Using the REA Ontology to Create Interoperability between E-Collaboration Modeling Standards

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Abstract. E-collaboration modeling standards like ISO/IEC 15944 and the UN/CEFACT Modeling Methodology (UMM) provide techniques, terms and reference models for modeling collaborative business processes. They offer a standardized approach for business partners to codify the business conventions, agreements and rules that govern business collaborations and to share business process information. Although effective in creating interoperability between organizations at the business process level, prospective business partners are required to commit to the same modeling standard. In this paper we show how the REA enterprise ontology can be used to semantically relate the ISO/IEC 15944 and UMM e-collaboration standards. Using the REA ontology as a shared business collaboration ontology, business partners can create interoperability between their respective business process models without having to use the same modeling standard.

Keywords: interoperability, business model, e-collaboration, business ontology.

1 Introduction

Today's fast paced global landscape calls for agile organizations that can swiftly integrate their business processes with that of other organizations. As many business processes are administrative processes that process information (as opposed to physical processes that handle and transform material goods), integrating such processes becomes a matter of creating interoperability, which is the ability of two different systems or components to exchange information and use information that has been exchanged [1].

Possible collaboration between companies gives rise to interoperability problems at different business levels: data, service, process and business level [2]. Over the years different kind of technologies (XML, schema standards and mapping, web services) have been proposed and used by different types of enterprise information integration tools (e.g. data warehouses, message mappings tools, virtual data integration) [3], which support the creation of interoperability at the data and service level(Functional Services View (FSV) of the open-EDI reference model [4]). Recently more attention is paid to solving the interoperability barriers at the process and enterprise level (Business Operational View (BOV)). Prospective business partners might use different languages to document and enact business processes (e.g. BPMN, BPEL, UML activities, EPC), which creates syntactic and semantic barriers to the integration

P. van Eck, J. Gordijn, and R. Wieringa (Eds.): CAiSE 2009, LNCS 5565, pp. 395–409, 2009.

of their respective business processes. A possible solution is the use of e-collaboration modeling standards like the UN/CEFACT's Modeling Methodology (UMM) [5] and the ISO/IEC 15944 standard [6], to describe the global choreography between business partners involved in collaborative business processes. E-collaboration standards address the Business Operation View and provide a set of terms (e.g. business conventions, agreements and rules), reference models (e.g. a standard business process lifecycle) and techniques (e.g. UML activity diagrams) that can be used to model business processes in a way that they can be integrated easily with other business processes that also use these standards.

When two organizations wish to establish a B2B e-collaboration relationship and merge their respective business processes into one collaborative business process (e.g. integrating the sales process of the supplier with the acquisition process of the customer), they must agree on a common BOV e-collaboration standard. As currently none of the available standards is predominant in any industry, enterprises might end up with multiple representations of business processes articulated in many different languages and committing to different conceptualizations, a situation which is clearly suboptimal from the point of view of development and maintenance costs.

An alternative for imposing a modeling standard is the use of a shared ontology onto which the local ontologies of the different actors are mapped. Several proposals have been made to compare the abstract syntax and semantics of enterprise and business process modeling languages via a common meta-model (e.g. UEML [7] for enterprise modeling languages and BPDM [8] for business process modeling languages). These meta-models are based on domain-independent ontologies (also called core or upper-level ontologies) or meta-meta-models.

Mappings between BOV e-collaboration standards like UMM [5] and the ISO/IEC 15944 standard [6] and these common meta-models may remove the syntactic barriers to the creation of collaborative business processes, but they do not guarantee the removal of domain-specific semantic barriers because they make abstraction of specific e-collaboration semantics like commitments, contracts and requiting money flows. Therefore, in this paper, we present an approach to the creation of interoperability between business processes of different partners wishing to engage in B2B e-collaboration by means of a shared domain-specific ontology which accounts for e-collaboration-specific semantics. In particular, we show how the Resource-Event-Agent (REA) enterprise ontology [9-11] can be used as a shared ontology for the UMM and ISO/IEC 15944 standards such that business process models articulated using one standard can easily be transformed into models articulated using the other standard, without losing domain-specific semantics.

This paper is structured as follows: Section 2 provides an overview of our approach. Section 3 briefly describes the REA ontology. Section 4 presents the UMM and ISO/IEC 15944 standards by means of an example based on the enhanced Telecommunications Operations Map (eTOM), which describes in detail the business processes required by a service provider in the telecommunications industry [12]. Section 5 then describes how the REA ontology is used to create interoperability between eTOM business process models developed using these two standards. Section 6 concludes the paper.

2 Ontology-Based Model Interoperability in the E-Collaboration Domain

According to Guarino [13], a core ontology is a formal representation of a conceptualization of the world (i.e. everything that exists or can exist), a domain ontology is a formal representation of the conceptualization of a particular part (i.e. a domain) of this world (e.g. business, medicine, sports) and a task ontology is formal representation of the conceptualization of a task executed within the world, possibly across different domains (e.g. planning, diagnosing, measuring). Domain and task ontologies should be defined as specializations of a core ontology meaning that their concepts add domain/task-specific meaning to the core ontology concepts.

Based on the ideas of Guarino, Guizzardi [14] defined the relationships between ontologies, conceptual modeling languages and models (Fig. 1). A model is articulated using some modeling language meaning that it instantiates the meta-model defining this language. The model is meant to represent an abstraction of a situation in the world (e.g. an order-to-cash process seen as an ordered collection of tasks). The abstraction of a given situation is constructed in terms of some domain or task conceptualization (e.g. workflows). This conceptualization is formally represented by a domain or task ontology and if this ontology is used to define the meta-model of the modeling language, then the language 'ontologically commits' to the conceptualization, meaning that the modeling language constructs derive their meaning from the concepts defined in the ontology.

Fig. 1 further shows that domain and task conceptualizations are generalized by real-world conceptualizations which are represented by core ontologies that generalize the domain and task ontologies used to represent the domain and task conceptualizations. These core ontologies define meta-meta-models (defining

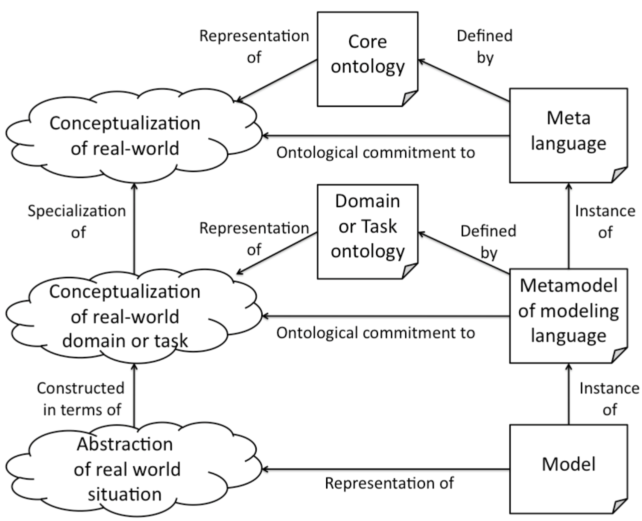

Fig. 1. Relation between conceptualization, ontology and modeling language

meta-languages) of which the meta-models of domain or task-specific modeling languages are instances. Fig. 1 also clarifies how interoperability between models articulated using different modeling languages can be established using ontologies. If the conceptualizations that the different languages commit to overlap and this shared conceptualization (i.e. intersection of conceptualizations) is represented by an ontology, then the meta-models of the languages need to be mapped onto the common ontology to explain how a phenomenon represented in one language would be represented in the other language.

Different researchers have recognized the potential of ontologies to provide precise semantics for conceptual modeling languages and have used core ontologies like BWW [15] or the Unified Foundational Ontology (UFO) [14] to evaluate the semantics of existing general purpose modeling languages like UML [16] and Petri-nets [17]. The mappings between the meta-models of these languages and the chosen reference ontology are then used to evaluate the ontological adequacy of the modeling languages. The ontological mappings identified are, however, not used to create interoperability between models articulated using different languages.

The Unified Enterprise Modeling language version 2 (UEML2), which was developed by the INTEROP Network of Excellence, follows the same approach but recognizes that the ontological mappings can also be used create interoperability between models. UEML2 acts as an intermediate language between existing enterprise modeling languages and facilitates interoperability between a wide variety of enterprise modeling languages and models [7]. In terms of Fig. 1, UEML2 is a meta-language defined by the BWW ontology, which is an upper-level ontology, and as such, UEML2 abstracts from specific domain or task semantics. Consequently, domain or task specific semantics attached to special-purpose modeling languages may get lost when mapping the meta-models of these languages to UEML2.

To preserve the domain or task-specific semantics of special-purpose modeling languages a mapping onto a domain or task ontology instead of a core ontology is required. For instance, for creating interoperability between models created using different BOV e-collaboration standards, a mapping onto a domain ontology for e-collaboration will preserve more of the domain semantics than a mapping onto a core ontology. The goal of this paper is to demonstrate such a mapping for the e-collaboration domain.

Ciocoiu and Nau described in general how ontologies can be used to formally define translations between models developed in different languages [18]. Their approach consists of three steps:

1. Define a function that can be used to convert a model articulated in a specific language into a model articulated in a logic-based language. This function is called a logical rendering function and results in a logical rendering of the model.
2. Define an interpretation for the concepts of the language using a shared ontology. Put differently, during this phase the semantics of the modeling language constructs are defined using an ontology. Together the logical rendering function and the ontology-based interpretation make it possible to convert a model in a specific language into an ontology-based model.
3. The results of the previous steps can now be used to create an ontology-based translation between models such that every model can be explained in terms of the conceptualization specified by the shared ontology.

We use the approach of Ciocoiu and Nau to create interoperability between models articulated in the UMM and ISO/IEC 15944 modeling standards (Fig. 2). Instead of using a formal first order predicate logic language, the description logic language OWL was used to specify the ontologies and the logical renderings of the models. We decided to use OWL because OWL is considered as the standard ontology language. Moreover, OWL provides mapping constructs that are used to relate terms in different ontologies. There also exist different easy to use OWL description logic reasoners which can be easily integrated into ontology engineering tools. Reasoners such as Pellet[1] can be used for consistency checking (identify contrary facts), concept satisfiability (verify that all classes can be populated with instances), classification (create a complete subclass hierarchy by identifying subclass relations) and realization (compute the direct types for individuals).

Fig. 2 shows how model interoperability is created by transforming two collaborative business process models (model 1 and model 2) that are developed following two different BOV e-collaboration standards (ISO/IEC 15944 and UMM) into OWL renderings of the models (model 1' and model 2') that refer to their own local ontology (OeBTO[2] and UMM ontology[3]). By mapping these local ontologies onto a global, shared OWL-formalized ontology (i.e. the REA ontology), both models can be interpreted in terms of the same global ontology.

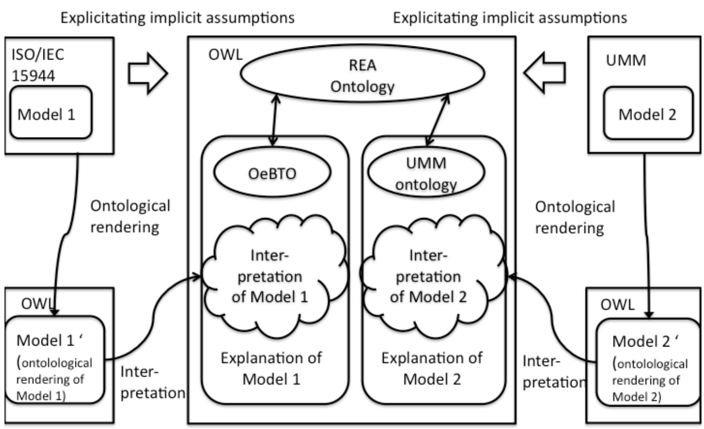

Fig. 2. Ontology-based e-collaboration model translation

3 The Resource Event Agent Enterprise Ontology

The Resource-Event-Agent ontology (REA-ontology) [10, 11] originates in a semantic data model for accounting proposed in [9]. The subject domain of REA can be described as 'the enterprise'. Hence REA is an *enterprise ontology* and as such it

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1 http://clarkparsia.com/pellet/

2 The Open-EDI Business Transaction Ontology (OeBTO) is the UML class diagram specification of the collaborative business process conceptualization that underlies the ISO/IEC 15944 standard.

3 The (unnamed) ontology of the UMM method is also specified using UML class diagrams.

provides a description of explicit knowledge about enterprises that is structured in terms of concepts, a concept classification based on 'is-a' relations, relations between concepts other than 'is-a' relations, and a set of axioms that hold for these relations. Other well-known business ontologies are the e^3-value ontology [19] and e-BMO [20], which focus on different, though largely overlapping aspects of business and as a result can be unified with REA to create a more encompassing business ontology, as demonstrated in [21].[21]

The particular conceptualization of enterprises specified by REA is heavily influenced by REA's accounting background. Primary attention is paid to what changes the value of the enterprise (i.e. recording these value-affecting events and the value composition of the enterprise is what we call 'accounting') and who can be held accountable for this (i.e. accounting enables control of the organization and its members). So enterprise reality is described in terms of **R**esources (having value), **E**vents (affecting this value) and **A**gents (having control over the resources and being responsible for the events); hence the name of the ontology. The conceptualization includes additional business concepts to predict future value changes (e.g. contracts, terms and commitments) or to specify policies for value creation, transfer and consumption (e.g. business policies).

Recently the REA-ontology has also been extended with a procedural component that states that all REA concepts can be considered as *business objects* which all have a defined lifecycle determining their states and state transitions. REA events may be decomposed into *business events* which each may trigger state transitions for multiple *business objects*. A *business process* is then defined as an aggregate of REA events. In our previous work [22, 23], we already formalized the REA-ontology in OWL[4] starting from an UML representation of the ontology. This OWL formalization is used in this paper as a reference ontology to create interoperability between models developed using the ISO/IEC 15944 and UMM BOV e-collaboration standards.

4 E-Collaboration Modeling Standards

In the next subsections the ISO/IEC 15944 standard and the UMM method, and their ontologies, are introduced by means of the enhanced Telecommunications Operations Map (eTOM) example [12]. In this paper we focus on the eTOM process used by a communication provider to reserve and schedule field technicians for the installation and configuration of goods and services.

4.1 ISO/IEC 15944 Standard

The ISO/IEC 15944 standard provides a methodology and tool for specifying shared business practices (as part of shared business transactions) in the form of scenarios, scenario attributes, roles, information bundles and semantic components. This is achieved by developing standard specifications of generally accepted business transaction conventions and practices as scenarios and scenario components. Fig. 3 and Fig. 4 show representations related to the 'reserve and schedule field technicians' process following the ISO/IEC 15944 standard. UML is the modeling language of choice in the standard though it is extended with domain-specific stereotypes.

[4] See http://purl.org/REA/REAontology.owl

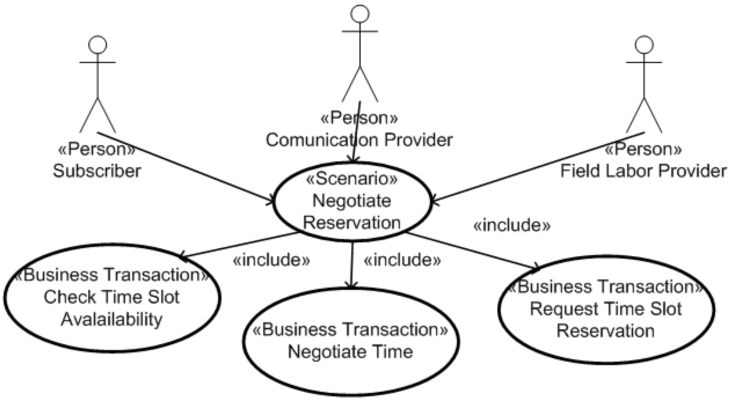

Fig. 3. Use case diagram for Negotiate Reservation following ISO/IEC 15944

The modeling of 'the reserve and schedule field technicians' process starts with a use case scenario Negotiate Reservation that interacts with 3 different *persons*[5]: the Subscriber, the Communication Provider and the Field Labor Provider (see the use case diagram shown in Fig. 3). This use case scenario[6] includes three separate *business transactions*: Check Time Slot Availability, Negotiate Time and Request Time Slot Reservation. Check Time Slot Availability queries the Field Labor Provider for available time slots which results in a list of available time slots. Negotiate Time negotiates an actual time slot using the available slots that correspond to the wishes of the Subscriber. Finally this time slot is reserved by the Communication Provider by means of Request Time Slot Reservation.

The Request Time Slot Reservation *business transaction* is described in more detail in Fig. 4. This UML activity diagram shows the *business events* that transition the state of the *business transaction entities*. The OeBTO defines a *business transaction entity* as a computable representation of any real-world entity that participates, occurs or is materialized during a *business transaction*. In Fig. 4 two *business transactions entities* are distinguished: Field Labor and Labor Contract. The *business event* RequestTime SlotReservation brings the *business transaction entities* Field Labor and Labor Contract into a 'proposed' state (called a *business transaction entity state*). If the Field Labor Provider accepts this request (AcceptTimeSlot Reservation *business event*) then the state of the two *business transaction entities* shown will change into 'specified' and the Communication Provider will receive the contract (Receive Contract *business event*), which ends the *business transaction*. The *business transaction entity states* are said to reside in the collaboration space between the Communication Provider and the Field Labor Provider and allow each partner to determine simultaneously what the exact status of the overall business collaboration is.

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5 Concepts in *italic* refer to concepts that are defined in the ontologies of the e-collaboration standards (here OeBTO; in the next sub-section the UMM-ontology).

6 Scenario is not an OeBTO concept, but is defined in the open-EDI reference model [3]. According to this reference model, business processes may consist of one or more use case scenarios.

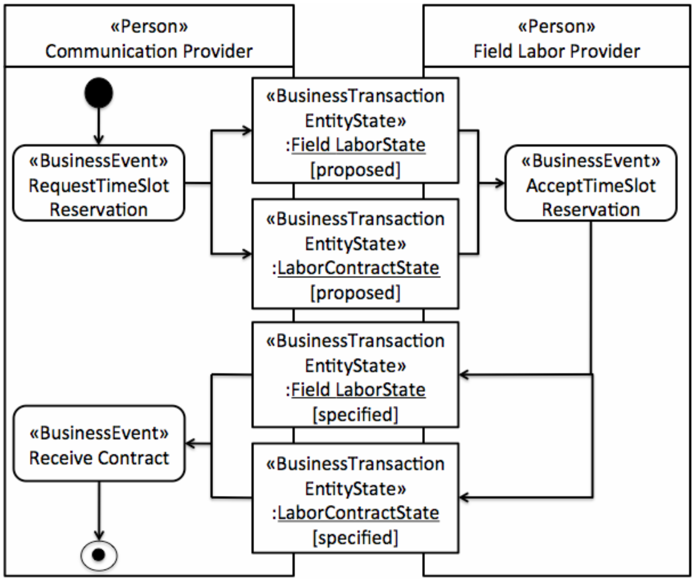

Fig. 4. Activity diagram Request Time Slot Reservation following ISO/IEC 15944

Note that in Fig. 3 and Fig. 4 the UML stereotype extension mechanism was employed for specifying BOV e-collaboration concepts like *person*, *business event*, *business transaction*, *business transaction entity* and *business transaction entity state*. Following the framework shown in Fig. 1, these domain-specific stereotypes represent the ontological commitment of the modeling standard to the conceptualization of the business e-collaboration domain that is specified by the Open-edi Business Transaction Ontology (OeBTO).

The model interoperability approach that we follow (see Fig. 2) requires that the OeBTO UML class diagrams must be translated into OWL. Specifying an OWL formalization of the OeBTO is straightforward because the ISO/IEC 15944 standard contains clear definitions of the concepts and the relationships between the concepts. As UML class diagrams are used to visualize the concepts and relationships, the Ontology Definition Metamodel (ODM) [24] was used to transform these UML class diagrams into OWL specifications. Additionally we followed the guidelines provided by W3C's Semantic Web Best Practices and Deployment Working Group [25] to formalize the part-whole relations of the OeBTO because OWL does not contain specific primitives for part-whole relations and as a result the ODM lacks this type of mapping.

4.2 UN/CEFACT's Modeling Methodology

The UN/CEFACT's Modeling Methodology (UMM) is an UML modeling approach to design a global choreography for the business processes between business partners [5]. UMM distinguishes three views (i.e. Business Domain View, Business Requirements View and Business Transaction View) each covering a set of well

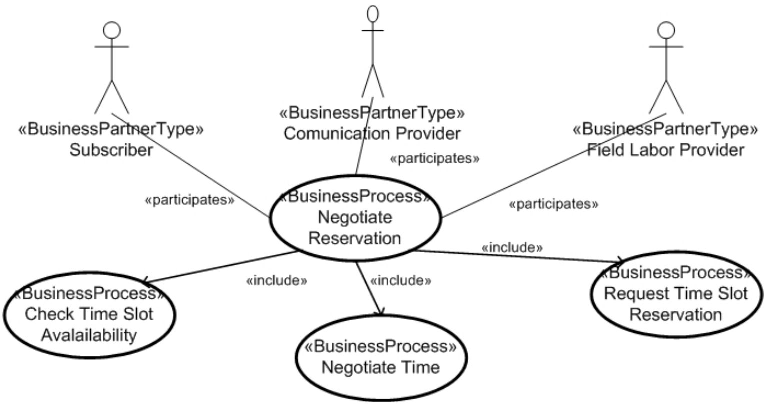

Fig. 5. Use case diagram Negotiate Reservation following UMM

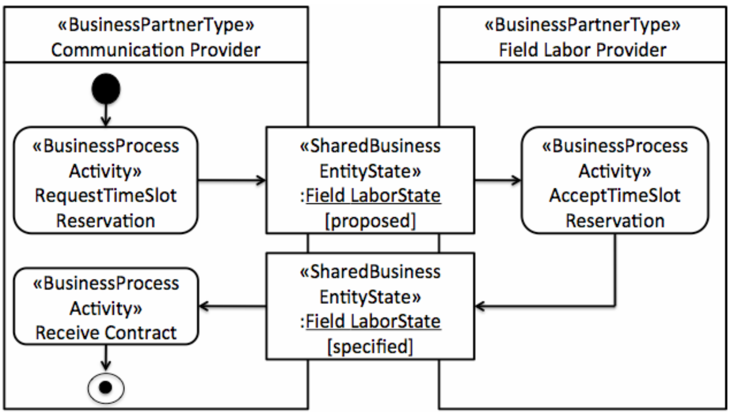

Fig. 6. Activity diagram Request Time Slot Reservation following UMM

defined artifacts of the open-EDI BOV and which can be used to model a complete business collaboration. In this paper only the Business Domain View and the Business Requirements View are considered because these views correspond to the abstraction level employed in ISO/IEC 15944.

In Fig. 5 and Fig. 6 the eTOM 'negotiate reservation' process is modeled using UMM. Although for humans the mappings between these models and the models developed using the ISO/IEC 15944 standard (Fig. 3 and 4) are obvious because we used the same names for the modeled concepts, in reality these mappings must be determined based on the semantic annotations in the models. Because both standards focus on the same semantic domain, there exists for different modeling concepts one-to-one mappings (e.g. an OeBTO *person* is an UMM *business partner type*). However, the semantic domains of both standards are not identical, but only overlapping, which means that some of the concepts defined in the ontology of one standard have no counterpart in the other standard. For instance, the ISO/IEC 15944 standard prescribes the use of *economic commitments*, a concept that is not used in the UMM approach. An *economic commitment* is a promise by one *person* to transfer *economic resources* to another *person* at some specified point in the future. Consequently, in Fig. 4 (following the ISO/IEC 15944 standard) the *business event* RequestTimeSlotReservation changes the state of two *business transaction entities*: FieldLabor and LaborContract, whereas in Fig. 6 the corresponding UMM *business process activity* only changes the state of the UMM FieldLabor *business entity* as LaborContract (an *economic commitment* in ISO/IEC 15944) cannot be represented using UMM concepts. Another difference between the two standards is that UMM makes an explicit difference between *shared business entities* and *internal business entities*. This difference is only implicitly present in ISO/IEC 15944 models by positioning the *transaction business entity states* in the collaboration space between two *persons*.

Compared to the ISO/IEC 15944 standard, UMM pays less attention to the formal specification of the business collaboration conceptualization that underlies the standard (i.e. the development of an BOV e-collaboration ontology) and more to the development of a domain-specific language (based on UML) that can be used to develop models for the different views. The syntax of the UMM views is defined by extending standard UML meta-models like the use case meta-model and the activity diagram meta-model with stereotypes. The semantics of the defined stereotypes are partly described in text and partly graphically presented by means of UML class diagrams. Based on the available meta-model descriptions we have developed an OWL formalization of the domain-specific concepts (e.g. *business process*, *business process activity*, *business entity state*, etc.) used in UMM.

5 E-Collaboration Model Interoperability via the REA Ontology

The federated model interoperability approach outlined in Fig. 2 requires that the concepts of the local ontologies (OeBTO and UMM) are mapped onto the concepts of the global ontology (REA). At this stage the mapping of the ontologies is done manually because the used ontologies are only lightweight ontologies. However in the future the ontologies are extended, we need to further investigate how ontology mapping techniques [26] can be incorporated in our approach. As all ontologies are represented in OWL (see sections 3 and 4), the equivalentClass and equivalent Property OWL mapping constructs can be used for this purpose. The OWL equivalent Class construct allows one to say that a class description (representing an ontology concept) has exactly the same class extension as another class description. Put differently, given their definitions, both class extensions would always contain the same set of individuals. Similarly, the OWL equivalentProperty construct can be used to state that two properties have the same property extension. OWL properties are binary relations on individuals, i.e. they link two individuals together. For instance, the OWL OeBTO ontology contains a *custody* property that links *person* individuals to *economic resource* individuals (meaning that the person has physical control over the resource). Two properties have the same extension if they link the same individuals together.

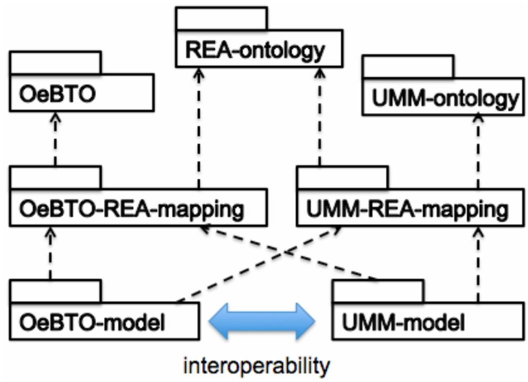

Fig. 7. OWL import hierarchy for creating interoperability between models developed using the ISO/IEC 15944 and UMM e-collaboration standards

Fig. 7 gives an overview of the OWL ontology files (represented as UML packages) that are needed to create interoperability between e-collaboration models developed using the ISO/IEC 15944 and UMM standards[7]. To define the ontology mappings, separate files (UMM-REA-mapping.owl and OeBTO-REA-mapping.owl) were created that each import a local ontology (OeBTO.owl and UMM-ontology.owl) and the REA ontology (REA-ontology.owl). Then, based on our understanding of the ontologies, we created ontology mappings. Next, the classification service of the Pellet reasoner was invoked to identify subclass relations between the classes of the local and global ontology and to detect equivalent classes, in order to verify our ontology mappings.

With the help of the reasoner some problems were detected that necessitated changes in the OWL ontologies or mappings. For instance, based on the UML class diagram specification of the UMM ontology and the examples given in [4], we defined *business partner type* as being disjoint with *business entity*. However, by specifying in the UMM-REA mapping that a *business partner type* is equivalent to an REA *economic agent* (which is a logical conclusion based on the definitions of these concepts and the granularity and intended use of the UMM and REA ontologies), Pellet infers that *business partner type* is a subclass of *business entity* (because UMM *business entity* is equivalent to REA *business object* which is the supertype of REA *economic agent*), which contradicts the disjointness constraint in our UMM OWL ontology. Table 1 gives an extract of the final version of the mappings defined in the UMM-REA-mapping.owl and OeBTO-REA-mapping.owl files[8].

Creating interoperability between an ISO/IEC 15944 model and an UMM model requires that the models are transformed into ontology-based models that can be interpreted in terms of the business collaboration conceptualizations that are specified by the ontologies referred to. Consequently, UML models like the ones described in rendering transformation in Fig. 2). In doing so, we decided to define the models as

[7] Readers can retrieve these OWL ontology files from the following URL: http://www.managementinformatics.ugent.be/CaiseInteropPaper.zip

[8] The extract contains those mappings that are required to create interoperability between the ISO/IEC 15944 and UMM eTOM models used for the eTOM example in the paper.

Table 1. Extract of OWL mappings e-collaboration ontologies and REA-ontology

e-collaboration ontology concept	REA-ontology concept
OeBTO:BusinessTransactionEntity	REA:BusinessObject
UMM:BusinessEntity	REA:BusinessObject
OeBTO:BusinessEvent	REA:BusinessEvent
UMM:BusinessProcessActivity	REA:BusinessEvent
OeBTO:BusinessTransaction	REA:BusinessProcess
UMM:BusinessProcess	REA:BusinessProcess
OeBTO:BusinessTransactionEntityState	REA:BusinessObjectState
UMM:BusinessEntityState	REA:BusinessObjectState
OeBTO:Person	REA:EconomicAgent
UMM:BusinessPartnerType	REA:EconomicAgent
OeBTO:EconomicCommitment	REA:Commitment
OeBTO:EconomicContract	REA:EconomicContract

ontology instantiations (i.e. using OWL individuals that are classified as instances of existing ontology classes) and not by specializing ontology concepts (i.e. by creating new OWL classes as subclasses of existing ontology classes), because this corresponds more to the UML view where the abstract syntax of a language is defined in a meta-model which can then be instantiated to create models.

The OeBTO-model.owl file (see Fig. 7) is the ontological rendering of the ISO/IEC 15944 model for the eTOM example (see sub-section 4.1) and will be used to illustrate the creation of model interoperability.[9] This OeBTO-model.owl file imports indirectly the OeBTO OWL ontology by importing the OeBTO-REA-mapping.owl file (see Fig. 7). In Fig. 8 the UML OWL profile of the ODM [22] is used to visualize the result of the ontological rendering of part of the ISO/IEC 15944 eTOM example, more specifically the activity diagram shown in Fig. 4. This result contains only the classifiers and instance-of relationships drawn with solid lines in Fig. 8.

After importing also the UMM-REA-mapping.owl file, the classification service of the reasoner (Pellet) is invoked to detect equivalent classes in the OeBTO and UMM OWL ontologies. Two classes are equivalent if they map onto the same class in the REA OWL ontology. The realization service of the reasoner (Pellet) can now be invoked to classify the OWL individuals (representing the elements of the ISO/IEC 15944 activity diagram shown in Fig. 4) as instances of the UMM OWL ontology classes. The inferred assertions after reasoning are shown in dashed lines in Fig. 8. For instance, after reasoning, the LaborContractState and the FieldLaborState are classified as UMM *business entity states*. These two OWL individuals are instances of the OeBTO BusinessTransactionEntityState class that is equivalent to the UMM BusinessEntityState class, and therefore they are inferred as instances of this UMM OWL class.

[9] Analogously, the UMM-model.owl file is the ontological rendering of the UMM model for the eTOM example (see sub-section 4.2).

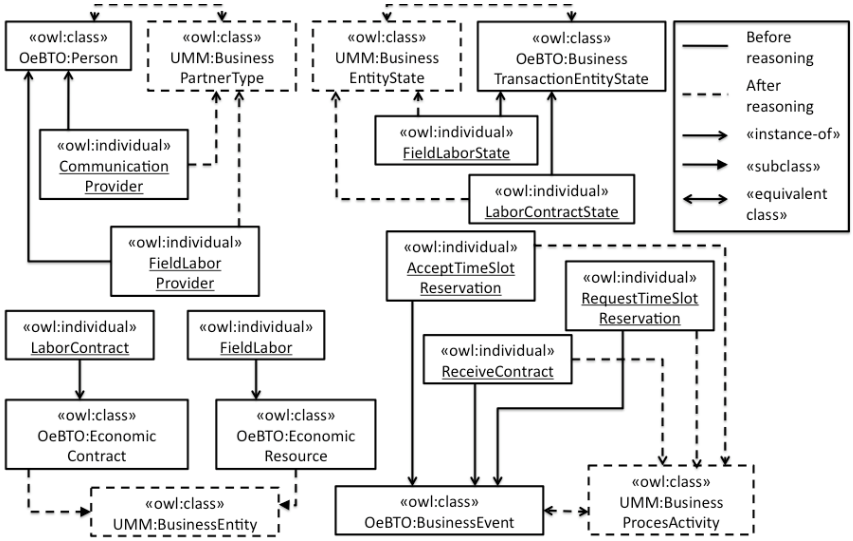

Fig. 8. OeBTO-model before (solid lines) and after reasoning (dashed lines)

Some OeBTO concepts have no direct counterpart in the UMM ontology but because of the classification hierarchy created after reasoning, the reasoner also makes assertions for these concepts. For instance, the LaborContract is an OWL individual of the OeBTO EconomicContract class which has no counterpart in the UMM ontology. However, based on the classification hierarchy, LaborContract is classified as an UMM *business entity* because the UMM BusinessEntity class is a superclass of the OeBTO EconomicContract class and LaborContract is an instance of EconomicContract.

6 Conclusions and Future Work

The goal of this paper was to show how ontologies can be used to create interoperability between models developed in different languages that have an overlapping semantic domain. More specifically, the REA-ontology was used to create interoperability between models that were developed following two different e-collaboration modeling standards: ISO/IEC 15944 and the UN/CEFACT Modelling Methodology. Model interoperability was realized by formalizing the ontologies that are part of these e-collaboration standards using OWL and relating these ontologies with the REA ontology using OWL ontology mapping constructs. The mappings between both e-collaboration ontologies and the REA-ontology were then used by an OWL description logic reasoner (Pellet) to identify equivalences between the two modeling standards. Next, we showed by means of an example that a model developed using one standard can be interpreted in terms of the other standard. First, the model was made ontology-based by translating it into an instantiation of the OWL formalized ontology that is part of the standard used to develop the model. Second, a reasoner was invoked that, based on the previously identified equivalences, automatically classifies the model elements as instances of the ontology concepts of the other standard.

A current limitation of our approach is that not all information in an e-collaboration model is preserved when translating it into an ontology-based model. Both e-collaboration standards prescribe the use of general purpose modeling techniques (use case diagrams and activity diagrams) to articulate collaborative business process models. Most of the constructs of these techniques (e.g. actors, use cases, actions, object nodes) are stereotyped so that they derive their meaning from the ontology of the standard. Other constructs (e.g. include relationships between use cases, control flow arrows in activity diagrams) derive their meaning from the meta-model of the modeling technique and are not ‘overloaded’ with domain-specific semantics. As a consequence, these model elements are not classified as instances of the domain ontology classes, so do not appear in the ontology-based models, leading to a loss of information. Therefore an ontology-based model cannot replace the model it is derived from. To transform a model developed using one standard into a model following the other standard, both the original model and the ontology-based model are needed. For the ISO/IEC 15944 and UMM standards, such a translation is straightforward because both standards prescribe the use of the same general purpose modeling techniques. For standards that use different modeling techniques the translation problem becomes more complicated. Further research is required to investigate how solutions for creating mappings between modeling languages (e.g. solutions like UEML [7] and BPDM [8]) can be integrated into our approach.

As future research we plan to build an extension to the REA ontology that integrates the UMM Business Transaction View. This more detailed view on business transactions is needed to extend our approach of creating interoperability between BOV e-collaboration models to Functional Service View (FSV) models. In this context we will also need to evaluate how our approach is related to existing information integration research and industry solutions [3]. Additionally the proposed approach needs to be validated using more complex practical examples.

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