Semantic Mediation of Information Flow in Cross-Organizational Business Process Modeling

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ABSTRACT

In this paper we propose a mediated business process modeling approach, where ontology-based information models are used for the semantic modeling of information flow in cross-organizational business processes. Rule-based semantic bridges are applied for the automated mediation between different domain vocabularies used in the organizations' process models. This allows for interchange and interconnection of business process models, as well as for mediation between the abstract business level and the concrete IT level. We implemented the approach as an extension of an existing BPMN modeling tool and evaluate it on the basis of an e-commerce use case.

Categories and Subject Descriptors

F.3.2 **[Logics and Meanings of Programs]**: Semantics of Programming Languages - *process models*, D.2.11 **[Software Engineering]**: Interoperability - *data mapping*, Software Architectures - *data abstraction*, H.4.1 **[Information Systems Applications]**: Office Automation - *workflow management*, J.1 **[Computer Applications]**: Administrative Data Processing - *business*.

General Terms

Management, Design, Languages

Keywords

Semantic Business Process Management, Semantic Mediation, Loosely-coupled Information Models, Ontology Mapping, Business-IT Alignment

1. Introduction

Semantic Business Process Management (SBPM) is the combination of Corporate Semantic Web technologies, such as rules, semantic event/action/state formalisms and ontologies, with Business Process Management (BPM). This unique combination promises enhanced automation in discovery, configuration and composition of appropriate process components, information objects, and services, as well as automated mediation between different heterogeneous interfaces and abstraction levels, targeted complex queries on the process space and flow, and in general much more agile business process management.

In previous works we have addressed the application of semantic technologies on the business process execution level [2,4,17,19,20]. Our new contributions in this paper address the business process modeling layer. In contrast to existing works on SBPM, which aim at improving business process management within an organization (see related work), we broaden the scope and address the semantic modeling of cross-organizational business processes and their information flows between domain boundaries. This imposes the important research problem of semantic mediation between business process models and their respective heterogeneous information models which we typically have it in agile business processes implemented as enterprise service networks and Web service supply chains. We are contributing a SBPM solution which semantically enhances the OMG BPMN standard with additional ontology-based information models for representing the cross-organizational information flow and introduce rule-based semantic bridges for the automated mediation between the different domains. As a proof-of-concept we implemented our approach as an extension of the Web-based BPMN modeling tool Oryx and evaluated it with an industrial use case scenario.

The further paper is structured as follows: Section 2 presents the general idea of mediated business process modeling and discusses the relevance of the approach. Then Section 3 compares it to related work and alternative approaches. In Section 4 a prototypical instantiation of the so called mediated business process modeler is presented and then evaluated by applying it to a cross-organizational purchase-order mediation scenario in Section 5. Finally, Section 6 provides a summary and conclusion and discusses possible future work.

2. General Idea

The SOA life-cycle starts from the business perspective on how processes can be supported by IT systems. Taking into account cross-organizational business processes in this context the challenge of heterogeneous information models used by different actors and organizations also affects the design phase of business process modeling and in particular the definition of information

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flow. Usually, business process experts use business-oriented high-level descriptions of information entities which are non-formal and natural language driven to define the general information flow in business processes. However, in cross-organizational business processes e.g. the usage of mismatching terms for semantically equal information entities can hinder the sound design of information flow across organizational borders. Moreover, the non-formal nature increases the so called business-IT gap as the used terms are not explicitly linked to already existing information or data models of the organization, which causes additional efforts and iterations for aligning the top-down requirements driven business perspective with the bottom-up IT perspective focusing on reuse of existing resources [1].

2.1 Mediated Business Process Modeling

The basic idea of what we call mediated business process modeling is to exploit ontology-based domain information models for the sound design of information flow in cross-organizational business process models. The idea is that during business process modeling corporate or domain ontology concepts are used to define the information flow on a non-technical conceptual level suitable for business process experts. Moreover, due to the formal nature of ontology-based information models a consistent link between the business or conceptual level and the underlying technical information or data models can be derived.

Furthermore, having the formal domain information models at hand facilitates the semantic mediation between heterogeneous conceptualizations used by different organizations or domains in terms of applying so called semantic bridges. Previous work has presented one possible approach for realizing semantic bridges exploiting production rule-based ontology mappings [2], which can be reused in the business process modeling context. Thus, the business process expert is enabled to seamlessly design the cross-organizational information flow whereas semantic heterogeneities can be handled transparently based on semantic technology-based tool support.

Moreover, taking into account as well the perspective of agile development and continuous maintenance, domain information models and correspondingly semantic bridges between them need to evolve over time. According to process-orientation this evolution should be driven by requirements derived from business processes. Consequently, mediated business process modeling does not only include the exploitation of domain ontologies and semantic bridges as described above but also should provide specific features for their requirement engineering during business process modeling. This demand-driven evolution includes for example the possibility for the process expert to specify information entities which are not already reflected within the ontology-based domain information model and as well to identify missing semantic mapping rules between information entities of different domain information models not reflected in the available set of semantic bridges.

All in all the goals and major tasks of mediated business process modeling can be summarized as follows:

- Provide functionality for the design of information flow in business process models on a non-technical conceptual level in terms of ontology-based information models suitable for business process experts.
- Ensure a consistent link between the business or conceptual level (ontology-based information models) and the underlying technical information or data models and thus provide improved Business-IT alignment.
- Integrate an existing semantic mediation mechanism based on semantic bridges to enable seamless design of cross-organizational information flow, whereas semantic heterogeneities are handled transparently for business process experts.
- Provide functionality for business process-driven evolution and extension of existing ontology-based information models and semantic bridges.

The following Figure 1 illustrates the relation between the major tasks for the business process expert during mediated business process modeling:

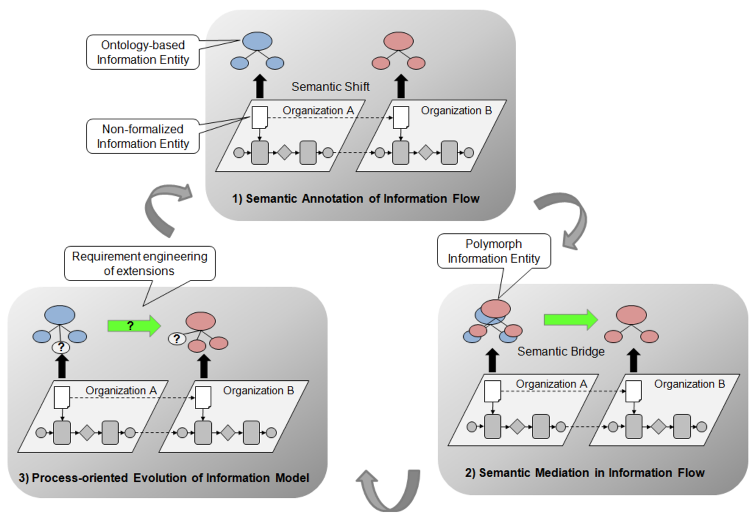

Figure 1. Mediated Business Process Modeling

The first task deals with semantic annotation of information flow within cross-organizational business processes. The business process expert defines a business-oriented information flow on the conceptual level using concepts from corporate or domain ontologies to annotate the non-formalized information entities and thus shifts them onto the higher semantically explicit level. This task requires a generic extension of the used business process modeling notation (e.g. BPMN) to visualize the higher expression level in terms of a semantic sub-graph of information entities in contrast to flat representations provided in current modeling notations. The following Figure 2 illustrates this required semantic extension:

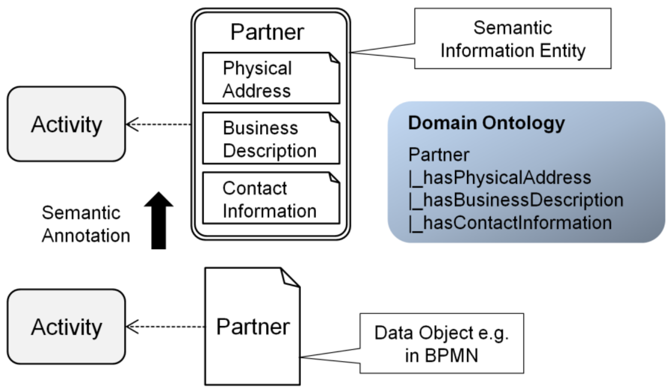

Figure 2. Semantic Extension of Information Entities in Business Process Modeling Notation.

In the second task semantic bridges are applied to the ontology-based information entities, in order to obtain polymorph information entities and thus overcome semantic heterogeneities. The underlying concept of loosely-coupled information models improving semantic interoperability in large-scale SOA landscapes has been presented in [4]. In the business modeling context semantic mediation based on semantic bridges can be exploited to suggest matching information entities in process parts of different organizations and thus enable seamless information flow design keeping information representation differences transparent for the process expert.

The third and last task focuses on the process-oriented evolution of information models and semantic bridges. Missing information entities and semantic bridges required for the information flow in the concrete business process not already reflected in the existing domain information models can be specified by the process expert. Then in a further external step they can be defined by domain information model experts in terms of iterative and demand driven development. Consequently, these evolutionary developed concepts and semantic bridges can be further utilized for semantic annotation and mediation of the information flow and thus closes the so to say micro-life-cycle of mediated business process modeling.

2.2 Relevance of the Presented Approach

Even though several approaches for integrating semantic technologies into business process modeling exist, their aim is rather different focusing on ontology-based annotation of process steps, in order to improve process management and search in process repositories (cp. Section 3). Therefore, the presented approach for mediated business process modeling focusing on cross-organizational information flow design requires a dedicated solution that supports semantic mediation between heterogeneous conceptualizations. However, taking into account that the field of business process modeling is well covered by mature industry tools and products the targeted tool-based realization of mediated business process modeling should reflect existing work. Therefore, after discussing related work and alternative approaches in Section 3 the subsequent Section 4 discusses a possible system architecture of a tool as an extension of a state-of-the-art business process modeling tool with integrated features for semantic mediation during information flow design. Furthermore, a concrete realization of this functionality is described and a scenario is performed to evaluate the approach.

3. Related Work and Alternative Approaches

Current BPM languages such as the adopted standards BPMN 2.0 for modeling and WS-BPEL 2.0 for execution are pure syntactic languages without any explicit declarative semantics for objects / data, agents, processes, events and activities.

Semantic Web Services (SWS) as a combination of ontologies, rules, and Web services have been extensively studied in several projects in the Semantic Web community and different approaches exist such as RBSLA [17], OWL-S (former DAML-S), WSDL-S, SAWSDL, SWWS / WSMF, WSMO / WSML, Meteor-S, SWSI . They are all aiming at semantically describing the interfaces of Web services, their functional and non-functional properties, and policies such as SLAs.

Several extensions to WS-BPEL using SWS approaches have been proposed. These works mainly address the execution layer of business processes, where the semantics solves technical integration, mediation and expressiveness (e.g. business rules) problems, but also semantic mapping problems between the business oriented modeling and management of processes, e.g. in BPMN, and the translation into an execution syntax such as BPEL. Homogenous SWS-BPEL approaches, such as SUPER [18], represent BPEL and the SWS descriptions in one homogenous ontology language. Heterogeneous approaches separate the process execution description in BPEL or some other execution language such as BPML, XLANG, WSCI, WSFL from the semantic knowledge representation of used business vocabularies and business rules. In [19,20] an ontologically-typed rule-based approach for executable business processes descriptions in BPEL+ is proposed which allows semantically combining (BPEL) orchestration models with expressive (business) rule choreography workflows and (business) ontologies.

SBPM approaches on the modeling and management level take similar approaches by either heterogeneously combining rules + ontology languages with a BPM modeling language such as BPMN, as e.g. done by SemTalk [21], or by providing an expressive enough homogenous modeling language which supports both modeling the processes and representing the semantics of the domain in terms of an ontology and the logic in terms of rules. While BPDM, which provides an underpinning formal FOL semantic for its process specification, has not been adopted at OMG in the favor of the graphical BPMN notation, there are efforts for adding semantics to BPMN via integrating of other standardization efforts aiming at representing business rules and business vocabularies (SBVR), representing (production) rule meta models (PRR), rule interchange languages (RuleML and W3C RIF) or UML/OCL rule models, defining ontology meta models (ODM) and mappings between ontology languages such as W3C RDFS, W3C OWL, ISO CL and ISO Topic maps and OMG UML (class) models[1].

[1] see OMG BMI.org, http://www.bpmi.org/, ruleml.org, and W3C Semantic Web

Although these approaches are related to our work their focus is on ontology-based annotation of process steps, in order to improve process management and search in process repositories in a homogenous ontology environment. In contrast our research presented in this paper, aims at mediating between different information models in cross-organizational design of BPM information flow and thus focuses on heterogeneous ontology environments.

4. The Mediated Business Process Modeler

In this section the proof-of-concept implementation of the mediated business process modeling tool is discussed. As the tool should be realized as an extension of a state-of-the-art business process modeling tool, the architecture has to incorporate an abstraction of it, in order to remain independent of any concrete tool or product. According to the goals and tasks described in the previous section a systematic use case analysis was performed. Along with the requirements engineering the prototypical implementation of the tool was carried out according to the Agile Unified Process (AUP), which methodology is based on the Rational Unified Process (RUP) framework enhanced with agile aspects [5] . I.e. the development process is composed of several iterations, where each one has few distinguished phases. After each iteration a set of artifacts is collected in order to systematically present the progress of the development. Critical in terms of most difficult to implement and core components have been designed first and then prototypically realized before further components have been addressed.

Based on these iterations the following system architecture has been developed which provides an overview of the main functional components and how they interact with each other:

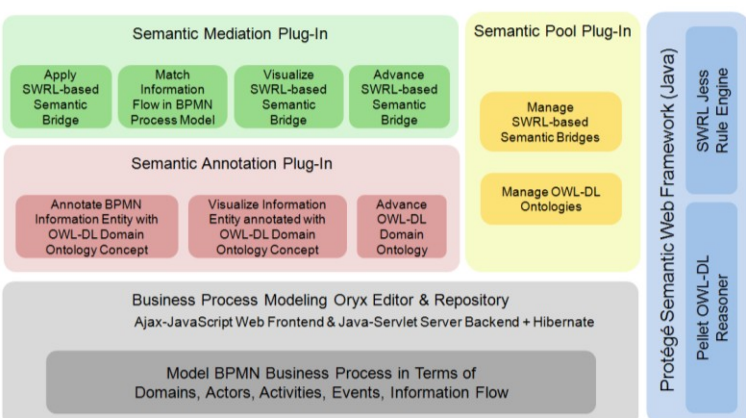

Figure 3. System Architecture of Extended Business Process Modeling Tool

The general architecture style is client-server based as this suits best the goal for distributed collaboration between multiple business process experts and domain information model experts in the targeted cross-organizational context. The tool is based on state-of-the-art functionality for business process modeling. On top of this bottom layer two more layers are added which are enabled by means of Semantic Web technologies provided by the vertically shown Semantic Web framework. The first additional layer provides the means for semantic annotation of information entities within the business process information flow. The second additional layer then contributes the functionality for semantic mediation based on polymorph information entities to facilitate a sound design of cross-organizational information flow. A further vertical layer named semantic pool provides complementary functionality to the before presented layers in terms of management support for utilized ontologies and semantic bridges. In the following these five basic components are described in more detail.

4.1 Business Process Modeling

The underlying layer is instantiated by the open-source based Oryx editor for the basic business process modeling functionality including a visual editor for modeling domains, actors, events and information flow, whereas multiple modeling notations such as BPMN or EPC[2] are supported. The Oryx editor has been chosen among a set of candidates in a systematic criteria-based evaluation, which has been carried out in [6]. The main criteria have been extensibility, support of standardized business process modeling notations such as BPMN, usability and an active developer community with support provision. The Oryx architecture comprises an Ajax-JavaScript Web-frontend combined with a Java-Servlet based backend including a Hibernate persistence layer. The open approach combined with its clearly structured and defined plug-in mechanism provides a solid foundation for the realization of the upper layers. A comprehensive technical description about the Oryx project can be found in [7].

According to the client-server architecture and the extension mechanism of the Oryx editor the upper layers are realized as plug-ins. Its functional components contain each a client-side Web frontend for the GUI including lightweight application logic and a server-side backend for more sophisticated processing. The backend includes in particular the functionality for the additional semantic layers using the Protégé API that provides the semantic technology stack. Furthermore, the backend provides the Oryx-based persistence handling of extended business process models with semantic artifacts such as domain ontologies for annotation of information entities and semantic bridges.

4.2 Semantic Annotation

The semantic annotation plug-in extends the Oryx BPMN modeling functionality by means of semantically enriched expression of information entities and information flow. The Oryx editor supports multiple notations for business process models. However, BPMN was chosen due to its standardization and wide industry adoption. The developed extension allows to link BPMN information entities to concrete concepts of a corporate or domain ontology described in OWL-DL. Among the three available OWL languages levels OWL-DL has been chosen for the following reasons: OWL-DL imposes some restrictions on the underlying RDF graphs in comparison to OWL-Full, which does not. Therefore, based on limitations in expressiveness OWL-DL is decidable and reasonably computable compared to OWL-Full. Moreover, OWL-DL enables arbitrary values for cardinality restrictions of properties, where OWL-Lite only allows to distinguish between 0 and 1 for *minCardinality*, etc. In this context it has to be kept in mind that providing further tool

[2] Business Process Modeling Notation (BPMN) and Event-driven Process Chains (EPC)

support in the SOA lifecycle requires that OWL concepts need to be mapped to XML Schema types taken into account path dependency of Web service technologies. The OWL-DL features for cardinality restrictions allow to cover the XML Schema feature of defining how often an element may occur within a complex type definition by *minOccurs* and *maxOccurs*, which are not restricted to 0 or 1. Therefore, the language level OWL-DL has been regarded as most useful for the developed prototypes including the fact that most OWL reasoners focus as well on OWL-DL.

By selecting a concept from a tree-based representation of the OWL-DL domain ontology graph the adequate semantic annotation for the business process information entity can be identified according to the domain ontology context and the properties describing the particular concept. The concept-tree representation focuses on the following OWL-DL ontology features:

- the concept and its sub-concepts
- the concept and its properties
- the properties and their domain and range

Further more sophisticated ontology features e.g. the qualification of a property as functional etc. are not represented, in order to focus on a high-level non-technical visualization for business experts without too much complexity. Therefore, the OWL-DL ontology is processed on the server-side using the Protégé-API. In order to display the ontology structure an XML object representation is utilized to serialize ontology representations to the client-side.

The information flow is represented in BPMN by means of linking annotated information entities to multiple activities between information entities are passed. Besides this annotation visualization taking into account the whole domain information model additionally a directly into BPMN integrated semantic extension of the information entity representation is provided. According to the approach presented in Figure 2 each annotated information entity is visualized in the business process model with the corresponding concept properties as cascading sub-shapes. Figure 4 below illustrates the two perspectives of the semantic annotation in a screenshot of the Web-based GUI of the extended business process modeling tool:

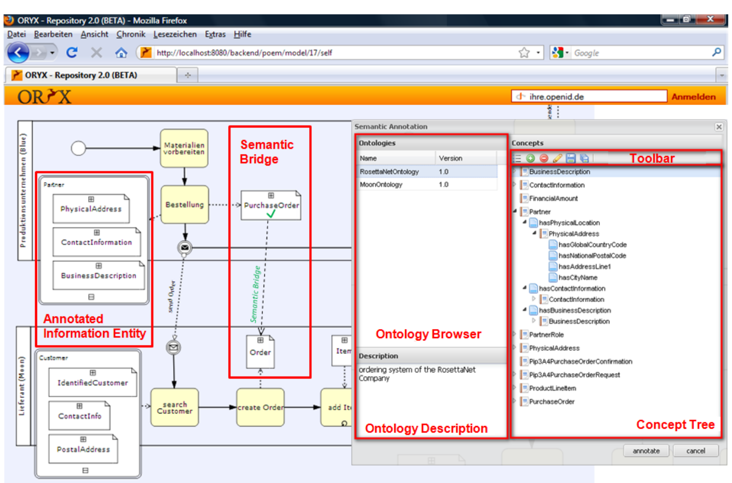

Figure 4. GUI of Mediated Business Process Modeling Tool

The BPMN extension of the annotated information entity is shown on the left hand side and the domain ontology browser including the concept tree on the right hand side. In the center a semantic bridge between the two semantically corresponding information entities *PurchaseOrder* and *Order* in different domains is highlighted, which will be further explained in the next section

Moreover, the mentioned dynamics of business requires adequate mechanisms for the maintenance and evolution of the utilized ontology-based information models. Therefore, the functionality to advance the domain ontology or particular concepts is integrated in the tree-based representation of the OWL-DL domain ontology graph. Basic extension features such as adding, changing or deleting a concept or a property of a concept can be directly performed in the provided ontology browser through specific buttons and context menus highlighted as a toolbar in Figure 4. More sophisticated advancements of the ontology can be specified in terms of textual comments by process experts and then have to be externally incorporated into the corporate or domain ontology by domain information model experts using separate more comprehensive ontology development tools such as Protégé.

4.3 Semantic Mediation

The semantic mediation plug-in applies preloaded semantic bridges in order to match semantically corresponding information entities in the cross-organizational business process model. As the application of semantic bridges represents the core part of the actual semantic mediation mechanism its realization is discussed in more detail in this section. The semantic bridges are realized in terms of SWRL forward-chaining rules combined with the facet classification semantics of OWL. By applying the semantic bridge rules, an instance of concept A is furnished with additional properties defined in concept B to which concept A has been identified as semantically equal [2]. Having the class definitions on hand, a reasoner is now able to classify the instance as polymorph, since all required properties defined in concept A and B are present. Thereby, the notion of so called defined classes [3] is exploited that have at least one necessary and sufficient condition describing exactly the properties defining a particular concept. Consequently, instances which fulfill the conditions can be classified by an OWL reasoner as members of such a defined class. Different third-party reasoners and rule engines have been examined in order to interpret and execute the SWRL rules and perform the required classification.

At first, KAON2 [8] was investigated, since it supports reasoning over OWL and SWRL. However, KAON2 implements a pure backward-chaining algorithm, which is designed for query answering; i.e. only facts necessary for answering one specific question are generated. It does not support the calculation of all facts based on a given knowledge base. That means it is not possible to trigger a forward-chaining reasoning, determining all facts that can be inferred from the given knowledge base [8]. However, this is necessary to generate polymorph instances containing all properties of each concept definition from the domain ontologies between the semantic bridge is applied.

Furthermore, the SWRL support of the Pellet reasoner [9] has been evaluated, which however at time of investigation did not include required built-ins [10], such as the *makeOWLThing*-built-in [11]. However, this built-in is necessary e.g. if a Semantic

Bridge defines a mapping between concepts, where the target concept is defined on a finer granularity level then the source concept. In this case new OWL individuals have to be created to accommodate the additional level of structure. Due to the lack of support of such specific built-ins, the Pellet SWRL support is not sufficient.

A third and finally adopted approach is the use of the Protégé-OWL Framework [12] in combination with Pellet and the Jess Rule Engine [13]. Protégé is an open source tool for managing and manipulating OWL. It provides a direct connection to Pellet for performing OWL-DL reasoning applied for facet classification. Since Pellet does not support all the SWRL-built-in-libraries as discussed above, the Jess rule engine is used for this purpose. The right hand Figure 5 illustrates the realization of the semantic mediation mechanism.

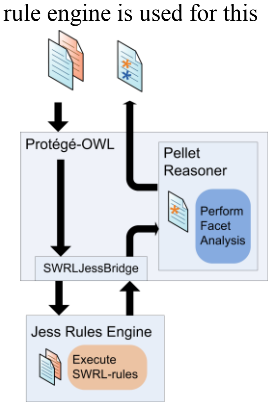

Figure 5. Semantic Mediation Mechanism

Protégé is utilized as the top-layer framework that coordinates the communication between the other frameworks. It is responsible for reading, importing and managing all ontological facts. While Pellet is directly integrated into the Protégé framework, Jess is an independent component by itself. Therefore, all the facts that are necessary for executing the SWRL-rules have to be transferred to the rule engine via the SWRL-JessBridge [14]. The available methods and the syntax for handling the rules is explained in [15]. Since rules operate on individuals exclusively, proxy OWL individuals have to be created for all ontology concepts involved in the semantic bridge. The proxy individuals simulate the actual instances of information entities that will be provided during process execution. After the semantic bride is executed, the now polymorph proxy individuals can be visualized in the concept tree of the ontology browser and as well directly in the BPMN model as illustrated in Figure 6 below:

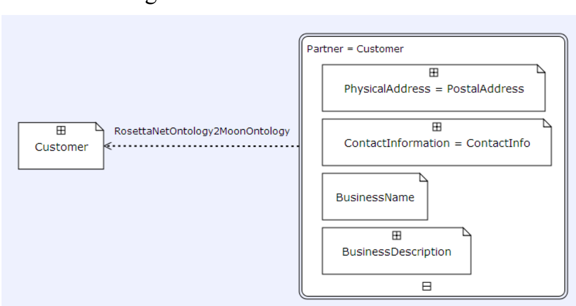

Figure 6. Polymorph Information Entities embedded in BPMN

Moreover, based on the polymorph proxy individuals the matching of semantically corresponding information entities across business domains can be performed. Iterating over the involved information entities in the process model by taking into account recursively sub-elements, the concept types can be directly compared. Matching information entities are highlighted and presented to the process expert. Furthermore, in an analog manner to the evolution of information models the tool provides advancement functionalities for the evolution of rule-based semantic bridges. Requirements for missing mapping rules between two concepts or as well for semantic bridges missing at all can be specified and are stored as textual comments to be addressed by domain experts. The technical realization of the visualization and advancement functionalities for semantic bridges are similarly realized as for the semantic annotations as described above.

4.4 Semantic Pool

On the one hand the semantic pool plug-in provides a repository to handle and manage domain ontologies to be used during annotation of information flow. On the other hand the analog functionality is provided to manage the used semantic bridges including dialogs for import, export, create and versioning operations required for the advancement functionality discussed above. After importing a corporate or domain ontology its URL is parsed on server-side and the tree-based representation for the client-side ontology browser is generated and stored. Thereby, the realization takes into account that the used ontologies and semantic bridges are persistently integrated into the data set of the business process model to restore them consistently when the business process is reloaded.

4.5 Semantic Web Framework

The Semantic Web framework has been chosen and utilized as discussed above in context of the realization of the semantic mediation mechanism. It includes the Protégé API framework combined with the Pellet OWL-DL reasoner and the Jess SWRL rule engine.

5. Designing Information Flow in the Purchase-Order Mediation Scenario

This section covers the validation and verification of the developed prototype for mediated business process modeling. Based on a briefly outlined scenario a subsection about validation analyses how the developed prototype meets the objectives defined in the Section 2, whereas a further subsection about verification deals with the question whether the prototype performs the mediated business modeling tasks correctly.

The performed scenario is based on the purchase order mediation scenario, which has been issued by the international Semantic Web Service Challenge (SWSC) [16]. For the purpose of this paper the focus is set on the modeling of the cross-organizational business process including the design of information flow across heterogeneously defined information representations. The basic idea of the scenario is that a customer “Blue“ wants to purchase goods from the manufacturer “Moon“. However, the systems responsible for issuing a purchase order on the Blue side and for processing the order on the Moon side differ in terms of information representation and in terms of interaction patterns. I.e. the granularity and denotation of the data elements used on both sides varies, as does the order and granularity of operations, necessary to complete the processing of an order. The following Figure 7 illustrates the scenario:

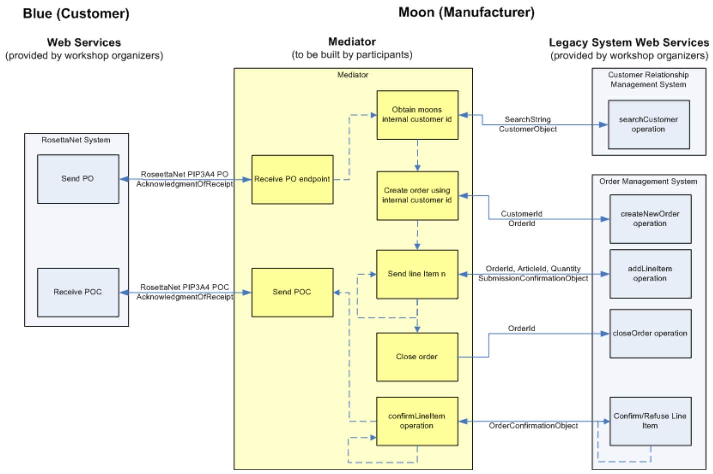

Figure 7. Purchase Order Mediation Scenario Overview [16]

The purchase order sent by the Blue system is based on the information model specified in the RosettaNet XML Schemas standard, while the Moon system defines its own information model with a proprietary XML Schema format. Consequently, the challenge is to implement a mediator that should bridge the heterogeneities regarding the different information models and interaction patterns of the two systems. The business process between the two companies was modeled with the developed prototype. Furthermore, the conceptual information flow was designed based on for the scenario developed domain ontologies "Blue" and "Moon" which capture the different conceptualizations of the information models on an ontology level. Thereby, additionally developed semantic bridges between the Blue and the Moon domain ontology were applied, in order to provide a transparent semantic mediation between the heterogeneous information models to the business process expert. Furthermore, the advancement functionality for information models and semantic bridges of the mediated business process modeling tool was used to complete the Blue and Moon domain ontologies and corresponding semantic bridges to fit adequately for the business process. Figure 8 below shows how the purchase order mediation scenario was mapped to a business process model designed with the realized prototype:

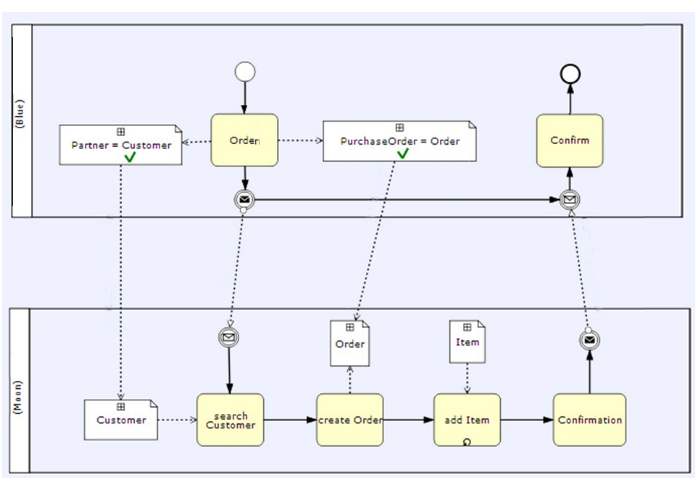

Figure 8. Scenario Performed with Mediated Business Process Modeler

5.1 Validation

The required functionality for the design of information flow on a non-technical conceptual level could be successfully provided: On the one hand by means of the ontology browser presenting the information model as a concept tree and on the other hand by extending the plain BPMN representation of information entities with concept annotations from a corporate or domain ontology. Furthermore, based on the underlying OWL-DL ontologies utilized for the expression of corporate or domain information models, the link to their processing in the further SOA life-cycle could be ensured. I.e. the OWL-DL domain ontologies can be reused in order build the additional semantic layer for Web service enrichment and Web service composition, which can be mapped to existing XML-based infrastructures and hence contribute to improved Business-IT alignment. The semantic mediation mechanism was realized by means of SWRL-based forward-chaining rules and the facet analysis classification semantics of an OWL-DL reasoner. Once loaded to the semantic pool and accordingly applied with the matching functionality, the semantic bridges enable a seamless design of cross-organizational information flow, whereas semantic heterogeneities are kept transparently in the background. Finally, the functionality for business process-driven evolution of existing information models was realized within the ontology browser and dialogs for the extension or completion of semantic bridges were integrated.

5.2 Verification

Guided by the scenario several tests were run to ensure that the prototype mainly performs correctly and stable in the expected behavior. In particular, a set of defined use cases covering the main functionalities have been performed. The tested use cases include: manage ontologies and semantic bridges in the semantic pool, create new ontology, define requirements for a new semantic bridge, annotate information entity with a concept, display annotated information entity, edit annotated information entity, link corresponding information entities with a semantic bridge, suggest semantically matching information entities, display semantic bridge and finally edit semantic bridge. Additionally, during the development of the prototype several unit tests have been run to check the correct implementation of the various methods. Thus, it can be stated that the prototype generally performs correctly.

Consequently, taken into account as well the validation discussion, it can be stated that the developed prototype for mediated business process modeling meets the defined objectives and provides a valid proof-of-concept implementation.

6. Conclusion and Outlook

In this paper we have presented our approach for mediated business process modeling which addresses the challenge to design cross-organizational information flow bridging borders of heterogeneously conceptualized domains. We have exploited ontology-based information models to enrich the limited expressiveness of information entities in BPMN in order to explicitly design the business processes information flow. This improves the alignment of business and IT perspectives as ontology-based information models can be consistently reused during process implementation and moreover enables the process expert to address the semantic integration problem on the higher abstract conceptual level. Therefore, rule-based semantic bridges are applied for the automated mediation between different domain vocabularies used in the interlinked organizations' process models. According to this approach we have presented a prototypical instantiation as an extension of an existing BPMN modeling tool. As a proof-of-concept we have evaluated and demonstrated the developed tool on the basis of an e-commerce use case.

Future work will consider the integration of the mediated business process modeling approach with previous work where the rule-based semantic bridges have been applied during service composition and BPEL-based process execution [2]. Exploiting the ontology-based information flow and semantic bridges directly for the mapping to service orchestrations provides the potential to further improve Business-IT alignment.

Moreover, the cross-organizational perspective will be addressed. Somehow it has to be ensured that all stakeholders in business process modeling covering multiple organizations and domains have access to the required assets including process models, information models and corresponding semantic bridges. Therefore, an organizational framework and clearinghouse is required to guide the stakeholders in the process of providing and sharing the process assets. Such a clearinghouse should include a repository to publish the various business process models, domain vocabularies and semantic bridges, to categorize them with expressive semantics and provide methods for versioning and quality assurance to ensure the sound evolution.

In the long run these activities should contribute to the vision of performing cross-organizational process integration purely on the conceptual business level by exploiting powerful tool support based on semantic business process management.

7. REFERENCES

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