GO4SOA: Goal-Oriented Modeling for SOA

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Abstract: The service-oriented architecture (SOA) has become a standard in business integration. In software engineering, several authors propose requirements elicitation from business goals. However, SOA application modeling does not address these goals, causing a gap that can hinder the application design. The work outlined in this paper proposes an approach to modeling SOA applications based on business goals. The goals are incorporated as semantic information to the application's architecture and are preserved until its implementation. Thus, the components that perform a particular business goal can be identified from its architecture model, through detailed design, and implementation. Case study "Purchase Order" was selected to verify the proposed approach. The major contribution of this research is the application of business knowledge to improve the service's descriptions in the application design. The case study indicated that business goals are preserved on models and implementation, making it easy to verify, through tracing its features, if the organization's goals were addressed as completely as possible.

1 INTRODUCTION

The service-oriented architecture (SOA) has become a standard for the integration of distributed systems, and its adoption has grown in the new applications developing (Rake et al., 2009). Associated with the SOA, the application design often uses semantic resources to facilitate interoperability (Agarwal et al., 2011). Sometimes, the adoption of SOA applications is used to facilitate collaboration between different business domains (Elvesæter et al., 2011). This interaction between distinct areas happens through business processes to meet business process goals. This interaction between distinct areas happens through business processes to achieve business goals.

Current SOA applications' modeling does not express clearly the goals that are part of business process modeling. However, service-based applications are in place to carry out the business processes and support their goals (Todoran et al., 2011) (Delgado et al., 2013). Therefore, this organizational knowledge should serve as a guide to define what services will be needed and their initial requirements (Horkoff et al., 2015).

An approach to design service-based applications must be aligned to business processes that, in turn, are directly linked to the organization's goals (Guizzardi and Reis, 2015). Some studies indicate that the absence of well-documented service is one of the main problems of the SOA applications design (Bravo et al., 2013). This gap between business modeling and discovery requirements contributes negatively to the applications' design.

This article proposes an approach to SOA application design, named "Goal-oriented Modeling Approach for SOA (**GO4SOA**)" (Costa, 2015). Guided by business goals, the designer uses modeling techniques to capture the application services' requirements. The goals become part of the semantic services' descriptions and are preserved until the implementation. Thus, all the elements that perform a specific business goal can be identified.

A proposed approach case study was developed as an experiment. The scenario chosen was an electronic purchase process where a consumer interacts with a provider and performs a purchase order.

The paper is organized in the following sections. Section 2 discusses other SOA applications modeling proposals associated with business processes. Section 3 describes the proposed approach, detailing its components and technologies used. Section 4 shows the case study "Purchase Order" with its architecture and

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modeled goals. Finally, Section 5 presents concluding considerations about the research developed.

2 RELATED WORK

The literature has various methodologies and techniques for modeling SOA applications. This section presents a few approaches that also use the business modeling associated with SOAML modeling.

Todoram et al. (2011) analyze and present how SOAML complements the UML, adding advantages for modeling services. The authors state that there is a strong possibility of SOAML being adopted on a large scale by industry and encourage further studies to create approaches in that direction (Todoran et al., 2011).

Minerva's framework was proposed by (Delgado et al., 2010) and aims automating the SOAML models' generation from business processes. Therefore, the approach integrates various paradigms such as Business Process Management (BPM), Service Oriented Computing (SOC) and Model Driven Development (MDD).

Hu et al. (2014) presented an architectural approach, modeling and simulation type for Model Driven System of Systems (SoS) based services. This approach use SysML to address the complex requirements inherent to SoS and SOAML to improve project implementation (Hu et al., 2014).

The work of Fazziki et al. (2014), proposed a Model Driven approach being intended to overcome the gap between business requirements and service-oriented architecture. The approach uses BPMN, and SOAML meta model for representing business processes in a language known by developers (Fazziki et al., 2012).

A Model Driven approach is presented in (Xu et al., 2009) with service-oriented systems described using SOAML with semantic annotations. Their approach is to create an extended version of the SAWSDL architecture and a tool that provides an notation editor. The main focus of the paper are the SOAML model, a model-based SAWSDL version and a platform independent editor.

We can find that there are several efforts in the literature aimed at achieving integration between business modeling and services-based system design. This continuity between different levels of abstraction seeks greater adhesion between the models. This lack of goals in the association between the two models can generate a gap that can hinder the identification of service requirements.

3 PROPOSED APPROACH

Requirements Engineering based on goals has been considered promising as part of several software-development processes. This section presents the proposed approach to SOA application modeling based on objective using SOAML (Service oriented architecture Modeling Language) (Berre, 2008) in conjunction with the URN (User Requirements Notation) (Amyot, 2003).

The proposal aims to establish a modeling process that makes use of the knowledge captured in the business model. Processes and organizational goals are detailed in an intermediate model that facilitates the transition to SOA application modeling. The transitions are facilitated by semantic information supported by ontologies, which are associated with various artifacts of the SOA during the application development process.

Figure 1: Proposed approach overview.

Figure 1 shows an overview of the modeling process that is premised on the existence of a business model wich will guide the creation of the following models. Service requirements are extracted based on the business model. The yellow box is the proposed approach, "Goal-oriented Modeling Approach for SOA (**GO4SOA**)" detailed in Figure 2.

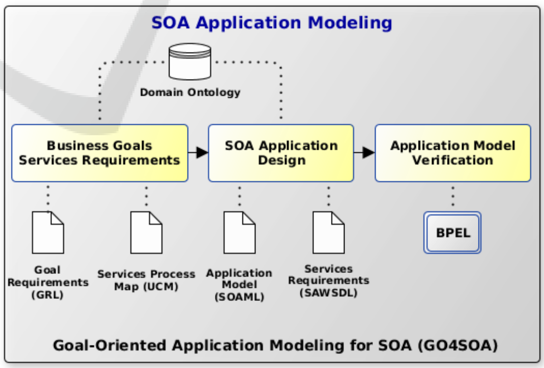

Figure 2: SOA Application Modeling (Costa, 2015).

The modeling process starts from an existing business model that serves as the basis for the preparation of SOAML model. In the presented approach, SOAML model was extended by semantic annotations using the standard SAWSDL. The semantic annotations are meant to enrich the SOAML model from specific URN goals. As shown in Figure 2, the modeling process are:

1. *Business Goals Services Requirements.* At this stage, an intermediate model that captures the business services requirements based on goals is built using URN.
2. *SOA Application Design.* SOA modeling starts with the preparation of an architectural model from the goals and processes that were detailed with the URN. It makes use of SOAML enriched with semantic annotations associated with the domain ontology;
3. *Application Model Verification.* The SOA project is implemented in BPEL for model verification purpose.

At the end of the modeling process, we have several levels of goals and services complementary models. The models artifacts are aligned according to domain ontology concepts, which facilitates tracking functions among the different abstraction levels.

3.1 Business Goals Services Requirements

The SOA modeling starts with the capture of business goals that will be reached by services based processes. Figure 3 shows "Business Goals Services Requirements" phase that uses the URN to represent in more detail the goals and processes that have been found in a macro way in business models.

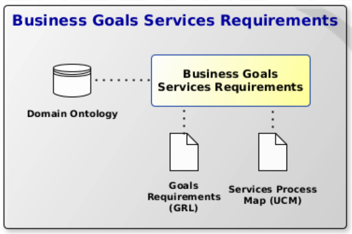

Figure 3: Business Goals Services requirements.

The URN is a visual notation that is designed to represent functional and non-functional requirements consistently. To achieve this purpose the URN consists of two graphical notations that complement each other: the GRL (Goal-oriented Requirement Language) to describe the goals and the UCM (Use Case Maps) to describe the scenarios that should perform these goals (Amyot, 2003).

The phase "Business Goals Services Requirements" has as input the business model and a domain ontology. The following activities should be performed in this process:

- Align the concepts between the business model and the ontology;
- Create the GRL diagram using as the base the business goals;
- Build the UCM diagrams with focus to achieve the goals mapped on the GRL.

This intermediate phase between the business model and the architectural design of the IT system is a differential in relation to other approaches. Without this vision, the transition between business modeling and application design can result in erroneous decisions and choices at the final model.

3.2 SOA Application Design

This modeling phase starts with the creation of an application architectural model using SOAML. As already indicated, SOAML model is annotated semantically to preserve its relationship with BPMN diagrams and UCM. Figure 4 illustrates the "SOA Application Modeling" process and its elements.

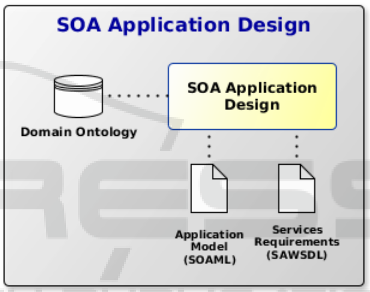

Figure 4: SOA Application Design.

To reference the SOAML model semantically with a domain vocabulary, we use SAWSDL. The business goals lists, the service capability descriptions and others' models artifacts can be supported by a domain ontology. A unified vocabulary enables alignment between service capabilities and business goals.

We chose SAWSDL based on the studies by Hobold (Hobold and Siqueira, 2012) and Sun (Sun et al., 2012). Its conclude that SAWSDL is more flexible and easier to use since it is a WSDL extension. Sun (Sun et al., 2012) also classified SAWSDL as possessing "high semantic expressivity".

In GO4SOA, the SOAML modeling is guided by URN diagrams. As we can see in Figure 4, as part of SOAML model, the semantic annotations link each model component to "service requirements" previously represented in URN.

The activities to be developed in the "SOA Application Modeling" processes are as follows:

- Build SOAML architecture from the GRL;
- Derive Service Interfaces from GRL resources, UCM maps and domain ontology;

- Develop Service Contracts from UCM maps;
- Semantically annotate the model artifacts.

This set of models, URN and SOAML semantically annotated produces a consistent design enough to support the implementation phase.

3.3 Application Model Verification

The ”Application Model Verification” modeling is shown in Figure 5. In this phase, the BPEL process is drawn from the SOAML enabling the verification of elaborated models and their adherence to business requirements.

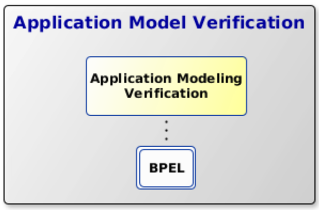

Figure 5: Application Model Verification.

BPEL processes run in a prototype environment, which enables the initial verification of previous models. Associated with BPEL requirement tracking documents can be elaborated. From BPEL with annotated WSDL, it’s possible to be listed which processes have been implemented and what services are responsible for carrying out a particular organizational goal.

The “Purchase Order” case study was developed to experiment the GO4SOA.

4 PURCHASE ORDER MODELING

The case study is a traditional “Purchase Order” application. Customer search and consulting products using an application, select items that want to buy and submit a purchase order. A company, through web services, confirms the purchase order after selected the delivery and payment mode. The following application issues an invoice and a delivery protocol for the customer.

Figure 6 illustrates the selected domain ontology that is published on the W3C site, being used by the SAWSDL standardization group as one of the rating application examples (Farrell and Lausen, 2007). The ontology describes in a simply way the fundamental concepts associated with the ”Purchase Order“ domain.

Figure 7 shows one of the processes of ”Purchase Order” modeled using BPMN notation (BPMN,

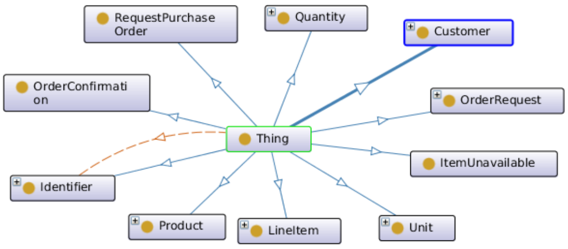

Figure 6: Purchase Order Ontology (Farrell and Lausen, 2007).

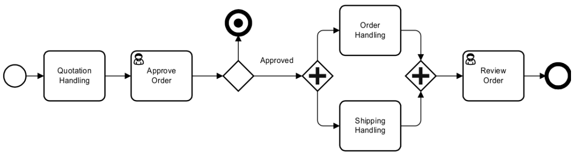

Figure 7: Purchase Order BPMN (BPMN, 2010).

2010). This is the primary process that begins with a product purchase order and ends with delivery to the customer. This BPMN diagram was used to develop a refinement of domain ontology shown in Figure 8.

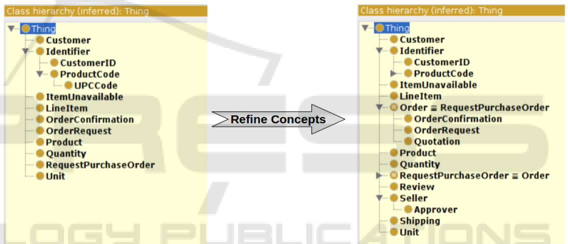

Figure 8: Refine Domain Ontology.

This refinement is to align additional concepts from business model with domain ontology. The domain ontology is extended by synonyms, new classes and properties that are perceived from the BPMN diagram in Figure 7.

At this stage, the following concepts to add to the domain ontology ”Purchase Order” were identified:

- Synonyms: Order = RequestPurchaseOrder
- New Classes: Quotation, Review, Seller, Approver;
- New Properties: hasCustomerApprover, hasProductApprover.

We point out that the original structure of the domain ontology has been preserved. The BPMN process and the refined Domain Ontology are the input for the business goals’ requirements and the SOAML modeling.

4.1 Purchase Order Business Goals

According to this approach, at this stage, from a BPMN model, GRL and UCM diagrams are prepared as intermediate models to represent the service requirements.

To model the goals using the GRL notation, it is necessary to identify the actors, their goals and macro processes that will accomplish these goals. In BPMN, Figure 7, we can identify the actors "Customer", "Seller" and "Shipper" as well as the macro processes associated with "Purchase Order". These actors and processes were associated with goals in the GRL from Figure 9.

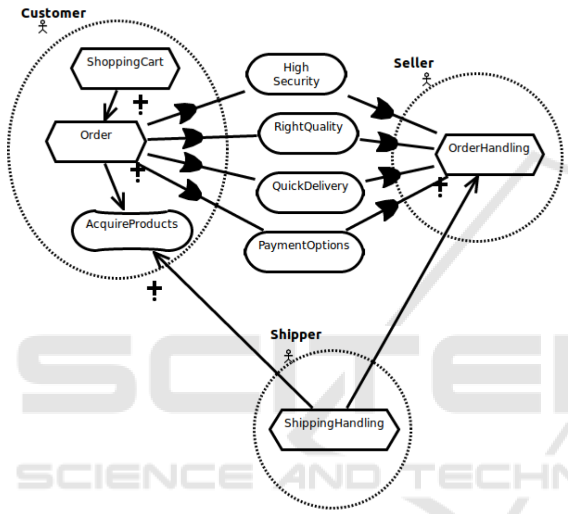

Figure 9: Purchase Order GRL diagram.

The goals were modeled and represented in the GRL diagram in Figure 9 with the processes and resources required to achieve the goals. On the border of the actors, responsibilities related to their goals are identified. The responsibilities represented in the GRL diagram are further detailed by UCM.

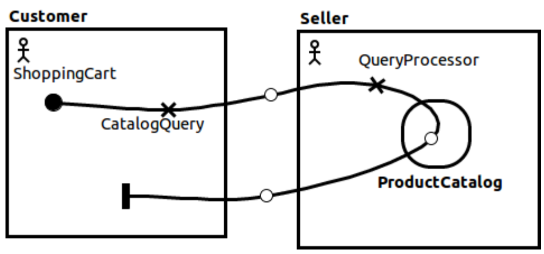

Figure 10: Shopping Cart UCM diagram.

In the GRL diagram we can see that the customer is responsible of starting two main activities, the Purchase Order itself and an earlier support activity, the Shopping Cart. The Figure 10 shows that the Shopping Cart process is a simple query to a products catalog made available by the seller.

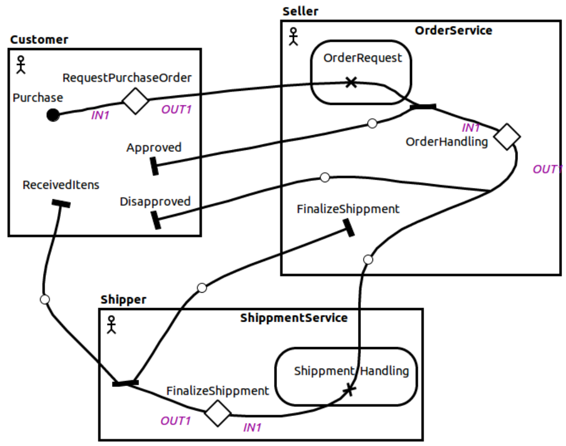

Figure 11: Purchase Order UCM diagram.

Figure 11 shows the Purchase Order process modeled on UCM already with the inclusion of references to the services to be used, for example, OrderService and ShipmentService. These services are identified from the BPMN and GRL diagrams as well as the assumption that the application uses SOA architecture.

From these perspectives represented in URN, we have the elements necessary to start SOAML modeling of "Purchase Order" application.

4.2 Purchase Order Application Design

The SOAML modeling begins with the analysis of the GRL and UCM diagrams in order to identify the capabilities that must be included in the SOA architecture model.

Figure 12 represents the main UCMs processes, Shopping Cart (Figure 10) and Purchase Order (Figure 11) as capabilities to be offered by a seller who wishes to provide services to a purchase order client. These capabilities were represented using the SOA architecture diagram: Shopping Cart, the Purchase Order and Shippment.

Additional capabilities were modeled on Figure 12 from UCMs. As the UCM is related to the GRL diagram to be responsible for proceeding with the goals, SOA application capabilities are also associated with goals through semantic annotations.

To annotate the SOAML model semantically, it was created an abstract data type based on SAWSDL standard. This abstract data type shown in Figure 13 is inserted in SOAML diagrams and stores a reference to the concept of the domain ontology, involving the element in focus on the vocabulary of the business. This semantic information is designed to main-

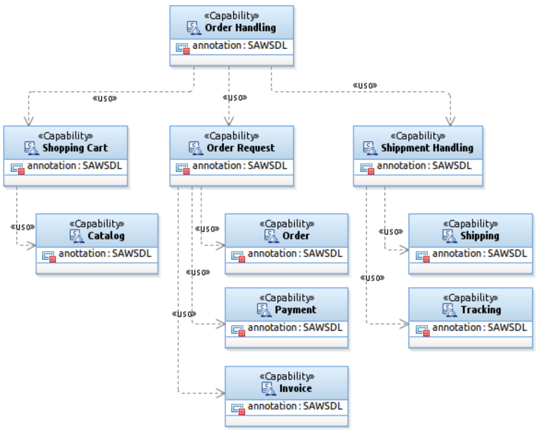

Figure 12: Purchase Order SOAML Architecture.

tain consistency between the models of application and business modeling.

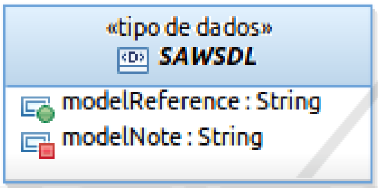

Figure 13: SAWSDL Annotation Type.

Figure 14 shows an architectural diagram of a consumer application that would be responsible for performing the client's goal of making a purchase simulation through a Shopping Cart. Diagrams of the Service Provider were prepared, Figure 12, and Services Consumer, Figure 14, so that we can demonstrate the interaction between provider and consumer in the case study.

Even from the UCM "Shopping Cart", Figure 15 shows the collaboration between a consumer application where the customer makes its electronic purchase simulation, and a provider application in which the services are provided to feed the necessary information for its Shopping Cart.

When making a reference to the UCM shown in Figure 10, we have here the division of responsibilities between two actors, the consumer and the provider. This cooperation is via a service interface, as shown in the diagram.

With the details shown in Figure 15 and contracts included in the SOAML model, we have the input needed for BPEL implementation. Some SOA modeling tools generate WSDL files from these elements that can be useful to elaborate BPEL process.

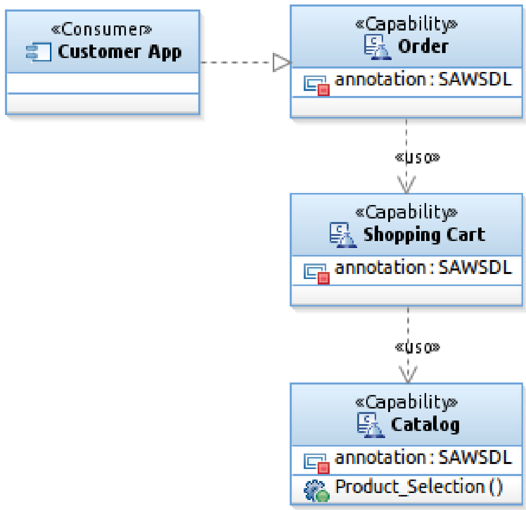

Figure 14: Customer App Capability Sample.

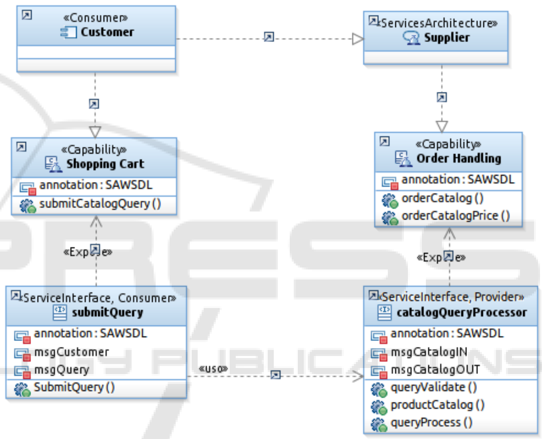

Figure 15: Purchase Order with provider.

4.3 Purchase Order Model Verification

Starting from UCM maps and SOAML diagrams, it was implemented a BPEL process for the shopping cart, as illustrated in Figure 16.

This process was simulated by the BPEL runtime environment and presented the behavior and modeled results. As BPEL uses to define service interfaces WSDL files, which in our case are annotated semantically, we can trace the implementation to business goals being realized.

4.4 Results Analysis

The case study "Purchase Order" was selected with the expectation of being achieved the following checks regarding the proposed approach:

- To explain the preservation of the objectives in the various models;

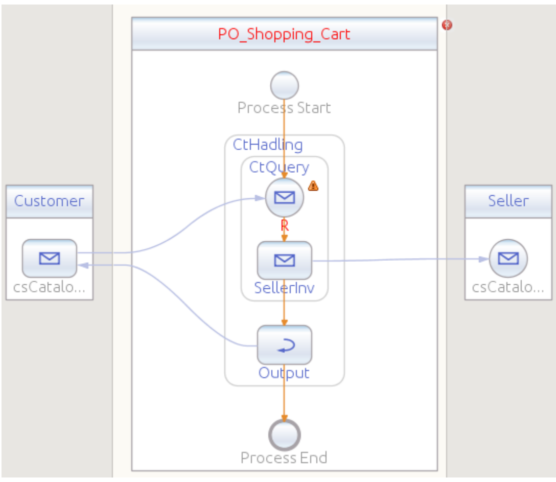

Figure 16: Shopping Cart Purchase Order BPEL.

- To ilustrate the Domain Ontology refinement;
- To explain the necessity for URN diagrams as an intermediary model between BPMN and SOA design.

The "Customer" goal of making a purchase preview using a "Shopping Cart" is present in the GRL diagram, aimed at UCM diagram as actions, in SOAML diagram as capacity and at BPEL process as a service. In these diagrams are preserved the initial goal that is always associated with the concept "Shopping Cart" of Domain Ontology.

The Domain Ontology refinement was presented, and the main focus is to make concept alignment with models developed by the addition of synonyms, classes and properties. At this point, it became clear that the original ontology was preserved in its essence and structure.

On the need for an intermediate model between business processes and application design, we can highlight some points that have been demonstrated. The URN diagrams facilitated the modeling of SOAML architecture with the discovery of capabilities from the responsibilities and the nomination of candidates to service this level of abstraction close to business processes. The association between goals and responsibilities, which is established in the URN, made possible subsequent tracking that enables the verification of the completeness of applications designed to meet business goals.

5 CONCLUSIONS

Most approaches to SOA system design end up moving away from business perspective. Designers and developers, with its technical view, lose much of the value that the business knowledge can bring to modeling applications. The service-based computing is closely linked to business goals and improve when this knowledge is part of solution to be developed.

This paper presented a new approach for modeling SOA applications based on business goals. Establish an alignment and a direct relationship between business processes and the application models is the main gain in the adoption of GO4SOA. The GO4SOA, from the point of view of the software-development life cycle, directly contributes to improve service-based application design. However, improvements in implementation can be viewed as a result of the semantic annotations.

The GO4SOA explores the business processes goals from the perspective of an SOA implementation. The insertion of URN as intermediate model is one of the approach contributions because it facilitates the transition between the business model and application design, eliminating or mitigating possible gaps between these two abstraction levels.

The modeling process is supported by a Domain Ontology. The adoption of the ontology and its evolution throughout the project contributes to the standardization and clarity of concepts and vocabulary using during the project, as well as their relationship with each other. The use of ontology as a support tool strengthens the semantics of each component of model associating to business goals.

The GO4SOA uses the URN to provide subsidies and facilitate the development of SOAML application design. Semantic annotations in SOAML artifacts relate the elements of the business domain concepts to model, enabling an understanding of the association between application and business goals. These semantic annotations enable a strong relationship between objectives, service requirements, architecture and implementation, associated to business process goals.

Thus, the GO4SOA enables a smoother transition between the various levels of abstraction preserving the knowledge and concepts through a domain ontology that is updated during the modeling process. The case study indicated that business goals are preserved on all models. This was more explicit in SOAML model with semantic annotations, enriching the architecture and providing more consistency to its elements and service descriptions. Future work includes the development of additional case studies in more complex scenarios.

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