in naming and layout conventions negatively influences the **comparability** of the models. As the models within the *Utility1* project as well as the underlying modeling technique do not have well-defined interfaces with models of other views (*e.g.* data), the **systematic design** quality of these models is rather low. The use of color coding to indicate the interrelations of the process models to the software applications can be viewed as an attempt to derive systematic design. However, this approach does not provide a clear interpretation about the degree of support provided by these applications, what sub-components are used for the activity, many-to-many relationships (between activities and supporting solutions), or how the individual software applications interrelate (or interface) with one another.

5. Conclusion and Outlook

This paper described a theoretical framework for the evaluation of the quality of conceptual models. It introduced the process modeling project, described and evaluated the modeling approach. We analyzed the extent to which each guideline was fulfilled and identified potential means of improving their existence, based on past studies conducted in related areas.

The evaluation was conducted from a generic perspective. However, it should be emphasized that the guidelines vary in their importance for different perspectives. For instance, process models used for requirements engineering for individual software developments or those used for actual software implementations will essentially require a high degree of syntactical correctness and systematic design. On the contrary, models that are used to communicate the business activities to end users and systems analysts, do not require such a degree of syntactical correctness or systematic design. Instead, such models require, semantic correctness and clarity.

This study is embedded in a comprehensive research project on the critical success factors of process models. Regarding *Utility1*, this study will be continued across the next phases of the project. It will be studied how the organization maintains these models and applies them for the system selection, configuration, adaptation and training phases. The evaluations of these models will be revisited at the end of the project and antecedent factors that lead to a successful process modeling initiative will be identified and documented.

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