Modeling Quality Information within Business Process Models

Robert Heinrich, Alexander Kappe, Barbara Paech

University of Heidelberg, Institute of Computer Science,
Im Neuenheimer Feld 326, 69120 Heidelberg, Germany
{heinrich, paech}@informatik.uni-heidelberg.de
kappe@stud.uni-heidelberg.de

Abstract. Business process models are a useful means to document information about structure and behavior of a business process. However, they do not aim at expressing quality information relating to business processes. Organizations are interested in the measurement and modeling of quality information for the enhancement of quality of business processes and supporting IT systems. This paper presents the results of an extensive literature and tool survey on modeling quality information within business process models.

Keywords: Business Process Modeling, Business Process Quality, Quality Model, Notation, Tool.

1 Introduction

Business process modeling is widely used within organizations as a method to increase awareness and knowledge of business processes and to deconstruct organizational complexity [2]. A business process model typically visualizes activities and their dependencies, involved actors and their communication with one another and external parties. In some cases, process models also capture information about data and resources (e.g. software systems) involved in the process. Therefore, a business process model is a commonly used means to express structure and behavior of a business process. Current business process modeling notations do not aim to model quality information (QI) such as information about maturity or time behavior of a business process. Thus, it is difficult to capture quality requirements at the modeling stage which results in increased costs and delays in the further development [22] of business processes and involved IT systems. It is desirable to capture as much QI as possible while modeling a business process to provide a comprehensive view on quality. A (graphical) expression of QI together with information on functionality within a single model would increase the modeler's focus on quality in the early stage of modeling and therefore prevent negative effects on the development of business processes and supporting IT systems.

In contrast to software product quality, which for example is standardized in the ISO/IEC 9126 quality model [11], there is no common quality standard for business processes. Therefore, we are developing a comprehensive quality model for business processes that is based on software product quality standards [6]. Moreover, we are developing a concept to present the QI of our quality model within a business process model. Hence, we analyzed related work.

This paper discusses the results of an extensive literature and tool survey to present the state of the art in modeling QI within business process models and point out deficiencies of current approaches. As we want to model QI graphically, we focus on graphical modeling notations. The paper is structured as follows: in Section 2 we present the background of this paper by describing our ongoing research on a comprehensive and practically relevant quality model for business processes. Section 3 discusses current approaches and in Section 4 we investigate how current tools support the modeling of quality within business process models. Section 5 concludes the paper and sketches future work.

2 Background

This section presents a summary of our work published so far in [6] to provide the background of this paper. We are developing the comprehensive Business Process Quality Meta-Model (BPQMM) [6], [7] using characteristics we transferred from software product quality standards like ISO/IEC 9126. We introduced a hierarchical structure of QI defined as follows. A *business process quality characteristic* is a category of business process quality attributes, for example maturity (see Figure 1). A *business process quality attribute* is an inherent property of a business process that can be distinguished quantitatively or qualitatively, for example the error density of an activity. A *business process quality measure* is a variable to which a value is assigned as the result of measurement, for example the number of detected errors per activity. In the following we use the term QI as a superset of characteristics, attributes and measures.

Business process quality refers to the components of a business process. Components are the activities of the process, the actors performing these activities, the objects handled and created by the process as well as the resources necessary for execution. As an activity can be subdivided into sub-activities, we consider a process itself as an activity. To each component of a business process we associated a set of quality characteristics. We took the ISO/IEC 9126 software product quality characteristics for resources and also adapted them for activities. For information objects we took the ISO/IEC 25012 [12] data quality characteristics. The actor characteristics we developed based on QI from practice. Figure 1 shows the BPQMM. The nodes correspond to the components and the characteristics are listed either within the node or on an edge between nodes. If the assessment of a characteristic depends on information of another component, we located it on the edge.

Some of the QI in our quality meta-model cannot be expressed within a business process model, for example *completeness of description* which is an attribute of the quality characteristic *understandability* (see [7] for details). However, we aim at modeling as much QI as possible together with information on functionality within a single model because having all information located at the same place facilitates the capturing of QI for the modeler.

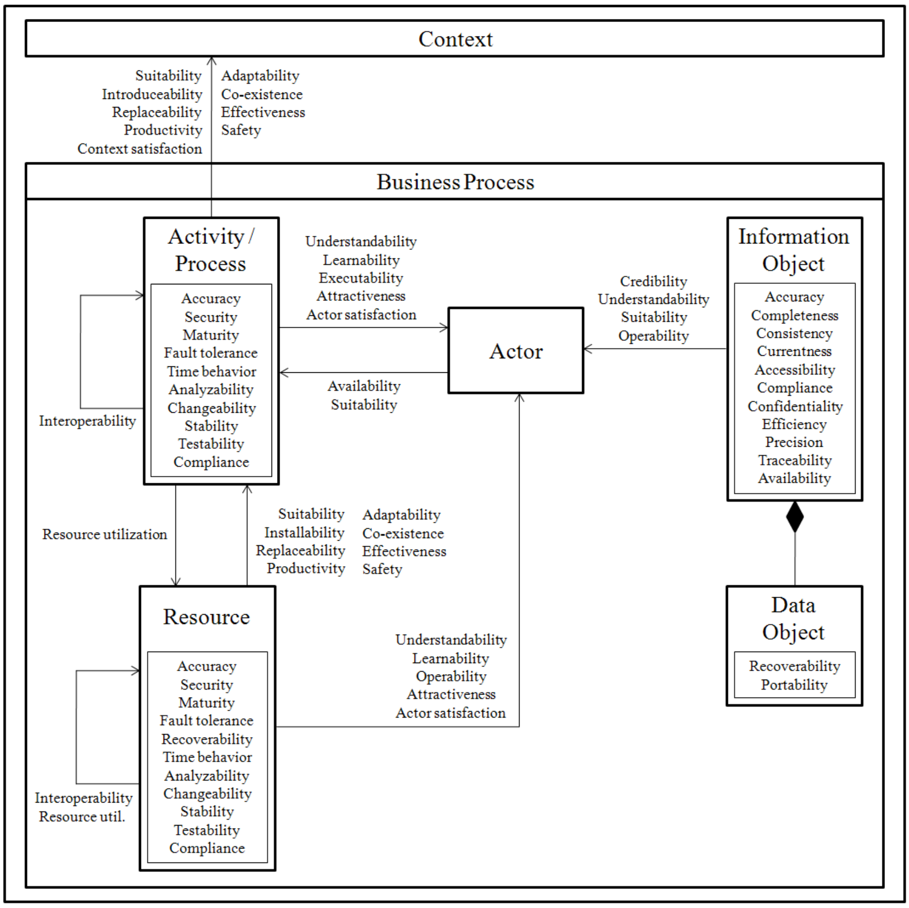

Fig. 1. Business Process Quality Meta-Model

3 Approaches to Modeling Quality Information

The approaches mentioned below are the result of an extensive literature research including the digital libraries of ACM (http://portal.acm.org), IEEE (http://ieeexplore.ieee.org) and SpringerLink (http://www.springerlink.com) because they give a reasonable confidence of covering the most relevant publications. Moreover, we utilized Google Scholar (http://scholar.google.com/) and the online catalogue of the university library which provides a variety of eBooks and eJournals. We used the following query: [‘business process (model)’ OR model OR graph OR diagram OR visualise OR visualize OR illustrate OR display OR picture OR depict OR represent OR capture] AND [‘quality information’ OR ‘quality characteristics‘ OR ‘quality requirements‘ OR ‘quality aspects‘ OR ‘quality properties‘ OR ‘quality attributes‘ OR ‘constraints’ OR ‘process characteristics’ OR ‘process properties’ OR ‘non-functional requirements’ OR ‘NFR’ OR ‘goals’ OR ‘business rules’ OR ‘metric’ OR ‘measure’ OR ‘ratio’].

As a result from 129 relevant matches we finally selected 9 publications that describe approaches which graphically represent QI within a process model. In the following we give a short description of 6 out of these 9 approaches and compare them in Table 1. We limit to these 6 approaches because [20] and [21] present QI similar to [13] and the approach in [19] allows to model arbitrary information and does not make regulations to the QI to be modeled, so it is not considered in comparison. Further details on the allocation of QI to characteristics can be found in [14].

In [22] the authors propose an extension of the Business Process Modeling Notation (BPMN) 2.0 meta-model with basic QI on time, cost and reliability (see Figure 2). This approach enables to capture QI quantitatively in tabular form as an extension of the activity model element (shown as rounded boxes).

a) Collapsed b) Expanded

Fig. 2. Illustration of time, cost and reliability in [22].

Fig. 3. Extension of activity elements with performance information in [5].

The approach presented in [5] introduces a concept to present performance-relevant information within business process models using a mix of graphical and textual notation (see Figure 3). For each activity a set of performance indicators is calculated and visualized. The area of the circular icon at the lower left corner of the activity box is an average measure of the number of executions per month for the respective activity. The size of the dark pie of the circular icon is an average measure of the duration of the respective activity. The latest trends of throughput and duration are shown as arrows pointing upwards or downwards.

In [16] the author presents extensions to the BPMN, EPC and UML Activity Diagram for modeling process goals, cost, several QI on time and quality of activities. In the case of the UML Activity Diagram the QI is only represented textually inside the diagram. However, within a BPMN and EPC model the QI is also graphically represented inside the model by a circular icon besides the textual description, as shown exemplarily in Figure 4.

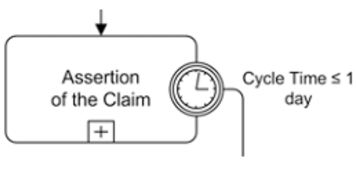

Fig. 4. An example of modeling QI in [16].

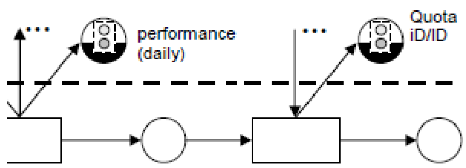

Fig. 5. Modeling performance indicators as places [18].

In [18] a concept for modeling performance indicators is proposed. It uses low-level Performance nets which extend traditional low-level Petri nets by the representation of performance indicators as places (see Figure 5). Once performance indicators are defined, they can be refined to machine-readable high-level Performance nets.

The graphical modeling notation Time-BPMN is described in [4] as an extension of the BPMN 1.2. Time-BPMN deals with the various temporal constraints and dependencies that may occur while characterizing real world business processes. Figure 6 presents an example of this notation by showing the activity "Complete Final Exam" which has a defined starting time, a Finish No Later Than constraint of 3 hours and a Start-to-Start dependency to the subsequent activity.

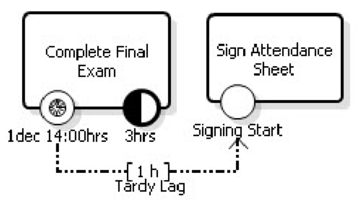

Fig. 6. Modeling temporal constraints and dependencies in Time-BPMN [4].

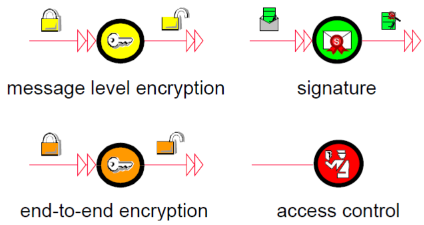

Fig. 7. Modeling artifacts for representing security information [13].

The approach described in [13] presents an extension to the ARIS SOA Architect that is capable of modeling security information. The extension enables the description of access control, data integrity, and confidentiality within a process model. In [13] the approach is applied to EPC models but it can also be applied to any other modeling notation. Figure 7 shows the security model symbols for each of the security properties. In [20] and [21] an approach to visualize similar security information is proposed. This approach is applied to UML 2.0 Activity Diagrams respectively BPMN models and uses a padlock symbol.

The approaches presented above extend existing process modeling notations by few or single QI such as time or security. However, they do not model a comprehensive set of QI as described in [7]. Altogether, regarding activities, the approaches contain QI covered by 7 of the 26 quality characteristics for activities in the BPQMM, namely time behavior, productivity, maturity, effectiveness, understandability, context satisfaction and security. Regarding information objects, QI covered by accuracy and confidentiality (2 of the 17 characteristics for information objects) can be expressed by the approaches. Regarding resources the approaches can only express security (1 of the 26 characteristics for resources). There is no actor characteristic expressible by the approaches. Note that we do not consider cost as a QI. In the following we summarize other important criteria used for comparison.

First we consider the granularity of the modeled information. The approach in [22] only allows the modeling of coarse-grained information within the diagram, e.g. time or reliability, whereas the other approaches allow the specification of much finer-grained information, e.g. waiting time or throughput of an activity.

Table 1. Comparison of current approaches on modeling quality within process models.

Approach/Criterion	Saeedi et al. [22]	Gulla [5]	Korherr [16]	Mevius [18]	Gagne et al. [4]	Jensen et al. [13]
Basic notation	BPMN	Arbitrary process modeling notation	BPMN, EPC, UML Activity Diagram	Petri nets	BPMN	EPC[1]
Way of expression	Graphical + textual	Graphical + textual	Graphical + textual	Graphical + textual	Graphical + textual	Graphical + textual
Expressible QI	Response time and reliability of activities	Performance indicators: average duration and number of executions per time unit (throughput) of activities	Cycle time, working time, waiting time, goals, complaints	Performance indicators for activities	Temporal aspects: time points, durations, temporal constraints and dependencies	Security aspects: access control for resources, encryption on message exchange, digital signature for information objects (integrity)
Covering quality characteristics from [7]	Time behavior, productivity, maturity (reliability[2]) (activity)	Time behavior, productivity, effectiveness (activity)	Time behavior, productivity, understandability, context satisfaction (activity)	Time behavior (activity)	Time behavior (activity)	Security (activity + resource) confidentiality, accuracy (information object)
Granularity of the Information	Coarse-grained	Fine-grained	Fine-grained	Fine-grained	Fine-grained	Fine-grained
Formality	Semi-formal	Semi-formal	Semi-formal	Formal	Semi-formal	Semi-formal
Maturity of the approach	New approach	Case study and tooling	New approach	Tooling	New approach	New approach

[1] Event-driven Process Chain

[2] According to ISO/IEC 9126 in [7] reliability is subdivided into the characteristics maturity and fault tolerance, and in the case of resources additionally recoverability. As in [22] for reliability only failures are considered, we only allocate maturity.

In [18] a formal approach is proposed while all others are semi-formal. A formal modeling including QI is necessary for analyzing, controlling, simulation and automation of the business processes.

The maturity of the approaches is another point we compare because there already might be hints on the appropriateness of the notation, the user acceptance or the benefit of applying the approaches in practice. However, as most of the approaches are rather new, there are no significant experiences to refer to. Only [5] conducts a case study including the prototypical implementation of the concept and [18] provides prototypical tooling.

4 Tools for Modeling Quality Information

Besides a literature survey on research approaches for modeling QI, we additionally analyzed current tools to understand the state of practice. Restricting our research only to business process modeling tools did not lead to satisfying results. These tools comply with a standardized process modeling notation (like BPMN or UML Activity Diagram) and as none of these notations allow the modeling of QI the tools do neither. Therefore, we extended our research to Business Process Management (BPM) systems and tools for Enterprise Modeling (EM). These tools usually include a process modeling component and additionally provide utilities to support other activities of BPM respectively EM, such as execution, monitoring, optimization or data modeling. The corresponding components are closely interconnected. Thus, the associated data is also more interconnected. That is the kind of data we want to visualize within business process models.

We finally analyzed[3] 42 BPM, EM and BPMN tools currently used in practice which we obtained from lists published by independent BPM-related organizations[4]. From these tools 16 enable the description of some kind of QI for business processes. However, we could not find a tool which satisfactorily enables the (graphical) modeling of QI within business process models as described above. Note that we do not consider prototypical tooling of approaches presented in Section 3 as we already discussed this QI in the previous section. Moreover, we are rather interested in tools used in practice than in research prototypes. In most cases QI can only be captured textually as a property of a model element in a tabular structure with predefined or free fields, or in separate views, which are not visible in the process modeling view. In few cases [1], [9], [17] the QI can be visualized as labels to the corresponding element and in [9] additionally with a freely selectable graphical symbol.

In Table 2 we compare five tools which allow the expression of QI. Due to the limited space we decided to present five representative tools which give an overview of the state of practice. Further tools can be found in [14]. For each tool we list the functional range, the supported process modeling notations, the expressible QI and the

---

[3] Analyzed means the tools were installed and executed, and associated white papers, tutorials and all sorts of published information material were consulted.

[4] An overview of current BPM- and BPMN-tools is available under http://www.bpm-netzwerk.de/content/software/listSoftware.do?view= respectively http://www.bpmn.org/BPMN_Supporters.htm

Table 2. Comparison of current tools from practice.

Tool/Criterion	ABACUS [1]	ADONIS [3]	Kern Process [15]	GRADE [10]	Horus [8]
Functional range	IT strategy, planning and EM	BPM	BPM	CASE	BPM
Modeling notation	BPMN	BPMN and own notation	Own notation	Own notation	Own notation
Expressible QI	- Process: processing time, frequency of execution, reliability, availability - Resource: utilization, business fit, reliability, availability, etc. - Actor: reliability, availability, etc.	Own notation: - Process: quantity of execution per time unit (throughput), tolerance waiting time (before cancelling) - Activity: processing-, waiting-, resting-, transport time	- Process: service time, customer satisfaction, employee satisfaction - Actor: qualification	- Activity: duration, goals	- Activity: quality (in %), error rate, processing- and transport time, execution frequency per time unit (throughput)
Covering quality characteristics from [7]	Time behavior, maturity, fault tolerance (because of reliability and availability[5]) (activity); resource utilization, suitability, maturity, fault tolerance, recoverability (because of reliability and availability) (resource); availability (actor)	Time behavior, effectiveness (activity)	Time behavior, productivity, context satisfaction, actor satisfaction (activity); suitability (actor)	Time behavior, productivity, understandability (activity)	Time behavior, maturity, effectiveness (activity)
Way of expression	Textual	Textual	Textual	Textual	Textual
Visibility within diagram	One property per model element (optional)	Not visible	Not visible	Not visible	Not visible

[5] According to ISO/IEC 9126 availability (just like reliability) is a combination of maturity, fault tolerance and recoverability.

covering characteristics of the BPQMM, and the way of expressing the QI.

Similar to the research approaches, the tools only allow the documentation of few QI and are not suitable to model quality comprehensively. Altogether, regarding activities, we found QI covered by 8 of the 26 quality characteristics for activities, namely time behavior, productivity, maturity, fault tolerance, effectiveness, context satisfaction, actor satisfaction and understandability. For resources, we identified QI covered by 5 of the 26 characteristics, namely resource utilization, suitability, maturity, fault tolerance and recoverability, and regarding actors, we found QI covered by availability and suitability (2 of the 2 characteristics). Regarding information objects, the tools are not able to express any characteristic. The tools as well as the research approaches do not support the hierarchical structure of QI as described in Section 2. This means they do not distinguish between characteristics, attributes and measures. This may lead to confusion of the concrete values that are to be captured. For example if an approach or tool requires the specification of reliability, it is not clear which attribute or measure should be used to specify the concrete value.

5 Conclusion and Future Work

In this paper we presented the results of a survey on approaches from research and tools from practice that targets to provide state of the art in modeling QI within business process models. Furthermore, we compared these results to the Business Process Quality Meta-Model. There are some approaches that are able to express few or single QI. However, we could not find an approach that is able to express a larger set of QI which is necessary for capturing quality requirements or doing process simulation comprehensively. Also tools from practice do not enable the capturing of QI satisfactorily; in fact, most of the tools we analyzed were not able to capture QI at all. Some of the tools were able to capture few QI but mostly these are not visible in the process model view. Our survey showed that there is a gap between the capability of current approaches and tools to present QI and the set of QI we want to capture within a business process model.

The deficiencies identified in the survey motivate us to develop a comprehensive concept on how to model QI within a process model [14]. The approaches and tools discussed in this paper provide first ideas however we need to extend them to capture a relevant set of QI. As a next step we plan to apply our concept to real processes to ensure practicality. Furthermore, we plan to provide tool support as an extension of the Eclipse-based CASE tool UNICASE [23].

References

1. Avolution Pty Ltd: ABACUS 3.2, http://www.avolution.com.au/ (Last Access: 2010.11.24)
2. Bandara, W., Gable, G.G., Rosemann, M.: Factors and measures of business process modelling: Model building through a multiple case study, European Journal of Information Systems Vol. 14 No. 4, pp. 347-360 (2005)

3. BOC Information Technologies Consulting AG: ADONIS 3.9, http://www.adonis-community.com/ (Last Access: 2010.10.26)
4. Gagne, D., Trudel, A.: Time-BPMN, In: Commerce and Enterprise Computing, CEC '09. IEEE Conference on, IEEE Computer Society, pp. 361-367 (2009)
5. Gulla, J.: Using Models in Enterprise Systems Projects, In: Krogstie, J., Opdahl, A.L., Brinkkemper, S. (eds.) Conceptual Modelling in Information Systems Engineering, Springer Berlin Heidelberg, pp. 107-122 (2007)
6. Heinrich, R., Paech, B.: Defining the Quality of Business Processes. In Engels, G., Karagiannis, D., Mayr, H.C., eds.: Modellierung 2010, Lecture Notes in Informatics Vol. P-161, GI, pp. 133-148 (2010)
7. Heinrich, R., Paech, B.: Business Process Quality - A Technical Report, Technical Report, Software Engineering Heidelberg (2010)
8. Horus software GmbH: Horus Business Modeler 1.2.1, http://www.horus.biz/ (Last Access: 2010.12.17)
9. IDS Scheer AG: ARIS Design Platform 7.1, http://www.idsscheer.com/en/ARIS_ARIS_Platform/3730.html (Last Access: 2010.11.21)
10. INFOLOGISTIK GmbH: GRADE 4.1, http://www.infologistik.com/grade/ (Last Access: 2010.11.21)
11. ISO/IEC 9126-1: Software engineering — Product quality — Part 1: Quality model, First edition (2001)
12. ISO/IEC 25012: Software engineering — Software product Quality Requirements and Evaluation (SQuaRE) — Data quality model, First edition (2008)
13. Jensen, M., Feja, S.: A Security Modeling Approach for Web-Service-Based Business Processes, In: Engineering of Computer Based Systems, ECBS 2009, 16th Annual IEEE International Conference and Workshop on the, IEEE Computer Society, pp. 340-347 (2009)
14. Kappe, A.: Entwicklung und Umsetzung eines Konzepts zur Modellierung von Qualitätsinformationen in einem Geschäftsprozessmodell, Master Thesis, Software Engineering Heidelberg (2011)
15. Kern AG: Kern Process 2.6, http://www.kern.ag/ (Last Access: 2010.12.17)
16. Korherr, B.: Business Process Modelling: Languages, Goals, and Variabilities, VDM Verlag, Saarbrücken, Germany (2008)
17. MEMOCenterNG build 2010-10-18, University of Duisburg-Essen, Chair of Information Systems, http://www.wi-inf.uni-duisburg-essen.de/FGFrank/index.php?lang=de &&groupId=1&&contentType=Project&&projId=19 (Last Access: 2010.12.19)
18. Mevius, M.: A Novel Modeling Language for Tool-based Business Process Engineering, In: Proceedings of the 2008 ACM symposium on Applied computing, SAC'08, ACM, pp.590-591 (2008)
19. Pavlovski, C.J., Zou, J.: Non-functional requirements in business process modeling, In: Proceedings of the 5th Asia-Pacific conference on Conceptual Modelling, (APCCM 2008), CRPIT, 79. Hinze, A., Kirchberg, M. (eds.) ACS, pp. 103-112 (2008)
20. Rodríguez, A. Fernández-Medina, E. Piattini, M: Security Requirement with a UML 2.0 Profile, ARES 2006, pp. 670-677 (2006)
21. Rodríguez, A., Fernández-Medina, E.,Piattini, M.: A BPMN Extension for the Modeling of Security Requirements in Business Processes, IEICE Trans. INF & SYST., Vol.E90-D No. 4, pp. 745-752 (2007)
22. Saeedi, K., Zhao, L., Sampaio, P.R.F.: Extending BPMN for Supporting Customer-Facing Service Quality Requirements, In: Web Services, IEEE International Conference on, IEEE Computer Society, pp. 616-623 (2010)
23. UNICASE, Technische Universitaet Muenchen, Chair for Applied Software Engineering, http://unicase.org/ (Last Access: 2011.01.11)