

BPMN Based Problem Domain Knowledge Specification Method

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Abstract— Business Process Model and Notation (BPMN) is one of OMG (Object Management Group®) product, standardized ISO standard. Nowadays BPMN become de-facto notation and is used to create different types and architecture levels of activity diagrams. The main point of this article is to integrate the BPMN notation into the knowledge-based IS engineering process, thereby reducing the empiricity and enabling semi-automated generation of a more precise operational model. For this reason there is created Algorithm for the representation of the activity meta-model element BPMN and detailed one element "Activity" type selection algorithm. The prototype, by using *Microsoft Access 2016* program, *MagicDraw 18.1* tool and interactive expert system *ES-Builder Web*, tests correctly operation of both algorithms.

Keywords— BPMN; Enterprise Model; Enterprise Meta-model; IS engineering process.

I. INTRODUCTION

Constantly changing and expanding information systems of organizations, is faced with the problem of displaying information flows. To reach goals of business, it might be used different types of interconnection and graphical imaging standard diagrams and notations of business processes, functions, objects and other elements. Each method has its own abilities to interpret and submit information about organization domain knowledge system.

From the point of view of organizations and companies, it is important to systematize stored information as easily and accurately as possible. For each participant of the activity to be equally well acquainted with the future benefits of the information system.

Different business activities require a variety of business models describing business processes. The more research and presentation of business process mapping techniques, the easier it will be for businesses to select the most appropriate option for them.

The work deals with the notation and modeling languages, which help to create business models in the field of knowledge. The main point of this article is to integrate the BPMN notation into the knowledge-based IS engineering process, thereby reducing the empiricity and enabling semi-automated generation of a more precise operational model. For this reason, the following tasks are considered, such as, to study the modeling languages

used to create business models; to explore the possibilities of generating the BPMN model from the meta-model and to apply the activity meta-model to the specifics of the BPMN; to offer an algorithm that generates an activity model in the BPMN notation and to test the options for realizing the offered algorithm.

II. RELATED WORKS

To reduce empirical influence of the factors to information systems development process, there was decided to use knowledge based IS engineering method. The main advantage of this approach is ability to approve specific data warehouse Enterprise Model and Enterprise Meta-Model, not only by formal criteria. It reduces the problems and guarantees efficiency [1]. Using business meta-model is created business process model with necessary field knowledge (actors, activities, processes, functions, goals, flows) for creating software [2].

OMG (Object Management Group®) [3] specialize in creation of specifications and notations for business model using business meta-model. Some specifications are used for clear tasks and cannot represent abstract business process models.

Business Motivation Model (BMM) [4] is a set of concepts, which show business plan elements connected neutral structure of methodology. Functions are created by three basic concepts: Business Process, Business Rule and Organization Unit [5].

Business Process Definition Meta-model (BPDM) [4] provides the ability to represent and model business process without reference to notation or methodology combined these different methods into a coherent functional dependence. It is created by using meta-model like perfect connection between terms and concepts based basic processes' vocabulary [6]. BPDM uses OMG standard – MOF Meta-Object Facility [7,8,9] capturing business process by common method and let XML syntax save and transform business process models using tools and infrastructure.

Date-Time Vocabulary (DTV) [4] modeling the continuous, discrete time, event relationships and time-space situations, language aspects, time tables and graphs [10].

Business Process Maturity Model (BPMM) [4] describes an evolutionary path of development that focuses on the organization's movement from immature, inconsistent processes to mature, disciplined processes. BPMM based Process Maturity Framework, which is basis widely used Capability Maturity Model for Integration (CMMI) to help organizations organize repeated software engineering processes [11].

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The most often there are used well-known modeling languages – UML and SysML or notation – BPMN. All these are OMG’s products. For more detailed information in the next subsections.

A. UML

Unified Modeling Language® (UML) is ISO standard created by OMG. UML has thirteen types of diagrams grouped in three categories [12]:

- Structure Diagrams includes Class Diagram, Object Diagram, Component Diagram, Composite Structure Diagram, Package Diagram, and Deployment Diagram. Those diagrams represent static application structure.
- Behavior Diagrams includes Use Case Diagram, Activity Diagram and State Machine Diagram – show basic types of behavior.
- To show different interactions aspects is needed to use Interaction Diagrams, like Sequence Diagram, Communication Diagram, Timing Diagram and Interaction Overview Diagram.

B. SysML

Another OMG’s modeling language is Systems Modeling Language™ (OMG SysML™). It is the general purpose graphical modeling language is intended to specify, analyze, design and test complex systems that may include hardware, software, information, personnel, procedures and services [13]. SysML is an extension of UML, so there are used basic Unified Modeling Language diagrams: Use Case Diagram, Activity Diagram, Sequence Diagram, State Machine Diagram. SysML includes graphical constructions to describe text-based requirements and link them to other elements of the model.

C. BPMN

Business Process Model and Notation (BPMN) is de-facto graphical standard notation in modeling of processes. BPMN is also OMG product and describes the progress of the business processes to the final process flow. BPMN specially designed to coordinate process sequences and reports that come from different process participants. At the same time enables BPMN diagrams to be transformed into components of the software development process [11,14,15].

In accordance with reference [16] complete BPMN specifications includes thirty eight different language constructions with attributes, grouped into four main categories of elements: Flow Objects, Business Process Diagrams (BPDs), Connecting Objects and Swimlanes. In the specification of BPMN published in OMG website, reference [17], are five categories of elements:

- 1) *Flow Objects*. The main graphic elements for describing the behavior of business processes:
 - a) *Events*,
 - b) *Activities*,
 - c) *Gateways*.
- 2) *Data*. All types of data:
 - a) *Data Objects*,
 - b) *Data Inputs*,

c) *Data Outputs*

d) *Data Stores*.

3) *Connecting Objects*. Used to interconnect flow objects with different types of arrows:

a) *Sequence Flows*,

b) *Message Flows*,

c) *Associations*,

d) *Data Associations*.

4) *Swimlanes* are used to group the initial simulation elements:

a) *Pools*,

b) *Lanes*.

5) *Artifacts*. *Artifacts are used to provide additional process information:*

a) *Group*,

b) *Text Annotation*.

These elements are used to create different level BPMN diagrams.

Similarities and differences among UML, SysML and BPMN in the next subsection.

D. Comparison among UML, SysML and BPMN

Kenneth D. Evensen and Dr. Kathryn Anne Weiss [18] compare UML and SysML: both are chart-oriented notation languages. UML and SysML diagrams specify types of graphical components in model. UML can be used to define both high-level architectures and detailed representations. For a more detailed description of the architecture, it is provided by SysML. It addresses problems such as broken down various subsystems, traceability requirements, and the location of arithmetic formula components.

UML and BPMN notations can adequately model most structures. There are not adequate graphic layout layers Interleaved Parallel Routing in UML activity diagram. Similar graphic representation of forms for the same models. BPMN has less basic objects. To avoid complexity in development process, there need to invent variants to those objects. Business sequence models are oriented to control flows between process activities. Data flow is used between activities in BPMN. Activity diagram and business process diagram are very close and are represented by the same meta-model [20].

According to reference [19], Table 1, there can be compared UML activities and BPMN business processes. The main elements of UML or BPMN correspond to the elements of the activity meta-model, but depending on the level of detail of the activity area or model, the activities in the meta-model are not sufficient.

There can be provided mappings and transformation algorithm from BPMN Business process model to UML Activity model at the later stage.

TABLE I.
COMPARING UML AND BPMN

UML Activity
Condition 1. The starting point is defined by an Initial Node. No method of specifying why the Activity was started is available.
Condition 2. The basic behavior unit in an Activity is the Actionelement. UML provides many different forms of Actions, although the simulation makes use of a small subset of these.
Condition 3. A Control Flow is used to connect the elements on an Activity diagram. A distinguishing feature is that only a single control flow may be followed from any node except for an explicit Fork Node. To restrict flow on a control flow, add a guard.
Condition 4. A Decision node is used to explicitly model a decision being made. A Merge node, which uses the same syntax is used when the potential flows are combined back into one.
Condition 5. A Fork node is used to concurrently execute multiple nodes, while a Join node, using the same syntax is used to wait for all incoming flows to become available and leave with a single flow.
Condition 6. There is no allowance for concurrently executing only some outputs from a node for UML Activities. If you needed this you would need to add later control flows with the appropriate guards.
Condition 7. A Call Behavior Action is used when behavior needs to be further decomposed by referring to an external activity.
Condition 8. Activity elements are used when behavior needs to be further decomposed without referring to an external activity.
BPMN Business Process
Condition 1. The starting point is defined by a Start Event. This implies a specific cause for the Activity to start, although it may be unspecified.
Condition 2. The basic behavior unit in an Activity is the Activity element. A number of different Task Types are available. These typically describe different methods of execution (for example Manual) as opposed to what happens.
Condition 3. A Sequence Flow is used to connect the elements on a Business Process diagram. These differ from UML Activity diagrams in that all valid sequence flows are taken by default. To restrict flow on a sequence flow set the Condition Type to expression and the Condition Expression.
Condition 4. A Gateway node set to Exclusive is used when a single path must be selected. It is also used to combine the potential flows again. A direction may be specified as Converging or Diverging to explicitly select between the two modes.
Condition 5. A Gateway node set to Parallel is used to explicitly model concurrent execution of multiple nodes. It is also used to wait for all incoming flows to become available and leave with a single flow. A direction may be specified as Converging or Diverging to explicitly select between the two modes.
Condition 6. A Gateway node set to Inclusive is used to explicitly model the situation where all outgoing flows with a true condition are executed concurrently.
Condition 7. Activity elements are set as CallActivity Sub-Process when behavior needs to be further decomposed by referring to an external activity.
Condition 8. Activity elements are set as an Embedded Sub-Process when behavior needs to be further decomposed without referring to an external activity.

III. PROPOSED DECISION METHODOLOGY

After analyzing the main features of the activity meta-model elements' representation and possibilities in different modeling languages and notation, moving in detailed analysis of Business Process Modeling and Notation elements [18].

BPMN has additional objects that are more detailed than the abstraction level. Some elements are used just like explaining the main ones.

There compose schema from activity meta-model class model elements, black color, with all BPMN elements, red color, shown in Fig. 2. The main focus is on how the elements used in the BPMN notation complement the activity meta-model. Although a large number of objects overlap in meta-models, such as a pool or lane match to the actor, the process matches the function in the activity meta-model, but elements such as sequence flow types or event types can more accurately convey the informative nature and use of the element itself.

Assumed, that some elements of meta-model and BPMN elements match, like "Events", "Actor" with "Pool", "Actor of Process" or "Actor of Function" with "Lane", "Function" with "Process", "Material Flow" with "Message Flow", "Information Flow" with "Sequence Flow" or "Data Object", "Processing Access Input" with "Data Inputs", "Processing Access Outputs" with "Data Outputs", "Information Activity" with "Task", "Activity Rules" and "Gateways". Other elements from BPMN can partly change in meta-model or be complementary.

A. Algorithm for the representation of the activity meta-model element BPMN

Elements, from the activity meta-model, in the development of the activity model BPMN notation, can be displayed with a certain sequence or according to certain rules. In order to reduce the empiricity of the element and its related elements, a macro-level algorithm is created, in Fig. 1.

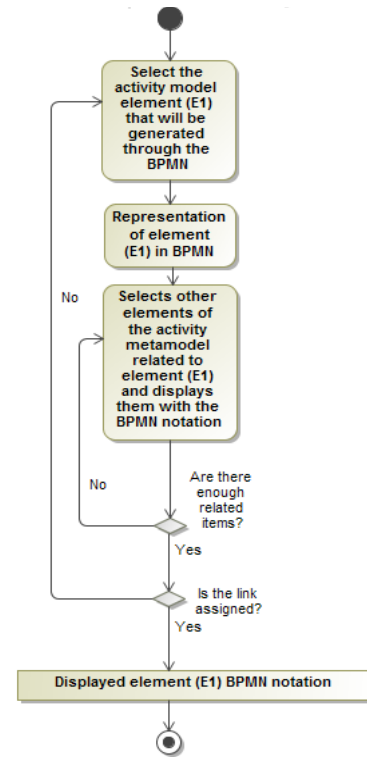


Fig. 1. Algorithm for the representation of the activity meta-model element BPMN



For the second step in the main algorithm, there is created element *activity* selection algorithm shown in Fig. 3. There are many types of activity in BPMN notation, so this algorithm helps to choose one of them. In each step of the iteration, the



Experiment is made for both algorithms. For more details in the next subsections.

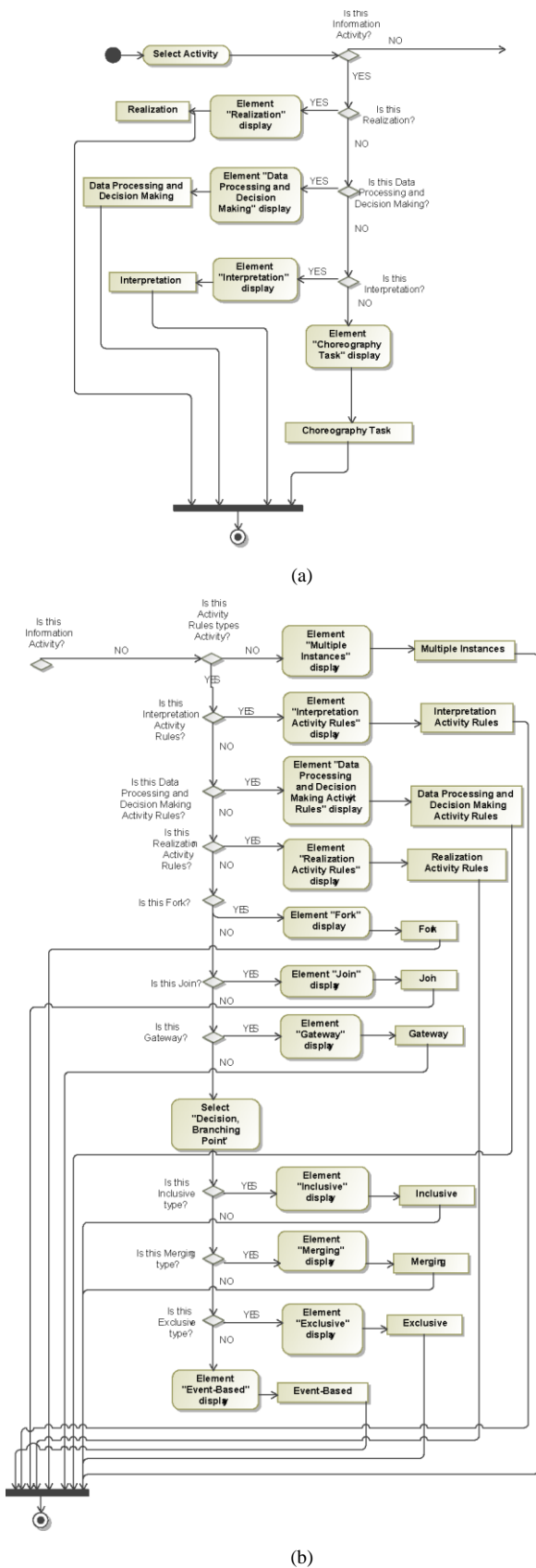


Fig. 3. (a) part is the beginning of element "Activity" type selection algorithm and (b) part is the end of element "Activity" type selection algorithm.

A. Algorithm for the representation of the activity meta-model element BPMN realization

To test Algorithm for the representation of the activity meta-model element BPMN proper operation, there is created prototype. User interface is executed using *Microsoft Access 2016* program. BPMN element is displayed in *MagicDraw 18.1* tool.

There is given a real example "Close Auction" Fig 4. At first, it is chosen element, Fig. 5. Whole cycle of the main algorithm is executes – select the element, represent the element in BPMN, select others related elements, control if there are enough related elements and if the link is assigned among elements. The last step of the algorithm is carried out in *MagicDraw 18.1* tool, Fig. 6.

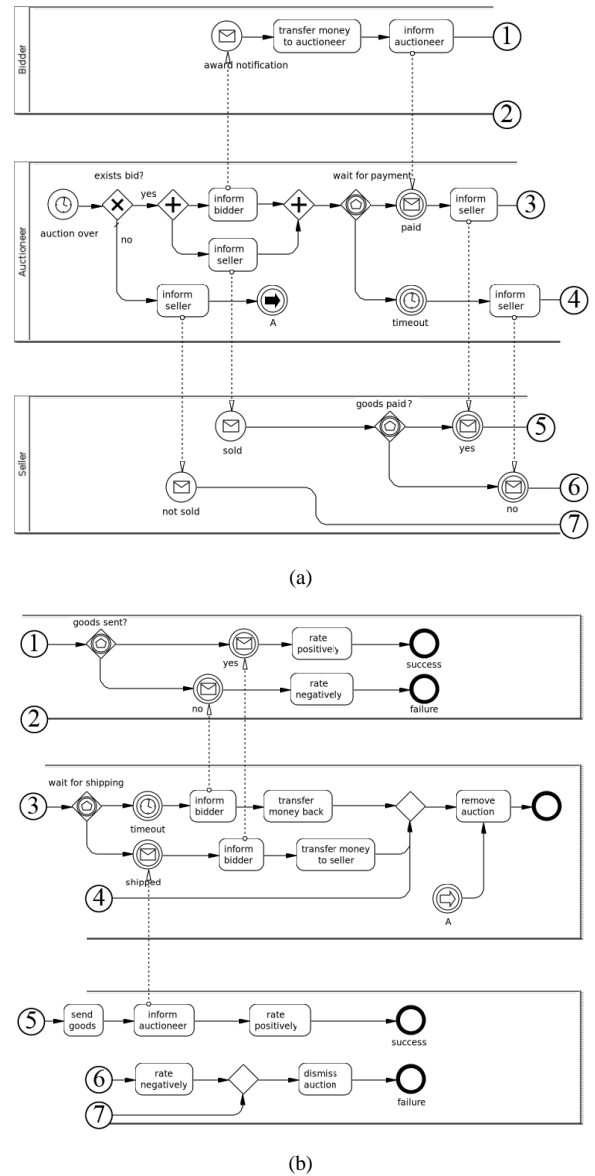


Fig. 4. The beginning (a) and the end (b) parts of BPMN diagram "Close Auction".

Element Selection

Please Select an Element

Actor

Flow

Activity

Next

Please Select Actor

Auctioneer

Bidder

Seller

Next

Fig. 5. User interface for excape “Close Auction”.

B. Element “Activity” type selection algorithm realization

Element “Activity” is complex element and has many types, in different hierarchy level. Algorithm shown in Fig. 3 realization is made in internet expert system platform *ES-Builder Web*. The value returned by the expert system (satisfies the condition that one element is selected) is the selection of the “Activity” type element, the activity meta-model element BPMN notation algorithm is executed at the beginning, that is, when the element of the activity model element is selected and assigned to it the element corresponding to the BPMN. [Expert system](#) is in the [www.mcgoo.com](#) platform (note, it is in Lithuanian language).

IV. CONCLUSION

OMG-based modeling languages UML and SysML are graph-oriented, notation languages. UML can be used to define high-level architectures, detailed imaging, modeling of applications and user interactions in an early life cycle. For more detailed architecture, SysML is used.

When comparing the BPMN Activity Diagram with the UML Activity Diagram, it is concluded that these notions provide the same solutions and very similar graphical representations of forms to many models. The BPMN has fewer essential objects and the potential complexity of creating business process diagrams; no significant difference is the terminology.

The elements of the activity meta-model can be displayed both in elements of the UML modeling language and in the main elements of the BPMN notation. However, depending on the level of detail of the field or model in question, the underlying elements may not be sufficient.

After examining all the elements in the BPMN notation, it can be concluded that some of the values of these elements correspond to the elements used in the activity meta-model. In addition, the BPMN elements have types, expanded values, which can more accurately convey the specifics of the business model being developed.

In order to reduce the empiricity of the development of a business model, a basic algorithm has been developed that shows how the sequence can be represented by the activity

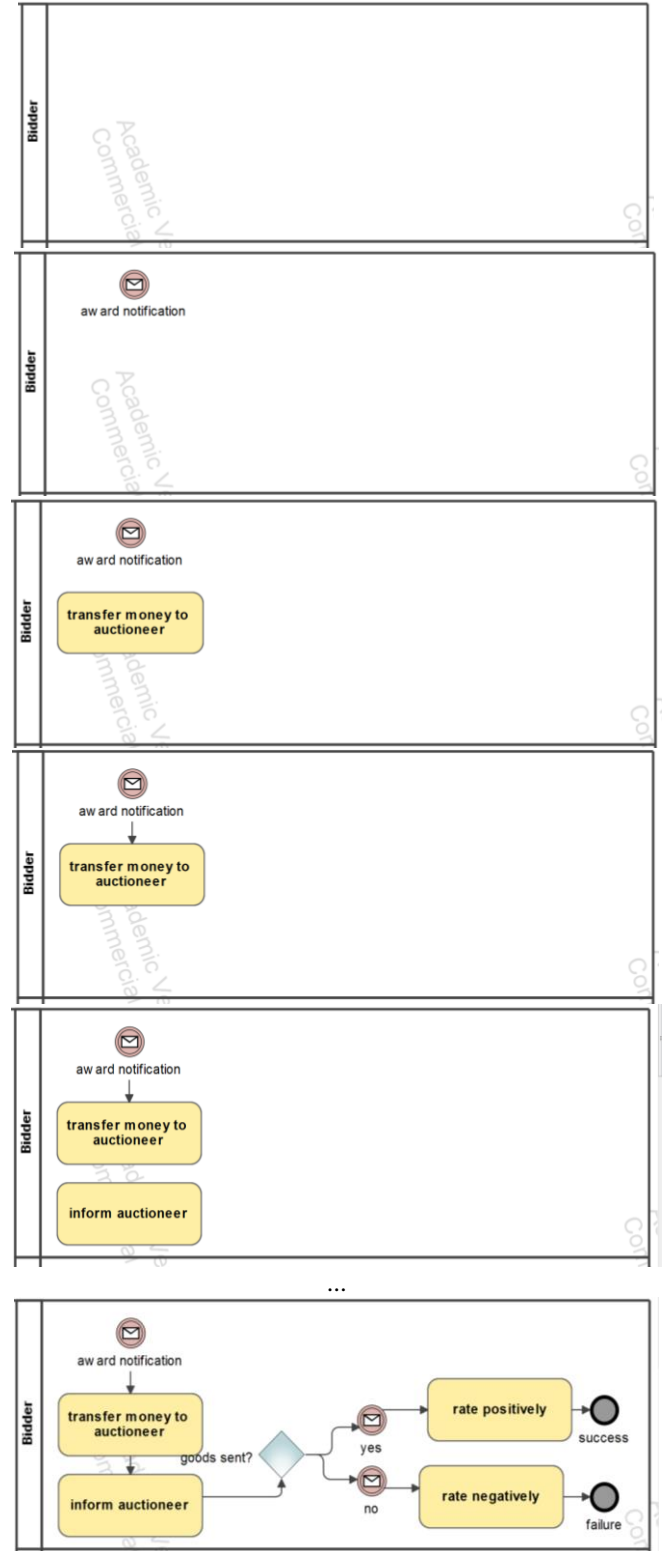


Fig. 6. Element Bidder display for excape “Close Auction”.

model element in the BPMN notation. A detailed selection of possible variations of one element "Activities" has also been developed. "Activity" type selection is made from all variants of the BPMN notation.

The experiment used to create the *Microsoft Access 2016* user interface program, the *MagicDraw 18.1* tool to implement BPMN charts, and an interactive expert development platform for setting the "Activity" type of the *ES-Builder Web* element.

The experiment was conducted with the example of the chosen subject area. It was verified that the invented tool - the prototype, according to the activity meta-model element BPMN notation algorithm, in a semi-automated way, can generate the activity model BPMN notation.

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