Background Ontology Used

in Ontologies Alignment to Support Integration

Process of Business Components

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Abstract

The approaches for building new information systems based on the integration of reusable components require to hide the semantic heterogeneity which needs a detecting and resolving semantic conflict. The integration systems and semantic conflict resolution are based mostly on ontology alignment techniques. In this work, we focus on semantic integration of Business Components (BC). That’s why; we rely on the ontologies alignment for resolving semantic conflict. Our contribution concerns a solution for the integration of BC based on the ontologies alignment in order to support information system designers.

Keywords: Component, Business Components, Semantic Integration, Ontology alignment.

1 Introduction

Developing new Business Information Systems (IS) from reusable components is today an approach widely adopted and used [1], [13], [5]. Using this approach includes implementation phases as well as preliminary phases of analysis and design. However, components needed during design and analysis phases are not technical but conceptual. In fact, this class of Components implements business
logic and knowledge of a domain. Components involved in analysis and design phases are commonly referred to as Business Components (BC). Many research, the last decade, have focused on how to design new IS from reusable components [1], [13]. Two ways of research in the area of the reuse are intensively explored. The first one called “design for reuse” is to develop methods and tools to produce reusable components. The second “design by reuse” is to develop methods and tools to exploit reusable components. We are concerned in this research by the second way. Literature outlines several questions when we address the topic of designing a new Information system by reusing available components. In fact, the reuse of components requires several operations such: research, selection, adaptation, composition and integration. This last operation has been identified by [1], the author also points the axis of semantic integration. In fact, Integrating into the same IS of several business components which emanate from various sources produces different conflicts both syntactic and semantic. We focus in this work on detecting and resolving semantic name conflicts encountered during the integration process of business components [14], [15] and [16]. We assume that the design of an IS intended generally a business domain and that business components model fragments of this domain. Otherwise, semantic integration systems are mostly based on the alignment of ontologies; this issue has given rise to several works [3], [14] and [15]. We relied on results of these works to support semantic integration process and have proposed semantic integration process based on the alignment of ontologies using domain ontology and a method of measuring semantic similarity [14]. However, this solution allows creating semantic relations between concepts that may generate conflicts, but does not present how to use this relationship as to achieve semantic integration. To overcome this insufficiency, we propose an extension of our semantic process integration [15], in the present work using rules derived from semantics relations detected in semantic matching process in order to generate actions for resolving conflicts. We will validate our results using a prototype that we have developed and tested on domain ontology and some BC. Our paper is organized as follow: First the problem of semantic integration of BC is presented in Section 3. Ontology alignment approach is presented in Section 4. Our proposal of BC semantic integration method is given in section 5. In section 6 an example of application presented in order to illustrate our proposal. Finally, section 7 presents the conclusion and perspectives of our work.

2 Business Components

Components based approach is considered since earliest 1990’s as a new information system development paradigm [4]. This approach aims to reduce significantly costs and cycle-time of developing software. Components based approach consists in building new systems by reusing available components. Using this approach in the earliest phases of system development presents a real
interest. According to this approach, a business IS will be built from a set of BC which are generally heterogeneous. In fact, these BC generally emanate from various sources. For example, a company trading IS could be designed from multiple BC such as: {"Sales", "Product", "Customer" etc...}.

3 Semantic Integration of Business Component

Integrating many components coming from different sources into the same IS can give rise to different types of semantic conflicts. Several researchers [11], [12] identified three types of semantic conflicts: confusion, measure and name conflicts. We are interested in the present work exclusively to name conflicts. Several research works and implementations have shown the interest and the potential applications of ontologies in the areas of software engineering, IS development [7], and semantic integration [3]. We rely on the results of this works to ensure detection and resolution of semantic conflicts between BC.

Building a business IS usually implies management domain: Trade, Finance, Human Resources etc. Ontologies describing these management domains are now available in many web sites. Moreover, components to integrate describe fragments of business knowledge in a language chosen by their designers. Several studies have focused on the transformation of BC described in modelling languages such as UML to ontologies. We have proposed [14] and [15] an integration processes that reduces the problem of semantic integration of BC to a problem of ontologies alignment. We are based on the definition proposed in [17] to define integration of business components: The integration of business components takes two components BCp and BCq and correspondence model Cpq between them as input and combines their elements into a new output component BCpq:

$$BC_{pq} = \text{integration}(BC_p, BC_q, C_{pq})$$

Integration is a binary integration, we rely on the latter to define the integration of a set of BC, denoted BC1 ... BCn, takes a set of components: BC1...BCn and correspondence model C1...n between them as input and combines their elements into a new output component BC1...n.

$$BC_{1...n} = \text{integration}(BC_1...BC_n, C_{1...n})$$

The semantic integration of BC takes a set of components: BC1...BCn and correspondence model C1...n which can be a Correspondence Ontology (CO) between them as input and combines their elements into a new output component BC1...n., which means:

$$BC_{1...n} = \text{semanticIntegration}(BC_1...BC_n, CO_{1...n})$$
We use domain ontologies for multiple reasons: Firstly, domain ontologies describe concepts related to a domain, this corresponds fully with our problem, since the design of an IS intended generally a business domain. Secondly, domain ontologies are reusable inside the same domain, this property is very interesting to consider in BC reusing, which is the central aim of design by reuse approach.

4 Ontologies alignment

Ontologies are recently initiated approach for structuring knowledge and are defined as a collection of concepts and their interrelationships, which provide an abstract view of an application domain. According to Gruber, ontology is defined as an explicit formal specification of terms of a domain and relations among them (Gruber, 1993), (Gruber, 2002). Aligning ontologies consists in establishing semantic relations among concepts of various ontologies which describe the same field of knowledge. Aligning ontologies represents a great interest in application domains that manipulate heterogeneous knowledge, such as semantic web, communication in Multi-Agent Systems, data Waterhouse, schemas/ontologies integration [6], etc. Several works on the alignment of ontologies have emerged over recent years; most of them are based on an external resource that can be either a general ontology or domain ontology [3], [6].

5 Business component integration process

Business Components provide services and / or data which are expressed in most cases, in a terminology freely chosen by their designers. Semantic integration of BC consists to attribute meaning to data and services in order to ensure their exchange between heterogeneous BC and thus to allow their integration into the same IS. We propose in this section an extension of the solution that we have presented previously in [14], [15]. Our solution allows:

- Detection and resolution of semantic name conflicts among components business to integrate into the new IS.

- Production a new BC obtained from the integration of original business components.

Our proposal relies on the results of several research projects including those on the components transformation from a component modeling language into an ontology modeling language, and those related to the alignment of ontologies [2], [3], [4], [8] and [9].

This solution consists of two complementary sub-processes:
Background ontology used in ontologies alignment

- The process of semantic pre-integration.
- The process of semantic integration.

A global description is provided in the following figure:

![Global view of Business Component integration Process](image)

**Figure 1: Global view of Business Component integration Process**

### 5.1 The process of semantic pre-integration

The objective of this process is the production of a set of semantic relation between concepts derived from the BC candidates for integration, represented by a correspondence ontology. This process consists of a process description is provided in the following:

The inputs of the integration process are:
- A set of Business Components selected by the designer in order to integrate them in the future Information system. We denote BC1,…,BCn, these BC.
- A domain ontology chosen by the designer according to the new IS domain. The domain ontology describes concepts and relations among concepts of the IS domain. The domain ontology will thereafter use to support the integration process.

The output obtained at the end of the integration process:
- Correspondence ontology (Alignment): In the first step, IS designer can use this ontology to detect and resolve semantic conflicts in a semi-automatic process. In the second step, the ontology could be reused in an automated process from the perspective of integrating BC while defining a set of integration rules derived
from the correspondence of BC. It will later be used as ontology support during the second process: the integration process.
The output of the process may be subsequently reused in another iteration to integrate new BC:
- A correspondence ontology (Alignment) can be used as enter the integration process
The pre-integration process comprises the following steps:
  1. Transformation the BC candidates for integration into ontologies
  2. Aligning ontologies obtained based on background ontology.
  3. Produce correspondence ontology.

A. Business Component transformation into ontologies.
Several research studies have focused recently on the transformation of conceptual models described in a language such as UML into models using ontology description languages such as OWL [8] and [10]. Relying on the results of these studies, each BC candidate for integration is transformed into ontology, thus bringing the problem of BC semantic integration to a problem of ontology alignment.

B. Ontologies alignment.
This step consists in aligning ontologies obtained from the transformation of BC. We use an alignment method based on domain ontology. This method is similar to ontologies alignment methods based on targeted complementary resources, also called background ontologies or support ontologies [2] and [3]. In our case, the ontology domain corresponds to that of the IS to design and from which BC to integrate are extracted. The domain ontology plays the role of targeted complementary resource and thus will be the support of ontologies alignment. This step of the process takes as input:
- A set of ontologies corresponding to each BC to alignment. These ontologies, denoted (BCOi) are outputted from the last process.
- The domain Ontology chosen to support the alignment.
The output of this process is:
- Ontology, denoted BCOr, resulting from the alignment of all BCOi ontologies submitted at input.

In order to carry out alignment we propose a method of measurement of semantic similarity which will be given the responsibility to detect and to solve naming conflicts between concepts. The method of measurement of similarity semantics, noted $\sigma$ thereafter, will be based on a method of measurement of syntactic similarity noted $\sigma'$ like on a domain ontology noted Od.
That is to say $E_{Ci}$ the set of concepts present in the ontology $O_{BCi}$ corresponding to the component $BC_i$. That is to say $EC$ the set of concepts present in all ontologies of components: $EC = \text{Union} (E_{Ci})$ $1 \leq i \leq n$. Let be $C_1$, $C_2$ two
concepts belonging to Ec. Let be Term (Ci) a function that returns the term used to describe the concept Ci.

<table>
<thead>
<tr>
<th>Syntactic similarity measuring</th>
</tr>
</thead>
<tbody>
<tr>
<td>σ' is defined as follows:</td>
</tr>
<tr>
<td>σ': EC. × Ec → {0, 1}</td>
</tr>
<tr>
<td>begin</td>
</tr>
<tr>
<td>if C1 and C2 are atomic concepts then</td>
</tr>
<tr>
<td>if Term(C1) = Term(C2) then σ' (C1, C2) = 1</td>
</tr>
<tr>
<td>else σ' (C1, C2) = 0</td>
</tr>
<tr>
<td>endif</td>
</tr>
<tr>
<td>else</td>
</tr>
<tr>
<td>C1 and C2 are composites. C1 and C2 are then written C1 = (C11, ..., C1i, ..., C1n) et C2 = (C21, ..., C2j, ..., C2n)</td>
</tr>
<tr>
<td>%</td>
</tr>
<tr>
<td>σ' (C1, C2) = 1/n (Σi j σ' (C1i, C2j)) 1 &lt;= i, j &lt;= n</td>
</tr>
<tr>
<td>endif</td>
</tr>
<tr>
<td>End</td>
</tr>
</tbody>
</table>

The method σ' proposed, thus takes value 1 when the concepts are syntactically identical and 0 in the contrary case.

**Semantic similarity measuring.**

The method of measurement of the semantic similarity between concepts, is based on the domain ontology and uses the method of measurement of the syntactic similarity σ', defined here before. Are C1 and C2 two concepts of EC, OD the domain ontology, R the set of semantic relations available in Od, and R (C1, C2) the subset of the existing relations between the concepts C1 and C2 within Od. Rod R (C1, C2) σ the method of calculating the semantic similarity is defined as follows:

<table>
<thead>
<tr>
<th>Semantic similarity measuring.</th>
</tr>
</thead>
<tbody>
<tr>
<td>σ : Ec × Ec → {0, 1},</td>
</tr>
<tr>
<td>Inputs :</td>
</tr>
<tr>
<td>- The two concepts C1 and C2 to compare semantically.</td>
</tr>
<tr>
<td>- The domain ontology DO</td>
</tr>
<tr>
<td>Outputs: 1 if C1 and C2 are synonymous similar, 0 otherwise.</td>
</tr>
<tr>
<td>begin</td>
</tr>
<tr>
<td>if (C1 and C2 ∈ DO) and (R (C1, C2) = ∅) then</td>
</tr>
<tr>
<td>% semantic similarity Measure coincides with the syntactic similarity measure %</td>
</tr>
<tr>
<td>σ (C1, C2) = σ' (C1, C2)</td>
</tr>
<tr>
<td>endif</td>
</tr>
<tr>
<td>else</td>
</tr>
<tr>
<td>if (C1 and C2 ∈ DO) and R (C1, C2) ⊃ a synonymous relation then</td>
</tr>
<tr>
<td>σ (C1, C2) = 1</td>
</tr>
<tr>
<td>else</td>
</tr>
<tr>
<td>if (C1 and C2 ∈ DO) and R (C1, C2) ⊃ an homonymous relation then</td>
</tr>
<tr>
<td>σ (C1, C2) = 0</td>
</tr>
<tr>
<td>else</td>
</tr>
<tr>
<td>σ (C1, C2) = σ' (C1, C2)</td>
</tr>
<tr>
<td>endif</td>
</tr>
<tr>
<td>endif</td>
</tr>
<tr>
<td>end.</td>
</tr>
</tbody>
</table>
C. Production of the correspondence ontology among BC
Alignment process of ontologies derived from BC candidates for integration. This process gives an output a Correspondence Ontology (CO) among the concepts of BC. Based on CO to product another Correspondence Ontology among BC (BCCO), which will later be used either as external resources or support in the semantic integration process is to support IS designers to achieve their design tasks. Each type of relationship can highlight a conflict is syntactic, semantic or structural.

5.2 Semantic integration process

The inputs of the integration process are:
- A set of business components, denoted BC1, ... BCn, selected by the designer for inclusion in the future IS.
- Correspondence Ontology among BC (BCCO) result of pre-integration process.
- A catalogue of conflict resolution rules and integration rules which includes a set of resolutions rules (for example resolution rule of homonymy conflict is the re-naming by different names).

The integration process outputs:
- A new Business Component result of the integration of a set of the BC.

The output of the process can be used later in future integrations for new components: The new Business Component result can be used as a candidate for integration with other components.

D. Production of BC result.

To demonstrate how to use correspondence ontology, we present resolution rules for naming conflicts derived from semantic relation: homonym and synonym existing in correspondence ontology result of our process.

**Conflict Resolution Rule 1:** if we have a semantic relation type synonym in the correspondence ontology between concepts of sources ontologies, we offer IS designer to rename the concepts with same name.

**Conflict Resolution Rule 2:** if we have a semantic relationship type homonym in the correspondence ontology between concepts of sources ontologies, we offer IS designer to rename the concepts with different names.

Based on correspondence ontology and the conflict resolution rules, we offer IS designer a decisions set represented by derived operations set. For example, if exist a relationship type synonym in correspondence ontology then find in the catalogue the resolving conflicts (conflict resolution rule 1), then propose to IS designer an operation “rename” one of concepts in conflicts and merge the two concepts or delete one of the concepts.
6 Illustrations

In order to validate our proposal, we give an example. The example is based on a fragment of ontology (figure 5) and two components (figures 6 and 7) all relating to the field of “medical visits management”. The fragment of ontology represents the domain ontology which will be used to support the semantic integration process. The business components noted BC1 and BC2, described in UML, represent the components candidates to semantic integration.

![Figure 5: Fragment of the “medical visits management” domain ontology](image)

**Figure 5: Fragment of the “medical visits management” domain ontology**

**Step n°1: Transformation of BC1 and BC2 into ontologies.**

We apply the transformations recommended in [9] and [10] for the transformation of BC1 (resp. BC2) towards OBC1.

![Figure 6: First Business Component BC1 to integrate.](image)
Ontology(OBC1)
(Class Marketing Department partial restriction(partOfsomeValuesFrom(Company))
(Class Sales Department partial restriction(partOfsomeValuesFrom(Company))
(Class Laboratory partial restriction(partOfsomeValuesFrom(Company)))
(Class Delegated medical partial restriction(partOfsomeValuesFrom(Laboratory))
(Class Medical Product partial restriction(partOfsomeValuesFrom(Laboratory)))
(Class Research Team partial restriction(partOfsomeValuesFrom(Laboratory)))

The transformation of BC1 into ontology generates the ontology OBC1 hereafter:

![Figure 7: Second Business Component BC2 to integrate.](image)

Ontology(OBC2)
(Class Marketing Department partial restriction(partOfsomeValuesFrom(Company)))
(Class Sales Department partial restriction(partOfsomeValuesFrom(Company)))
(Class Manager partial restriction(partOfsomeValuesFrom(Company)))
(Class Workshop partial restriction(partOfsomeValuesFrom(Company)))
(Class medical representative partial restriction(partOfsomeValuesFrom(Workshop)))
(Class Research Team partial restriction(partOfsomeValuesFrom(Workshop)))

The transformation of BC2 into ontology generates the ontology OBC2 hereafter:

**Step n° 2: semantic integration and obtaining OBCr**

Ontology OBC1 generated from component BC1 comprises a concept called “Laboratory”. Ontology OBC2 resulting from the component BC2 comprises a concept called “Workshop”. The two concepts belong to the domain ontology. (C1 and C2 OD) without admitting semantic relation between them (R (C1, C2) =Ø) The two concepts having child sub-concepts “Medical Representative” and “Research team” are similar; we can deduce that “Laboratory” and “Workshop” are synonymous. A new relation “synonymy” is detected. The calculation of σ (“workshop”, “laboratory”) then gives value thus the concepts “Laboratory” and “Workshop” thus will be linked by the synonymy type semantic relation. This relation is then added in OBCr ontology. Figure bellow presents the result of this processing.
Step n° 3: Obtaining the integration process result BCr.

At this step, designers can, as appropriate:
- Rely on OBCr ontology to note that BC1 and BC2 are synonymous; and to then choose BC1 or BC2 to use it in their new IS.
- Automatically transform OBCr ontology into a business component BCr. Figure bellow describes the resulting component BCr.

![Business Component BCr](image)

<table>
<thead>
<tr>
<th>Ontology(OBCr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Class Marketing Department partial restriction(partOfsomeValuesFrom(Company)))</td>
</tr>
<tr>
<td>(Class Sales Department partial restriction(partOfsomeValuesFrom(Company)))</td>
</tr>
<tr>
<td>(Class Manager partial restriction(partOfsomeValuesFrom(Company)))</td>
</tr>
<tr>
<td>(Class Workshop partial restriction(partOfsomeValuesFrom(Company)))</td>
</tr>
<tr>
<td>(Class Research Team partial restriction(partOfsomeValuesFrom(Workshop)))</td>
</tr>
<tr>
<td>(Class medical representative partial restriction(partOfsomeValuesFrom(Workshop)))</td>
</tr>
<tr>
<td>(Class medical Product partial restriction(partOfsomeValuesFrom(Workshop)))</td>
</tr>
</tbody>
</table>

Figure 8: The Business Component BCr resulting from integration

“Laboratory” and “workshop” are synonym then find in the catalogue the resolving conflicts (conflict resolution rule 1), then propose to IS designer an operation “rename” one of concepts in conflicts, merge the two concepts or delete one of the concepts. Is the same for “Delegated medical” and “medical representative”.

CONCLUSIONS

Our research lies within the scope of information systems engineering by re-use. We were interested more precisely in the resolution of semantic conflicts of naming type encountered during the re-use of business components in the analysis and design phases of new information systems. Our proposal is an application of domain ontologies to design IS by re-using conceptual business components; it consists of a three-step process. The first and last step concerns the transformation of conceptual representations of business components into ontological
representations and reciprocally. The second step, which constitutes the fundamental part of our work, consists of a method of calculating semantic similarity; it is based on the results of recent works on the ontologies alignment based on domain ontologies. An example of application has illustrated our proposal. We think firstly to continue this work by a formal validation of the solution, and then by the research of the possibilities of extending it to solve other types of semantic conflicts, in particular measurement and confusion conflicts.

References

systèmes d'information », thèse de doctorat à l’institut polytechnique de
grenoble, le 26 Septembre 2009.

integration of business components” International journal of computer science
& information Technology (IJCSIT), ISSN:0975-3826 (Online); 0975-4660
(Print), February 2010

integration of Business Components » IEEE NOTERE 2011, 11th annual
International Conference on New Technologies of Distributed Systems, 9-13
May 2011, Paris, France,

[16] Larbi Kzaz, Hicham Elasri, Abderrahim.Sekkaki « Résolution des conflits
sémantiques pour l’intégration des composants métier » 4es Journées
Francophones sur les Ontologies – JFO’11, 22 – 23 Juin 2011, Montréal,
Canada

[17] Jean Bézivin, Salim Bouzitouna, Marcos Didonet Del Fabro, Marie-Pierre
Gervais, Frédéric Jouault, Dimitrios S. Kolovos, Ivan Kurtev, Richard F.
Paige "A Canonical Scheme for Model Composition" EBCDA-FA 2006:
Bilbao, Spain.

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