From Economic Drivers to B2B Process Models: a Mapping from REA to UMM

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Abstract. Inter-organizational B2B systems are most likely tending to change their business requirements over time - e.g. establishing new partnerships or change existing ones. The problem is that business analysts design the business processes from scratch, disregarding the economic drivers of the business network. We propose to use business modeling techniques - such as REA (Resource-Event-Agents) - to ensure that business processes beneath do not violate the domain rules, i.e. to fulfill the basic economic principle for every business transaction - the give-and-take convention, called economic reciprocity. This helps us to quickly adapt the B2B processes to changing requirements without the need to change the overall architecture. In this paper we provide a mapping from REA, which represents one of the most prominent ontologies for business modeling, to UMM (UN/CEFACT's Modeling Methodology), a standardized methodology for modeling the global choreography of inter-organizational business processes. We formalize the mapping by the use of the model-to-model transformation language ATL (Atlas Transformation Language).

Key words: Business modeling, Business Process Modeling, REA, UMM

1 Introduction

In order to open-up enterprise applications to e-business and make them profitable for a communication with other enterprise applications, a business model is needed showing the business essentials of the business case to be developed. However, most current approaches are limited to the technical process aspects, disregarding the economic drivers [1] [2]. Therefore specific business modeling techniques have been introduced in order to capture the business perspective of an e-commerce information system. Presently, there are three major and well-accepted business modeling techniques - e3-value [3], Resource-Event-Agent (REA) [4] and the Business Modeling Ontology (BMO)[5].

e3-Value was designed for getting a first overview of the economic values exchanged in a business network. Furthermore, e3-Value allows to proof the economic sustainability of the business idea by quantifying the net value flow

for each actor in the value web. Whereas e3-Value concentrates more on the profitability of the IT system, an REA business model focuses on issues that may be relevant for the implementation and alignment of an IT system from an economical point of view. Thus, we see the e3-Value ontology one layer above REA since it describes the value exchanges on a rather abstract level. In [6] we already published a mapping from e3-Value to REA. The third methodology is BMO, which focuses on the position of a specific business partner in the e-business network and how he can make profit. Due to the fact that BMO concentrates on the business semantics from an internal perspective and e3-Value concentrates on the economic sustainability of an entire exchange system, we propose to use the REA ontology as a starting point for designing business processes. The basic idea of this multi-layered approach, in which we propose to use different ontologies and techniques for the development of maintainable inter-organizational systems has been shown in [7].

As mentioned, REA was initially designed for specifying the domain rules assuring soundness and consistency of business software applications from the business perspective [8]. However, the REA concept found its place in some standardized specifications as well. The ISO Open-edi specification [9] uses REA as an ontological framework for specifying the concepts and relationships involved in business transactions. Furthermore, the REA ontology definitions are part of the work of UN/CEFACT (United Nations Center for Trade Facilitation and Electronic Business), which is an international e-business standardization body known for its work in the area of electronic data interchange(EDI) - UN/EDIFACT and ebXML [10]. This is the reason why we propose a mapping from REA to UMM (UN/CEFACT's Modeling Methodology), which is one of the most promising standards for modeling the global choreography of B2B processes [11]. We, as the authors of this paper, are part of the editing team of the current UMM 2.0 specification [12] as well as for the REA specialization module for UMM [13]. The goal of this REA specialization module project, which is led by the originator of REA, William E. McCarthy, is to provide two types of specific guidance to UMM users as they develop their collaboration models: (1) an ontology-based methodology for developing the class diagrams and (2) state machine life cycles for business entities within the Business Entity View of the UMM Business Requirements View.

Our contribution within this paper is (1) to explore the different perspectives of these two modeling techniques and to find overlaps between them on the meta model layer (2) to define a conceptual mapping between REA and UMM, and (3) to formalize the mapping by the use of a model-to-model transformation.

2 Input and output models for our transformation

2.1 REA - the input model

The concepts of REA originate from business accounting where the needs are to manage businesses through a technique called double-entry bookkeeping [4]. By the help of this technique every business transaction is registered as a double

entry (a credit and a debit) in a balance sheet. REA is using this technique in order to fulfill the basic economic principle for every business transaction - the give-and-take convention, called economic reciprocity. The acronym REA comes from the core concepts *Resource*, *Event*, and *Agent*. The intuition behind these concepts is that every business transaction can be seen as an event where exactly two agents exchange resources. An economic resource is a good, right, or service of value, under the control of an economic agent. These basic REA concepts are illustrated in the cutout of the simplified REA meta model using a UML class diagram. Figure 1 illustrates the simple Resource-Event-Agent structure at the meta model layer (MOF M2)[14]. The high level semantic view of the essentials of the REA meta model is the economic exchange (*EconExchange*), where the trading partners engage in the exchange of resources with value. Each economic exchange must have at least two:

- economic agents (*EconAgent*) - one requests (*toParticipte*) the resources from another agent and the other one offers (*fromParticipate*) the resource
- economic events (*EconEvent*) - one *initiates* an economic event and the other one *terminates* it
- economic resources (*EconResource*) - one decreases the inventory of an economic agent by increasing the inventory of the corresponding agent, and the other does it vice versa (*stockFlow*)

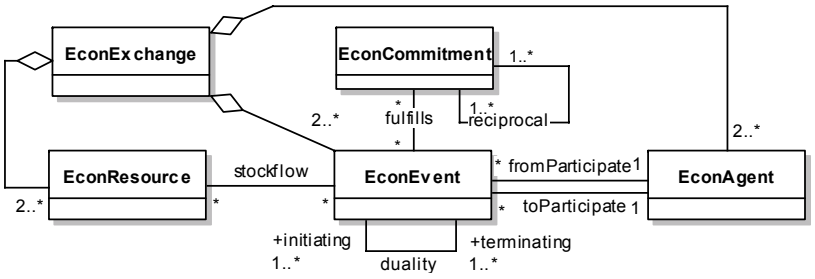

Fig. 1. The base of the conceptual REA meta-model

An economic commitment (*EconCommitment*) is a promise or obligation of economic agents to perform an economic event in the future. Due to space limitations the REA meta model is not depicted in its full version. Concepts such as *typification*, *business locations*, and *economic claims* have been skipped, since they are not relevant for a mapping between REA and UMM. The interested reader is referred to [6], where we explained REA in more detail by means of a mapping between REA and e3-Value. Note, that all REA concepts are based on UML classes at the instance level (see Figure 3 in Section 3.1). A business transaction or exchange has two REA constellations joined together, noting that the two parties of a simple market transfer expect to receive something of value

in return when they trade. For example, a seller, who delivers a product to a buyer, expects a requiting cash payment in return. Assuming a simple buyer and seller scenario, REA covers the four fundamental questions of a business collaboration: **Who** is involved in the collaboration? **What** is being exchanged? **When** (and under what trading conditions) do the components of the exchange occur? **Why** are the trading partners engaged in the collaboration? By answering these questions it is possible to specify the economic requirements, which are necessary for developing a B2B process model with UMM.

2.2 UMM - the output model

UN/CEFACTs Modeling Methodology is a UML modeling approach to design the business services that each business partner must provide in order to collaborate. It provides the business justification for the service to be implemented in service-oriented architectures (SOA). In other words, UMM enables to capture business knowledge independent of the underlying implementation technology, like Web Services or ebXML. It concentrates on the flow of interactions between collaborating business partners. However, it does not address their private processes. In general, the execution of an inter-organizational business process depends on commitments established between the participating partners. UMM is used to model these procedural and data exchange commitments that must be agreed upon between the business partners at design time of the inter-organizational business process, i.e. before executing the process. UMM is defined as a UML profile [12], i.e. a set of stereotypes, tagged values and constraints, in order to customize the UML meta model to the special purpose of modeling global B2B choreographies.

The UMM follows a well-defined development process that produces a set of well-defined artifacts. Figure 2 depicts a cutout of the simplified UMM meta model. The development process runs through three major phases, which correspond to the three top level packages of UMM: the *business requirements view (A)*, the *business choreography view (B)*, and the *business information view (C)*. The *business requirements view* is used for three reasons: first, to gather the domain knowledge (A.1) and existing process knowledge (A.2) of the business domain under consideration; second, to capture the relationships of the business partners and stakeholders (A.3) participating in the business network, and third, to depict the so-called business entity lifecycle (A.4). A business entity is a real-world thing having business significance that is shared between two or more business partners in a collaborative business process (e.g. order, account, etc.). The *business choreography view (B)* comprises the artifacts for the core parts of UMM, the *business collaboration protocol (B.1)*, which spans over multiple *business transactions (B.2)*. A *business transaction* covers the semantics of a business information exchange between exactly two business partners. It follows that a business collaboration protocol is the sequence of such binary business information exchanges or other nested multi-party business collaborations. The information exchanged within a business transaction is modeled by so-called *information envelopes (C.1)* in the third view - the *business information view*.

Since REA captures the business requirements from an economical point of view, it only makes sense to map REA artifacts to the *business requirements view* of UMM. For this reason and due to space limitations we do not go into detail of UMM's *business choreography view* and *business information view*. Furthermore we only discuss UMM on the MOF meta model layer M2. The interested reader will find examples of UMM instances in [11] [12].

The meta model depicted in figure 2 defines only the conceptual view of UMM's business requirements view - i.e. the nomenclature of the stereotypes and the relationships (constraints) between each other. It does not give any information about which stereotype inherits the properties of which UML base class. Thus, we summarize the most important UML artifacts for the requirements view, which are relevant for our mapping: (A.1)UML packages and UML use case diagrams; (A.2)UML activity diagrams; (A.3)UML actors; (A.4)UML classes and UML state machine diagrams;

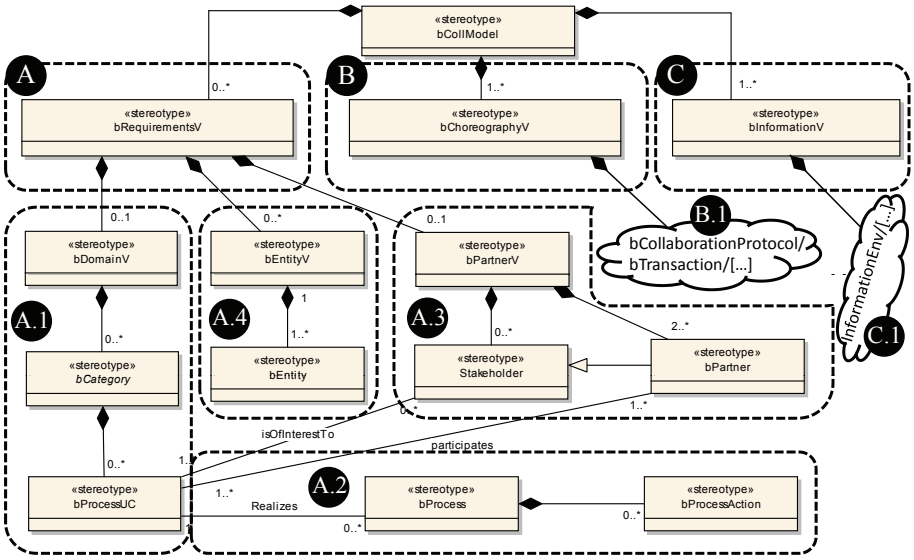

Fig. 2. Simplified UMM Meta Model

3 Mapping REA to UMM

3.1 A real life example from the print media domain

The following example has been taken from the use case scenario of a national funded IT project called BSopt[1] (Business Semantics on Top of Process Technology) in which we applied our business modeling approach and its transformation

[1] http://www.bsopt.at

to business process models. We will use this simplified example to show the conceptual mapping between REA and UMM. In the print media domain customer fluctuation is mostly affected by competitors and their aggressive enticement of customers. Thus, it is very important for a newspaper publisher to acquire new test readers in order to keep the customer stock. The customer acquisition is either done in-house (e.g. by mail advertisement) or outsourced (in our case by a call center). Within this use case we have a lot of inter-organizational business processes and information exchanges (e.g. the upload of a set of addresses, the exchange of successfully acquired test subscriptions, or the automated invoicing for the consumed service). For the sake of simplicity we demonstrate only the collaboration between the newspaper publisher and the call center. Following our approach we propose not to start with modeling the B2B processes from scratch, but to capture the requirements from an economic point of view by REA to ensure that the domain rules are not violated.

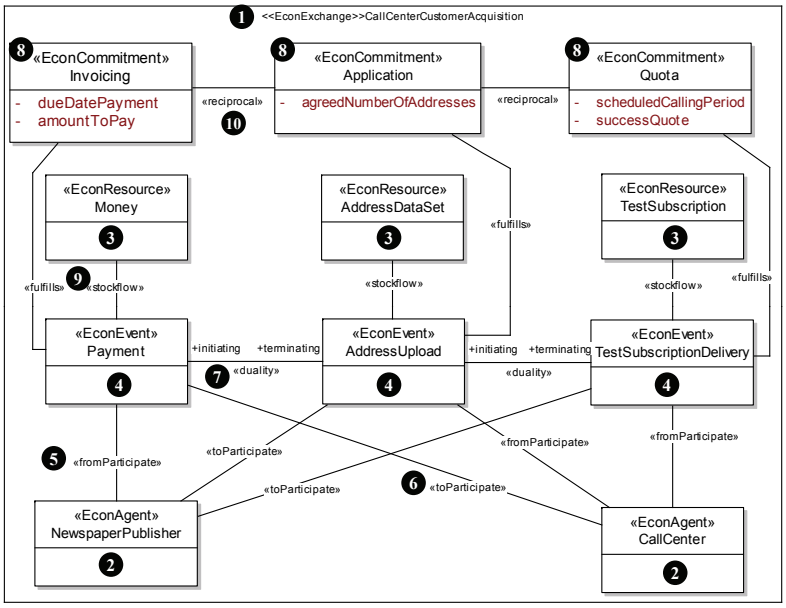

Fig. 3. REA Example

In the following we detail our use case scenario by the help of REA. The REA class diagram in Figure 3 depicts the economic exchange *CallCenterCustomer-Acquisition* (1). As explained above the exchange happens between the economic agents (2) *NewspaperPublisher* and *CallCenter*. Both agents have the intention to exchange economic resources (3), which are furthermore the actual objects of exchange. In our scenario the *NewspaperPublisher* pays the *CallCenter* for the acquisition of new customers. To execute the economic exchange both agents

have to participate in adequate events. The economic events denoted by (4) are used to fulfill a resource-flow from one partner to the other. Since a resource-flow is always a directed association, indicating the role of each participant, the involved agents are connected to an event via (5) *fromParticipate* and (6) *toParticipate* associations. The first one points out that one agent gives up the control over a specific resource, whereas the later one defines who receives the resource. The *Payment* event for example provokes that *Money* will be transfered *from* the *NewspaperPublisher to* the *CallCenter*. Since the REA ontology follows the give-and-take principle each event must have at least one opposite event, which will be fulfilled in return. Assigned to our scenario the *CallCenter* has to fulfill two economic events: *AddressUpload* and *TestSubscriptionDelivery*. Both are connected by so called (7) *duality* associations with the *Payment* event. This association denotes that if the *NewspaperPublisher* fulfills a *Payment* event, the *CallCenter* has to fulfill *AddressUPload* and *TestSubscriptionDelivery*, too. The detailed specifications of the economic events are specified by the means of (8) economic commitments. A commitment can be seen as an obligation to (9) fulfill specific events in the future. In the *Invoicing* commitment for example the *NewspaperPublisher* engages to pay a fixed amount of money to the *CallCenter*. The execution of this obligation is done by the *Payment* event. The same concept applies for the other commitments - *Application* and *Quota* and their corresponding events *AddressUpload* and *TestSubscriptionDelivery*. The give-and-take principle, as it has already been used with economic events, also applies for economic commitments. The resulting reciprocity is formalized by (10) *reciprocal* associations.

3.2 Conceptual mapping

In this section we describe the conceptual mapping from REA artifacts to UMM artifacts. Our approach is twofold: first, we describe the mapping rules from a meta-level perspective to provide a compact overview about the source (REA) and target (UMM) artifacts. Second, we apply these rules to the simplified real world business scenario - the customer acquisition by a call center. As listed in Table 1 we identified seven rules. All of them can be applied to UMM artifacts used within the business requirements view. Each rule is indicated by a number, which is also important for further descriptions (first column). The second column defines the REA artifact that is mapped to a UMM concept specified in column 3. The fourth column refers to the UMM stereotype that is affected by the mapping. The last column indicates whether the rule can be applied fully automated (•) or if the transformation needs additional semantic information (-), which should be provided by the business analyst. In the latter case it is not possible to do a straight forward mapping between the source and the target artifact since both concepts share similar but not equal semantics. This semi-automatic mapping applies to rule R3 and R7. In general, REA concepts, such as events and commitments are mapped to process related UMM artifacts and REA concepts, such as agents and resources are mapped to entities that are involved in business processes. In the following we describe the mapping rules in detail.

Table 1. Mapping table for REA to UMM artifacts

Rule	REA	UMM concept	UMM Stereotype	Auto
R1	EconExchange	Business Process Use Case	≪bProcessUC≫	•
R2	EconAgent	Business Partner	≪bPartner≫	•
R3	EconRessource	Business Entity	≪bEntity≫	-
R4	EconEvent	Business Process Use Case	≪bProcessUC≫	•
R5	EconCommitment	Business Process	≪bProcess≫	•
R6	duality(initiating)	Business Process	≪bProcess≫	•
R7	stockflow	Business Process	≪bESharedState≫	-

Figure 4 is separated into two parts indicated by a dashed line to distinguish between REA (upper part) and UMM (lower part). The annotations in the UMM part refer to the different views of the UMM meta model as depicted in Figure 2 (e.g. [A.4] bEntityV). Note, so far we described the concepts of UMM on the meta model level (by using UML class diagrams). In the mapping figure, UMM is depicted on the instance level by means of UML use case diagrams, activity diagrams, etc. Based on the mapping rules listed in Table 1 we demonstrate how to translate REA concepts to UMM concepts that are used in the business requirements view. The identifiers beside the description follows the annotation in Figure 4 and corresponds to the rule numbers in Table 1.

R1 : An *EconExchange* in REA is mapped to UMM's *Business Process Use Case*. In UMM, a business process use case is a set of related activities that together create value for a business partner. Both concepts contain the business transactions, data exchanges, events, and business partners that are necessary to fulfill the business goal.

R2 : An *EconAgent* is similar to a *Business Partner* and therefore mapped to *bPartner* in UMM. The mapping is straight forward since both concepts share the same semantics. An economic agent in REA and a business partner in UMM are both independent participants with the intention to join a business collaboration. According to the UMM meta-model (see Figure 2) a *Business Partner* is modeled within (A.3) *bPartnerV*.

R3 : *EconResources* in REA are the actual subjects of exchange. Business Entities in UMM have a similar meaning. Both concepts are used to transfer something of interest between participating business partners. However, there is a significant distinction between both stereotypes. In REA, an economic resource is a good, service, or right with economic value that is beeing exchanged between business partners. In UMM such business entities are used to model different states in order to synchronize the interfaces between the business partners (e.g. the *AddressDataSet* is in state `validated`, thus it is ready for an upload). In figure 4 the business entity (denoted by R3 in the *bEntityV*) is a UML class. Its state changes are further on modeled as a state machine diagram. Those states are then used as objects in the business process (see R7). Furthermore,

a straight forward mapping between both concepts is often not possible, due to the very generic nature of the resource concept in REA. To map a resource to a corresponding business entity we need a detailed domain knowledge. For example the economic resource `Money` can not be mapped 1:1 to a business entity `Money`. Since it is rather likely that a business entity Money does not change its states during a business process we propose to use the term `Invoicing`, which is commonly used for electronic data interchange.

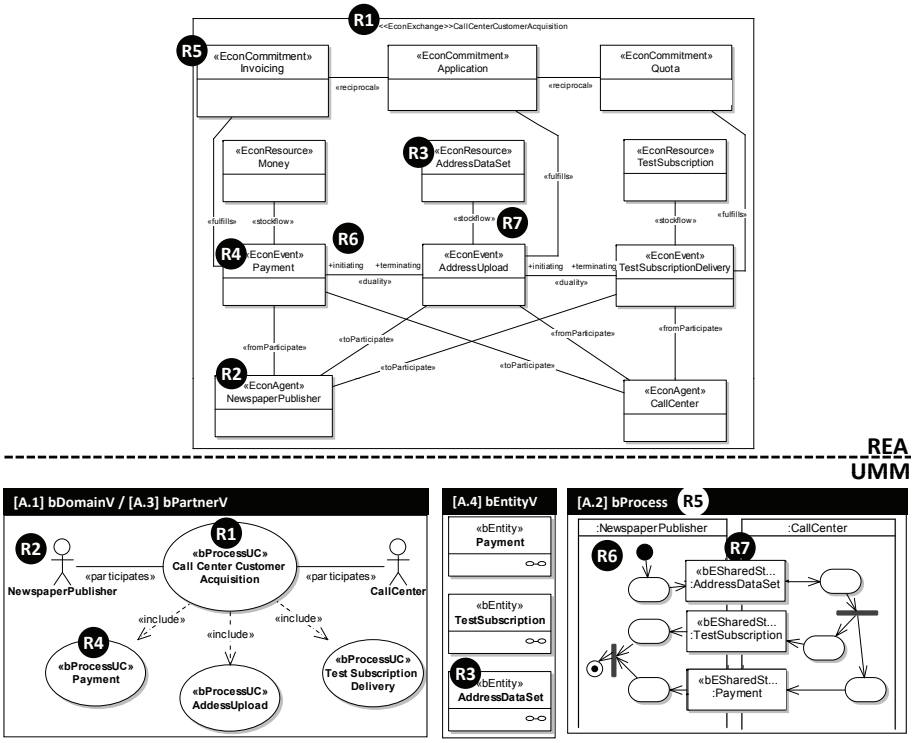

Fig. 4. Applying the REA2UMM mapping

R4 : An *EconEvent*, similar to an *EconExchange*, is mapped to the concept of a *Business Process Use Case*. Since an economic event is always nested within an economic exchange the mapped busienss process use case has an include relationship to the *bProcessUC* created by rule R1.

R5 : An *EconCommitment* details an *EconEvent*. Therefore we propose to map an *EconCommitment* to the concept of a *Business Process*. A business process in UMM is modeled as a UML activity diagram. An economic commitment comprises the agreements made between business partners involved in an

inter-organizational business process. Those agreements are reflected in UMM's business processes as well.

R6 : The initiating role of the duality association denotes that the event holding this role initiates an economic exchange. It follows that the involved *Economic Agent* associated via a *from/toParticipate* association plays the initiating role in the business process. Note, it does not necessarily mean, that the terminating role is hold by the opposite business partner. In our use case scenario the initiator is the Newspaper Publisher by starting the business process with an upload of the address data set.

R7 : This rule is related to R3. The stockflow association denotes the flow of resources triggered by an economic event. The business entity have already been created by R3. Although we do not know anything about the underlying business entity life cycle, we can already include the objects that are classified by the business entities into the corresponding business process. In UMM, these objects are stereotyped as *Shared Business Entity States*. As soon as the modeler has specified the life cycle state of the business entity (e.g. first, the address data set is in state `validated`, then in state `uploaded`, then `processed`, etc.) he can assign these states manually to the generated *bESharedStates*.

3.3 Transformation Rules

In this section we formalize the conceptual mapping rules described in section 3.2 by using the Atlas Transformation Language (ATL). ATL provides a model-to-model transformation engine which is able to transform any given source model to a specific target model. Before the engine can perform the transformation a proper ATL program specifies the rules that are necessary for a mapping. For a complete description of the abstract syntax of ATL and its execution semantics we refer to the ATL user manual [15]. In order to demonstrate the transformation we use the Eclipse Modeling Framework (EMF). Figure 5 shows the model-to-model transformation pattern for our customer acquisition example.

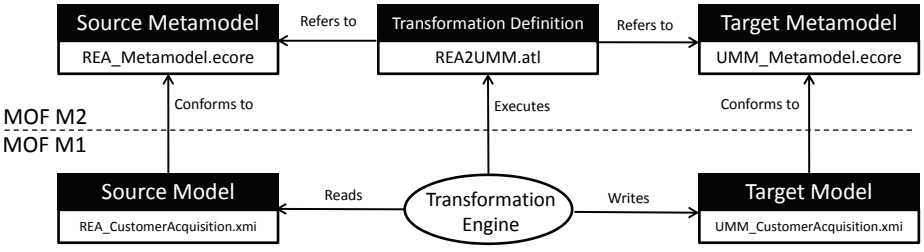

Fig. 5. The transformation pattern for mapping an REA model to a UMM model

At the top we define two EMF meta models (Ecore) on the MOF M2 layer - the REA meta model and the UMM meta model. The first one serves as the

input for the transformation and the second one for the output. The transformation definition specifies the mapping rules in ATL and refers to both meta models. At the MOF M1 level we specify the REA example model of 3 (REA_CustomerAcquisition.xmi) which is expressed in XMI (XML Metamodel Interchange) - the de-facto standard for formal descriptions of UML based models. In order to transform this example model into a UMM model, the transformation engine reads the source model and generates the stub for a UMM compliant model. The code listing in Figure 6 shows the mapping rules specified in ATL. Due to space limitations we only present a basic transformation example of the ATL file, in order to show the essentials of the formal mapping.

```
[1]  module REA2UMMTransformation;
[2]  create OUT : UMM from IN : REA;
[3]
[4]  rule EconExchange2bProcessUC{
[5]     from
[6]          r : REA!EconExchange
[7]     to
[8]          u : UMM!UseCase(
[9]                name <- r.name,
[10]               stereotype <- 'bProcessUC'
[11]         )
[13] }
[14]
[15] rule EconEvent2IncludedBPUC{
[16]    from
[17]       r : REA!EconEvent
[18]    to
[19]       u : UMM!UseCase (
[20]             name <- r.name,
[21]             stereotype <- 'bProcessUC',
[22]             includes <- r.contains
[23]       )
[24] }
```

```
[25] rule EconAgent2BusinessPartner{
[26]    from
[27]       r : REA!EconAgent
[28]    to
[29]       u : UMM!Actor (
[30]             name <- r.name,
[31]             stereotype <- 'bPartner',
[32]             participates <- r.fromParticipates,
[33]             participates <- r.toParticipates
[34]      )
[35] }
[36]
[37] rule EconResource2BusinessEntity{
[38]    from
[39]       r : REA!EconResource
[40]    to
[41]       u : UMM!bEntity (
[42]             name <- r.name
[43]       )
[44] }
```

Fig. 6. Excerpt of the REA2UMM.atl file

4 Related work

Two prominent approaches for linking business models and business process models have been introduced by Weigand [16] and Schmitt [17]. Both, define a methodological approach for using business models as a basis for deriving business process models.

Influenced by these approaches, the authors of [18] introduced a reference ontology for business models. As a basis they took concepts from e3-Value[3], REA[4], and BMO[5]. Furthermore, they enriched their reference ontology by additional concepts detailing the resource transfer between participating business partners. A similar approach has been published by the authors in [19].

A more conceptual approach exploiting synergies between goal models and business models (e3-Value) is introduced in [20] and [21]. As a result they were able to complement e3-Value by revealing the strategic reasoning behind the value exchanges. In addition they provide guidelines for the transformation of goal-models to value-models and vice versa. Another ontology-based approach

for improving the early requirements engineering phase using goal-models has been proposed in [22]. To incorporate the domain knowledge into their method they incorporated business modeling concepts taken from e3-Value and REA. Thereby the ontological foundations of the business modeling techniques serve as guidelines during the modeling process.

In [23] the authors introduce a transformation approach targeting the interoperability of business process models. The authors argue that in order to gain interoperability on a business process level using business process modeling standards such as UMM or ISO/IEC 15944 [9] both business partners have to use the same business process modeling technique. To overcome this problem they propose to use REA as a shared global knowledge base for transforming model instances from UMM to ISO/IEC 15944.

5 Conclusion

In this paper we introduced our approach about combining two major modeling techniques in the field of B2B. UMM needs to gather business domain knowledge for its business requirements view in an early design phase. REA delivers the requirements from an economical point of view and serves as input for modeling a UMM compliant business process model. In other words, our mapping rules should help the modeler setting up a UMM compliant model without disregarding the give-and-take principles to ensure economic reciprocity. It is not said, that one is able to generate a complete business process model out of an REA model by using our mapping rules. But the modeler can (semi-)automatically generate a stub of a UMM model, which needs to be finalized during further modeling steps. There are still open issues and refinements for future work. In our mapping we propose only a transformation from REA artifacts to UMM artifacts that are relevant in the *business requirements view*. However, the attributes of REA's *economic commitments* capture significant information that may be relevant for further phases in UMM (e.g. the so-called *quality of service* parameters in the *business choreography view*). Furthermore, as a critical reflection we need to say, that we did not consider REA's state machine driven approach [13]. This concept would help us to gather requirements for generating UMM artifacts, which are also used in later modeling steps (e.g. to generate concrete *business transactions* as part of UMM's *business choreography view*). At last, REA's economic resources contain information which can be used to design the information envelopes that are being exchanged in UMM's *business information view*. Integrating those concepts into our approach is a major challenge for future work.

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