Analysis of Business Process Models based on Business-Action Theory and DEMO

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Abstract: Very often, organizations have to deal with the fact that diversified backgrounds, terminologies, knowledge, tools, and techniques, are a significant obstacle to consensual model representations of the business. In fact, the development of business process model representations, encompassing correctly human universal patterns of communication is still hard to achieve as there are very few methods and tools devoted to this purpose. The choice of business process model representations may not be consensual, in terms of the modelling tools and techniques used to express business flows and activities, but it can be consensual in terms of recognizing that humans always reproduce the same patterns of behaviour when requesting and providing services and products. It opens doors to a shared platform of understanding between those interested in the model representation as the main question is less “how to draw the model”, and more, “what draw in the model”. So this shared platform can be achieved through Enterprise Ontology. An ontological model does not dismiss other modelling techniques, instead, it can complement them by reducing conceptual and terminological confusion and by helping organizations to focus on designing models that capture those patterns of behaviour when humans request and offer products and services. This way, Enterprise Ontology can assist managers, information system designers, and IT specialists to enable understanding and communication, despite context or domain differences. So this document proposes the use of DEMO methodology to refine flow and activity based model representations.

Keywords: Enterprise Ontology, Responsibility, Business Process, DEMO.
1 Introduction

In the last decade, business processes are receiving more attention as process-centric representations of an enterprise. Whereas earlier, mostly data-driven approaches have been pursued as starting point for information systems modelling, there is currently a tendency to use more process-driven requirements engineering (Nuffel, Mulder, & Kervel, 2009). This trend has even increased by recent developments like Service-Oriented Architectures (SOA) where business process languages are considered as primary requirements sources (Zimmermann, Schlimm, Waller, & Pestel, 2005).

To model business processes, a large number of notations, languages and tools exist. There has been an increasing use of business process model representations to capture business processes in the early phases of systems development (Dijkmana, Dumas, & Ouyang, 2008). So the research made in this work was motivated by the need to produce unambiguous and coherent representation models of business processes. This need is due the fact that flowchart and activity-based modelling representations in general have some drawbacks. Regarding the basic assumptions of current business process modelling languages, following remarks are mentioned: absence of formal semantics, limited potential for verification, message-oriented approach, and the modelling of multi-party collaborations (Barjis, 2007). When analyzing flowchart and activity-based modelling languages like BPMN, for example, the lack of formal semantics is caused by the heterogeneity of its constructs, and the absence of an unambiguous definition of the notation (Dijkmana, Dumas, & Ouyang, 2008).

The evaluation of flowchart and activity-based modelling representations mainly concentrates on the following relevant aspects of research: the facts concerning completeness, consistency, construct redundancy, and ambiguity of the modelled business process. Thus, it can be mentioned that the theoretical studies still indicate a number of problems that practitioners actually suffer from when dealing with conventional flowchart and activity-based modelling representations (Recker, Indulska, Rosemann, & Green, 2006). Most problems are moreover indicated by people with an IT background who need more rigor and details to use models like BPMN, for example, as input for software implementation projects (Nuffel, Mulder, & Kervel, 2009). Considering these drawbacks, mainly regarding ambiguous and unclear descriptions of their constructs, the motivation of this work resides on the need to design coherent and structurally complete business process.

1.1 DEMO – Enterprise Ontology

According to Jan Dietz (Dietz, 2006), a complete enterprise ontology consists of four related aspect models: the construction model, the process model, the action model, and the state model.

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1 For example, in BPMN modelling language a thing can be represented by both a pool and a lane, a transformation is represented by an activity, a task, a collapsed sub-process, an expanded sub-process, and a transaction.
1.1.1 Construction Model

The construction model is very unlike usual organization models. Usually, an organization model is understood to be a hierarchical structure of organizational units, like divisions, business units, and departments, and/or organizational functions, like managers, salesmen, and accountants. However, in the Ψ (PSI) theory, these units and functions belong to the realm of implementation. The essential unit of authority and responsibility is the (elementary) actor role. Moreover, the notion of organization is first of all considered to be about the interaction of the actor roles. Therefore, an interaction model shows the ontological construction or composition of an enterprise: the elements (actor roles) and their mutual influences. The Construction Model (CM) specifies the identified transaction types and the associated actor roles, as well as the information links between the actor roles and the information banks (the collective name for production banks and coordination banks); in short, the CM specifies the construction of the organization. It occupies the top of the triangle in Fig 1.

1.1.2 Process Model

The ontological process model shows how the distinct transactions are interrelated. There are two kinds of links between transaction steps: causal links and conditional links. A causal link from a transaction T1 to a transaction T2 means that T2 is initiated from within T1. A conditional link from a transaction T1 to a transaction T2 means that T2 has to wait for the completion of T1 before it can proceed. Although actors act autonomously, they follow guidelines or procedures in order to act responsibly. These guidelines or procedures are called action rules. The action rules that pertain exclusively to the enterprise ontology are collectively called the ontological action model. The Process Model (PM) contains, for every transaction type in the CM, the specific transaction pattern of the transaction type. From the Ψ (PSI) theory, this is either the complete transaction pattern or a part of it, such that it comprises at least the basic pattern. The PM also contains the causal and conditional relationships between transactions. These relationships determine, in addition to the transaction patterns, the possible trajectories in the C-world (coordination world). In other words, the PM specifies the state space as...
well as the transition space of the C-world. The PM is put just below the CM in the triangle because it is the first level of detailing of the CM, namely, the detailing of the identified transaction types.

### 1.1.3 Action Model

The Action Model (AM) specifies the action rules that serve as guidelines for the actors in dealing with their agenda. It contains one or more action rules for every agendum type. These rules are grouped according to the actor roles that are distinguished. The AM is put just below the PM in the triangle because it is the second level of detailing of the CM, namely, the detailing of the identified steps in the PM of the transaction types in the CM.

### 1.1.4 State Model

The ontological state model specifies the state space (i.e., the set of allowable states) of both the production world and the coordination world of the enterprise. Stated differently, it contains the conceptual model of all facts that are produced and all facts that are used (Dietz, 2006). The State Model (SM) specifies the state space of the P-world (Production world): the object classes and fact types, the result types, and the ontological coexistence rules (Dietz, 2006). The transition space of the P-world is not contained in the SM since it is fully derivable from the transition space of the C-world (Dietz, 2006). The SM is put on top of the AM in Fig 1 because it is directly based on the AM; it specifies all object classes, fact types, and ontological coexistence rules that are contained in the AM (Dietz, 2006). On the other side, the SM is put just below the CM (and therefore at the same level as the PM), because it may also be viewed as the detailing of a part of the CM, namely, the contents of the information banks (coordination and production banks).

### 2 Related Work

In this section we present the related work. Our intention is to introduce some important comparisons between DEMO and BPMN, and then between DEMO and ArchiMate.

#### 2.1 DEMO versus BPMN – Theoretical comparison

Nuffel, Mulder, & Kervel (2009) presents us some conclusions about the enhancement of the formal foundation of BPMN by Enterprise Ontology (EO). We summarize here the conclusions of their work. For more informations please see (Ettema & Dietz, 2009). It can be stated that EO and DEMO have proven their strength for enterprise engineering. The main advantage is that a shared and formally correct conceptualization for all stakeholders has been established as the one and only right point of departure for any implementation.

Preliminary results of research by the authors show that the EO and the DEMO methodology deliver formally correct models which allows the construction of a DEMO automata, the core of Enterprise Ontology derived information systems. Moreover, DEMO ends where BPMN starts. Therefore, a way to construct formally correct BPMN models by applying the DEMO methodology will be identified. As such, we gain the DEMO advantages and have a formal correct BPMN model.

Nuffel, Mulder, & Kervel, (2009) state that the design of enterprises, expressed by an ontology containing concepts of social interaction, in its implementation includes an
ontology for rational information systems, and an ontology for documental systems. However most ontologies are implicit regarding the concepts constructing the realities of their to be represented systems, such as the enterprise and information systems. Therefore it can be argued that documental and informational ontologies are subsets of an Enterprise ontology, leading to the conclusion that instead of investigating an one-to-one mapping, a many-to-many mapping has also to be further researched. The authors thus argue that Enterprise Ontology, combined with the DEMO methodology, can provide a formal foundation to BPMN models. Using EO as underlying domain ontology results in explicitly specified BPMN models, mainly because EO delivers constraints to which BPMN constructs should adhere. Moreover, revising existing BPMN models with DEMO can be used to verify completeness and consistency of the modelled business processes. The main contribution of (Ettema & Dietz, 2009) is thus combining the rich representational aspects of BPMN with the formal correctness of DEMO.

To conclude, (Ettema & Dietz, 2009) present us a set of a consistency checks that can be performed regarding the communicative actions. These consistency checks could involve:

1. Checking the completeness of the BPMN diagram on the ontological level (are all communicative actions mapped?)
2. Check if each communicative action has a documental and/or informational implementation (this means that the customer call is mapped on the ontological as well as the documental level)
3. Checking the implementation of Actors to persons/departments
4. Checking the sequence of the communicative actions (are these conform the DEMO process model?)
5. Check the implications for the BPMN diagram of a redesign of the DEMO process model.

2.2 DEMO versus ArchiMate – Theoretical comparison

Ettema & Dietz, (2009) carried out a comparative evaluation of ArchiMate and DEMO, both theoretically and practically, i.e. on the basis of the analysis of the same case by each approach (Ettema & Dietz, 2009). In this section we then present the conclusions formed by the authors. For more information please see (Ettema & Dietz, 2009).

A thorough assessment of the strengths and weaknesses of ArchiMate and DEMO can only be performed on the basis of multiple real-life and real-size cases, taken from different areas. Nevertheless, some conclusions can certainly be justified already now. The first conclusion is that ArchiMate and DEMO are hardly comparable, for several reasons. One is that ArchiMate is a second wave approach, whereas DEMO is a third wave approach, as was discussed in Section 1 already. Another reason is that DEMO is founded in a rigorous and appropriate theory, whereas ArchiMate lacks such a foundation. Therefore, its semantics are basically undefined, which unavoidably leads to miscommunication among ArchiMate users. One would expect that having a rigorous semantic definition would be a prerequisite for an open standard.

A second conclusion regards the abstraction layers as distinguished by ArchiMate and DEMO. DEMO (in fact the Ψ-theory) makes a well defined distinction between three abstraction layers: the B-organization, the I-organization, and the D-organization. Only in
the B-organization original new production facts are brought about (deciding, judging, manufacturing etc.), by which the enterprise world is changed. In the I-organization one computes, calculates, reasons; this does change the world. In the D-organization one stores, copies, transports etc., documents. Despite the fact that ArchiMate belongs to the second wave, it does not make a distinction between infological and datalogical issues in the business layer.

Although ArchiMate and DEMO are to a large extent incomparable, we think that they can usefully be combined. As a matter of fact, several studies have been carried out concerning the combination of DEMO with some second generation approach, since DEMO does not really cover the implementation of an organization. As one of the practical outcomes, a procedure has been developed for producing EPCs on the basis of DEMO models. In this way, the rigorous semantics of DEMO are so to speak enforced upon the EPC. Such a combination is also possible and beneficial for ArchiMate and DEMO (Ettema & Dietz, 2009).

3 Refining process models

This section describes a method that relies on DEMO methodology as a way to improve and verify the consistency and completeness of business process models (BPM). These business process models can be BPMN diagrams, flowchart diagrams, or activity diagrams, for example. It encompasses two modelling approaches: the Bottom-up modelling approach and the top-down modelling approach.

![Diagram](image.png)

Figure 2 - The two approaches of to refine business process diagrams

3.1 The Bottom-up modelling approach

In this phase, the goal is to produce the ontological model, by capturing the essential aspects of the input business process model (BPM) and discard other details that may not be relevant from the point of view of human patterns of interaction and communication within socio-technical systems. So this approach starts with a specification and analysis of the input model, in respect to its notation and graphical representation.
3.1.1 Input models: Notation compliance analysis

The input models subjected to this evaluation are expected have, or to incorporate at least, the basic look and feel that relies on the core elements illustrated in Fig. 4, which means, its graphical representation relies essentially on the following flow elements: Events, Activities, and Gateways. In order to satisfy additional modelling needs, new modelling concepts can be added to those basic flow elements, by using, for example, the concept of Artefacts provided in BPMN (Minoli, 2008). This way, an Artefact can be linked to the basic flow objects through Association.

3.1.2 Producing the process model

In this stage of analysis the goal is to produce the Process Structure Diagram (PSD) and the corresponding Information Use Table (IUT) by capturing all the information we need from the input model. So Fig. 4 indicates the steps performed to produce the Process Model (PM).
According to the Fig. 5 we indicate the following procedures that can help to make easier the design of the PM:

1) In the input model, identify every request C-acts (and nothing else). Label each Activity element identified as such (as T0n/request, n = 1, 2, ...) following as much as possible its order of execution. If this step is performed successfully, we know now how many transactions will exist in the resulting PSD. Then, for each previously identified request C-act (for each T0n/request, n = 1, 2, ...) follow the order of execution of the Activity elements in the input model to identify and label every corresponding remain transaction steps (promise C-acts, execute P-acts, state C-acts, accept C-acts, or decline C-acts).

2) After performing steps (3) and (4) of Fig.6.7, and by observing the input model alone, we may still have some difficulty to visualize the correct order in which the identified transactions are being executed. So the next step requires the identification of every Activity elements labelled or marked as P-acts (as T0n/execute, n = 1, 2, ...) in the input model. According to the correct knowledge we have about the business and the order in which its products or services are created, we can now make use of the composition axiom to picture the sequence of execution of those services or products. This step is not always necessary, unless we are dealing with a very complex input BPD and we can’t figure out exactly the correct sequence of execution of the identified transactions. Even skipping this step, one should know that the composition axiom must be respected when producing the PSD. To conclude, this step is executed as a way to validate the correct sequence of the transactions identified in the input model and to make easier the design of the ontological PSD.

3.2 The top-down modelling approach

This new phase of analysis is focused on using the DEMO artefact produced previously, in order to propose the improvement of the input model. The most important aspect of this top-down modelling approach is the ‘projection’ of the transactions (its patterns) – graphically represented in the Process Structure Diagram (PSD) – against the input model. The intention is to target every process steps in the PSD and establish its direct
correspondence with the respective Activity elements in the input model. Even being derived from a potentially incomplete or inconsistent business process diagram, the produced PSD, is always and consistent, a property that is guaranteed by the $\Psi$ theory.

3.3 The $\Psi$ compliance analysis

The Fig. 7 is a generic illustration that shows the direct correspondence between each process step in a produced PSD and the corresponding business process Activity element from Business Process Diagram (BPD). The rule establishes a way to line up together the graphical elements from both diagrams, in order to highlight eventual process steps in the PSD that cannot be matched up with any of the Activity element from the input business process diagram. It is done considering that in the previous phase of analysis, during the production of the PSD, we assumed that those process steps had to be performed somehow, at least tacitly; otherwise the resulting transaction would not have the correct pattern according to the transaction axiom of the $\Psi$ theory. As illustrated in Fig. 7, the process steps T02/req and T0n/pm, instead of pointing to graphical Activity elements, the 'correspondence arrows' point to question marks. It indicates that those process steps were either assumed as being performed tacitly, or they simply were neglected or missed during the design of the business process model. By performing this analysis, one is able to focus on and perform changes that can really have a significant impact in terms of the description of the analysed business process. It means that the analyst has the opportunity to reason about the relevance of ignoring or taking into account the discrepancies found when performing the correspondence analysis of the Fig. 7

3.3.1 Redesigning business process models

After performing the compliance analysis from the previous section, one may decide to redesign the input model in order to make it a $\Psi$ compliant business process model,
which means that it will reflect every transaction patterns characterizing human interactions. The redesign of the input models may imply two things:

1) Adding to the input business process diagram new Activities elements previously ignored or eventually missed by the modeller. However, the compliance analysis tells us the ontological nature of those missing Activity elements, but only the knowledge we have regarding the business itself can tell us what each activity is about, in the context of the organization.

2) Searching for more information about the business process designed in the input model. This is one the most important aspects of this analysis, as it can help analysts to know exactly what information they should get from the stockholders in order to complete and improves the business process models.

So to exemplify the application of the method described, let’s consider the BPMN diagram of Fig. 8, after performing on it the steps (2), (3) e (4) of Fig. 5.

![Figure 8 – Example of a business process diagram (BPD).](image)

By applying the remaining steps of Fig. 5, the resulting PSD is shown in Fig. 9 (on right). On left, the figure shows the corresponding composition structure.

![Figure 9 – The produced PSD.](image)
Fig. 10 shows an example of applying the correspondence analysis on the input model of Fig. 8. It shows how the process steps of the produced PSD (in Fig. 9) are used to identify missing or unmatched elements in the input model.

To refine the input model of Fig. 8, we added to it the found missing Activity elements (coloured red), as shown in Fig. 10 (by the diagram on right). From the compliance analysis (in Fig. 10) we can only predict what kind of ontological acts these new activities are. As one can see from Fig. 11 (on right), the new added activities have already been labelled to indicate its ontological nature. These new activities also exhibit question marks, which means they were not identified yet in the context of the organization.

![Image of Fig. 10 - PSD-BPD correspondence analysis.]

![Image of Fig. 11 - Improving the input model through the Ψ compliance analysis.]

4 Conclusions

The analysis described here is not a recipe, it involves some state of the art, knowledge, as well as, a good understanding of the business process we are evaluating, and most of the time it should be performed iteratively. It means, for example, that after performing one step we might find the need to go back and redo the previous step. In some situations, we could end up redoing every steps several times until get to the point where the input model is refined.

The execution of this evaluation will generally raise more questions than answers about the consistency and completeness of the input models, including the real meaning of some activities described in it. However, it is not bad news at all. Many of these questions might help to clarify responsibilities and even determine how it is being delegated and which levels of information access it implies. For example, in a customer service department where customer complaints are filed, every resolution plan implemented (produced) to attend a customer’s complaint is ultimately a responsibility of that department, even if such responsibility is fully delegated or transferred to some other actor role. The transference of responsibilities through delegation might raise, in advance, questions about accountability and security, such as, which levels of access the delegated actor role should have towards the information involved? In cases where the delegated actor is not fulfilling its goals who should respond for that and who should be held accountable for that? In situations where business process reengineering is needed, the knowledge...
provided by the resulting ontological model can be useful to redesign the input business process diagram and from there, to suggest alterations at the business process structure.


