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Graph-Based Approach For Representing Business Process Models In Case Of Measuring Business Logic Dependencies

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GRAPH-BASED APPROACH FOR REPRESENTING BUSINESS PROCESS MODELS IN CASE OF MEASURING BUSINESS LOGIC DEPENDENCIES

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Abstract

The paper presents an approach to convert business process models into a graph structure. Examples of patterns used to create business process model in the two most widely used standards Event-driven Process Chain (EPC) and Business Process Model and Notation (BPMN) and their oriented graphs analogues are shown. A large number of diverse metrics that allow a business process model to be assessed are discussed.

Keywords: Business process model, Modeling patterns, Business metrics, Directed graph.

1 Introduction

Over the last few decades, the use of business processes as a business management tool has grown considerably and is playing an increasingly important role in decision-making. A large number of enterprises, especially in the service sector, use a set of business processes to create the products or services they offer. A major part of the expenses of these enterprises is the creation and maintenance of business processes, which are very important for product quality and customer satisfaction. With the development of global markets over the last decade and increasing competition, the implementation of business processes has also begun to take place in small and medium-sized businesses (Elias, Shahzad and Johannesson 2010).

The parallel development of business organization and management systems tends to automate the analysis and implementation of business processes. This method improves the performance of the organization, but is difficult to be applied for large and logically more complex business processes.

The most companies produce their products or services by performing a set of core business processes. These processes generate the bulk of the cost of each business and also have a strong impact on product quality and customer satisfaction.

Due to the big competition in globalized markets, which requires rapid innovation, companies are aware in recent years that they are looking at the business processes and their optimizing as at an important key to economic success these days. As a result, business process management and their automated implementation require standardization, constant analysis and optimization.

A prerequisite for this analysis and optimization is the measurement of important external attributes of the business process model, such as cost, duration, or probability of error occurrences. It would be desirable to be able to predict these values before the process model is implemented and executed.

Process measurement addresses this problem. It was highly motivated and inspired by software measurement. There, external attributes such as cost, duration of deployment, and number of errors are predicted for piece of the source code by applying software metrics to a number of internal (structural) characteristics of the source code.

Later metrics have been defined to measure the complexity, quality and performance of a business process model, either with software metrics adapted or with the new metrics to measure business process characteristics.

Retrieving and analyzing new metrics from business processes structure will allow for more accurate results in automated decision-making in business process modeling and implementation.

This article aims to present an algorithm allowing the transformation of business processes to graph structure and the extraction of new metrics and logical dependencies. Such transformation has been proposed for two of the most common standards for business process modeling, which supports both the implementation of metrics for graph structures and the re-use of existing business process models.

2 Related work

The measurement of business process models is a part of the methodologies for their analysis and optimization. Collecting various data related to their performance and behavior is becoming more and more important to business because it allows for more accurate forecasting of the results obtained. There are several studies on the subject discussing the measuring of various aspects of business process models.

Irene Vanderfeesten and colleagues (Vanderfeesten et al. 2007) review quality metrics, which analyze the business process model under consideration and determine the likelihood of its erroneous performance. A business process model exhibits many similarities with traditional software programs. A software program is usually partitioned into modules or functions (i.e. activities), which take in a group of inputs and provide some output. Similar to this compositional structure, a business process model consists of activities, each of which contains smaller steps (operations) on elementary data elements. Moreover, just like the interactions between modules and functions in a software program are precisely specified, the order of activity execution in a process model is predefined using logic operators such as sequence, splits and joins.

In the study (Jung, Chin and Cardoso 2011) the authors suggest metrics that track the variability and uncertainty in a business process, which would be useful in terms of risk measurement. The process uncertainty is defined in terms of the transition and execution of tasks. In managing business processes, the process uncertainty and variability are significant factors causing difficulties in prediction and decision making, which evokes and augments the importance and need of process measures for systematic analysis. The proposed measure enables capturing the dynamic behavior of processes, in contrast to other works which focused on providing measures for the static aspect of process models.

In the research report (Latva-Koivisto 2001) several different metrics applied to the business processes to measure their complexity are examined. Measuring the complexity is recognized as a basic activity of any systematic approach to improvement, and forms the basis of scientific methodology. To analyse and improve a business process, its properties should be measured. Similarly, also the complexity of the business processes should be measured.

Measurement and data collection related to business processes behavior is applied at different stages of their lifecycle. A method for analyzing business process models during their design and redesign stages is presented in the paper (Han, K. H., J. G. Kang and M. Song 2009). By combining micro- and macro-level analysis, extended with simulation of the processes under consideration, the method provides a way to measure performance and efficiency by which processes with the greatest impact on the enterprise can be identified. At the early stage of business process analysis, macro process analysis is conducted to identify the influence of a business process on a target key performance indicator. If target business processes that need improvement are identified through the macro process analysis and to-be processes are newly designed, micro process analysis using simulation is conducted to predict the performance. By using the proposed, two-stage process analysis, company staff involved in process innovation projects can determine the processes with the greatest influence on enterprise strategy, and can systematically evaluate the performance prediction of the newly designed process.

One of the most common and the most used metrics applied to business process models refers to their performance. Measuring the added value generated by the business process is one of the key business-related indicators. This is most often achieved by collecting and analyzing data in real time or by simulating of business process. An approach to determining business process productivity is presented in (Glykas 2013). The article discusses the use of Fuzzy cognitive maps and Strategy maps as a means for determining and evaluating logical scenarios. The method examines business objectives in detail by decomposing the business process through the prism of different levels in a business organization.

The results of applying the same methods of business processes measurement and analysis can be interpreted differently depending on the field of application and the individual needs of the business organization. A detailed analysis of what and how should be measured in a business process model in the context of determining its performance levels is presented in (Robson 2004). The study examines how a process should be analyzed and compared to the organization's goals, performance criteria, and how to determine the minimum number of parameters that affect measurement accuracy. Using basic principles from complexity theory, psychology and management theory the author demonstrates that many traditional methods of identifying performance measures may not result in improvements in overall performance. Rather than proposing yet another, different approach, the paper outlines the steps that integrate other approaches into a single, unified measurement approach to improving process performance.

The measuring of different characteristics of business process models can generate large amounts of data. In order to achieve optimal results when analyzing the business processes, it should be measured and evaluated with as many metrics as possible in the final assessment. The processing a large set of data requires more time and effort and allows for errors. In (Yen 2009) the idea of combining the basic metrics for evaluation of business process models into a single metric has been considered, affecting all parties involved in the implementation of the business process. An attempt is made to combine all relevant measures (with respect to the goals of the business process) into one overall measure. The overall measure is to reflect all stakeholders' perspective and importance on the goals of business process in question. Unlike most of the studies, the single metric is not formed by parameters applicable only to business processes, but components of probability theory, queueing theory, software engineering, and others are also used.

The variety of metrics and methods for assessing business logic in various aspects and through different stages of a business process's life cycle create the impression of chaos. The lack of a standard or a single methodology for assessing business processes, as well as the fact that each organization interprets the data as well as the ways to collect it according to its needs and objectives, requires the need to reflect the current state of business process measurement methods and metrics. A comparative analysis of 19 publications on the subject presents the main metrics for business process measurement as well as the trends for using the data obtained (Sánchez González et al. 2010).

The metrics considered are a good starting point for measuring key features of business process models, but the information obtained is not sufficient to accurately predict, analyze, or automate a business process model. Depending on the specific needs of a business organization, data from the above-mentioned metrics may have low or even no significance in the performance of narrowly specialized business process models. The proposed in this paper algorithm allows for the creation of new data about business process measurement characteristics, which, combined with the above discussed, allow for more accurate and in-depth forecasting and analysis of the business process model performance results.

Following a literature review of the business processes measurement some generalizations can be made.

The first thing that is noticed is the fact that authors define their metrics suggestions using different process modeling languages (for example, BPEL, BPMN, EPCs, and Petri nets). These definitions can often be adapted to other language models, but in some cases this is not possible.

The second important fact is that the authors state that their metrics measure different concepts. For example, there are publications that discuss measuring the complexity of the business process model, offering and using metrics of complexity. Others describe metrics related to the quality of the process model or quality metrics as the implementation of the business process model. Often, however, there are no definitions of these characteristics.

As stated in (Sánchez González et al. 2010) the authors describe measures according to what they believe their measures quantify, and the majority of them do not follow any standard, or have previously performed a theoretical validation of the measures, which may lead to confusion.

3 Algorithm for transforming a business process model into a graph structure

The conversion of a business process model to a logically identical but physically different structure allows analysis and assessment of business logic through the capabilities for analysis of the new structure. The metadata obtained can be analyzed and used in the automated design and execution of business processes (Dallas and Wynn 2014).

The choice of graph structure as the basic for the algorithm is distinguished by the similarities between business process models and particular oriented graphs (both structures can express connectivity and consistency). Another important factor for choosing a graph-based structure to interpret the business logic is the broad application of graphs in various fields of science and the wide variety of metrics that can be applied. In this way, we can evaluate the logic of business process through metrics used in mathematics, software engineering, and so on.

The algorithm for transforming business logic into a graph structure is divided into three main stages and is consistent with the characteristics and similarities between the two structures. Figure 1 presents the architecture of the algorithm in the three stages of its implementation.

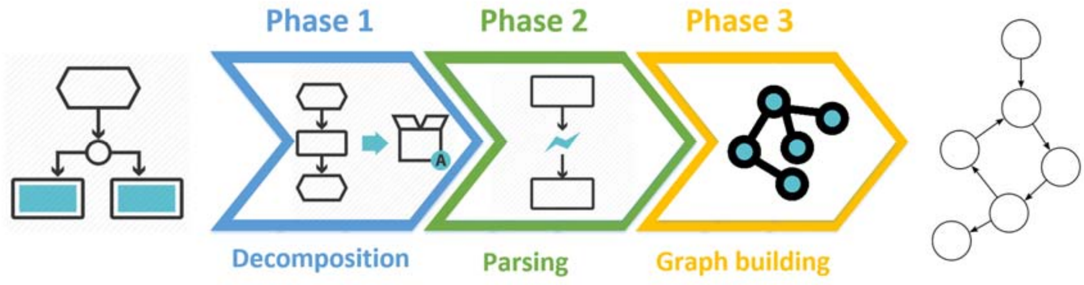

Figure 1. Algorithm for transforming a business process model into a graph structure

Stage 1 is characterized by a decomposition of the business process model that is the subject of the analysis. Starting from the general concept of business process - a sequence of related tasks, we can define two groups of objects. The first consists of the individual tasks and the second of the links between them.

The second part of the algorithm represents the actual comparison of the elements of the two structures and aims to determine the components of the oriented graph. The decomposed tasks of the business process model are transformed into the vertices of the new graph. Each vertex takes the value of the task it represents, thus the logic of the whole process is preserved. The decomposed connections between the tasks are transformed into the edges of the oriented graph. If necessary, the edges may contain information that exists in the primary business process model, mostly such as a value or a branching condition.

Stage 3 is characterized by the construction of the oriented graph and its preparation for retrieving the selected metrics. As a result, a logically identical oriented graph is obtained, the analysis of which generates metadata applicable to the business process model under consideration.

4 Interpretation of logical scenarios to graph structure in EPC and BPMN

The applicability of the proposed algorithm can be determined by measuring its performance in the most commonly used business process modeling standards – EPC (Scheer, Thomas and Adam 2005) and BPMN (Chinosi and Trombetta 2012). For this purpose, we will look at basic logical scenarios for a business process and the ability to interpret them to oriented graphs (Frye and Gulledge 2007). The business process scenarios are used for defining the requirements for any system implementation project in any organization.

4.1 Sequence

The sequence serves as a basic building block for each process. It is used to present a series of related tasks that are performed sequentially one after another. The minimum requirement for consistency is the presence of at least two tasks and the existence of controlling dependence from one task to the other. The logic behind this model is that in order to have consistency in a business process, the previous task must have ended before the execution of the current has started. In the graph structure, the sequence may be represented by at least two vertices and an edge showing the direction of execution. Figure 2 shows a sequence in EPC, BPMN, as well as by oriented graph.

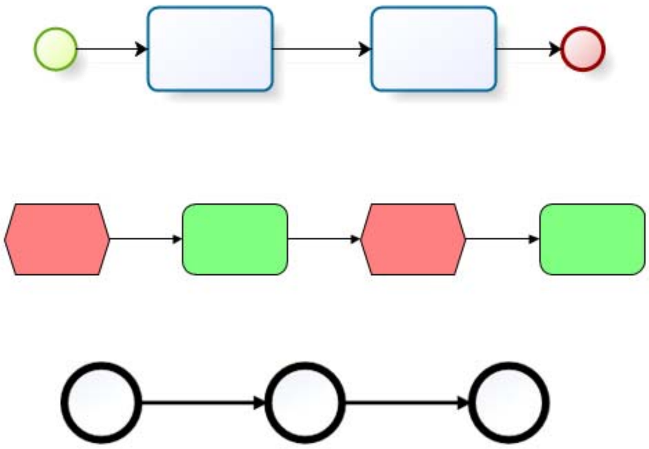

Figure 2. *Sequence in EPC, BPMN and as oriented graph*

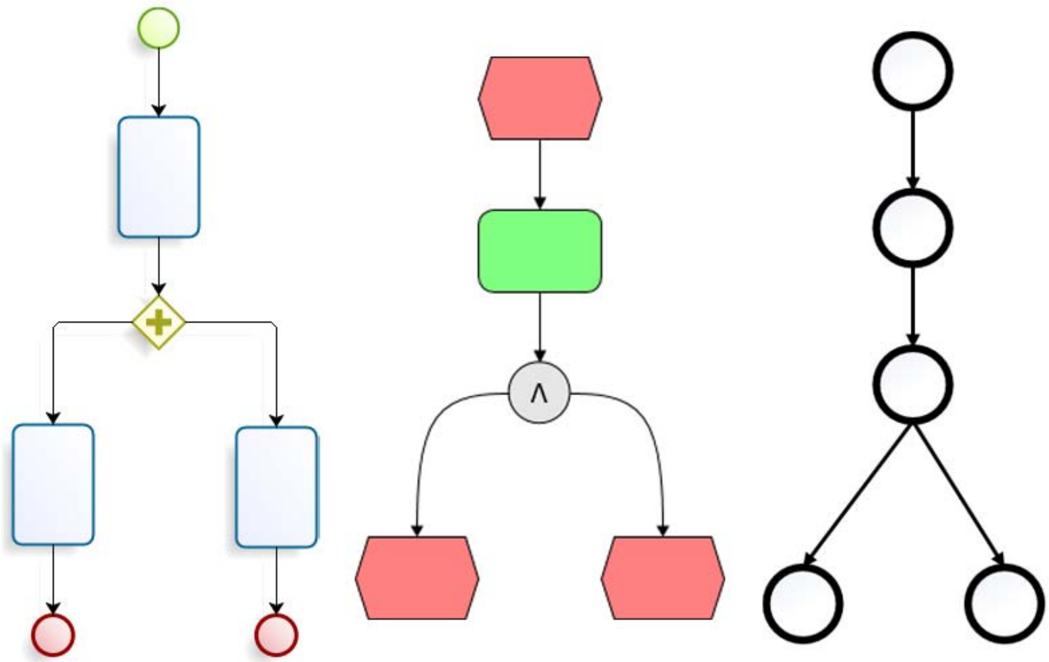

Figure 3. *Parallel splitting in EPC, BPMN and as oriented graph*

4.2 Parallel splitting

Parallel splitting is one of the main logical elements in business process models. Using it allows splitting the main logical thread into two or more parts that perform different tasks. Parallel splitting is used when presenting processes that requires multi-threaded (parallel) task execution. This pattern does not necessarily require synchronization between the individual threads resulting from the separation. Figure 3 shows parallel splitting by oriented graph, as well as its equivalents in the EPC and BPMN standards.

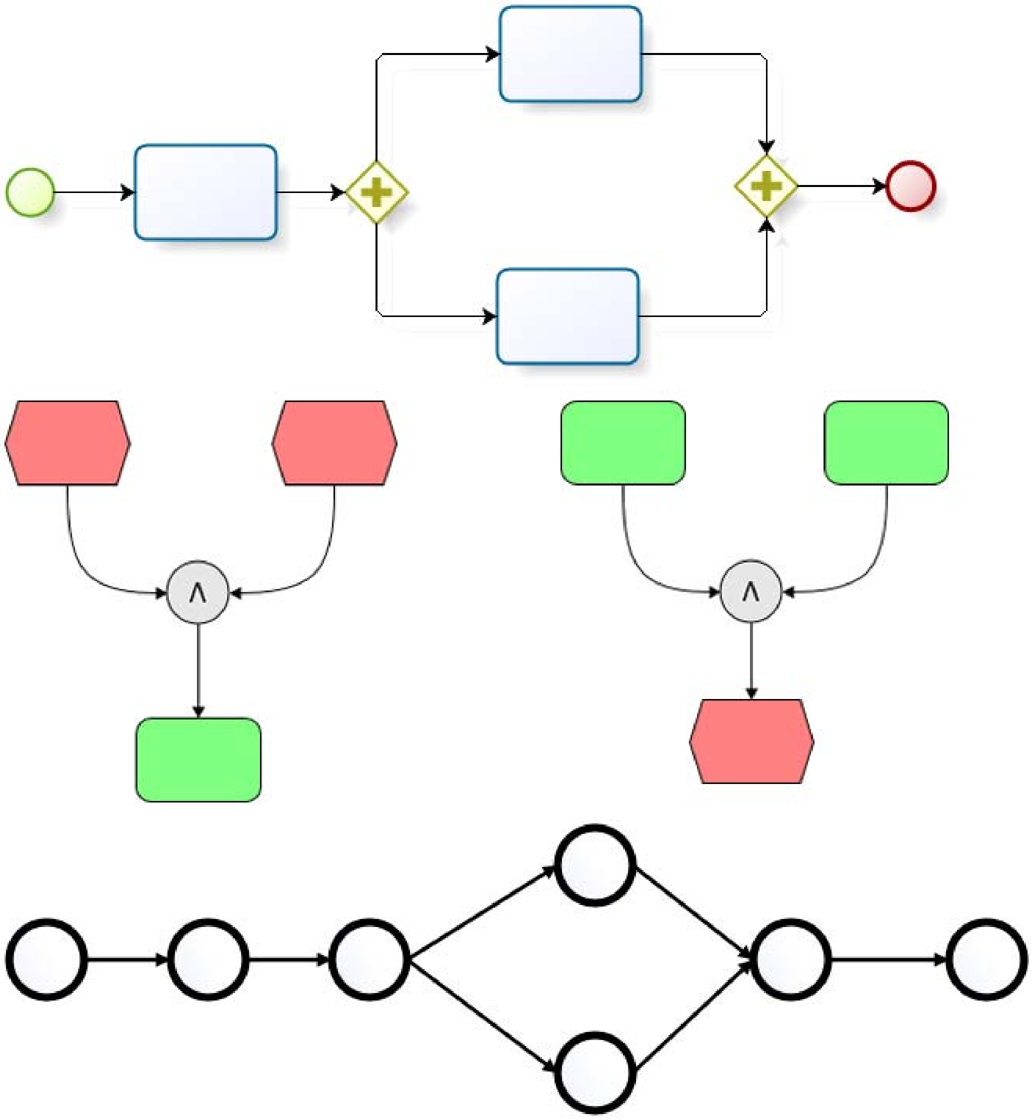

Figure 4. Synchronization in EPC, BPMN and as oriented graph

4.3 Synchronization

Synchronization serves as a logical merging of two or more branches from a business process chart. Using sync enables individual logical threads to be united into one. It is not necessary for the threads to be collected to be synchronous or the tasks to be performed in parallel. One of the main synchronization applications is the pooling of separate components that share a common scenario in the next stages of the business process. It can be said that synchronization and parallel splitting are interconnected and mutually exclusive logical operations. Figure 4 shows synchronization by oriented graph, EPC and BPMN.

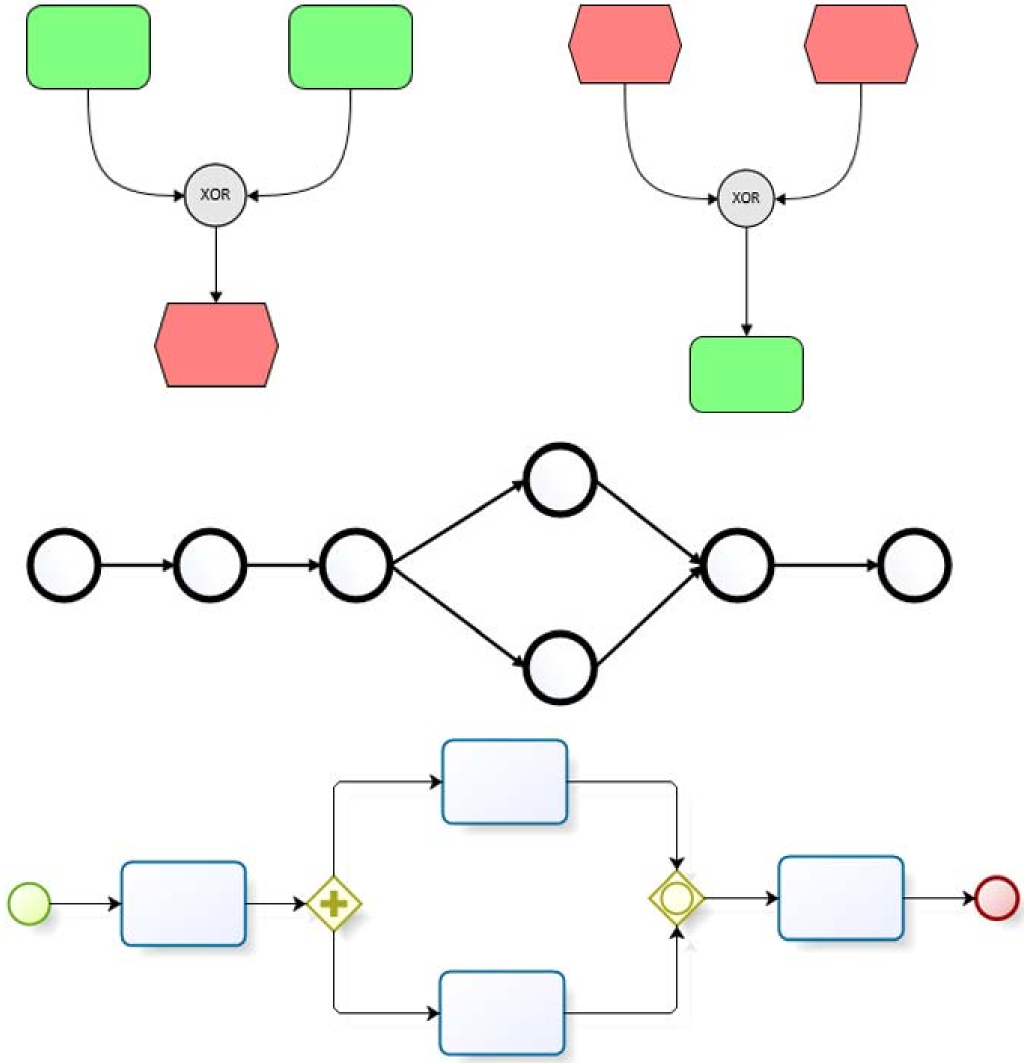

Figure 5. Simple merge in EPC, BPMN and as oriented graph

4.4 Simple merge

Simple merge is one of the main scenarios that is often used in business process design. This logical element serves to collect two or more threads of execution. The element has a purely unifying meaning and does not require parallelism of the threads it connects. After the element, the control over the business process is transferred to the first element after the simple merge. It is often used in process modeling, where different scenarios merge and go through the same logical path. This allows the creation of well-structured, optimized and comprehensible business models. The simple merge is presented in Figure 5.

4.5 Exclusive choice

This is a logical mechanism that allows the choice of one option from several available ones. Its name is derived from the fact that after selecting a logical thread, others are excluded as an opportunity. In business process modeling, the exclusive choice is used to present a scenario where only one option has to be selected. It is often used when presenting a decision-making mechanism. The element does not contain a logic that defines which thread should continue to run the business process, so it is often combined and preceded by an element that defines the implementation scenario. Figure 6 shows an exclusive choice by oriented graph, as well as its equivalents in EPC and BPMN.

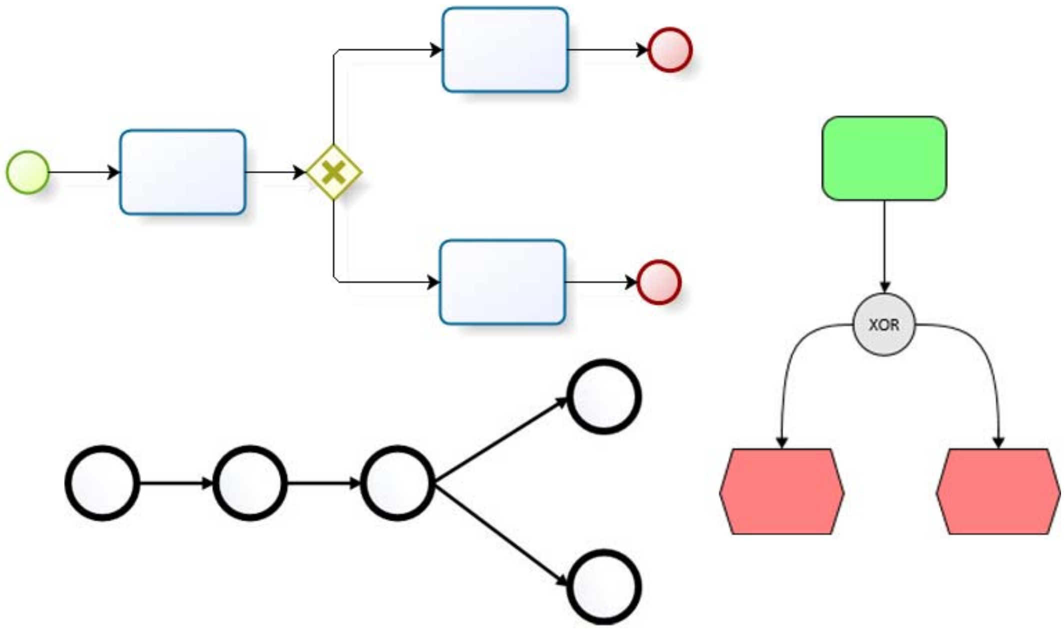

Figure 6. Exclusive choice in EPC, BPMN and as oriented graph

4.6 Multiple choice

This component allows the thread to be split into two or more executable scenarios. In business process modeling, this type of choice is used when the number of possible implementation paths varies. The multiple choice allows the logical execution of the process in one or several branches. It is a practice to describe all possible scenarios of work and to create a mechanism that defines the needs of the business process and chooses the most appropriate ways to complete the task. Multiple choice allows the use of multiple parallel streams, but this is not always required. It does not have a logical decision making mechanism, so it has to be combined with one that determines the future functioning of the process. Figure 7 represents the expression of multiple choice by oriented graph, EPC and BPMN.

From the logical scenarios considered, it can be concluded that the proposed algorithm is applicable in all major business process modeling cases in the EPC and BPMN standards. This makes it suitable for system level implementation and automation retrieval of new metrics.

5 Graph-based metrics for measuring business process models

The use of graph structures in various fields of science allows the differentiation of heterogeneous metrics that can be applied in the context of measuring business process models (Hernández and Van Mieghem 2011). Each complex network presents specific topological features which characterize its connectivity and highly influence the dynamics of processes executed on the network. The analysis, discription, and synthesis of complex networks therefore rely on the use of measurements capable of expressing the most relevant topological features.

Considering the wide field of application of business processes, the purpose of this study is to identify general and field-independent metrics that allow measurement of both the overall business process and its components.

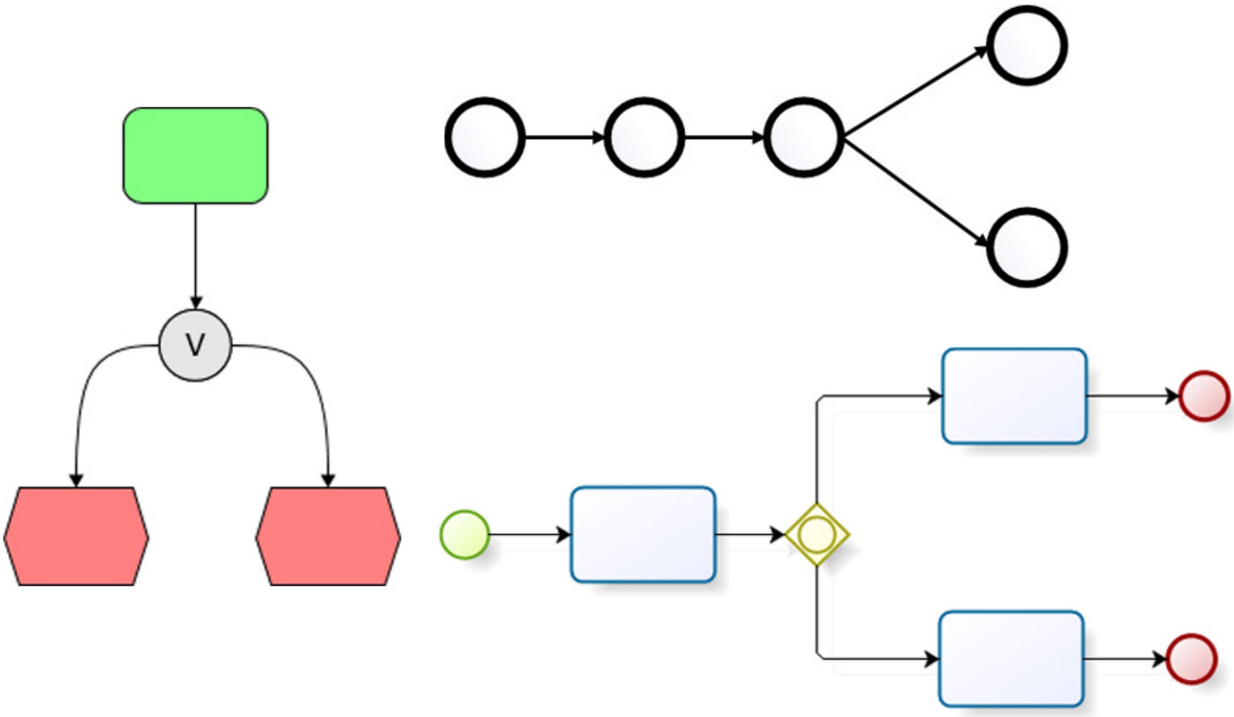

Figure 7. Multiple choice in EPC, BPMN and as oriented graph

5.1 Cyclomatic complexity

The cyclomatic complexity (Watson, Wallace and McCabe 1996) or also known as the McCabe metric is applied in software engineering as a means of measuring the complexity of the program code. Essentially, it tracks the number of branches from the main program line.

Independent path is defined as a path that has at least one edge which has not been traversed before in any other paths. The cyclomatic complexity can be calculated with respect to functions, modules, methods or classes within a program.

In the context of measuring of business process models, this metric can be used to determine the degree of complexity of a process to measure the various scenarios in which the process can be performed. On the basis of such information, business process models can be classified according to their complexity, those that are suitable for automated execution can be differentiated, as well as those that need to be optimized or redesigned.

5.2 Model size

Physical measurement of the model is one of the primary metrics that can be derived from each business process model. Used primarily to determine the size of a software component, this method "counts" the separate lines of program code. When measuring a business process model, there is no program code, but all the activities that take place in the model can be quantified in a similar manner. The number of activities in the model can be regarded as an equivalent to the number of executable statements in a piece of software. For this reason, the ”number of activities” is a simple, easy to understand measure for the size of a business process model.

However, the ”number of activities” metric does not take into account the structure of the model, that is why by itself, this metric is not very useful, but combined with the complexity of the process measured as described in 5.1, it is possible to define a systemic relationship between the two metrics, which allows to derive a coefficient showing the efficiency of the measured model.

5.3 Topological metrics

Topological measurement of business process models allows to determine metrics that are applicable in analyzing and optimizing business tasks. The discovery of dependencies between purely topological parameters such as number of branches, shortest path of execution, availability of interactivity, etc. allows the creation of new data, the analysis of which will lead to the determination of non-logical parameters such as: risk assessment, possibility for automation, level of optimality, and more.

5.3.1 The shortest path of execution

Typical of business process models is the availability of more than one possible scenario to perform the described business task. Achieving high productivity is one of the main results that the business process execution should result. In the context of analysis and design of business process models, defining the shortest path of execution helps to measure the effectiveness of the process. With repeated simulation of the same business process, the high frequency of execution of the detected shortest path shows that the model under consideration is well-designed and efficient. It is possible to differentiate such a value to be used in analysis and optimization in terms of model performance.

5.3.2 Number of branches

Creating functional models of business processes requires the description of different logical scenarios on which the specific task will be performed. Branching of the primary flow of execution occurs most often through logical operators which track for specific parameters during business process implementation. Measuring the number of branches can help in the classification of business processes by the following criteria: complexity and abstraction level. Looking at the number of branches as a quantitative indicator, it is possible to identify all logical scenarios and sub-scenarios in the considered business process. Depending on the number of scenarios, the level of complexity can be measured, and it is proportional to the number of scenarios. By measuring the number of individual tasks in each scenario, the level of abstraction can be determined and the relationship between these indicators is inversely proportional.

5.3.3 Number of tasks requiring human intervention

Except for fully automated business processes, all other models require some degree of interference by a person during the execution of individual business tasks. The quantitative measurement of this indicator allows classification of business process models according to their degree of risk and determination of possible levels of automation. Business process models requiring a large number of human interventions are identified as risky and unsuitable for automation.

By combining this metric with the average time to perform any task requiring human intervention, it is possible to identify potential weaknesses in the business process model under consideration. These data are applicable to the selection of processes for automation as well as to measuring the impact and effectiveness of the human factor in the business process model.

5.3.4 Parallel execution

Reflecting the real business environment, many business processes are created with the ability to perform tasks in parallel. Measurement of this indicator can be used to classify business processes in the context of efficiency and value. Parallel implementation of individual business scenarios greatly increases the performance of the entire business process but at the same time requires more resource for implementation. The measurement of the relationship between execution time and value gives a quantitative effect on the effectiveness of the considered business process.

5.3.5 Identifying the main business tasks

In the process of business process design, a large number of companies focus and pay more attention to business tasks that are directly related to their organization, but not always these tasks are the key to the business processes (Vergidis, Tiwari and Majeed 2008). Often, tasks such as automated email delivery are performed in each scenario of a business process, and at the same time not much attention is paid to them during the business process design.

The discovery of the key tasks of a business process implementation is important from a security and a possible optimization point of view. Using the proposed algorithm to present a business process as an oriented graph, the number of all edges leading to a particular task can be determined. By measuring this indicator, it is possible to separate such tasks, which would most often be performed. Having a list of these tasks, they can be analyzed, specified, and improved. Key business tasks can be viewed and classified in the context of other proposed metrics, and depending on whether a task requires interference from a human or is involved in the shortest execution path, it can be treated differently.

Looking at the proposed metrics individually, a partial assessment of the business process can be made in a specific context. For optimum results, it is necessary to determine the impact for each metric depending on the different measurement points - performance, safety, efficiency, and so on. Future work and the next step of this study is to determine the logical dependencies between the proposed metrics and their "weight" in forming a complex assessment in a given context.

6 Conclusion

The article proposes a new approach to measuring business processes and generating new metadata that are used in analyzing, optimizing and designing business process models. Interpreting business process to oriented graph allows business logic to be applied to new analysis and measurement techniques that are characteristic of graph structures only. The proposed algorithm is able to "cover" all the major logic scenarios that are found in the EPC and BPMN standards.

New metrics have been proposed that can be used to measure business process models and their data are intended to facilitate the automated implementation of business process models as well as their analysis and optimization.

Taking into account the tendencies to automate more business activities and the business needs of making quick and effective decisions, it can be said that the future development of this project will involve the extraction of logical dependencies on the basis of new metrics in the context of automated execution of business processes. It is envisaged to create a methodology for classification of logical dependencies, which will be discovered through a series of empirical studies and simulation of real business process models.

Acknowledgments

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