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A New Approach to Evaluate Correctness in Graph Based Business Process Modeling Languages (case study: BPMN)

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Abstract. So far, many studies on measurement and evaluation criteria for software engineering have been done, but few researches have been conducted on the business processes. On the other hand, nowadays many business modeling languages have been designed and introduced. Selecting a proper business process modeling language has a large impact on the design's result. One of the key criteria in assessing the quality of business process modeling language is their correctness. This criterion has a direct relation with desirability of a business process modeling language. This study provides a new framework for evaluating correctness of business process modeling languages. The suggested framework can be useful in choosing the right modeling languages and also comparing them.

Keywords: Business process modelling languages, Graph-Based, formal framework, evaluating Correctness of business process modelling languages, BPMN

1. Introduction

Today, process modelling is widely used within organizations as a way of increasing awareness and knowledge of business processes, and to reduce organizational complexity [11]. Business Process Modelling Languages (BPMLs) is the most important tool for modelling. At present, more than 350 languages and tools for modelling and design of business processes have been introduced [1]. Recker in [2] mentioned that: "Process Modelling is like turning a lot of light bulbs on in the minds of managers." Unfortunately due to the large number of BPMLs, select the appropriate language is very difficult. Also, no detailed assessment and analysis of BPMLs exist. So users can not easily recognize the strengths and weaknesses of modelling languages. So far, many studies have been conducted on the evaluation criteria of programming languages. But very little research has been done on the business processes. In general a good model should have two basic characteristics, Correctness and Usefulness [4]. Correctness is one of the most important criteria in assessing the quality of BPMLs. We can say that BPMLs correctness is a precondition for their usefulness. Recently, several quality frameworks for BPMLs have been proposed, but in most studies [5, 6, 7], according to this criterion is less important.

Also in these works, No formal method has not proposed to measure the accuracy of the model. Assessing the accuracy of BPMLs, make them easier to compare. Also provide a formal approach for evaluating BPMLs, can be a great help to improve them. These parameters help business participants to improve the model with less error, easier to understand and have better performance [8]. Measurement is a key to strategic planning. As Lord Kelvin, a noted mathematician once said [9]: "If you can measure something and put a number to it, you can begin to understand it. If you cannot measure it, you have a very sorry ability to understand it...".Therefore, a comprehensive and formal approach for assessing the correctness of BPMLs is so useful.

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This paper is organized to study, in the next Section, business process modelling languages. The proposed framework introduced in Section 3, as well as how to measure the evaluation criteria are expressed. In section 4, BPMN as one of the most popular BPMLs, is evaluated. Finally, Section 5 concludes the paper.

2. Business Process Modelling Languages(BPMLs)

Business Process Modelling (BPM) has emerged as a dominant technology in current enterprise systems and business solutions, BPM solutions have been prevalent in both industry products and academic prototypes since the late 1990s [10, 12]. Process modelling is a key instrument for the analysis and design of process-aware IS, service-oriented architecture, and web services [11].

In general, there are two most predominant formalisms on BPML development [12]:

1) Graph Based Modelling Languages: Graph based formalism that has its root in graph theory or its variants. They have the visual appeal of being intuitive and explicit, even for those who have little or no technical background. In a graph based modelling language, process definition is specified in graphical process models, where activities are represented as nodes, and control flow and data dependencies between activities as arcs. The graphical process models provide explicit specification for process requirements.

2) Rule Based Modelling Languages: Rule based formalism that is based on formal logic. These languages require good understanding of propositional logic and the syntax of logical expressions thus are less attractive from the usability point of view.

Rule based languages have less attractiveness and less efficiency. So in recent years, graph-based modelling language, have much growth. Syntax is one of the main features of graph-based modelling languages. Syntax shows the elements of a language and the relationship between business processes. This paper is suggesting a new formal framework to evaluate graph-based BPMLs correctness.

3. New Framework for Evaluate Correctness in BPMLs

This approach is a formal method for the measurement accuracy of BPMLs. In this framework, the accuracy Metrics is extracted. Then the measurement of each metric is expressed.

3.1. BPMLs Perspectives

Modelling language that can be evaluated from different aspects, so different aspects of BPMLs must first consider evaluating them. Cutis et al in [8] suggested a framework consists of four perspectives: Functional, Behavioural, Organizational and Informational perspectives. A new perspective of BPMLs is mentioned in [13]. The five main perspectives for BPMLs have been introduced as follows:

- Functional Perspective
- Organizational perspective
- Process perspective
- Informational perspective
- Business process context perspective

These five perspectives can capture all important information of BPMLs. According to these perspectives, a generic meta-model [16, 17] is designed for every BPMLs. Different aspects of BPMN and its meta-model shown in Fig.1.

3.2. Formalization of the BPMLs

A BPML is defined as a 3-tuple BPML= <V, O, R >, where:

- V is a set of BPMLs views;
- O is a set of generic BPMLs objects;
- R is a set of generic Relationships;

Also to provide a formal framework, some additional definitions are needed as follows:

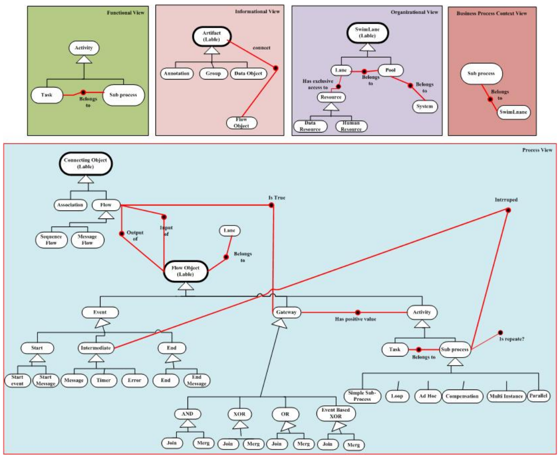

Fig 1.The Meta-Model of BPMN

- O_{Base} is a set of core and essential BPMLs objects. Based on the generalization relationship, O_{Base}={o ∈ O|∃ d ∈ O: <o, d> ∈ O×O} contains all base objects that play a sub type role [4];
- all_subroles $R \times \mathbb{N}^{+} \rightarrow \wp(O_{Base})$, calculates the number of all $o \in O_{Base}$ that can play a specific role in a given relationship [4];
- $d: R \rightarrow \wp(O \times \mathbb{N}^{+})$, Distinguishes objects that occur more than once in a relationship. $card(r\epsilon R) = |d(R)|$, measures the number of roles in a Relationship r;
- $A \subseteq (O \times R) \times V$, defines in which BPML Views the Objects and Relationship appear;
- $M: V \rightarrow \wp\ (O \cup R)$, maps BPML Views to the set of objects and relationships that appear in the view. The definition is $M(v) = \{o \in (O \cup R) | < o, v > \in A\}$;
- $UC \subseteq R \times \wp(\mathbb{N}^{+})$, Uniqueness Constraints is the set of combinations of roles of which the combination of corresponding instances of generic concepts corresponding to these roles may occur only once in the set of individual knowledge primitives that belong to the generic knowledge primitive [4];
- $\mathrm{RQ} \subseteq \mathrm{R} \times \mathbb{N}^{+}$, Required Roles is the set of required roles which is comparable to obligation or totality constraints other role modelling approaches [4];

According to these definitions, evaluation criteria for BPMLs correctness are expressed.

3.3. Criteria of Correctness

A common way to understand the quality of something is to subdivide quality in a number of quality properties that each addresses a particular aspect of quality [18]. So, to evaluate the BPMLs correctness, in this paper we have conducted a formal framework. The main criteria for assessing BPMLs correctness is shown in Fig.2.

In the proposed framework, the assessment of measurement for each criterion is completely specified. This framework is used to formal metrics for the measurement on BPMLs. Formal metrics are very accurate and reliable, because as Hommes in [4] mentioned, the process of calculation is free of human judgment and Values are calculated out of the Meta model of BPMLs that is Investigated. But in some criteria, formal method is not possible, so the only possible using is a mixture of inquiring and formal methods.

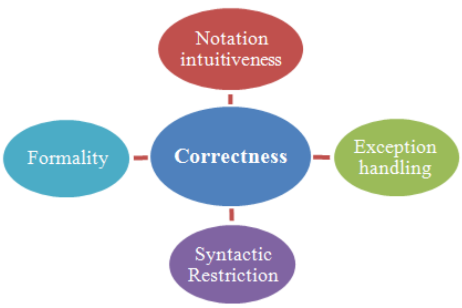

Fig 2. A Framework for Assessing Correctness of BPMLs

Table I. Grading Scale in Questionnaire Method

Grade	Explanation
0	There is no support of the requirement
1	The requirement is partly supported
2	There is satisfactory support of the requirement
3	The requirement is very well supported

Table II. Correctness Measures for Evaluating BPMLs

Based Measures					Derived Measures	
	Property	**Metric Name**	**Proposed Metric**	**Metric Type**	**Metric Name**	
1	**Notation Intuitiveness**	VNI (View Notation Intuitivenes)	$VNI = \frac{Sum(vni)}{18}$	Semi Formal	**WNI**	WNI $= \frac{\sum_{i=1}^{V} VNI}{\lvert V\rvert}$
2	**Syntactic Restriction**	RSR (Relationship Syntactic Restriction)	$RSR_{r\in R,v\in V} = \prod_{i=1..card(r)} \frac{\lvert all\_subroles(r,i)\rvert}{\lvert M(v)\cap O_{Base}\rvert}$	Formal	**WSR**	$WSR = \sum_{v\in V} \frac{VSR_v}{\lvert V\rvert}$
		VSR(View Syntactic Restriction)	$VSR_{v\in V} = \sum_{r\in M(v)\cap R} \frac{RSR_{r,v}}{\lvert M(v)\cap R\rvert}$			
		VUC(View Uniqueness Constraints)	$VUC_{v\in V} = \frac{\lvert M(v)\cap \{r\in R \mid \exists n\in \wp(\mathbb{N}^+): <r,n>\in UC\}\rvert}{\lvert M(v)\cap R\rvert}$	Formal	**WUC**	$WUC = \sum_{v\in V} \frac{VUC_v}{\lvert V\rvert}$
		VRQ(View Required Roles)	$VRQ_{v\in V} = \frac{\lvert M(v)\cap \{r\in R \mid \exists n\in \wp(\mathbb{N}^+): <r,n>\in RQ\}\rvert}{\lvert M(v)\cap R\rvert}$	Formal	**WRQ**	$WRQ = \sum_{v\in V} \frac{VRQ_v}{\lvert V\rvert}$
3	**Formality**	VF (View Formality)	$VF = \frac{\lvert MTPN\rvert}{\lvert M(V)\cap O_{Base}\rvert}$	Formal	**WF**	$WF = \frac{\sum_{i=1}^{\lvert V\rvert} VF}{\lvert V\rvert}$
4	**Exception Handling**	SEP (Supported Exception Patterns)	$\lvert SEP\rvert$	Formal	**EXH**	$EXH = \frac{\lvert SEP\rvert}{\lvert AEP\rvert}$
		AEP(All Exception Patterns)	$\lvert AEP\rvert$			

Table III. Questionnaire Measure of the Clarity of Notation

	Questions	Scale
1	Are the symbols used for different generic concepts well distinguishable [4]?	
2	Is the notation intuitive, i.e. in line with current and past practice [4]?	
	Is it easy to differentiate between the different symbols in the language [7]?	
3	Are the symbols that are used different from standard shapes such as rectangles, circles, ovals, diamonds, et cetera [4]?	
4	Did the concepts name similarity as it is in the domain [7]?	
5	Does the BPML have a guideline for the use of it [7]?	
6	Is it possible to understand BPML's symbols, without having prior knowledge of it?	
	vni	Sum

Table .1 is used in a questionnaire method for measuring criteria [7].

3.4. Measuring The Quality Metrics of BPMLs Correctness

For the use of formal methods, must have a thorough understanding of the criteria of each of BPMLs. So fully understand of BPMLs criteria is needed [4]. Table 2 shows the obtained equations for every metrics.

3.4.1. Notation Intuitiveness

Notation Intuitiveness (NI) means that how much a BPML is understood by modelers and stakeholders. It means comprehensibility [5]. BPMLs notation affect to language's understandability [6]. Based on [4], NI cannot be measured with formal metrics, so a good alternative is the mixture method of formal and inquiring metrics. Table 3 shows the NI questionnaire. These questions should be asked for each of the BPML's view. The VNI (View Notation intuitiveness) is a based metric that shows NI in a certain view of a BPML. Finally, the WNI (Whole Notation intuitiveness) is obtained by calculating the average of all VNI. If WNI is the maximum value, being 1, thus the notation BPML is so intuitive.

3.4.2. Syntactic Restrictions

Syntactical restriction(SR) mentioned in [5] as arbitrariness, that means the degree of freedom that a given modeling techniques can offer when modeling a particular field .The BPML is strict if it restricts how concepts can be combined to form complex constructs. SR is determined by consistency and well-formedness. Firstly RSR, VSR, VUC and VRQ as based metrics are calculated. Finally, WSR, WUC and WRQ are determined as a derived metric [4].

3.4.3. Formality

Formality is the level of mathematical formality needed in process modeling [5]. To measure formality, one formal language like Petri Net [14] is selected, and BPML map to it. After that, |MTPN|shows the number of concepts that cannot map to Petri Net, in a certain view. For example in [15], BPMN [19] mapped to Petri Net.

3.4.4. Exception Handling

The Exception Handling (EXH) increases BPML difficulty but also increases the adaptability of BPMLs [6].EXH is mentioned in [5] as Flexibility that means the capability of a given modeling techniques to deal with the change or unexpected situation. To evaluate EXH, supported exception patterns (SEP) and all Exception Patterns (AEP) should be calculated. EXH is determined for the whole model of BPMLs.

4. Measuring The Correctness of BPMLs

The Business Process Modeling Notation (BPMN) [19, 20] is a graphical standard notation for capturing business processes, especially at the level of domain analysis and high-level system design. BPMN creates a bridge between business process design and implementation. The main goal of BPMN is to provide an understandable notation for those who are dealing with business processes in various fields, as it said [3]. Table 4 shows the evaluation results of BPMN. The average of correctness measures is 0.51 for BPMN.

5. Conclusion

This paper proposes a new formal framework to evaluate correctness in graph based BPMLs. The notation intuitiveness, syntactic restriction, formality and exception handling are four evaluation factors that are derived and calculated explicitly. The method of measuring is formal and results are between [0..1]. Several modeling languages can also be compared with this framework. As a result, we evaluated the correctness of BPMN. In future work we are going to extend this framework, and propose a comprehensive BPMLs evaluation framework.

Table IV. Evaluate BPMN correctness

Correctness measures	Scale
WNI	0.58
WSR	0.55
WUC	0.34
WRQ	0.42
WF	0.43
EXH	0.29

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