Integrating Modelling Disciplines at Conceptual Semantic Level

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Abstract. For an organization to maintain (or achieve) a competitive edge and to be continuously compliant with ever changing regulations, it is necessary that it can react in a timely and cost-effective fashion to changes in the immediate environment which affects its business. This can only be achieved if the organization has an effective grip on its total body of knowledge.

In order to get grip on its knowledge, an organization needs insight and control in the way the overall goals of the organization and the associated laws and regulations are translated into an operational way of working. As new technologies are introduced frequently, it is of great interest to have a sustainable knowledge description of the operational way of working, independent of any physical realization, including a two-way audit trail (from source to implementation and back).

In this paper we explain that for an organization to gain true insights in its operations, it is not enough to create independently conceived process, information and rules models, but that it is of importance to gain insight in (and thus understanding of the relationships between these different models.

Keywords: Integration · Fact-based model · Conceptual · Semantic

1 Introduction

In today's business environment, the challenges an organization has to face, have increased in both number and complexity. Not only competition has become tougher, organizations also have to fulfil an increasing number of regulations imposed by external organizations and have to become more and more cost-effective.

For an organization to maintain (or achieve) a competitive edge and to be continuously compliant with ever changing regulations, it is necessary that it can react in a timely and cost-effective fashion to changes in the immediate environment which affects its business. This can only be achieved if the organization has an effective grip on its total body of knowledge.

In order to get grip on its knowledge, an organization needs insight and control in the way the overall goals of the organization and the associated laws & regulations are translated into an operational way of working. That is, the operational way of working of the organization needs to be defined before physical realization in, for example, IT systems or mechanization.

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As new technologies are introduced frequently, it is of crucial interest to have a sustainable knowledge description of the operational way of working (independent of any physical realization in a specific technology), preferably including a two-way audit trail (from source to realization/implementation and back).

In particular, the organization needs insight in:

1. The services and products it delivers in order to achieve its business goals,
2. The processes it executes in order to deliver its services and products,
3. The information (fact types, object types, including terms and definitions) it needs for executing its processes, and
4. The rules it has to obey (use) for proper execution of its processes.

These form together the body of knowledge and can be subject to (partial) automation.

In section 2, the major pitfall of the disconnected approach is discussed. Section 3 specifies the structural framework of the proposed approach by identifying the knowledge classes and their meaning, while in section 4 a small meta model fragment for the complete approach is given. In section 5, a conclusion and further research issues are provided.

2 Major Pitfall of the Disconnected Approach

Process modelling, information modelling and rules modelling are the disciplines that aim to provide insight into a specific aspect or perspective of the body of knowledge of an organization. For each of them, standard languages exist that are intended to provide the best fit for the modelling goal or perspective at hand. Think for example of BPMN (Business Process Modelling and Notation) [1] for business process modelling, DMN (Decision Model and Notation) [2] for (derivation) rule modelling and SBVR (Semantics of Business Vocabulary and Rules) [3] for rules and (to a certain extent) information modelling.

While all of these types of models have their own merits, it is argued in [4] that: *"if left unconnected and uncontrolled, instead of integrated and interconnected, they can result in a fragmented perspective on the enterprise and thereby can negatively affect the overall coherence of models as well as the performance of the organization"*. In particular, within organizations, each discipline is due to historical organizational reasons approached from its own perspective, using standards that provide the best fit for the desired modelling viewpoint and the purpose at hand, thereby overlooking integration aspects.

2.1 Insight and Understanding Requires a Semantic Approach

In order for an organization to gain *true* insight in its operation and long term possibilities, and thus providing the necessary and sustainable grip on its body of knowledge, it is not enough to create independently conceived process, information and rule models. It is necessary to gain insight in the relation between these different models, and in particular to understand how, during execution, rules, information and processes influence each other.

The term "insight" implies "understanding". It is therefore required that processes, information and rules as well as the interactions between these model types are represented in such a manner that they are communicable and understandable to all stakeholders involved. This requires a definition at the conceptual (semantic) level void of any implementation details, focusing on the semantics.

3 A Fully Integrated Modelling Approach

The fully integrated modelling approach suggested in this paper consists of a framework based on the fact-based modelling methodology, covering the process, information and rule perspectives. For this, the knowledge triangle as depicted in Figure 1 is introduced.

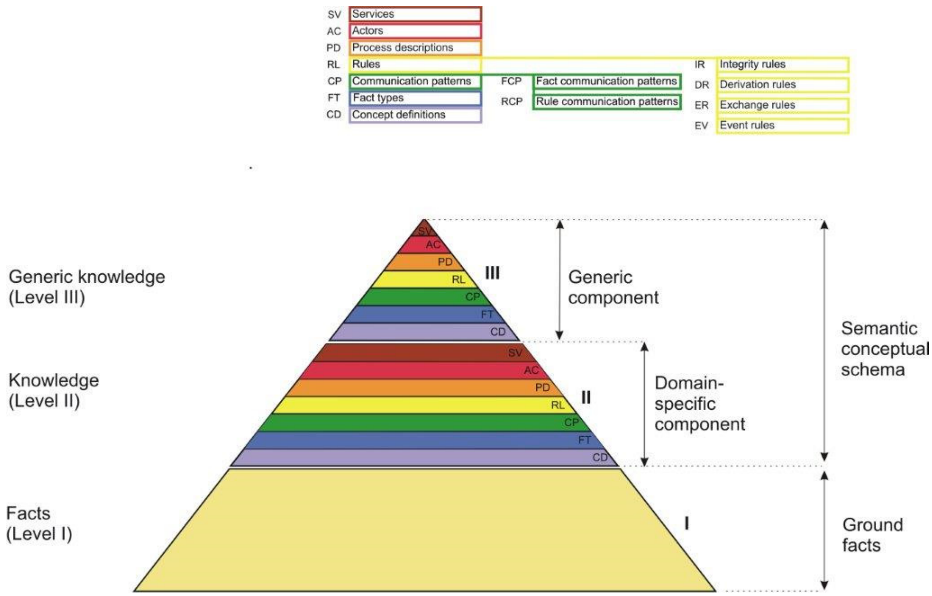

Fig. 1. The Knowledge Triangle.

Level I: The Ground Facts or Assertions

The assumption of fact-based modelling methodologies is that the most concrete level in any structured knowledge description or business communication consists of *ground facts*. It is observed that these comprise the vast majority in business, engineering or technical communication.

A ground fact is defined as "*a proposition taken to be true by a relevant community*" and is expressed as an assertion that either simply predicates over individual objects or simply asserts the existence of an individual object. Examples are:

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"Marie Curie received the Nobel prize in Physics in
1903".
"Linus Pauling received the Nobel prize in Chemistry in
1954".
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Ground facts, expressed by means of sentences, describe factual, planned or imagined situations, in the past, current time or future; they do not prescribe any grammar aspect.

Level II: The Domain Specific Component of the Knowledge Triangle

Level II of the knowledge triangle consists of the domain specific conceptual schema. It consists of knowledge categories to which the ground facts of level I must adhere as well as concept definitions to understand the ground facts; it could be said it provides interpretation semantics. In other words, level II specifies the rules that govern the ground facts at level I and defines the concept definitions of the terms used in the facts, when there is the slightest doubt they could be misunderstood. Moreover, the usage of ground facts is also described at this level. Level II is expressed by means of a series of knowledge categories, namely:

1. *Concept definitions*, which have as function to describe the meaning of every term or group of terms in the ground facts for which it is assumed that the meaning is not fully known to the intended audience and common understanding of the meaning is required. In case the meaning of a term is assumed to be known it is good practice to state this explicitly in order to avoid any confusion.
2. *Fact types*, which provide the functionality to define which kinds of ground facts are considered to be within *scope* of the system, subject or domain of interest. A fact type is either:
   (a) variable-based fact type, i.e. a fact type seen as a populatable construct, generalizing level I ground facts on the basis of common properties, using fact-communication patterns.
   (b) A role-based fact type, i.e. a fact type seen as a construct that generalizes level I ground facts on the basis of common properties, using rule-communication patterns.

   The boundary (scope) of the system, subject or domain is determined by the set of fact types.
3. *Communication patterns*, whereby there is a distinction between:
   (a) *Fact communication patterns*: their function is to act as communication mechanism to be used as a template to communicate ground facts in a language and using terms the subject matter expert is familiar with, and
   (b) *Rule communication patterns* , whose function is to act as communication mechanism for communicating the rules, listed in point 4 below, of the conceptual schema.

   Both types of communication patterns use community-specific terminology.

4. *Rules*, distinguishing between:
   (a) *Integrity* or *validation rules*, also known as constraints. These have as function to restrict the set of ground facts and the transitions between the permitted sets of ground facts to those that are considered useful. In other words, integrity rules have the function to restrict populations as well as transitions between populations to useful ones.
   (b) *Derivation rules*, which are used to derive or calculate new information (ground facts) on the basis of existing information. That is, derivation rules describe how to derive new ground facts on the basis of existing ground facts.
   (c) *Exchange rules,* which have as function to move ground facts from the domain under consideration into the administration of that domain and vice versa, or to remove ground facts from the administration. In other words, they specify how ground facts are added and/or removed from the knowledge base such that the knowledge base stays in sync with the communication about the outside world.
   (d) *Event rules*, which specify when to update the set of ground facts by a derivation rule or exchange rule in the context of a process description.
5. *Process descriptions*, specifying the fact consuming and/or fact generating activities (the exchange and/or derivation rules) to be performed by the different actors for that process, as well as the event rules invoking those exchange and derivation rules in an ordered manner.
6. *Actors* identifying the involved participants and their responsibilities in the processes (in terms of the exchange and derivation rules they need to execute).
7. *Services*, identifying the realizations of the process descriptions in terms of information products to be delivered.

Level III: The Generic Component of the Knowledge Triangle

The third level of the knowledge triangle, the generic component, independent of any specific domain, consists of the knowledge categories to which each conceptual schema of level II must adhere. In other words, Level III of the knowledge triangle consists of the generic conceptual schema, expressed in the same knowledge categories as any domain-specific conceptual schema. Each element in the generic component of the knowledge triangle or the generic conceptual schema is independent of any specific part of the domain or system. Interestingly enough, the generic conceptual schema is a population of itself.

4 Processes as an Ordering of Rules

At the highest level of abstraction, a process is nothing more than a fact-generator (a derivation): based on input facts, new facts, the output facts, are generated in order to provide a (requested) service. Typically, several steps have to be undertaken to achieve the output. That is, in most process-views, a process consists of a series of steps that together generate the output on the basis of the input, triggered by an event. From an integrated perspective, these steps correspond to exchange rules and derivation rules in combination with event rules.

While derivation rules are well-known within the fact-based modelling community, exchange rules have been only recognized in the CogNIAM variant of fact-based modelling. These rules are however of importance since only through exchange rules it is possible to ensure communication between the system to be realized and the outside world.

The main reason for considering processes as an ordering of exchange and derivation rules in combination with event rules is that it aids in identification of the granularity of the possible actions as well as to enable a consistent way of using the Business Process Model and Notation.

4.1 Exchange Rules

Exchange rules are the mechanism to bring facts into the system, to remove them from the system, to update them or to report on them. Exchange rules always work on combination of related fact types. That is, exchange rules always apply to so-called conceptual structures. A conceptual structure is a grouping of fact types and object types whereby the grouping is determined through the existence-dependency of the fact types and object types on the object type under consideration. Determination of a conceptual structure is part of the FAMOUS-2 research performed with ESA and is described in [5].

Create rules are exchange rules that bring facts into the knowledge base from the outside world. A creation rule can only be performed if all the integrity rules that are part of the conceptual structure are fulfilled. This means that, in a BPMN-representation of an activity that corresponds to an exchange rule, there is always a conditional boundary event associated to the activity that is triggered when not all constraints are fulfilled. Consider the following use case text:

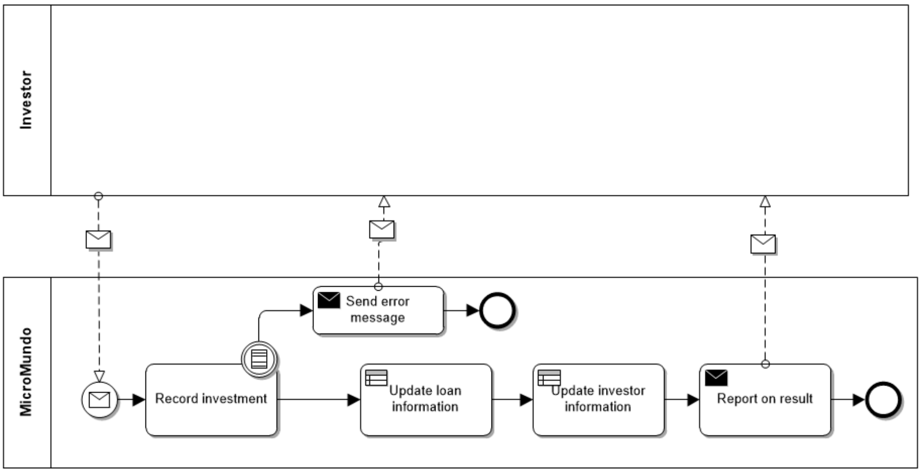

Fig. 2. An example BPMN collaboration view.

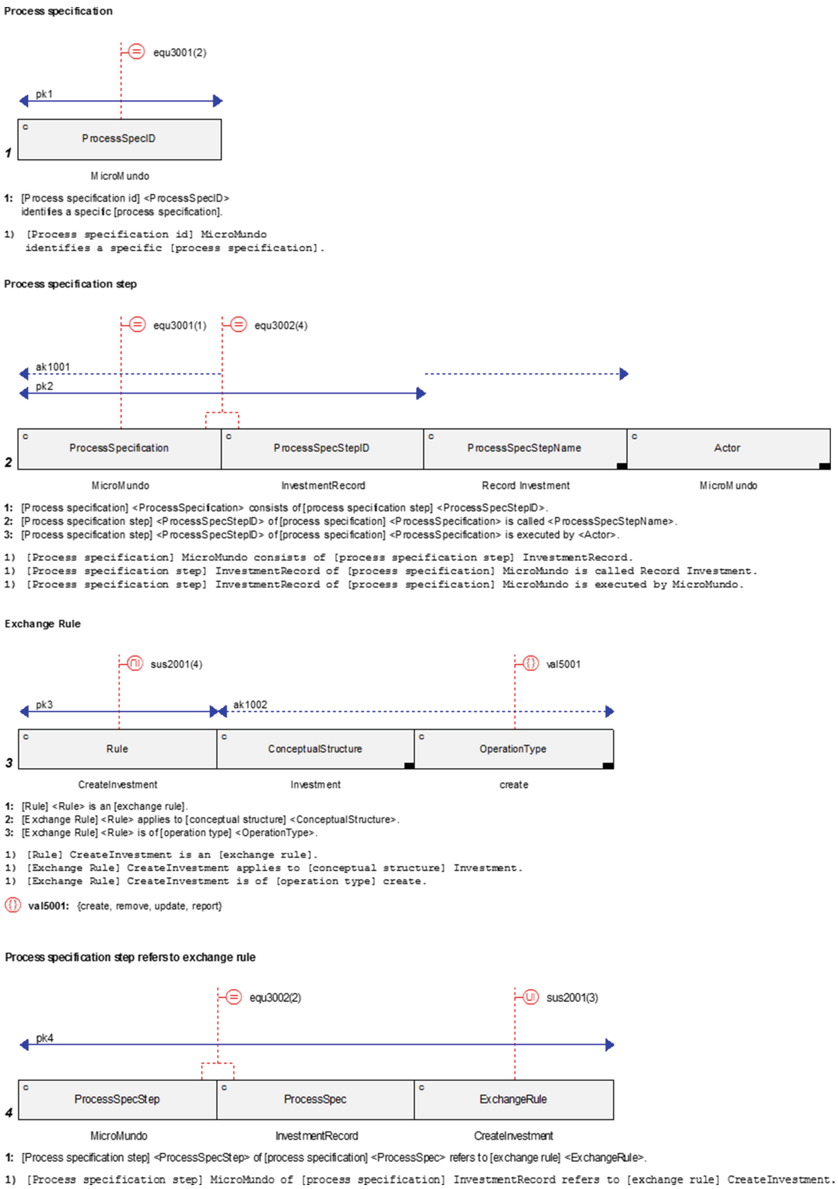

Fig. 3. Meta model fragment: a process specification step corresponds to a create exchange rule.

“An investment is a transaction where money is transferred from the account of an investor to a loan of a business. Each investment is assigned a unique investment number by MicroMundo, in order to provide an identification for each specific investment within the collection of all investments performed at MicroMundo.

The investor and the invested amount of each investment are recorded. Furthermore, the loan for which an investment is made and the date of each investment are recorded. Regarding the investments of investors in loans the following applies: an investment amount of an investment may not exceed the non-collected capital at the time of the investment of the loan that is invested in. The collected capital and non-collected capital of a loan are updated after each investment made.”

In the BPMN collaboration diagram of Figure 2, the activity “record investment” corresponds to a creation rule that creates an investment. The boundary event associated with the activity is a conditional event that is triggered when the integrity rules associated with an investment, as described above, are not fulfilled. For example, if the investor is not known, or if the date of the investment is not recorded, or if any of the other rules is not fulfilled, the boundary event will be triggered, resulting in the sending of an error message that describes which integrity rules have been violated.

The result of the creation rule is that facts are added to the system under consideration.

The meta model fragment associated with the above is given in Figure 3. As is depicted, through populating the associated model fragment, it is shown that a BPMN activity, called a process specification step in the meta model fragment, refers to an exchange rule that creates an instance of a conceptual structure, namely the conceptual structure associated with the object type ‘investment’.

5 Conclusions and Future Research

In this paper, we showed a small fragment of the integrated approach to business modelling at semantic level. In this fragment, it is demonstrated that a process can be seen as an ordering of rules, each of which are grounded in fact types.

The integrated approach, of which a portion is illustrated in this paper, complies to the following ISO principles [6]:

The Helsinki Principle: “Any meaningful exchange of utterances depends upon the prior existence of an agreed set of semantic and syntactic rules. The recipients of the utterances must use only these rules to interpret the received utterances, if it is to mean the same as that which was meant by the utterer.”

The Conceptualization Principle: “A conceptual schema should only include conceptually relevant aspects, both static and dynamic, of the universal discourse, thus excluding all aspects of (external or internal) data representation, physical data organization and access as well as all aspects of particular external user representation such message formats, data structures, etc.”

The 100 % Principle: “All relevant general static and dynamic aspects, i.e. all rules, laws, etc., of the universe of discourse should be described in the conceptual schema. The information system cannot be held responsible for not meeting those described elsewhere, including in particular those in application programs.

Moreover, it complies to a fourth principle, namely the principle of "early validation" which implies that the development process builds on a representative set of examples that is used to validate the model throughout the development of the model, not only afterwards.

Using this approach, the author believes that through this approach, greater flexibility and agility in the implementation (of changes) can be achieved. That is, the author considers an integrated approach as a prerequisite for the realization of customer-oriented services and for securing the collaboration between organizations (interoperability).

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