Journal of Information Technology and Computer Science
Volume 5, Number 2, August 2020, pp. 207-220
Journal Homepage: www.jitecs.ub.ac.id

Quality Evaluation of EPC to BPMN Business Process Model Transformation

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Received 02 January 2020; accepted 12 July 2020

Abstract. Due to the expressiveness of BPMN for representing the business processes, it has replaced EPC as a de-facto process modelling standard. As such, enterprises require to transform their existing EPC business process models to BPMN to keep their competitiveness. ARIS Architect & Designer, as a popular business process modelling tool, provides a model transformation feature, e.g., EPC to BPMN. For the sake of quality, it must guarantee that the resulting model has syntactic correctness and syntactic completeness. However, there is currently a limited scientific approach available to evaluate the quality of the model transformation in ARIS Architect & Designer. This study proposes an evaluation of model transformation in ARIS Architect/Designer based on syntactic correctness and syntactic completeness criteria using an experimental approach. The result shows that the model transformation in ARIS Architect/Designer has not completely fulfilled the criteria. The result opens further research challenges to improve the quality of EPC to BPMN model transformation.

Keyword : EPC, BPMN, Model

1 Introduction

Business Process Modelling Notation (BPMN) has replaced the Event-driven Process Chain (EPC) as the most used business process modelling standard due to increasing the popularity of BPMN in recent years [1]. However, there still exists a significant number of EPC models that are used as a basis for process execution and management in enterprises [2]. Recently, enterprises require to model their interaction and communication as a consequence of collaboration between enterprises. Nevertheless, EPC can only represent a private process in enterprises [3]. The BPMN is one possible language for modelling a collaborative business process [4]. As such, enterprises require to transform their existing EPC process model to BPMN to improve the expressiveness of their business process models.

Enterprises will require significant effort and resources to transform their existing EPC process models to BPMN manually. Furthermore, enterprises have hundreds or even thousands of models process business in their process repository [5]. Therefore, this is crucial to provide a tool for transforming EPC process models to BPMN automatically. There exist 14 EPC modelling tools [6], including 2 tools that provide transformation feature from EPC to the BPMN models automatically, i.e., ARIS Architect/Designer and Signavio Process Manager.

ARIS Architect & Designer[1] is part of the ARIS toolset, produced by Software AG, that provides various modeling language to model processes, such as EPC, BPMN, and Unified Modelling Language (UML). ARIS Architect/Designer provides 2 features to transform the EPC model to the BPMN model, i.e., model generation and solution design features. While, Signavio Process Manager[2] is the main product of Signavio that provides a web-based modelling process tool using EPC, BPMN, and Decision Model and Notation (DMN). Signavio Process Manager allows transforming EPC to BPMN automatically on Migrate EPC to BPMN 2.0 feature. The long existence of the ARIS Toolset makes it the most widely used EPC business process modelling tool standard compared to the Signavio Process Manager[7]. Therefore, this study mainly focuses on the ARIS Architect & Designer.

EPC in ARIS Architect/Designer has extension elements that are grouped into 5 dimensions, i.e., organization, data, function, process, and product. There are some elements in EPC notation, which are not transformable to elements in BPMN notation [8]. For example, EPC has elements to express process outcome or to model risks, but BPMN doest not have it. Therefore, it is not possible to directly transform each element in EPC to BPMN completely. This condition will cause information loss if the model transformation tool does not have a mechanism for preserving that information [9].

Furthermore, based on Men's and Gorp [10], a model transformation tool must guarantee that the resulting model is syntactically and semantically correct. The resulting model must follow defined syntax in the target modelling language (syntactic correctness), for each element in the source model have the corresponding element in the target model (syntactic completeness), and the resulting model has the same meaning with the source model (semantic correctness). As such, we need to know the quality of the resulting BPMN models, through identifying any potential missing elements or information loss in EPC to BPMN model transformation using ARIS Architect & Designer. Unfortunately, there is no scientific evaluation approach available for enterprises to assess the quality of BPMN models transformed from EPC. Syntactic completeness can be identified by evaluating used transformation rules to transform it, but there are no official published. Further, the transformation rules, which are entirely used by ARIS Architect & Designer, is not publicly accessible. Therefore, this study proposes a scientific approach to evaluate the syntactic quality of the resulting BPMN models and to derive the transformation rules used for mapping EPC to BPMN in ARIS Architect and Designer. We only focus on syntactic correctness and syntactic completeness because semantic correctness is a more complex notion that involves model interpretation.

This paper is structured as follows. Section 2 discusses the EPC and BPMN modeling concepts. The basic theory of model transformation is described in Section 3. The method for evaluating BPMN models resulting from the transformation process is described in Section 4, and a discussion of method execution results in Section 5. Finally, at the end of the discussion, we derive a summary in Section 6.

[1]https://www.softwareag.com/corporate/products/aris_alfabet/bpa/aris_architect/default.html

[2] https://www.signavio.com/products/process-manager/

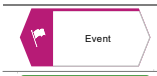
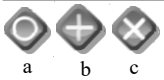
2 EPC and BPMN Modelling Concepts

Both of EPC and BPMN are graphical modelling languages that are used to model business processes. Each modelling language has different elements and specifications. This section will discuss the EPC and BPMN elements.

2.1 EPC

EPC is a type of flowchart used for business process modelling. EPC was first introduced by Keller et al. [11] in the early 1990s. In the initial version, EPC only has four basic elements, namely Event, Function, Control Flow, and Connector [3], as described in Table 1. With these elements, a basic process model can be specified and documented. However, each EPC modelling tool defines a different extension element to support modelling processes in order to produce a more expressive model. For example, Signavio Process Manager adds Organizational Unit, Process Link, Position, System, Data element.

Table 1. The Core of EPC Elements [3]

Elements	Description
	An Event describes the situation before and/or after a Function. An event can be triggering a Function or the result of the Function.
	A Function represents an activity or task. It creates and manipulates information objects.
	Connector elements are used to split or join three or more Function and Event. The connector consists of OR-Connector (a), AND-Connector (b) and XOR Connector (c)
	Control flow is an element that connects one element to other elements.

ARIS Architect/Designer adds more extension elements compare to the Signavio Process Manager. EPC in ARIS Architect/Designer has extension elements that allow detailing the pure procedural description of the business process by integrating data, risks, resources, organizational, application, and product/service elements, as presented in Table 2. The corresponding objects are called satellites. The satellites can only be mapped to a function with a relation.

Table 2. Extension Element of EPC in ARIS [12]

Category	Extension Element/ Sub Extension Elements
Process Interfaces	
Organizational elements	
Data & Risks elements	

EPC in ARIS Architect/Designer offers different connection types to connect organizational elements and Functions. The connection is made via the RA(S)CI method; it describes how organizational elements participate in completing tasks in the business process. The participation of organizational elements can ben responsible, accountable, supportive, consulted, or informed role, as presented in Figure 1.

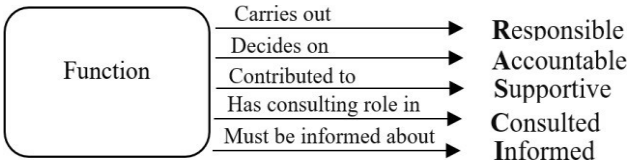


Figure 1. RA(S)CI Connections Method [12]

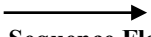
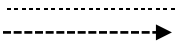
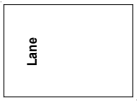
22 BPMN

BPMN is a graphical modelling language for specifying business processes. BPMN was developed by the Business Process Management Initiative (BPMI). The latest version was 2.0.2 released in January 2014. The primary goal of BPMN is bridging the communication gap between process design and implementation that frequently occurs [13]. There are 62 software vendors support BPMN registered by OMG [6]. BPMN has been ratified as International Organizational for Standardization (ISO)/International Electrotechnical Commission (IEC) 1950.

BPMN modelling scope is constrained to support only the concepts of modelling applicable to business processes. Modelling of organizational structures, functional breakdowns, and data models are out of the scope of BPMN. BPMN provides five categories of elements for modeling business processes. All elements in the BPMN are described in Table 3. Nevertheless, business process designers can add variation element to support complex modelling needs [14]. These five basic categories are:

a. Flow objects, which are used to define business process behavior. They are the main graphic elements. There are 3 elements of flow objects, namely: Events, Activities, and Gateway.
b. Data, which are used to represent information about what activities require to be performed and/or they produce. There 4 elements to represent data, namely: Data Objects, Data Inputs, Data Outputs, and Data Stores
c. Connecting Objects, which are used to connect flow objects together or to other information such as data. There are 4 ways to connect objects, namely Sequence Flows, Message Flows, Associations, and Data Associations.
d. Swimlanes, which are used to group primary modeling elements. There are 2 ways to group modeling elements through Pools and Lanes.
e. Artifacts, which are used to provide additional information about the process. There are 2 standard artifacts, namely group, and text annotation.

Table 3. Overview of BPMN Elements [14]

Element	Description
 **Event**	An event is something that "happens" during process or choreography. It used to affect process flow and usually has a trigger or a result.
 **Activity**	An Activity is a generic term for work that the company performs in a process. The activity can be atomic or compound. It used to represent atomic or compound activity in a process. Task represents atomic activity, and Sub-Process represents compound activity.
 **Gateway**	A Gateway is a decision point that can adjust the path of a flow based on certain conditions. It used to control the divergence and convergence of Sequence Flow in a process and choreography.
 **Sequence Flow**	A Sequence Flow is a connector between two elements. It used to indicate the sequence of activities to be carried out in process and choreography.
 **Message Flow**	A Message Flow is a connector flow of messages between separate pools/lanes. It used to show the flow of messages between two participants who send and receive messages.
 **Association**	An Association is a connector flow of artifacts. it used to link artifacts with other BPMN graphical elements
	A Pool is the graphical representation of a participant in a collaboration. It used to partition a set of activities from other Pools.
	A Lane is a sub-partition within a process. Lanes are used to organize and categorize activities.
	Data Objects is information about what activities require to be performed and/or produced. It can represent a singular object or a collection of objects.
	A Message is used to depict the contents of a communication between two participants
	A Group is used to group graphical elements that are within the same category. The category name appears on the diagram as the group label.
	Text Annotations is a mechanism for a modeler to provide additional text information for the reader of a BPMN Diagram

3 Model Transformation

Model transformation is a conversion process from a model to another model in the same system [15]. Kleppe et al. [16] define model transformation as the automatic generation of target models from the source model based on the transformation description. Mens and Van [10] expand the definition into the generation of one or several target models from one or several source models automatically, based on a

description of the transformation. Czarnecki and Helsen [17] define the 4 components of the transformation model as follows: the source model, target model, transformation rules that define the mapping rules from the source model to the target model and transformation tool which is an application that implements transformation rules so that it can transform from the source model to the target model automatically.

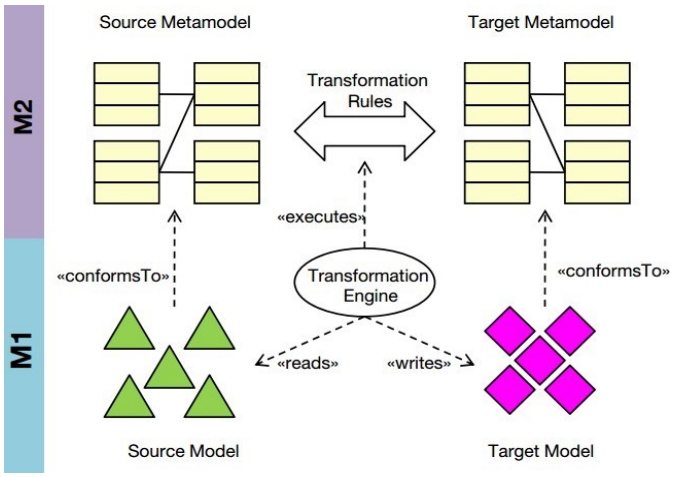


Figure 2. Model Transformation Approach [18]

Jouault et al. [18] describe the model transformation approach, as in Figure 2. They separate M1 and M2 layers. Thus, the transformation model consists of 2 levels of abstraction. First, Higher level abstraction (M2), defines the structure of the model (metadata). Second, a lower-level abstraction, which intensifies the source model, the target model. The concept can be expanded; for example, there is more than one source model that is transformed into a target model.

4 Evaluation Method

There are 2 features in ARIS Architect/Designer to transform an EPC model to its corresponding BPMN model. *First*, Model Generation, it generates new model views from existing database contents. This will impact the validity of the EPC model at the definition level when making changes in the BPMN models. *Second*, Solution Design, provides a Business Process Analyst (BPA) to jump start the solution design for processes implemented in web methods. Engineer of Software AG recommended Solution Design and did not recommend to use the Model Generation feature to create BPMN from existing EPC because EPC and BPMN have different syntax structures [19]. So, Model Generation will produce incorrect BPMN models. Therefore, the object of the study is the Solution Design.

4.1 Evaluation Criteria

Men's and Gorp proposed 2 criteria to verify and guarantee the quality of model transformation, namely syntactic and semantic correctness [10]. They divide syntactic correctness into 2 sub-criteria, namely syntactic correctness, and syntactic completeness. We will use syntactic correctness and syntactic completeness as evaluation criteria, as in detail described in Table 4. However, we exclude discussing

semantic correctness because it is another more complex notion, and we have to deal with the process specifications in detail.

Table 4. Evaluation Criteria

Evaluation Criteria	Description
Syntactic Completeness	There should be a relation elements in the BPMN model for each element in the EPC model or if M is set of elements in EPC model and M' is set elements of BPMN model, and $M \neq \emptyset$ and $M' \neq \emptyset$, then model transformation $f : M \rightarrow M'$ has syntactic completeness if $dom\ f=M$
Syntactic Correctness	The model transformation tool generates BPMN models that comply with the BPMN syntax rules based on reference [14].

We use syntactic correctness to ensure that the resulting BPMN model complies with the BPMN syntax rules standardization defined by OMG and the syntactic completeness to verify that elements in EPC represent all information have a corresponding element in BPMN. We define no information loss if all elements are transformed completely.

4.2 Test Case Development

Test case development is focused on ensuring the model transformation tool in ARIS Architect & Designer transforms each element in EPC to BPMN completely. Test case development is based on categorization of EPC elements in ARIS Architect & Designer as presented in Table 2. EPC elements in ARIS Architect & Designer consists of core elements and extension elements. EPC core elements consist of an Event, Function, Gateway and Connector. EPC extension elements can be grouped based on ARIS Method modelling view point namely Organization, Data, Function/Application and Product/Service (see Section 2.1). Actually, We just need a single EPC model that consists of all EPC elements in ARIS Architect & Designer to ensure model transformation tool in ARIS Architect & Designer transform EPC elements to BPMN completely. Nevertheless, we define 8 EPC model test cases to facilitate the analysis process of transformation rules derivation as presented in Table 5. The expected result of each test case is the corresponding BPMN model full fill syntactic correctness and syntactic completeness criteria.

Table 5. Test Case for Evaluating BPMN Transformed from EPC

ID	Test Case
TC01	EPC model with only core elements
TC02	EPC model with a Process Interface element
TC03	EPC model with a single organizational element
TC04	EPC model with multiple organizational elements responsible for executing activities
TC05	EPC model that contains a Functions that is connected with organizational elements with RA(S)CI relationships simultaneously
TC06	EPC model with Data elements

TC07	EPC model with Application elements
TC08	EPC model with Product/Service elements

Each view point has many EPC elements extension to represent a more specific modelling view point but describes something that has the same representation as a group of view point. Also, ARIS Architect & Designer adds a Risks element to represent an activity that may have critical effects and a Process Interface element to link another EPC model at the same process hierarchy level.

4.3 Evaluation Procedure

We evaluate each BPMN model generated in ARIS Architect/Designer tool using Solution Design features in the following way:

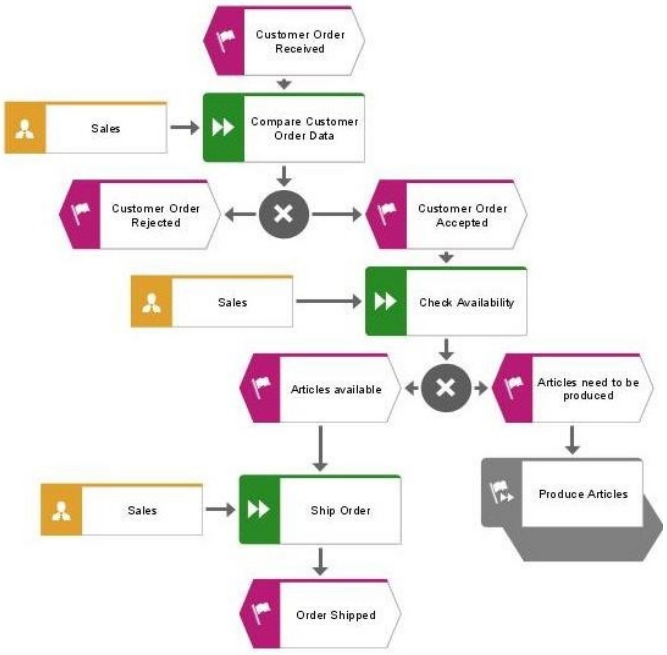
1. We model defined test cases that must comply with EPC syntax rules.
2. We transform such models into the BPMN model in the ARIS Architect/Designer tool using the Solution Design feature.
3. We check each model based on the BPMN syntax rules that have been defined by OMG. If the rules are violated, we notice syntax error.
4. We check every element in the EPC model and ensure that each element is correlated with any element in the BPMN model. If there exists any element which cannot be transformed, we notice as an element/information loss.

5 Results and Discussion

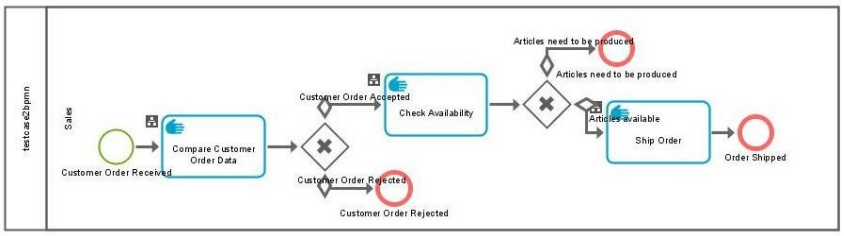
5.1 Evaluation Results

We present an example of EPC to BPMN transformation in ARIS Architect/Designer in Figure 3. Figure 3a represents of EPC model (TC02) represent customer order processing, which means Sales will check the article's availability after receiving a customer order. If articles not available then there will be another process that must be executed, namely produce articles process that is presented with a Process Interface.

Figure 3b is a BPMN model that has been generated from a model transformation tool in ARIS Architects & Designer. However, we did not find any element associated with a Process Interface in the BPMN model. It shows a model transformation tool in ARIS Architect & Designer did not transform a Process Interface element in the EPC model to any element in the BPMN model. So, the resulting BPMN model from the model transformation tool in ARIS Architect & Designer in TC02 has a different meaning compared source model that represents in EPC model. We present the complete results of the syntactic correctness and syntactic completeness evaluation experiments in Table 6.



a. EPC Process Model (TC 02)



b. Transformed BPMN Process Model

Figure 3. Example of EPC to BPMN Transformation in ARIS Architect/Designer

Table 6. Actual Results of Syntactic Correctness and Syntactic Completeness

ID	Test Cases	Actual Results	
		Syntactic correctness	Syntactic completeness
TC01	EPC model with only core elements	√	X
TC02	EPC model with a Process Interface element	√	X
TC03	EPC model with a single organizational element.	X	√
TC04	EPC model with multiple organizational elements responsible for executing activities	√	X
TC05	EPC model that contains Functions that is connected with organizational elements with RA(S)CI relationships simultaneously	√	X

TC06	EPC model with data elements	√	X
TC07	EPC model with application elements	√	X
TC08	EPC model with product/service elements	√	X

Remarks:

√ : The resulting BPMN model complies with the syntax rules, or all elements in the EPC have corresponding elements in the BPMN.

X: The resulting BPMN model does not comply with the syntax rules, or there are elements in the EPC that do not have the corresponding element in the BPMN.

5.1.1 Syntactic Correctness

Table 6 shows that most of the resulting BPMN models from EPC models using ARIS Architect/Designer have complied with OMG syntax rules. The model transformation tool in Architect & Designer transforms organizational elements into a Pool or Lane. However, in the case, the EPC model only has a single organizational element (TC03) that does not require to be transformed into a Pool or Lane. The EPC models that do not have an organizational element or have only a single organizational element represent business processes that occur in a specific organizational unit. It is known as a private business process in BPMN, which does not require any Pool or Lane.

5.1.2 Syntactic Completeness

Table 6 shows that the model transformation tool in ARIS Architect/Designer does not transform all EPC model elements into their corresponding BMPN model elements. Some EPC elements have no relation to any BPMN elements, i.e., Process Interface, data elements, risks element, application/function elements, and product/service elements. The model transformation tool in ARIS Architect/Designer only transforms the EPC core elements and organizational elements to BPMN elements. Although the model transformation tool in ARIS Architect/Designer has transformed the organizational elements into a Pool or Lane, however, the model transformation tool only transforms the organizational element that is responsible for carrying out the activity and ignore other organizational elements (see Figure 1).

We prove model transformation from EPC to BPMN is complete if $dom\ f=M$ (based on completeness definition in Section 4.1). If we define EPC model in Fig. 3a as M and BPMN model generated from the model transformation tool in ARIS Architect/Designer in Fig. 3b as M', so each element in EPC model can be defined as e_i is Event in M, f_i is Function in M, o_i is Organizational Element in M, xor_i is XOR-conector in M, p_i is Process Interface in M and each element in BPMN can be defined as e'_i is Event in M', f'_i is Task in M', xor'_i is Exclusive Gateway in M', o'_i is Pool/Lane in M'. We represent the mapping of EPC elements to BPMN elements in Figure 3 with set theory as shown in Figure 4.

The mapping from M to M' is incomplete because there $e_2 \in M$, $p_1 \in M$ and $e_5 \in M$ so $e_2 \neq \in M'$, $p_1 \neq \in M'$ and $e_3 \neq \in M'$ as a result e_2, p_1 and e_5 don't have relation in M. So, the mapping from M to M' doesn't fulfill $dom\ f=M$.

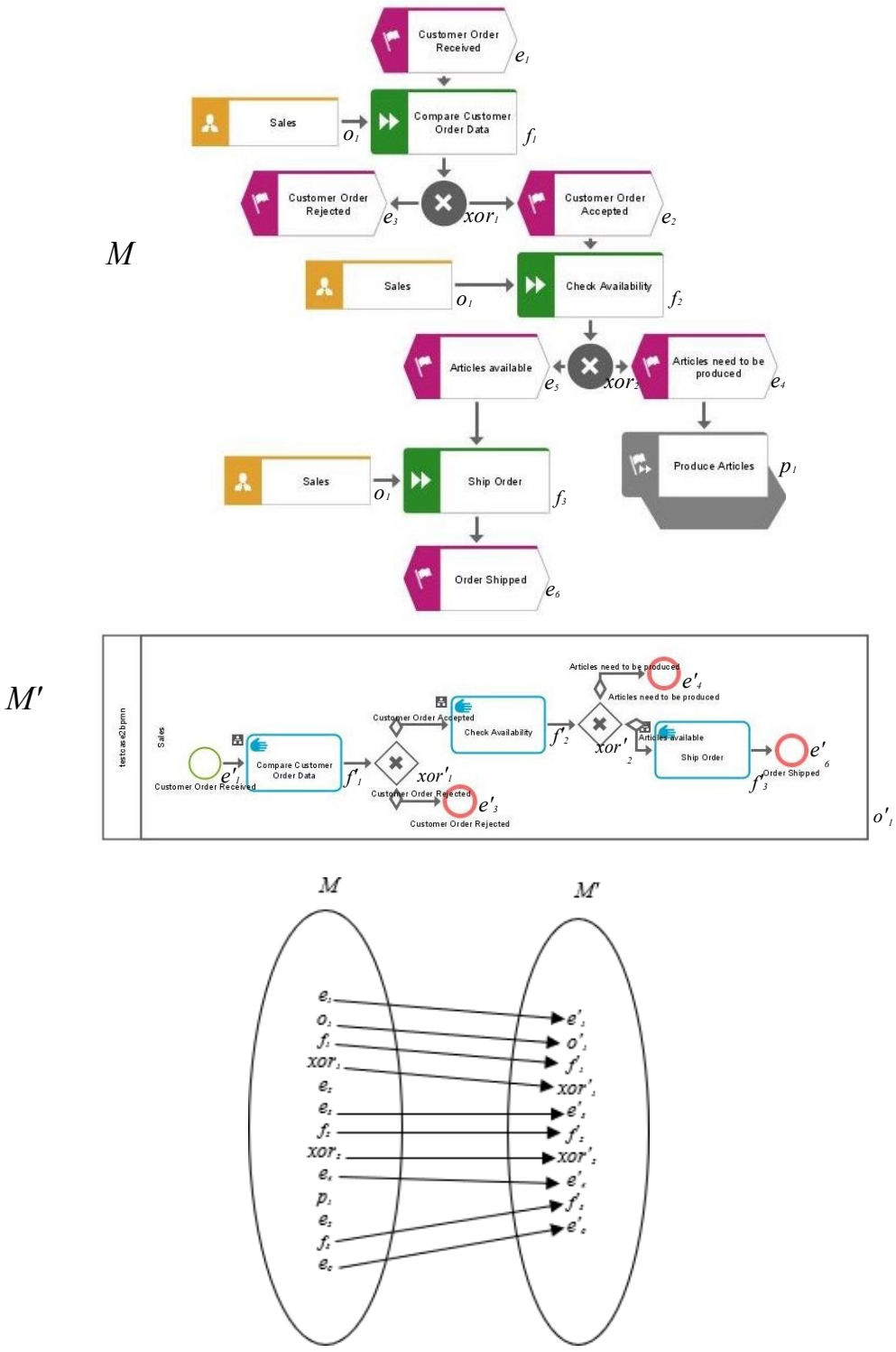
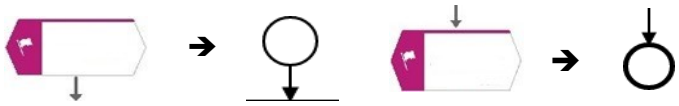


Figure 4. Representation of Model Transformations (TC02) Using Set Theory

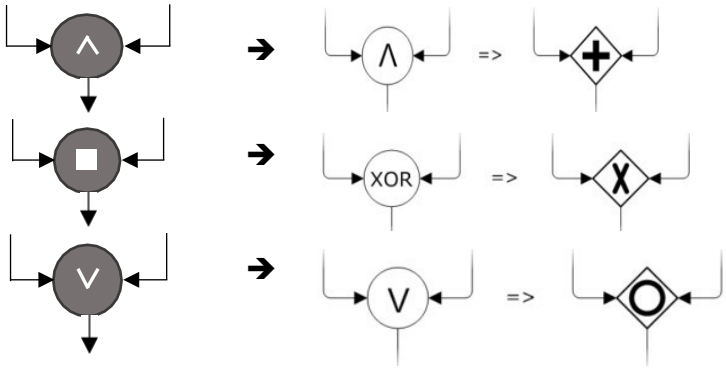
52 Transformation Rules Derivation

Based on the experiment results, we can derive transformation rules used to transform EPC to BPMN. Model transformation tool in ARIS Architect & Designer map EPC to BPMN elements directly. Figure 4 shows that a Function element is mapped to Task (Figure 4a). An Event with outgoing control flow is mapped to Start Event and an Event with incoming control flow is mapped to End Event (Figure 4b). An AND-Connector is mapped to a Parallel Gateway, an XOR-Connector is mapped to an Exclusive Gateway and an OR-Connector is mapped to an Inclusive Gateway (Figure 4c). Organizational elements (organizational unit, role, position) are mapped to a Poll or Lane (Figure 4d).

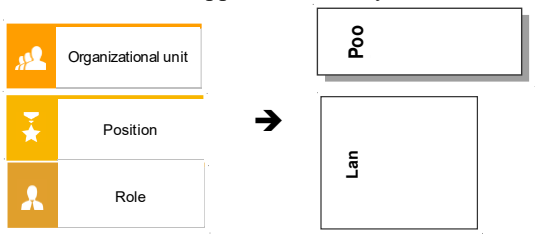
a. A Function is mapped to Task



b. An Event is mapped to Event



c. Connectors are mapped to Gateway



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d. Organizational elements are mapped to Pool or Lane

Figure 4. EPC to BPMN Transformation Rules in ARIS Architect & Designer

6 Summary and Outlook

This study has evaluated the BPMN model transformed from EPC on the ARIS Architect/Designer tool with 2 parameters, namely syntactic correctness, and syntactic

completeness. The result of the syntactic correctness evaluation showed that the model transformation tool in ARIS Architect/Designer had produced BPMN models that do not fully compatible with the BPMN syntactic rules defined by OMG. Furthermore, on the syntactic completeness evaluation, ARIS Architect/Designer only transforms the core EPC elements and an organizational element responsible for executing activities. This study also derives the transformation rules used for mapping EPC to BPMN in ARIS Architect and Designer. In Solution Design feature, An Event in EPC is mapped to an Event in BPMN, a Function is mapped to a Task, Connector is mapped to Gateway, and Organizational elements are mapped to Pool or Lanes. The result opens further research to improve the syntactic completeness of the EPC-TO BPMN model process business transformation.

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