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An automatic alignment of the business process and business value models: a novel MDA method

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ABSTRACT

With the massive development of end-users requirements, the model alignment has become an essential stage in software engineering, especially in the model driven architecture (MDA) approach, to absorb the end-user's need. The purpose is to facilitate the alignment of new models from existing ones. Our contribution in this paper is to deal with the MDA higher abstraction lever by focusing on the automatic alignment of the business value with the business process models for the information system (IS). For our case, the data-flow diagram (DFD) illustrates the business process model, and the E^3value model illustrates the business value model. However, the ATLAS-transformation language (ATL) ensures automatic alignment. The main goal is to facilitate and accelerate IS implementation while enhancing its quality.

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1. INTRODUCTION

Nowadays, model alignment has become an important step in the software engineering domain to be more competitive in the field of software engineering, as the end-users in terms of software development have become very demanding. In this vein, we based on the model driven architecture (MDA), an approach spearheaded by the object management group (OMG) [1] to absorb the end-users demand. Moreover, the OMG delivers for this approach three levels of abstraction: higher, medium, and lower levels.

We start with the higher level anointed computation-independent model (CIM), which presents the business requirements models, and its models do not treat the technical details. The medium level is called platform-independent model (PIM), which forms an abstract design model without knowing any execution details. However, since platform-specific model (PSM) is directly connected to the platform execution, it is the lowest abstraction level.

After highlighting all the OMG proposed levels, and since one of the MDA approach purposes is the model alignment between these different levels; we have in practice that the PIM and PSM levels are widely used in most of the conducted research [2]. However, papers that work with the CIM level are rare and have only recently been started because this level is regarded as the most complicated while also being an interesting level [3]. It is complicated because the CIM modeling level has no defined standards; and it is interesting because any change in this level has an impact on the PIM and PSM models [4]. Our challenge in this contribution is

to propose a novel method that generates models at the CIM level to align the business value with the business process models for our information system. The E^3value model [5] depicts the business value model and the data-flow diagram (DFD) [6] depicts the business process model.

In our proposed method, we chose the E^3value model as it is an approach to model graphically and unify the business value model [5] and explains how economic value is produced, exchanged, and consumed in a network of multiple actors. The purpose is to ensure a rigorous definition and common understanding of the business model. And we generate the DFD model because it is a simple, comprehensible, and graphical process modeling. Also, DFD is among the first languages for business process modeling, and is popularized in the late 1970s and is used by many researchers in their approaches. Also, it describes our process's information flow in relation to the information system.

In this paper, we cope with the atlas transformation language (ATL) [7] to automate the model alignment, which is based on the subsequent OMG standards; XML metadata interchange (XMI) [8], object constraint language (OCL) [9], and meta object facility (MOF) [10]. To get to the heart of our method, this essay is divided into five sections. The following section describes the related work. The third section highlights our proposal; it presents the source and target descriptive metamodels and elucidates all the alignment rules that were used. A case study illustrating our method is presented in section four. The fifth section offers an analysis and discussion of all obtained results. The last section concludes our contribution and emerges our upcoming work.

2. RELATED WORK

In this section, we study the methods dealing with the MDA higher-level models to build their information system in the last five years. Unfortunately, rare studies focus on the CIM level for their models' alignment, but we were able to locate some studies on the topic. First, Beggar *et al.* [11] based their modeling of the requirements for data warehouses at the CIM abstraction level on a UML profile. GoalCases are used to model the initiative view of the system requirements, and the strategic goal analysis process (SGAP) is used to model the analytical view of the system. This method aims to obtain a semantic of business vocabulary and rules (SBVR) [12] structured English to ensure the semi-automatic definition of the CIM level for the data warehouse requirements. In other work, a semi-automated method was suggested by Bouzidi *et al.* [13] to address the alignment issue in the MDA approach between CIM-level for business process models and PIM-level for notations and UML use case diagrams. To specify their generation rules, they employ the ATL 7 and Acceleo [14].

Moreover, Rhazali *et al.* [15] in their method generated the UML models: use case diagram, package diagram, class diagrams [16], [17], and state diagram at the PIM level automatically, with the ATL language, from the UML activity diagram to develop their information system. In addition, Laaz *et al.* [18] proposed connecting domain ontologies and business process model and notation (BPMN) models at the CIM level to produce interaction flow modeling language (IFML) models [19] automatically with QVT [20]. According to Kharmoum *et al.* [21], their UML's communication diagram that presents the behavior and interactions model is automatically generated from the data-flow diagram with ATL language. In Sajji *et al.* [22], generate their IFML Model automatically from the BPMN model dealing with the ATL language.

After studying the different works. We have that most papers have a graphical representation for the representation of their source and target models, and all of them are based on metamodels for their models' alignment, which is advocated by the MDA approach. Also, we have all papers dealing with a transformation language to automate their models' alignment. But few studied papers generate their models at the CIM MDA level. Thus, all methods are based on a case study to evaluate their methods. So, in this paper, we suggest a new method that automatically aligns the E^3value model with the DFD model for a graphical representation and benefits from the metamodel definition. Moreover, the following section will present and detail our proposed method.

3. PROPOSED METHOD

This section emphasizes the development and improvement of the CIM level because, as was mentioned in the introduction, it is thought to be the most challenging and crucial level of abstraction. So, our challenge is to suggest a novel, MDA-based approach for building a solid and reliable CIM level. We emphasize that our proposal will profit from the experience we gained while creating the CIM level models [23]-[25].

The goal is to achieve a consistent CIM level that includes business value and business process models. Will make it easier for an information system to generate all subsequent PIM and PSM levels models. Also, to foster the systems' understanding and the communication between technical and business actors for an information system project. In this regard, Figure 1 outlines our proposal, which allows aligning automatically our chosen models. For our method implementation, we start by the definition of the source and the target metamodels, which describe the structural elements and their relationship for both E^{3}value and DFD models. We will also show the rules for automatic mapping between our models.

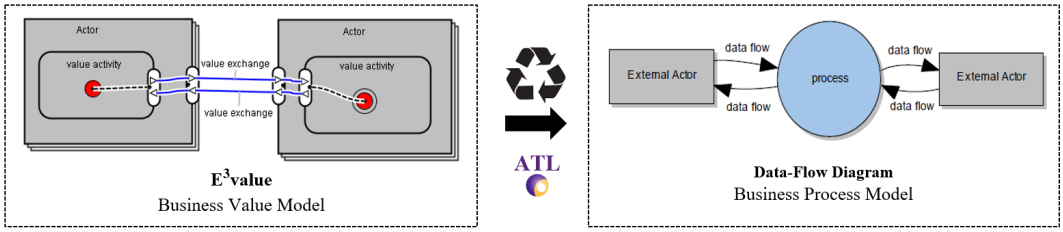

Figure 1. The proposed method

All defined metamodels respect the ECore's meta-metamodel of the eclipse modeling framework (EMF) [26]. Additionally, all alignment rules are implemented using the straightforward ATL language, which is based on the subsequent OMG standards; XMI, OCL, and MOF. It also allows us to guarantee a traceability connection between the source and target models.

3.1. Source and target metamodels

The proposed source metamodel Figure 2 explains the structure of our E^{3}value model, which must adhere to the E^{3}value elements [5], as well as the value viewpoint representation of the information system. It also explains how economic value is produced, exchanged, and consumed in a network of multiple actors. However, the generated DFD diagram respects the proposed target metamodel Figure 3, describing our process's information flow in relation to the information system. For our proposed method, the only constraint to create a correct source E^{3}value model is to respect its metamodel that is illustrated in Figure 2.

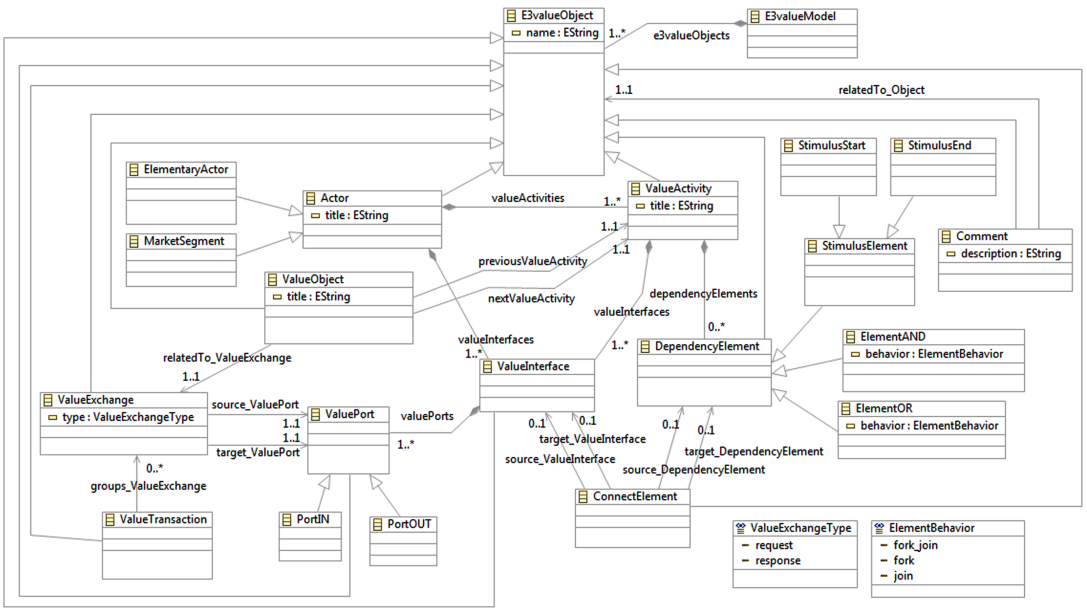

Figure 2. The E^{3}value metamodel

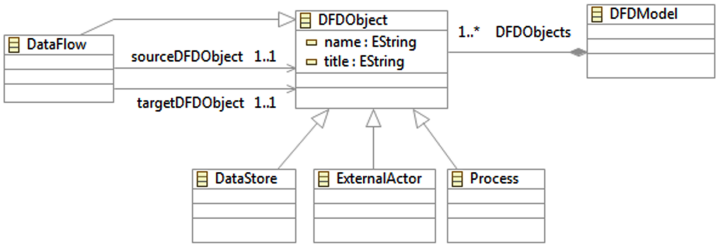

Figure 3. The DFD metamodel

3.2. Alignment rules

The ATL transformation language is used to automatically implement and carry out the suggested alignment rules. Details of the alignment rules from the E^{3}value model to the data-flow diagram are shown in Figure 4. We start with the first ATL rule (Rule11), the E^{3}value model "actors" (which include the basic actors and market segments) may all be converted to DFD "external actors". For the second ATL rule (rule), Two cases are distinguished ; the first is to transform all "value activity" to "process". The second is to generate new "data flow" that have the generated "external actor" in (Rule1) as "source DFD objects" using the helper function "getValueActivityActor()" and the generated "process" as "target DFD object". The ATL Rule3 also generates the DFD "data flow", but in this case from E^{3}value "value object". In this rule, the "source DFD object" and the "target DFD object" are generated successively based on helper functions "getSourceDFDObject()" and "getTargetDFDObject() ". Moreover, the ATL Rule4 purpose is to group all generated DFD objects ("external actor", "process" and "Data flow") in one model. In the end, we were able to extract the two attributes "name" and "title" from the E^{3}value model attributes and apply them to all generated DFD objects.

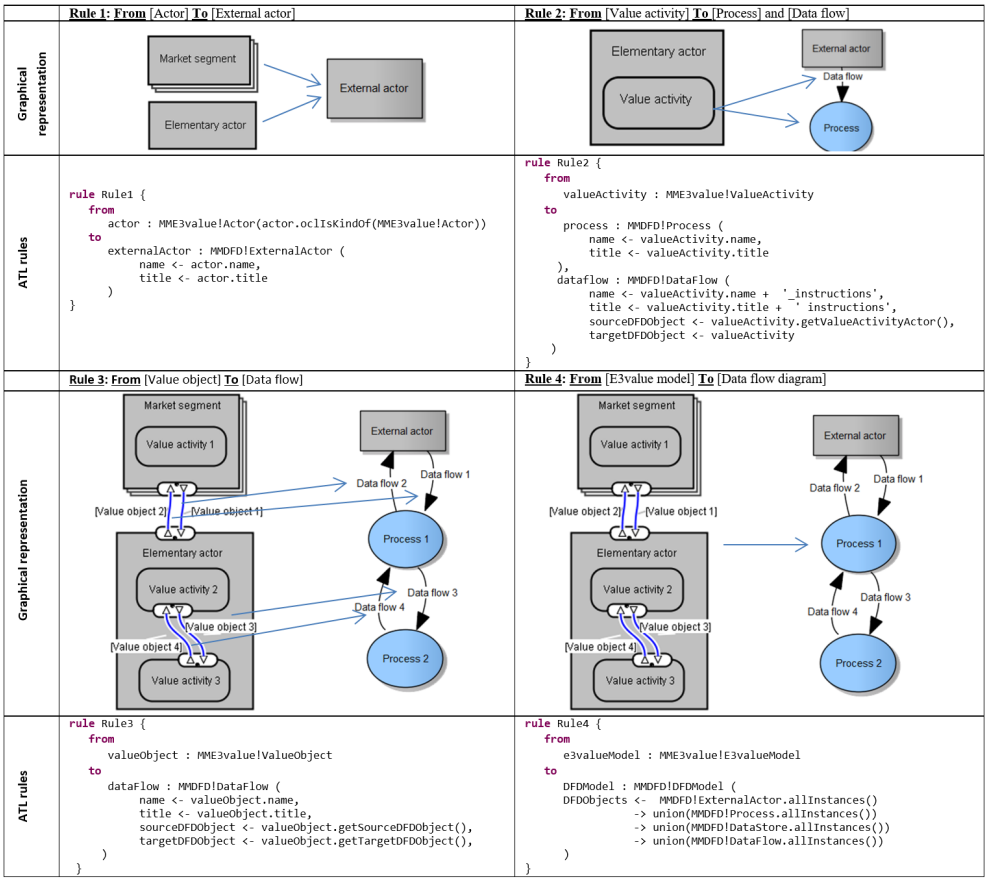

Figure 4. Alignment rules from E^{3}value to DFD

4. CASE STUDY

To illustrate and evaluate our proposed method, the "Service Delivery Laboratory management" case study gives an example of the business value model to business process model alignment. We mention that our case study is formally verified through a standard alignment tool (via ATL Eclipse). In this case study, we propose the following actors: service delivery laboratory, researchers, providers, and experts. Every researcher can access the laboratory resources, such as analysis, advice on scientific problems, and training, by paying the chosen access fees. For its part, the service delivery laboratory is always attentive to the researcher's requests; it performs analysis, solves scientific problems, and organizes training if the requested need exists, if not, it manages its needs by communicating them to these suppliers who are providers to offer the raw materials, expertise and advice.

4.1. Proposed E^{3}value model

The source model focuses on the E^{3}value model, which presents the business value models of the "Service Delivery Laboratory management", as described in Figure 5. The actors can identify with elementary actors like "Service Delivery Laboratory" or can be Market Segments such as "researchers", "providers" and "experts". In our model, each actor can engage in at least one value activity, the researchers can access laboratory resources, the Service Delivery Laboratory can perform analysis, solve scientific problems, organize training and manage laboratory needs, the Providers sell raw materials, while experts give expertise and advice. The value objects are fees of analysis, advice on scientific problems, training, raw materials, as well as expertise and advice. The E^{3}value model employs "value exchange" to aid in the comprehension of business value models to define the direction of dependency paths. These latter, link E^{3}value dependency elements, such as "StimulusStart", "StimulusEnd", "ElementAND", or "ElementOR".

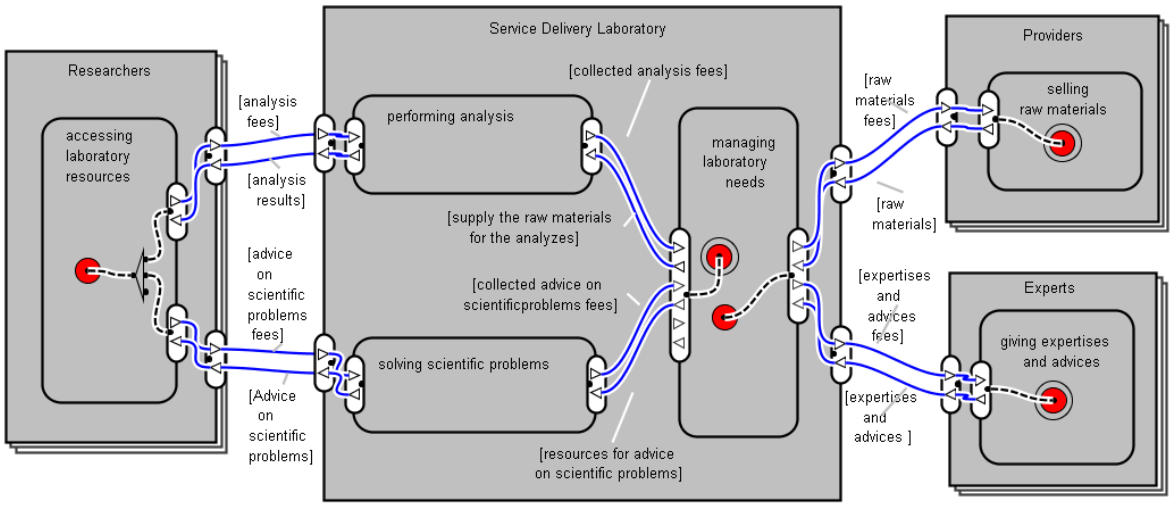

Figure 5. The E^{3}value source model

4.2. Generated data-flow diagram

The generated data-flow diagram Figure 6 depicts the target model which, presents the business process model. The elementary actor "service delivery laboratory" and the following market segments "researchers, "providers" and "experts" are transformed into DFD external actors. Then, the value activities are transformed to process and data flows. So, in our case, we have the process: "Accessing laboratory resources", "Performing analysis", "Solving scientific problems", "Organizing training", "Managing laboratory needs", "Selling raw materials", and "Giving expertise and advice". We generate a new data flow for every generated process that has the external actor as a source and process as a target. Also, we generate data flows from value objects that have the same properties, including the source and target objects.

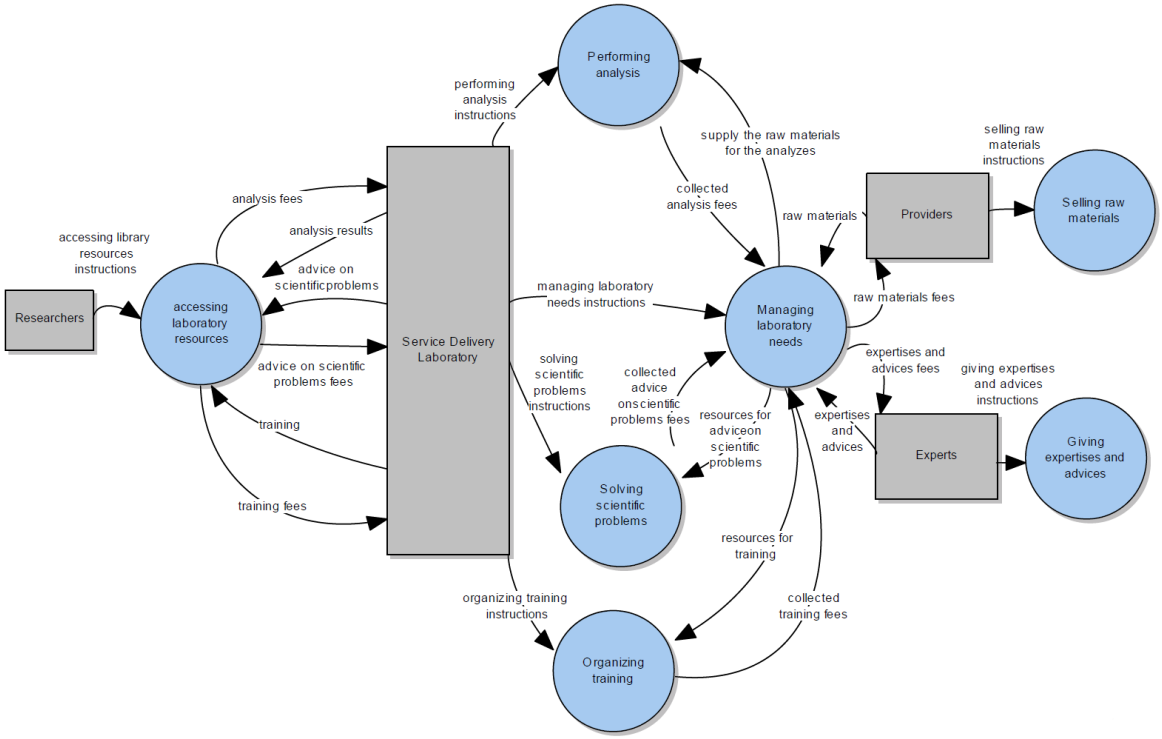

Figure 6. The generated DFD diagram

5. ANALYSIS AND DISCUSSION

Based on an analytical review of all related work that has been studied, we analyze, discuss, and evaluate our suggested methodology in this section. Table 1 shows our evaluation criteria analysis of the six studied methods with our proposal. For that, the table lines present studied papers, whereas the table show the chosen criteria. In this table, we will focus on the source, target, model alignment, and their assessment criteria.

Table 1. Studied papers comparison

	Source model			Target model			Model Alignment				
Studied paper	MDA Converage	MDA Level	Graphical representation	Representation	MDA Level	Graphical representation	Representation	Type H: Horizontal V: Vertical	Converage Meta-models	Type	Representation	Assessment methodology
El Beggar *et al.* (2017) [11]	Yes	CIM	Yes	SGAP (Strategic Goal Analysis Process)	CIM	Yes	GoalCases SBVR (Semantic Of Business Vocabulary And Business Rules)	H	Yes	Semi-automatic (Transformation language & Human language)	ATL	Case study
Bouzidi *et al.* (2017) [13]	Yes	CIM	Yes	BPMN (Business Process Model and Notation)	PIM PSM	Yes	Use Case Diagram Textual Case model	V	Yes	Semi-automatic (Transformation language & Human language)	ATL Acceleo	Case study
Rhazali *et al.* (2018) [15]	Yes	CIM	Yes	UML Activity diagram	PIM	Yes	UML diagrams : (Use Case, State, and Class) Web modeling diagram	V	Yes	Automatic (Transformation language)	ATL	Case study
Laaz *et al.* (2020) [18]	Yes	CIM	Yes	BPMN (Business Process Model and Notation) ODM (Ontology Definition Metamodel)	PIM	Yes	IFML (Interaction Flow Modeling Language)	V	Yes	Automatic (Transformation language)	QVT	Case study
Kharmoum *et al.*2020 [21]	Yes	CIM	Yes	DFD (Data-Flow Diagram)	PIM	Yes	UML Communication diagram	V	Yes	Automatic (Transformation language)	ATL	Case study
Sajji *et al.* (2022) [22]	Yes	CIM	Yes	BPMN (Business Process Model and Notation)	PIM	Yes	IFML (Interaction Flow Modeling Language)	V	Yes	Automatic (Transformation language)	ATL	Case study
Proposed Method	Yes	CIM	Yes	E'value	CIM	Yes	Data-Flow Diagram (DFD)	V	Yes	Automatic (Transformation language)	ATL	Case study

As a result, all the studied papers are centered on the MDA approach for their proposed methods. The majority of source and target models are graphical in nature, which is advocated by the OMG except the paper [11] their authors generate the SBVR model and the paper [13] their authors generate a Textual Case model. For the model representation, all the studied papers start their alignment at the CIM level, and they use the flowing models; SGAP for [11], BPMN for [13], [18], [22]. UML Activity diagram is used by [15], DFD by [21] and E^3value is proposed by our method. All studied papers deal with a process model in their source model, except our paper, which we based on a business value model for our source model, which gives a new dimension for representing the CIM level.

For the target models, all studied papers generate their models at the PIM level except the paper [11] and our method. Our purpose is to have a consistence CIM model represented by different models. For the target models representation, we have a textual representation for SBVR in [11], and the textual case model at [13]. All other paper generate graphical models like GoalCases in [11], use case diagram at [13], UML diagrams for [15], [22], IFML for [18], [22]. For our proposal, we generate the DFD which is a business process model, that can be used in the future for other research as a source model to generate their information system models as all studied papers based on it as a source model.

Additionally, focusing on the alignment criteria, we have that all studied methods generate models use an automatic way; except papers [11], [13] the authors utilize a transformation language and human language which is considered as a semi-automatic way. For the used transformation language, most authors use ATL transformation language, which is simple and based on different OMG standards. We have also the use of Acceleo for the text generation in [13] and QVT in [18]. Besides, all authors deal with a vertical generation in their methods; it means that the source and the target used models are in a different abstraction level, reverse the methods [11] and our proposal we deal with a horizontal generation; as the source and target models are in the same abstraction level. Furthermore, to evaluate their proposal, all approaches are based on a case study.

In the end, our paper is aligned with all the studied papers which respect the OMG guidance on the choice of source and target models, the transformation language as well as on the evaluation methodology. In this paper, we align the business value and business process models to have a consistent CIM abstraction level that can have different business dimensions. Moreover, the alignment is done automatically based on a transformation language; the purpose is to save time and effort, and increase the quality of the information system building [27], its testing [28], and to master IS resource management [29].

6. CONCLUSION AND FUTURE WORK

Facilitating and accelerating an information systems implementation and enhancing its quality was this paper's challenge. To confront this challenge, we are keen on the fact that our MDA higher level contains a business value and business process models. Therefore, we automatically align the data-flow diagram presenting the business process model from E^3value model illustrating the business value model, based on the ATL transformation language. In our upcoming work, we anticipate generating the MDA medium abstraction level models, based on our consistent CIM level, and respecting of course the OMG guidance.

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