

Semantic Mediation between Loosely-Coupled Information Models in Service Oriented Architectures

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Abstract: Managing and integrating semantic differences in heterogeneous distributed IT landscapes remains critical and cost intensive. The dominant semantic integration approach of developing a single organization-wide business information model in terms of a single shared ontology has failed. The complexity of business semantics demands for a flexible mechanism for loosely-coupling of information models and their autonomous management. This PhD thesis aims at developing a mechanism for semantic mediation between independently managed but conceptually overlapping domain ontologies. The approach will be integrated into the life-cycle of service oriented architectures (SOA) with a focus on cross-organizational integration aspects from conceptual business process modeling to runtime service execution and monitoring. A case study of an exemplary distributed organization that applies SOA will be carried out in order to evaluate and demonstrate the potential of the developed mechanism for semantic mediation.

1 Introduction and Problem Statement

Considering historically grown and heterogeneous IT systems in organizations interoperability is the enabling factor in order to achieve IT-supported business processes across intra- and inter-organizational boundaries. Thereby, interoperability can be understood along three dimensions: technical, semantic and organizational interoperability [EC03]. Although the concept of service oriented architecture (SOA) and widely accepted Web service standards have benefited technical interoperability in recent years substantially, managing and integrating semantic differences in heterogeneous distributed environments remains critical and cost intensive [VL05]. In an exemplary distributed organization such as the German Chamber of Commerce 81 decentralized sites are operated by four different IT service providers resulting in a heterogeneous IT landscape. In order to establish organization-wide business processes, existing historically grown information models need to be integrated. The semantic integration challenge further increases taking into account the various external business partners to be integrated in cross-organizational business processes.

2 State-Of-The-Art and Related Work

In order to preserve the precise meaning as data is moved from one IT system to another, ontologies have evolved as the concept of choice from academia to first industry adoption [N04]. Thereby, ontologies provide means for generating explicit formal information models as vocabularies to share between applications. However, the dominant approach of developing globally shared ontology-based standards for information models has turned out limited in real world cross-domain context. Organizational boundaries in community processes and the complexity deriving from inherent domain-specific differences in requirements force a coexistence of independently managed but however conceptually overlapping information models. Thus, ontology-based standards could only alleviate the problem of semantic heterogeneity and a mapping between ontologies originating from different contexts is needed [N04].

Considering SOA as a concept to manage complexity from a functional viewpoint in IT landscapes this concept can as well provide an approach on how to manage the complexity of semantics in distributed organizations. The core concept of SOA lies in the decomposition of complex business processes into a composition of loosely coupled independently managed services providing distinct business functionalities. The same principle of loosely coupled units can be applied to information models, in order to capture the complexity of semantics.

3 Objective and Contribution

According to this principle, this PhD thesis will develop a concept and mechanism for semantic mediation that allows for independent management of domain-specific ontologies that formalize information models of specific business domains. Thereby, these heterogeneous domain-specific ontologies are interlinked by a loosely-coupled mediation mechanism to facilitate semantic integration in cross-domain scenarios. The technology enabling the concept of semantic mediation can be based on Semantic Web technology, in particular description logic rules describing ontology mappings which are referred to as semantic bridges [BFS06]. Semantic bridges provide a declarative reasoning-based mechanism for aligning heterogeneous information models and thus ensure semantic interoperability while remaining organizational independence of information models. Given the horizontal nature of semantic interoperability, consequently, implications of the concept of semantic mediation can be derived and applied to the whole SOA life-cycle with a focus on cross-organizational aspects from conceptual business process modeling to runtime service execution and monitoring.

Objective of this PhD thesis is to develop a concept (1) for semantic mediation between loosely-coupled information models and to derive implications in order to develop a methodology (2) for applying it to the SOA life-cycle. In order to enable key steps of the methodology, a toolkit (3) based on Semantic Web technologies will be developed that provides and extends available functionality for semantic mediation, in particular the design of ontology mapping rules [RD07], their systematic testing and integration into business process modeling, service composition design and runtime execution. The methodology and the toolkit will be evaluated by reflecting it on a practical case study (4) of an exemplary distributed organization, in order to demonstrate their potential and provide a benchmark for achieving semantic interoperability in SOA.

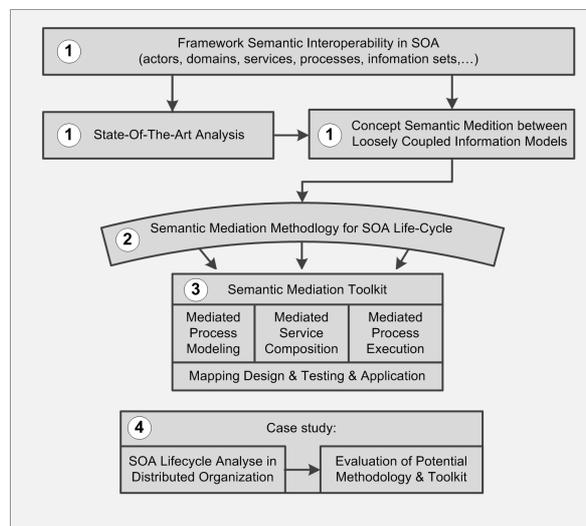


Figure 1: Structure of the thesis illustrating relations of parts (1) – (4).

The central research question is how semantic interoperability can be achieved effectively and efficiently in SOA-based distributed organization? This central research question can be further refined into the following partial research questions:

- How can semantic interoperability be conceptualized in an abstract model for organizations that apply service oriented architectures considering actors, domains, services, processes, information sets, etc. in key scenarios?
- What is the sufficient granularity of a network of loosely coupled domain-specific ontologies? How to map the structure of a distributed or virtual organization to an adequate set of domain-specific ontologies and how to relate these ontologies to each other?
- How can a specific methodology be designed for structuring the development and application process of ontologies and ontology mappings in the SOA life-cycle?
- How can an effective toolkit based on Semantic Web technology be designed to support the above-mentioned methodology and what are still limitations of the underlying technology?
- How can the potential of the developed methodology and toolkit for loosely-coupled domain-specific ontologies be qualitatively analyzed and demonstrated? How can these results be applied as a benchmark to state-of-the-art approaches for achieving semantic interoperability in SOA-based organizations?

4 Current Status

The PhD thesis is in an early stage. However, work on the concept and structure of this PhD thesis has been carried out along the last year. First results have been achieved for part (1) concept for semantic mediation, part (2) semantic mediation methodology for SOA life-cycle and part (3) semantic mediation toolkit. The results have been published at national and international research conferences such as NIA SOA Day 2008 Korea [AB08], FTWI 2008 Germany [Ba08] and ESWC 2008 Spain [BWF08].

5 Conclusion and Outlook

This PhD thesis will develop a mechanism for semantic mediation between loosely coupled information models in service oriented architectures. The approach considers multiple independent information models materialized in domain ontologies and takes into account the realistic point of view that in a system integration scenario the availability of a single global ontology covering the needs of all autonomous actors and organizations across various domains cannot be assumed. The well established paradigm of loose coupling is reflected on the semantic level by using independently evolving information models in terms of ontologies that are loosely coupled through semantic bridges. The approach aims at demonstrating that the complexity in semantic system integration can be reduced substantially for process experts and IT architects and thus fulfill the conceptual promise of SOA to enable sound alignment of business with information technology.

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