

Business Process Modelling for Measuring Quality

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Abstract—Business process modelling languages facilitate presentation, communication and analysis of business processes with different stakeholders. This paper proposes an approach that drives specification and measurement of quality requirements and in doing so relies on business process models as representations of business processes. The approach is presented in the form of a conceptual model and its application is demonstrated for a simplified version of a business process. However, communication becomes a challenge in cross-organizational business processes where multiple business process modelling languages are being practiced which calls for an abstraction as an integration of concepts of these business process modelling languages. In this paper, a business process integrating meta-model is presented as an abstraction of concepts of seven mainstream business process modelling languages. Attaining such level of understanding and specifying business processes fosters specification and measurement of quality requirements.

Keywords- *Quality requirements, Quality specification, Quality measurement, Business process, Business process modeling, Business process integrating meta-model.*

I. INTRODUCTION

Today, new businesses are demanding enterprises to understand the behaviour of the business systems and its influence on the development of information systems that supports their operation. Rapid business and organizational changes, knowledge intensity of goods and services, the growth in organizational scope, and information technology have intensified organizational needs for such understanding. The approach of describing organizations in terms of business processes not only helps organizations to be more responsive to the business and organizational changes but also helps them in the development of information systems. Moreover, the collective ability of business processes to achieve its requirements is central to achieving high-performance organizations.

Attaining a level of understanding and specifying business processes is a challenge, which calls for business process modelling [1]. Business Process Modelling is currently not only of core importance to the development of software systems [2, 3] but also in presenting, analysing

and improving business processes [4] within enterprises. Business process models are domain specific conceptual models that support presentation and integration of business processes' requirements within an enterprise. Linking business process quality requirements to business process concepts enables IT and business experts to define their requirements collaboratively at a common abstract level during the earliest stage of design and development of information systems. In addition to quality requirements, annotation of business process models with related information artefacts using domains' vocabulary leverages different concepts (e.g., goals, rules, patterns, motivation, etc.) into the scope of business process [5, 6].

Business process modelling provides the realization and the presentation of business processes in different levels of abstraction from individual concepts (e.g., activity), to composition of concepts (i.e., sub-processes), and to the business process as a whole. The motivation of this paper is to show how business process modelling can be deployed for quality specification and measurement of business processes in different levels of abstraction. The focus is not on the evaluation of the models themselves as it is assumed that the models are well-formed and syntactically and semantically correct.

Quality evaluation of business processes in the context of their models is not a straightforward task. Many different business process-modelling approaches have been developed, each with their own specific business process modelling languages designed to meet a specific business requirement. The proliferation of business process modelling techniques is realized as a notorious problem for business process management [7]. Standardization has been discussed for more than ten years, none of the proposals is commonly accepted as de facto standard in the industry [7]. In practice, multiple business process languages are often being used within one and the same enterprise. A systematic realization and representation of concepts and relationships between the concepts of different business process modelling languages in a business process meta-model is essential [8]. This meta-model is universal and language independent abstraction of

the concepts of today's mainstream business process modelling languages. This paper provides a brief introduction on an integrating business process meta-model and its application. Besides, evaluation of business process in through its model is addressed in this paper. The levels of business process concepts are considered for specification and measurement purpose. The approach is exemplified using a real-life business process in an industrial case.

The paper is organized as follows: Section II presents a brief summary of related works. Section III elaborates on business process integrating meta-model, and its application and it introduced an enriched version of it with quality factors. Section IV introduces the approach to specification and evaluation of quality of business processes' concepts. Section V illustrates the proposed approach for a business process and instantiate the framework for it. The paper concludes in Section VI with a number of observations, reflections and suggestions for future work.

II. RELATED WORK

Quality has been the topic of research in several closely related disciplines such as requirement engineering, software engineering, workflow analysis, industrial engineering, system dynamics and discrete event simulation [1].

Different levels of granularity can be considered for realizing and measuring quality in an enterprise involving many organizational layers from the very general, i.e., organization-wide quality to concepts of business processes. The analysis of the current state-of-the-art reveals variations in specification and measurement of requirements. The plethora of approaches has led to compare the existing approaches based on a set of criteria.

Synoptically, investigation of the most relevant approaches in following aspects will be considered in this section: (A) the way they are being practiced (i.e., methodology e.g., systematic or ad hoc), (B) representation of business process and quality requirement (modelling and language dependency), (C) generalizability of the approach (i.e., application scope e.g., generic vs. specific), (D) measurement method (e.g., quantitative vs. qualitative) is conducted in this section.

A. Methodology

While "focus of work", "required inputs", "expected outputs" and a "set of phases", "technique used" and possibly "support tool" are prescribed with details in an approach, the approach is considered to be systematic in terms of methodology (e.g., [14], [9], [10], [11], [12], [1], [13]); otherwise the approach is considered to be ad-hoc in terms of methodology (e.g., [14], [10],[15]).

Wolter et al. [16] deploys a method to assign elements of their security model to a process model. Capturing quality dimensions of a business process in the form of a framework are considered by Heravizadeh et al. [17]. A framework for

evaluation of business process quality is introduced by Kedad et al. [18]. A requirements engineering framework with the aim of allowing active stakeholder participation is introduced by Donzelli et al. [11]. Pourshahid et al. [19] introduces a framework to measure and align processes and goals subjectively. In their work, key performance indicators (KPI) are added to user requirement notation (URN) together with explicit goals for each business process. A scenario-based methodology and a toolset for business process modelling and analysis is introduced by Glykas [12]. The approach defines and measures KPIs in qualitative as well as quantitative manner.

Heidari et al. [13] proposes a systematic approach in the form of meta-models and method steps to capture and evaluate quality of individual concepts of business processes, considering non-functional requirements defined by stakeholders. The evaluation results are compared with the quality objectives derived from non-functional requirements. They identify quality dimensions of performance, efficiency, reliability, recoverability, permissibility and availability for corresponding business process concepts and introduce objective and quantitative formulae for evaluating them.

The approach by Firesmith [10] proposes a checklist of questions over which defects in software-intensive system architectures would be realized. Measurement is included in the structure although the process toward the measurement is not discussed. In a theoretical attempt, Lohrmann et al. [15] provides a definition for business process quality and introduce business process quality model. There are no details provided on how the measurement should be conducted.

B. Modelling and language dependency

Modelling is concerned with the way an approach represents a business process. The consideration here is the use of formal or semi formal languages in the representation (e.g., [8], [17], [14], [9], [20]) Language dependency examines this fact if an approach's focus is on a specific language. Language independent approaches are not tied to any specific modelling languages (e.g., [18], [21], [13], [1], [8],[22]).

Heidari et al. [13] identifies quality metrics and factors for business process having its model as a given. Their approach is language independent and considers different concepts of business process (i.e., event, input, output and activity).

Heinrich et al. [23] uses the quality characteristics and attributes of processes. They distinguish on the basis of the ISO/IEC standard for software quality [14] to enhance BPMN. Saedi et al. [14] proposes a set of quality requirement factors for BPMN concepts. Role Activity Diagram notation is considered for representation of business processes by Aburub et al. [20]. The strategic rationale for the choice of business processes to be specified in BPMN

models and described in terminology familiar to business people are considered by Decreus et al. [9].

Heidari et al. [8] introduces a business process meta-model as an integration of concept of seven business process modelling techniques. The meta-model is enriched with quality related information (i.e., quality factors). The result presented as a quality-oriented meta-model encompassing quality factors of throughput, cycle time, timeliness, cost, resource efficiency, cost efficiency, maturity, recoverability, security and availability.

C. Application scope

The application aspect is concerned with the target of the approach. Generic approaches can be applied to all or most situations (e.g., [22], [18]). Specific approaches (e.g., [16], [20]) are dedicated to a particular class or application or business sector.

From a managerial point of view, TQM and ISO quality standards act as general guidelines that are applicable to all types of organization regardless of the types of product and service they offer, organization size, turnover, location, type of industry, etc. The literature on business process performance measurements systems such as [24] and [25] try to provide generic guidelines for developing business process performance measurement systems. Quality tools and techniques [26] and tools for process improvements such as Kaizen Blitz, Poka-Yoke and process simulation [27] are generic and try to assist stakeholders in improving their processes and presenting output of quality measurements without realizing quality dimensions, factors and metrics.

Wolter et al. [16] focuses on security requirements. Aburub et al. [20] introduces an approach in remodelling business processes for identification and inclusion of Non-Functional Requirements (NFRs) for a specific case. With the focus on quality of business process model, the approach by Said-Cherfi et al. [21] considers ontologies in a number of specific domains.

Powel et al. [28] and An et al. [29] focus on the area of supply chain management and production and define quality dimensions, factors and metrics for a specific situation. Similar to the efforts in system dynamics, discrete-event simulation is used for simulation and analysis purposes and introducing the quality dimensions and factors for a specific situation [30-32].

D. Measurement method

This aspect is concerned with the degree to which an approach can support quantitative measures, that is, the results of an evaluation based on objective and quantitative metrics (e.g., [33] in the area of workflow and web-services, [13] measuring individual concepts of business process), or qualitative measures, that is, the results based on analysis requiring individual judgement and interpretation (e.g., [34]).

Cardoso et al. [33] proposes an approach for estimation of workflow properties (e.g., execution cost, execution time, and reliability), using the properties of activities constituting block-structured process models containing sequences, XOR blocks, AND blocks, and structured loops. Reduction of patterns is the common technique of analytical models in quantitative approaches.

Heidari et al. [13] identifies quality dimensions of performance, efficiency, reliability, recoverability, permissibility and availability for corresponding business process concepts and introduce objective and quantitative formulae for evaluating them in business process concept level (i.e., activity, input, output, event).

Most of managerial approaches (e.g., TQM [26], ISO standards [35], business performance measurement [24], quality tools and techniques [27]) provide generic guidelines and assistance for organizations, while the realization of the quality factors and metrics are not in their scope.

To conclude, there are variations in methodology, in the specification approaches used for presentation, the target application and measuring method of these quality approaches. The majority of approaches discussed above are based on the assumption that a formal language (e.g., BPMN) is used to describe business processes, the majority of which use one representation scheme. A few are language independent. Some provide a systematic way of working and some are generic enough to be applied in generic situations. Some are quantitative and some focus qualitative method of measurement. The approach introduced in this paper in some ways complements and in others extends existing approaches by emphasizing a well-structured way for specification and objectively measurement of business processes, which is generic in application and language independent. The desire of this paper is to provide an approach, which is systematic and well-structured, generic enough and not tied to a specific domain or situation, quantitative and objective, and while considering the formal expression of business processes, it is not tied to any particular business process modelling language.

III. BUSINESS PROCESS INTEGRATING META-MODEL

During requirement analysis, an important consideration is to understand current business processes. In this effort, business process modelling plays a key role. There are currently many business process modelling languages being advocated or practiced [36]. A closer inspection however, shows that there are many similarities and a great deal of convergence. From a theoretical perspective, it is vital to have a clear understanding of the semantics of these approaches, their overlaps, differences and similarities. Only then does it become possible to systematically and objectively understand the similarities and limitations of different approaches.

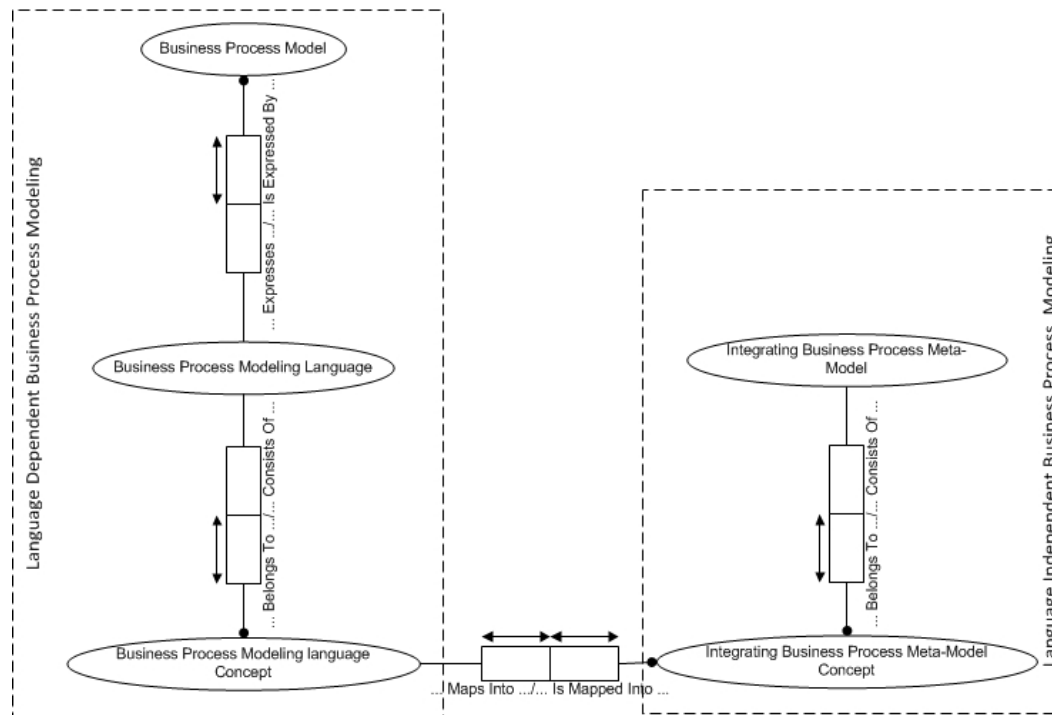


Fig. 1. Principles of the integrating meta-model development

Synchronization between requirements and business process models requires a common basis. This common basis can be presented in the form of a meta-model confined to requirement aspects. Such abstraction is to provide an explicit representation of knowledge, that can be understood by both computers and people [37]. Therefore, having an abstraction as the basis for quality specification and measurement of any business processes, using a corresponding model, would go a long way to integrating the field (i.e., business process modelling approaches) in the form of a meta-model and to facilitating a more systematic way of treating quality.

This paper argues that there is a need to view modelling structures through a lens that focuses on the semantics of concepts and relations and their ability to express different aspects of a business process rather than on syntax of the language used. This meta-model provides a language-independent business process ontology and is open to further extensions.

A meta-model is an explicit model of the constructs and rules needed to build specific models within a domain of interest. A valid meta-model is an ontology, as its constructs and rules represent entities in a domain. The formalism of a generic purpose modelling language (GPML) (e.g., UML class diagram) provides the ontology description. An ontology makes knowledge explicit expressing the concepts and relationships between them in a language close to the natural language; fostering an “understanding bridge”

between business and IT experts [2]. In Siau et al. [38] meta-modelling is classified as positivism in epistemology and realism in ontology. In essence, a meta-modelling approach aims to be independent of an observer’s appreciation of the modelling methods. In comparison to other approaches for describing modelling languages such as graph grammars, meta-models offer an intuitive way to specify modelling languages [39].

A business process integrating meta-model represents an abstraction of business process concepts, which is universal and not dedicated to one single business process modelling language. The approach in formation of the meta-model is presented as a conceptual model (Fig. 1). In this paper, a business process is analysed for its quality through its model, which obviously would be expressed in some business process modelling languages. Building a domain ontology includes the task of defining basic concepts and structures that are applicable in the target domain [40]. In this approach the concepts of different business process modelling techniques are going to be integrated to form the meta-model. In an example, Heidari et al. [41] proposes a meta-model resulted from integration of following languages: Business Process Modelling Notation (BPMN), Integrated Definition for Function Modelling (IDEF0 and IDEF3), Role Activity Diagram (RAD), Unified Modelling Language Activity Diagram (UML-AD), (Structured Analysis and Design Technique (SADT), and Event-driven Process Chain (EPC). The meta-model of each language is created and the

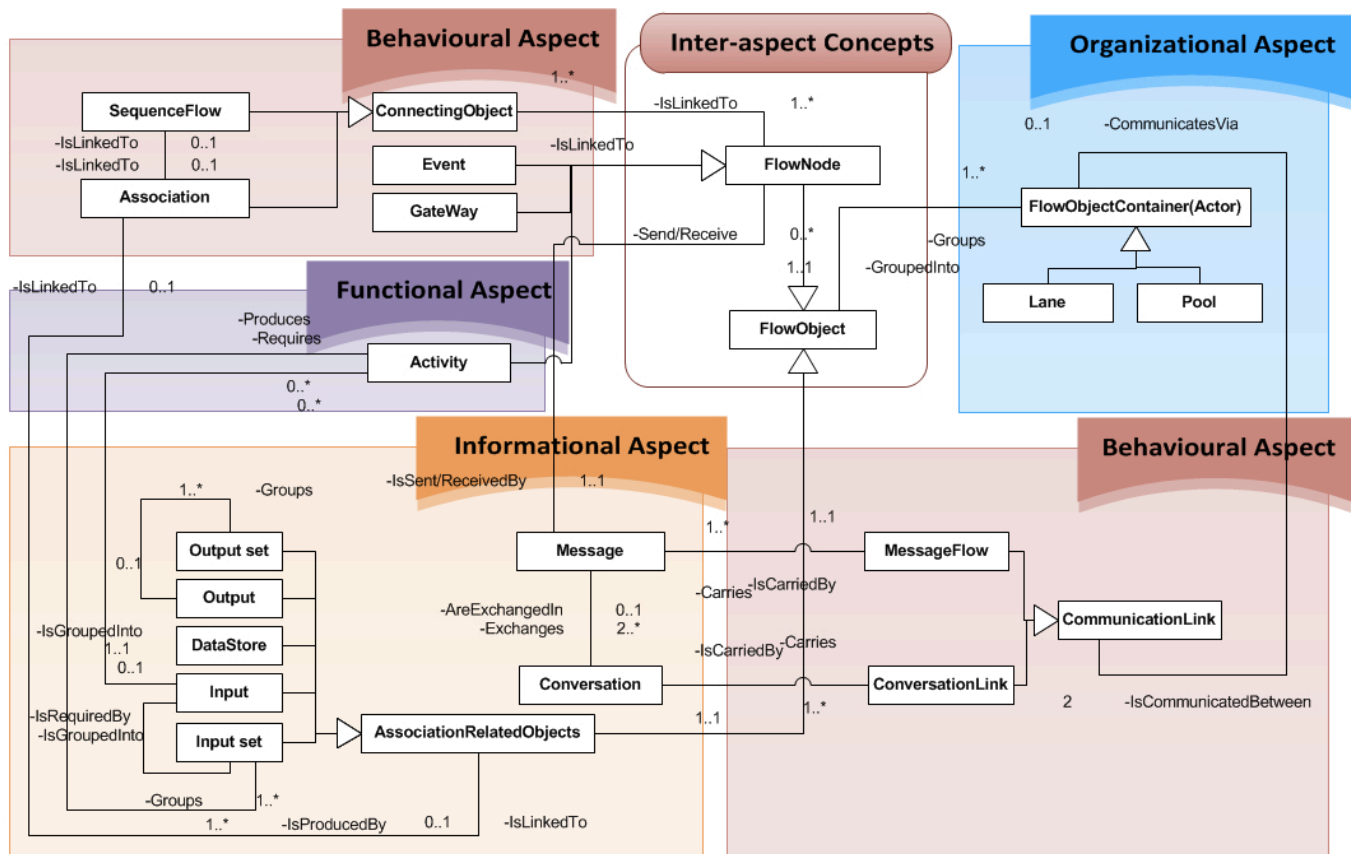


Fig. 2. The overview of the integrating business process meta-model in relation to different aspect

semantics of each individual concept are identified in this approach.

Each business process modelling language has its own and rich underlying semantics. As concepts from different languages do not perfectly match semantically, the unified framework first categorizes concepts into different aspects of a business process namely: *functional*, *behavioural*, *organizational* and *informational* in the form of a taxonomy. In this taxonomy for example role (RAD), organizational unit (EPC), swimlane (BPMN), partition (UML AD) are grouped together in the organizational aspect as they can serve the purpose of representing executors of an activity.

Fig. 2 demonstrates a general view of the business process meta-model in terms of the main concepts and relationships between different aspects. The proposed business process integrating meta-model represents an abstraction of business process concepts, is universal and not dedicated to one single business process modelling language. The business process integrating meta-model clarifies the exact relationships between the concepts. Moreover, it provides an adequate semantics specification prohibiting invalid interpretations by experts in different domains. Transforming these explicit syntactic relationships into a machine-readable language like Web Ontology Language

(OWL) provides the option of direct implementation. The ontology also provides an abstraction upon which elicitation, definition and documentation of requirements can happen.

One of the applications of business process ontology as a repository is as a reference to support explication of requirements. An ontology can describe both functional and non-functional requirements [2]. One of the applications of a business process ontology confined to quality aspects is that stakeholders can define their desired requirements in a higher level (meta-model) rather than in specific business process model, that covers just one situation. A business process ontology, enriched with the desired requirements, can act as a reference model for future enriched business processes generations (Fig. 3).

Fig. 3 provides a partial view of the instantiation of the meta-model and incorporation of requirements to the business process concepts (meta-level) and instances (Model). Fig. 3 shows that the desired requirements not only can be incorporated into the business process concepts in the meta-level but in instantiations using Protégé, Protégé provides direct, objective and straightforward incorporations of requirements. This facilitates not only communication between different stakeholders but also provides a guideline independence of the developer appreciations. This can

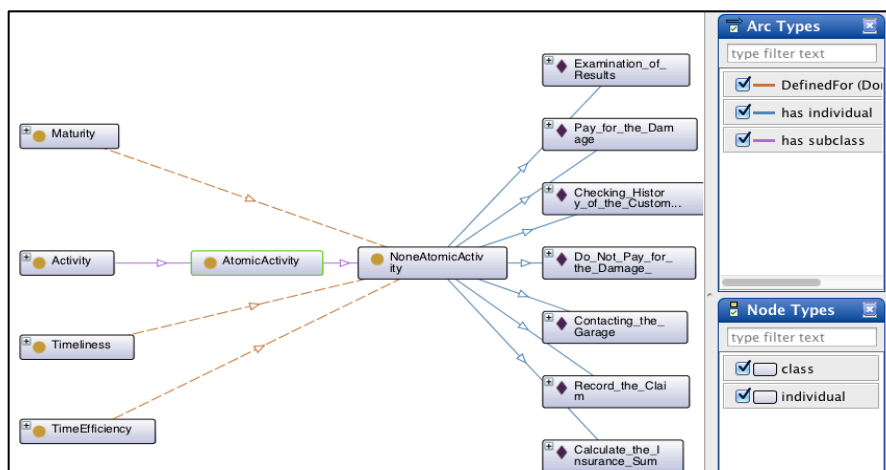


Fig. 3. An example of the instantiation and incorporation of quality requirements

fosters efficiency, integrity, consistency, and reusability and reduces human mistakes, etc. The business process integrating meta-model can also act as a repository. This repository can have several applications: (a) to represent models created via deploying any of the constructing modelling languages as its instantiations, (b) to be a reference between multiple business process modelling approaches of the same project, (c) to provide the basis for a repository of emerging business process models irrespective of the language used, (d) to be extended to a knowledge

base, (e) to facilitate direct implementation, and (f) to be a reference model fostering incorporation of stakeholders' requirements.

The quality factors can be realized for specific concepts of the integrating business process meta-model. Heidari et al. [13] introduces quality factors of throughput, cycle time, timeliness, cost, resource efficiency, cost efficiency, time efficiency, reliableness, failure frequency, time to failure, time to recover, maturity, authority, time to shortage, time to access and availableness for their related business process

Table I. Quality Dimensions and Factors

Dimension	Factor	Business Process Concept			
		Event	Output	Input	Activity
Performance	Throughput	X	X	X	
	Cycle Time				X
	Timeliness			X	X
	Cost			X	X
Efficiency	Resource Efficiency				X
	Time Efficiency				X
	Cost Efficiency			X	X
Reliability	Reliableness				X
	Failure Frequency				X
Recoverability	Time to Failure				X
	Time to Recover				X
	Maturity				X
Permissibility	Authority			X	X
Availability	Time to Shortage			X	
	Time to Access			X	
	Availableness			X	

concepts namely, event, output, input and activity (Table I).

The integrating business process meta-model can be enriched formally with these quality factors. The resulting meta-model is shown in Fig. 4. Note that this is a subset of the entire integrating meta-model, focusing on those concepts that are related to the quality aspects. Business process concepts are shown in white classes and quality factors are shown in grey classes. The meta-model enriched with quality factors can be used for quality modelling and business process redesign and can help practitioners to consider quality requirements of a business process at the earliest stage of system development.

IV. THE MODEL-BASED SPECIFICATION AND MEASUREMENT APPROACH

This paper proposes an approach to the specification and the measurement of quality requirements for business process concepts. This approach considers quantitative metrics for business processes in its specifications and measurement. The conceptual framework of the approach is

The “conceptual framework” encompasses a set of concepts that link requirements to specific business process concepts, their factors and corresponding metrics. Requirements can be classified into functional and non-functional requirements of a business process [42].

Functional requirements refer to the ability of the business process to deliver qualified products and services as well as the ability of the outcome to fulfil its functional expectations [43]. Glinz [44] offers a set of classification rules for distinguishing between functional requirements (FRs) and non-functional requirements (NFRs) in system engineering. In this classification, the concept of non-functional requirements can be defined as: requirements about timing, processing or reaction speed, input volume or throughput as well as specific quality of business process concepts as a whole reflected in those ended in “-ilities” namely: reliability, security and availability etc. This paper considers the notion of non-functional requirements by [44] as quality.

Fig. 5 depicts that “Quality Requirements” (e.g., capturing customer data must be most of the time without failure), are associated with a “Business Process” (e.g., accepting client). A “Business Process” is responsible for fulfilling a set of “Quality Requirements”. A “Business Process” consists of numerous “Business Process Concepts”. A “Business Process Concept” (e.g., capturing customer data) belongs to a “Business Process” (e.g., accepting client).

A “Quality Requirement” is expressed by a “Stakeholder” (e.g., company manager) and is operationally queried by a set of “Quality Questions” (e.g., what is the percentage of the time that the execution is without failure out of the whole time of execution?). Operationally querying

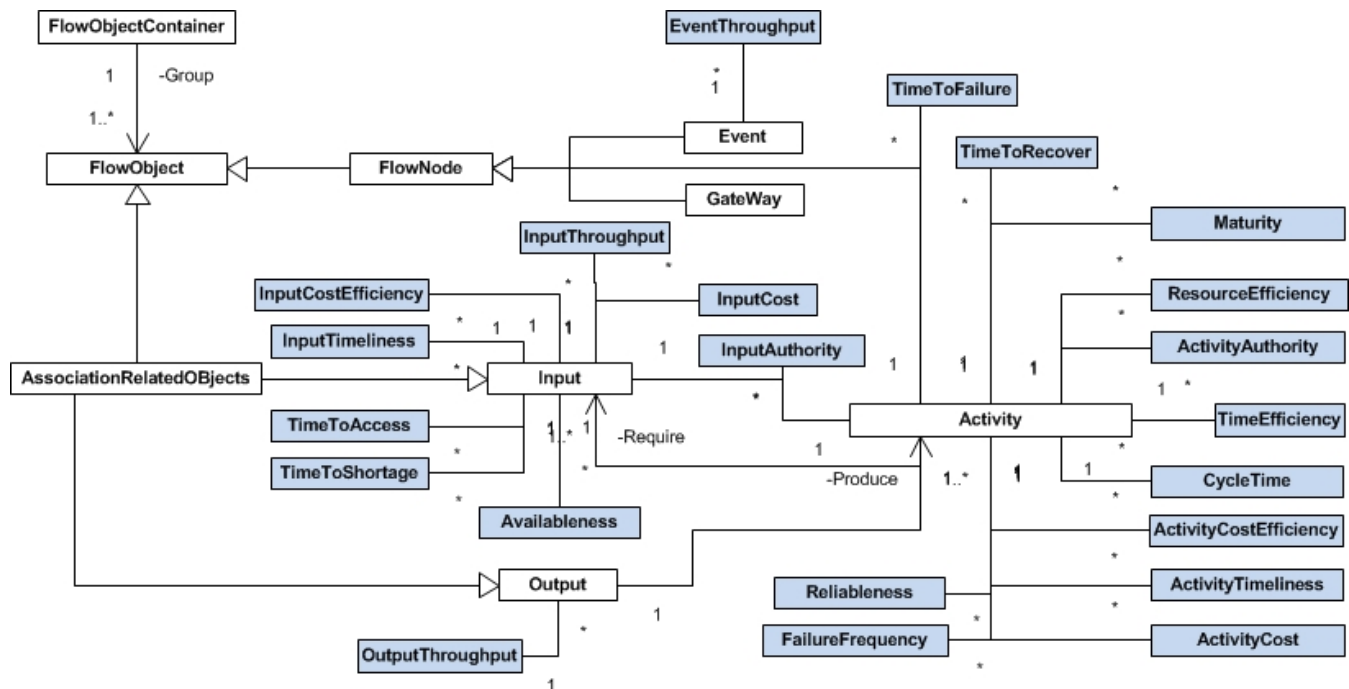


Fig. 4. The business process integrating meta-model enriched with quality factors

“Quality Requirements” are linked to components that participate in measuring achievement of the “Quality Requirement”. “Quality Question” essentially is a query on the 3-nary relationship of “Business Process Concept”, “Quality Factor” and “Quality Metric” as depicted in the objectified relationship “Result” related to “Quality Question”.

A “Business Process” consists of a set of “Business Process Concepts”. A business process “Quality Factor” is an inherent property of a “Business Process” or a “Business Process Concept” that can be measured quantitatively by “Quality Metrics”. Similar to [45], ‘Quality Factors’ are grouped into “Quality Dimensions”, each “Quality

Dimension” representing an aspect of business process concept quality e.g., performance, efficiency and those colloquially referred to “-ilities”.

The “Quality Objective” (e.g., more than 95% of the time, execution should be without failure) is a way of quantitatively analysing the “Quality Requirement” and is defined as some “Target Quality value” (e.g., $\geq 95\%$), which is shown as objectified relationship of three concepts namely those of “Quality Factor” (e.g., maturity) for particular “Business Process Concept” (e.g., capturing customer data) and a corresponding “Quality Metric” (e.g., $M(a)=[TF(a)/TF(a)+TR(a)]*100$).

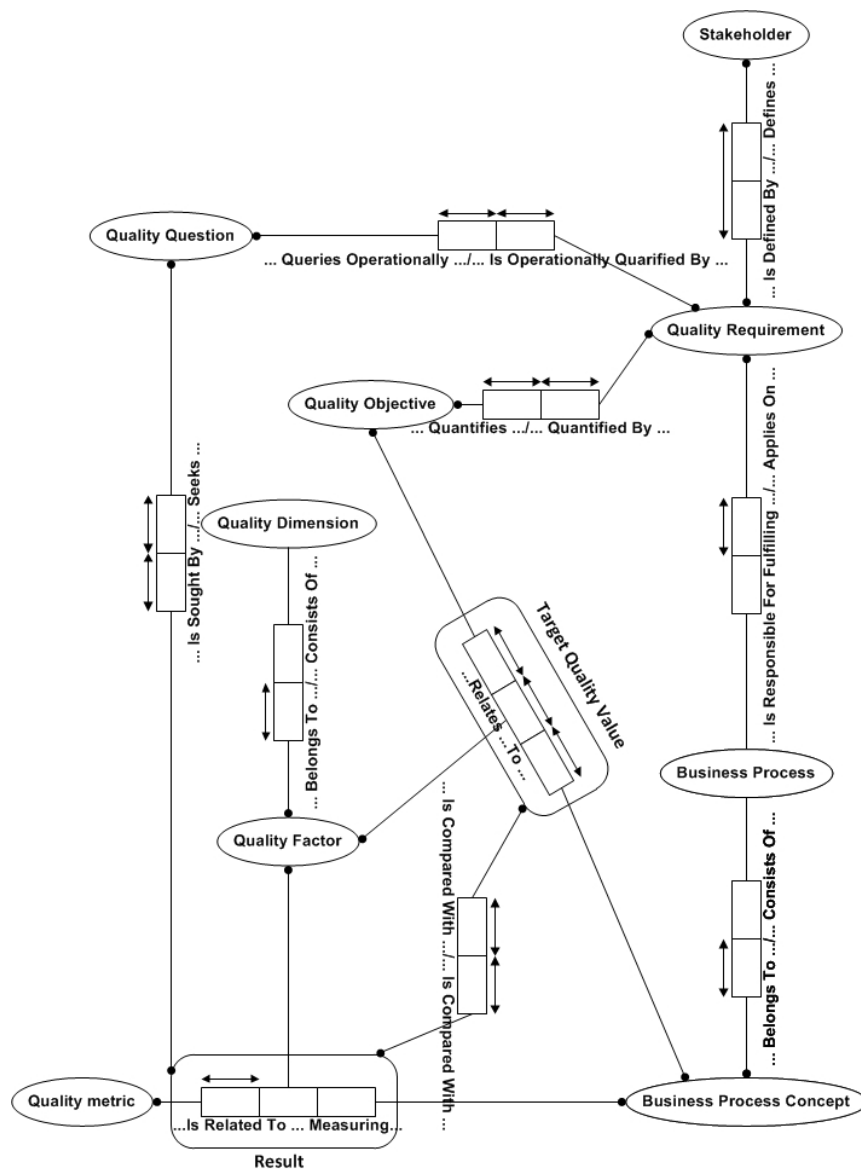


Fig. 5. Conceptual framework for business process concept quality specification and measurement

The gap between “Quality Objective” and the observed current performance through “Quality Question” is shown in the relationship of “Target Quality Value” and “Result”. Several “Quality Metrics” can be associated to a single “Quality Factor” as there might be several ways for evaluating it. Different stakeholders can indicate different quality metrics based on their needs [18].

The conceptual model guides the systematic application within the approach. Specifically, the process is described as an algorithm in Pseudocode (Fig. 6).

The contribution of this framework is in the establishment of a set of conceptual structures that are independent of the descriptive languages, or applications. Applicability of the framework is illustrated for an example of business process in the next section.

V. DEMONSTRATION OF APPLICABILITY IN AN EXAMPLE

The applicability of the approach this paper proposes is demonstrated for a simplified version of business process, namely “Accepting clients” from an anonymous enterprise. The business process is known to this enterprise.

First, in a more visual way, the instantiation of the

conceptual framework is provided (Fig. 7). Fig. 7 illustrates not only the business process in terms of a model but also provides examples of the related elements for quality specification and measurement considering the business process concepts. Later, the conceptual framework is instantiated formally (Fig. 8) to demonstrate its application relates to the example in the form of an ORM model.

As can be observed from Fig. 7, there are different departments/roles involved in the process. The process trigger is the arrival of a request to accept a client. To accept the client, a set of activities is performed in a predefined order. Some related quality factors are shown in Fig. 7 namely, time to recover, time to failure, maturity, authority, timeliness, cycle time, and throughput. Quality factors are assigned to the business process concepts via dashed lines as shown. For the matter of distinction, quality factors are shown in a separate box below the example. The “business process” is presented via applying BPMN as a “Business process modelling language” supported by a business process meta-model e.g., [8].

Fig. 7 shows that the quality requirement of “Capturing client data should be executed more than 95% of the time without failure”, is associated with the business processes concept of “capturing client data”; this concept belongs to

ALGORITHM.

BEGIN

A stakeholder defines Quality requirements in natural language

FOR each quality requirement

Define the business process referenced in the quality requirement;

Define a quantified expression as quality objective;

FOR each quality objective

Determine the business process concept to which quality is referred;

Define quality factor for this concept;

Define the metric to be applied to this quality factor;

ENDFOR

Query the quality of the business process as a question;

FOR each question

Identify the business process concept being queried;

Identify quality factor for this concept;

Apply the metric to be applied to this quality factor;

Obtain result of measurement;

ENDFOR

Compare the result of measurement with quality objective;

Define degree of satisfying quality objective;

ENDFOR

Return the results to stakeholder;

END

Fig. 6. Algorithm for quality specification and measurement

business process of “accepting client”. The Requirement is expressed by a the “company manager” as the stakeholder and is operationally queried by questions of “What is the percentage of the time that the execution is without failure out of the whole time of execution?” The quality factor “maturity” can be measured by a quality metric expressed as follows:

$$M(a)=[TF(a)/TF(a)+TR(a)]*100 \quad (1)$$

Where “a” denotes the “Activity”, TF(a) is the “Time to Failure” and TR(a) is the “Time to Recover”.

Applicability of the proposed approach is also demonstrated via instantiation of the conceptual framework (Fig. 8) with regards to the example. The instantiation is focused on the quality requirement of “ capturing client data should be executed more than 95% of the time without failure”. Instances are introduced as “roles” in “fact tables”. Information in the fact tables is in line with the example described earlier and provided in Fig. 7.

VI. CONCLUSION AND FUTURE WORK

This business process integrating meta-model as an

abstraction provides an explicit specification of the shared conceptualization and understanding of enterprises between IT and non-IT experts. This paper focuses on a specific modelling approach, that of Business Process Modelling, and the use of a meta-model for modelling and evaluating quality aspects of business processes. Specification and measurement of requirements based on concepts in business process meta-model fosters communication between experts.

Many different approaches have been developed, each with their own specific business process modelling languages (BPML) designed to meet specific business requirements. In cross-organizational business processes and heterogeneous organizations where multiple business process modelling languages are deployed, there is a need for a unified and integrating view to ease communication and foster understandability.

This paper proposes an approach that drives specification and measurement of quality requirements. This paper assumes that the quality of a business process can be defined by the degree to which pre-defined properties of pre-defined concepts identified within a business process are linked to stakeholder requirements. The methodological stance of the

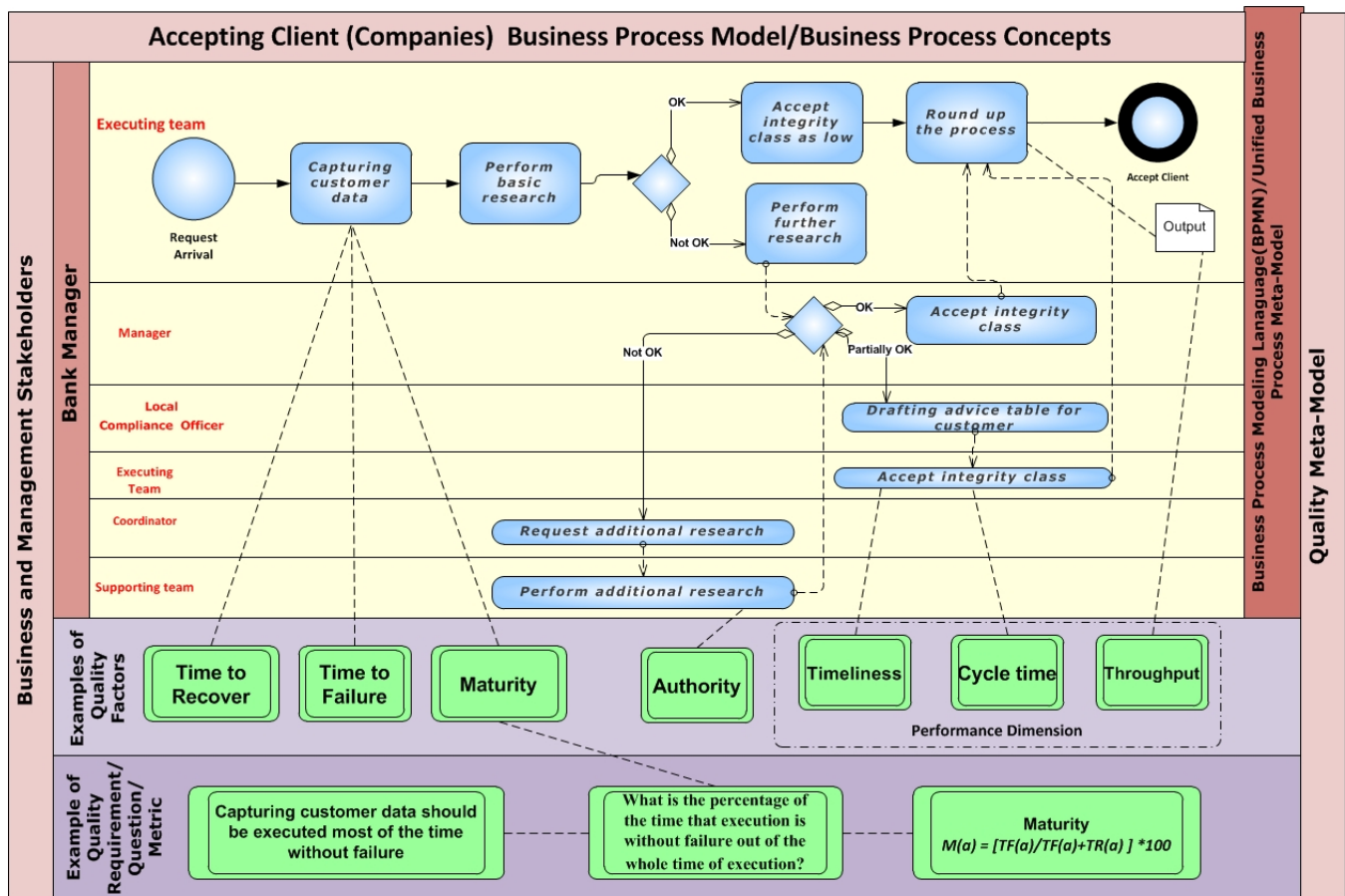


Fig. 7. Business process “Accepting Client” and examples of quality factor, requirement, question and metric

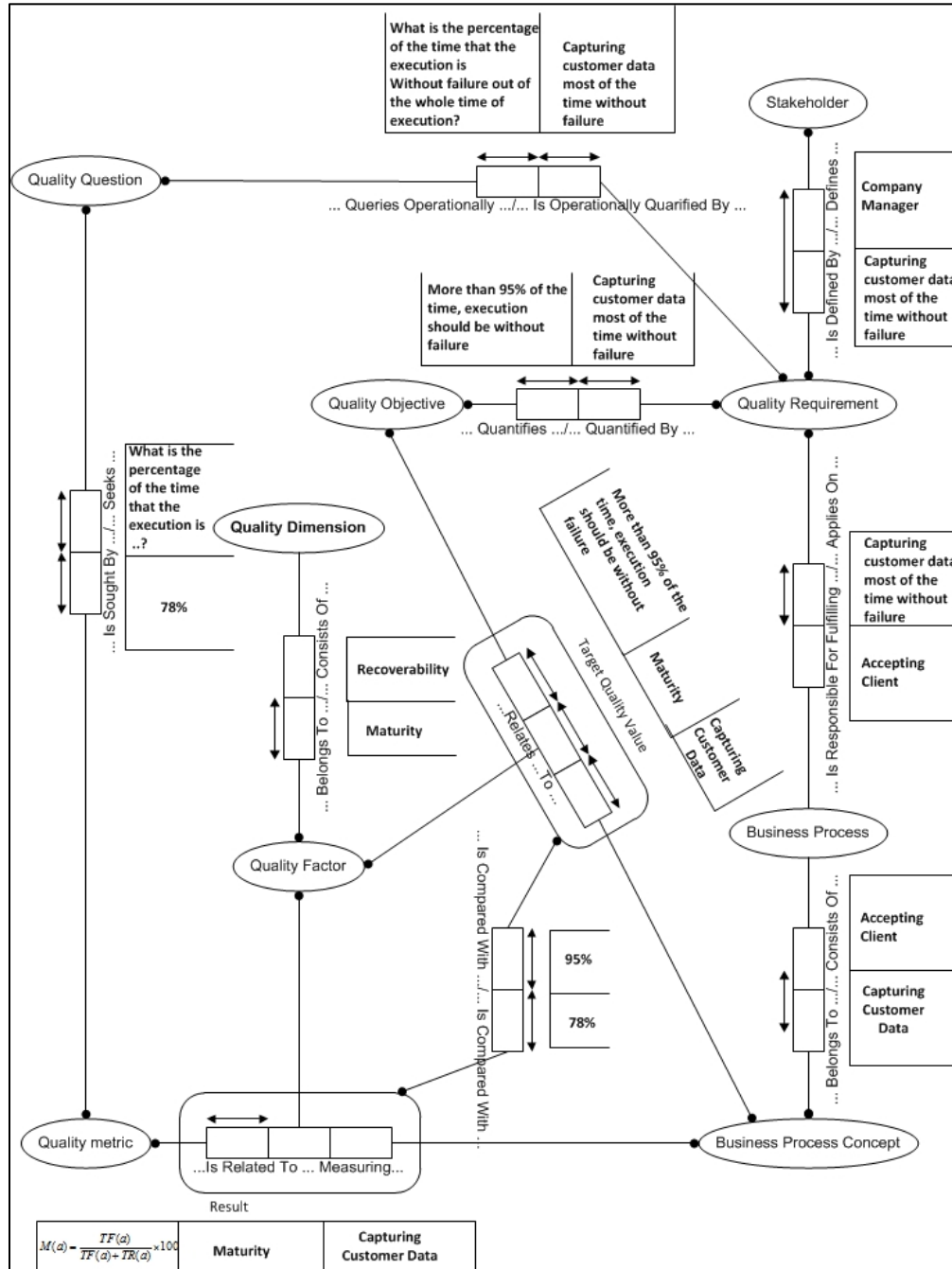


Fig. 8. The conceptual framework instantiation for “accepting client” business process (quality requirement: capturing client data should be most of the time without failure)

approach proposed in this paper is systematic. Stakeholder goals are transformed to objectified components, a quality objective and a quality question, that are directly linked to quality factors for a pre-defined business process concept. The approach relies on *formal* expressions of business processes in business process models. At the same time, it is *independent* of any language. The utility of the approach is *generic*, i.e., applicable to any application and within any domain.

The approach is systematic and provides methodological means to specify and measure requirements for business processes. In line with the items introduced in Section IV, a set of phase is prescribed with details on the “way of working” within each phase, i.e., (a) focus of work, (b) required inputs, (c) expected outputs, (d) techniques used and (e) support tools. On the basis of these four criteria, the

approach is considered to be systematic in that there is an identifiable and generic approach to business process quality computation (the focus), analysing business processes given the stakeholders' requirements (the input), deriving a quality evaluation (the output), using objective formulae for such a measure (the technique) and finally having a formal representation scheme for automated support (the tools).

The outcomes of this research are beneficial in the areas of business and management, requirement engineering, software engineering, business process modelling and service-oriented architectures. In the areas of requirement engineering and software engineering, these results make it possible for practitioners to consider quality requirements at the earliest stage. In the area of process modelling, the outcomes lead to a quality-driven modelling and redesigning. Moreover, qualified business processes have direct impacts on the quality of web-services.

This paper establishes a strong framework upon which different methodological and technological developments may emerge such as an enhancement of existing business process modelling tools with a simulation component, the development of a workbench for analysing measured qualities and the development of further cases on an industrial basis [46]. Future research will focus on extensions and developments both in theoretical and practical perspectives. Exploring possibilities to enhance existing industrial business process-modelling tools with quality evaluation extensions is currently subject of research. Also, strategic modelling approaches such as system dynamics are to be coupled to business process modelling using parametric definitions according to quality criteria and experimenting with 'what-if scenarios' thus giving stakeholders an early view of the impact of their choices, on the behaviour of a business process [47]. In addition to the specification and measurement of quality requirements for individual business process concepts, there is a need for measuring requirement fulfilment by a business process as a whole or a part of a business process. There is a need for an approach that can foster objective evaluation of the degree to which a quality requirement for a business process is achieved based on the achievements of its individual concepts.

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