BUSINESS CONTEXT SENSITIVE BUSINESS DOCUMENTS: AN ONTOLOGY BASED BUSINESS CONTEXT MODEL FOR CORE COMPONENTS

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Abstract

One and the same inter-organizational business process - such as e-procurement - may be executed differently in different industries, geopolitical regions, etc. Thus, a standardized reference model for inter-organizational business process must be customized to the specific business context (industry, region, etc.). In order to share, search, and (partially) re-use context specific adaptations it is essential not only to store the adaptations, but also a business context model where these adaptations are valid. Therefore, we present our ontology based business context model and explain how it can be applied to generic models of semantically interoperable data blocks, so-called Core Components. Core Components are standardized by the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT), and their adaptations are exchanged between business partners in the course of inter-organizational business processes. If we could assign a business context to a business process, we could prevent negative trends in today's business, such as interoperability issues, inconsistencies and heterogeneous interpretations of the interchanged electronic business documents.

I. Introduction

Today, there is not a uniform modeling approach to represent the circumstances in which business processes are or are not relevant. Thereby, it is very difficult to describe, explain and to predict the execution flows of different business scenarios. More precisely, in our research these scenarios address the particular domain of inter-organizational business processes where business documents are exchanged between business partners thereby synchronizing their own private business processes. In such complex business systems, for example, being able to speed up a procedure of creating interchanged electronic documents, to ease management of business chains or to re-use already existing business solutions are possible steps to reduce the material expenses, time delays, operational costs and human efforts. Therefore, we argue, that the main prerequisite to foster management operations of the business processes is to provide a new approach to formally represent Business Context (BC) where these processes are executed.

We describe BC as metadata that specify a situation (industry, geopolitical location, etc.) in which some particular business process is or is not executable. In this paper we define BC more precisely and we show our new modeling approach to formally express its structure. The starting foundations of our research originate from the work which is already done in the field of the Semantic Web techniques. Accordingly, ontology based context modeling is today applied to model different scopes of context, such as the context which is relevant to the pervasive systems [1], smart environments [2], ubiquitous robots [3], home health monitoring [4] and mobile devices [5]. In the following we research further whether the ontology based modeling approach could be harnessed to model the BC particularly. In this vein, we present our Business Context Ontology based model (BCOnt) and explain its beneficial characteristics, such as reasoning mechanism, high degree of formalism, knowledge sharing and capabilities of dynamic interrelations with external ontologies. We especially highlight the application of the business contextual information in the domain of the semantically interoperable data building blocks, so-called Core Components, which are encompassed by business documents. These documents conform to the UN/CEFACT's Core Components based business document standards [6], and they are exchanged between business partners in the course of inter-organizational business processes.

The remainder of the paper is structured as follows. First, Section II presents our BC definition and gives an overview of the UN/CEFACT's Core Components based business document standards. In Section III we highlight the benefits of the ontology based modeling approach and propose our BC model. In Sections IV we show the application of the BC model in the real-world example. Finally, Section V concludes the paper and gives an outlook on future work.

II. Related Work

A. Business Context

The relevant scientific literature ([7], [8], etc.) describes context as an *enumeration of examples*, such as: location, time, temperature, or in terms of *relevant synonyms*, such as: user's environment, application surroundings, user's situation. Starting from the outcomes of our general BC survey presented in [9] and considering one of the most applied context understandings proposed by Dey and Abowd [7], we have defined BC in the following way: *BC is any information that can be used to characterize the situation of an entity within a scope where business operates. An entity is a person, place, or object that is considered relevant to the interaction between a business process and a business environment, including the business process and business environments themselves.*

The entities which are introduced by our BC definition can be described by different attributes, where each of these attributes can be grouped into one of the primary BC categories. Our research [9] shows that we can distinguish between three primary BC categories which are particularly important for the characterization of BC, namely location, industry and activity. In the following these categories serve as a basis for providing contextual metadata on electronic business documents exchanged in the course of inter-organizational business processes. For example, a piece of an information which encompasses a specific geopolitical region with a specific industry branch, for example: Macedonia and the Book industry, Austria and the DVD industry, or Germany and the Aircraft industry, can be used to describe the situation of the business documents which are involved within a particular user activity, such as invoice order, purchase order and goods receipt. An atomic piece of knowledge that represents one aspect of the BC (industry, location or activity) represents a BC value.

B. *Business Document Standards*

The United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) is an intergovernmental body established by the United Nations. It proposes Core Components Technical Specification (CCTS), the methodology which main aim is the standardization of business documents for electronic interchange.

CCTS introduces a Core Component business document modeling approach. Accordingly, every business document consists of business data which are encompassed by semantically interoperable data building blocks. CCTS distinguishes between two primary concepts: Core Components (CCs) and Business Information Entities (BIEs). The corresponding example is shown in Fig. 1. CCs represent conceptual data model components for the creation of business documents that are not specific to any particular BC. Thereby, they can be used in any business scenario. CCs consist of three main entity types: Basic Core Components (BCCs), Aggregated Core Components (ACCs) and Association Core Components (ASCCs). A BCC is a piece of information which is located in a business document. Each ACC represents a collection of BCCs. Relations between ACCs are established by ASCCs. On the other hand, BIEs are logical data model components which have assigned BCs. Thereby, they are used in a context specific business scenario. Each BIE is d*erived by restriction* from a CC. Correspondent to the CC concept, building elements of each BIE are: Basic Business Information Entities (BBIEs), Aggregated Business Information Entities (ABIEs) and Association Business Information Entities (ASBIEs). In the following of this paper we consider that communication models established between inter-organizational business processes conform to CCTS.

III. Ontology Based BC Model

Today, ontologies are a widely exploited modeling approach which is used in different domains, such as home smart environments [2], medicine [4] and tourism [5]. In a nutshell, an ontology describes the concepts (entities, classes) in some particular domain and the relationships that hold between them. A concept is presented as a set of individuals (facts) which share common properties. More complex concepts are defined by derivation from simpler concepts.

Ontologies are formally expressed by a knowledge representation language, such as the Web Ontology Language (OWL) [10], Ontolingua [11] and LOOM [12]. It is essential

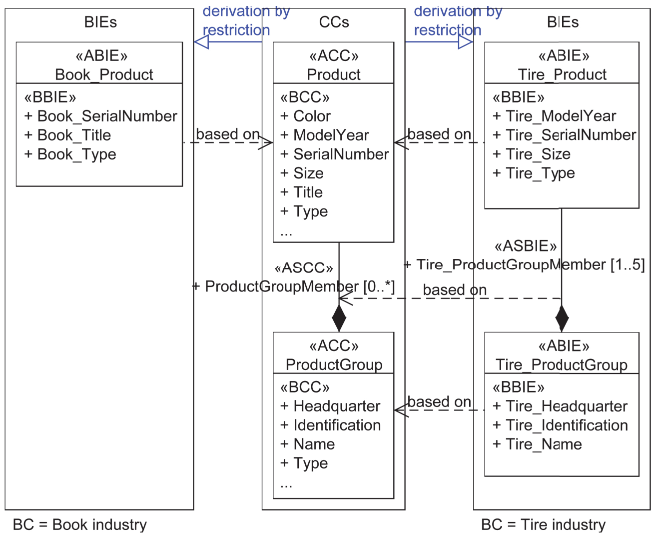

Figure 1: Overview of the CCTS business document standard.

that these languages provide a support for reasoning. Nowadays, there are tools known as reasoners developed especially for this purpose. Reasoners can check automatically whether the concepts and the corresponding definitions are or are not consistent. Moreover, they can maintenance and classify all concepts from an ontology into the hierarchical structures. Finally, concepts defined in different ontologies can be interrelated. Thus, knowledge from different ontologies can be interwoven by the Linked Open Data (LOD) techniques [13].

A. *Ontology and BC Domain*

Strang and Linnhoff-Popien in [8] conclude that ontologies are the most promising approach to model context in ubiquitous environments. The other relevant authors ([1], [2], [3], [4], [5], etc.) have widely accepted this opinion. Moreover, they present new outcomes which underpin it even more. On the other hand, our corresponding investigation [9] has shown that the uniform technique to model context does not exist and that the choice of the most proper context modeling approach strictly depends on a domain specific nature of the context. However, (i) the domain specific nature of the BC, (ii) the explained benefits of the ontology based modeling approach and (iii) the opinion of the relevant scientific community strongly implicate that exactly ontologies could be a constructive choice to model the BC in the scope of the interchanged electronic business documents which conform to the UN/CEFACT standard.

B. *Ontology Language for BC Modeling*

In our work we use OWL to develop the ontology based BC model. Our choice of the ontology language is underpinned by the following reasons. First, OWL is a family of the formal knowledge representation languages which application is strongly recommended by the World Wide Web Consortium (W3C). Second, it is built on the foundations of RDF Schema (RDF-S), the Resource Description Framework (RDF) and Extensible Markup Language (XML). Thus, BCs expressed by OWL can be serialized and shared. Third, OWL provides

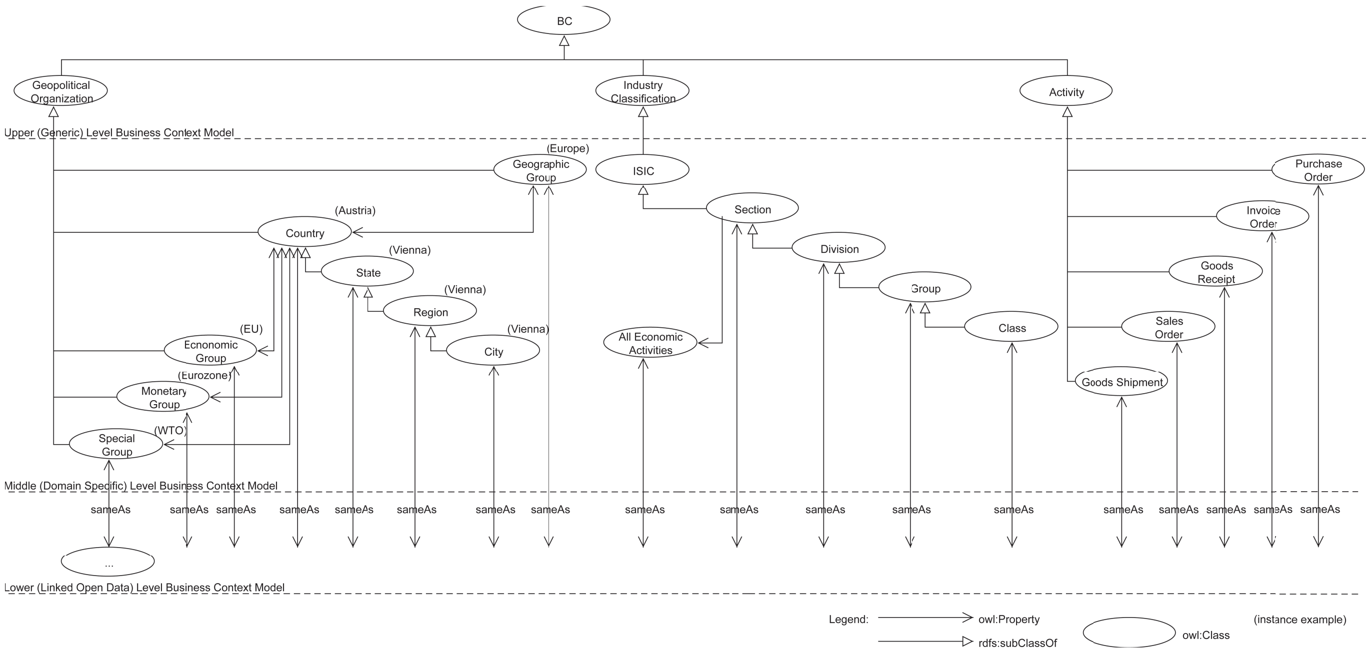

Figure 2: BCOnt ontology model.

a capability to semantically interconnect different ontologies by interrelating their formally expressed concepts, attributes, relations or individuals. Thereby, interoperability issues can be easily undermined. Finally, OWL provides a support for reasoning. More precisely, the OWL family consists of three increasingly expressive and decreasingly decidable sublanguages: OWL-Lite, OWL-DL and OWL-Full. In our research we apply OWL-DL. It is more computationally complete than OWL-Lite and, in opposite to OWL-Full, all computations are guaranteed to be finished in finite time.

C. Business Context Ontology

Business Context Ontology (BCOnt) is the model which we have developed to formally represent BC. It is the OWL based ontology composed by the following elements: classes, individuals and properties. Classes are concrete representations of concepts or groups of concepts with similar characteristics. They are organized in a superclass-subclass hierarchy (taxonomy). Individuals are instances of classes, and they are related by properties. We present the BCOnt model in Fig. 2. Accordingly, this is the three level ontology model which comprises the upper, middle and lower level.

The upper level of BCOnt is a high level ontology which describes general concepts of BC. It is implemented by the classes: *GeopoliticalOrganziation*, *IndustryClassification* and *Activity*. Correspondent to our BC definition presented in Section II, these classes encapsulate domains restricted by the location, industry and activity BC categories, respectively.

The middle level of BCOnt encompasses more domain specific subontologies which sharp concepts introduced by the upper level. First, we specify the geopolitical domain by the BCFAO subontology. It is based on the corresponding classification introduced by the Food and Agriculture Organization of the United Nations (FAO) [14]. According to its general specification, the FAO geopolitical ontology has been developed to facilitate data exchange and sharing in a standardized manner among systems managing information about countries and/or regions. Second, we implement the industry domain of BCOnt by the BCISIC subontology. It is based on the International Standard Industrial Classification of All Economic Activities (ISIC) [15], proposed by the United Nation Statistics Division. We have decided to use the FAO and ISIC foundations to develop the middle level subontologies of BCOnt due to the following reasons: (i) both of these approaches are today the most complete and worldwide accepted classifications, and (ii) FAO, ISIC and UN/CEFACT are all standardized and propagated by the same institution, the United Nations. Finally, as shown in Fig. 2, the Activity subontology is the third middle level subontology of BCOnt. It extends the upper level ontology with all possible user activities.

The lower level of BCOnt is the collection of the subontologies which refer to the more specific details of the more general concepts implemented in the upper levels. In respect to the particular business context, these subontologies can be plugged in or unplugged from the model. Furthermore, this level provides an extension point to LOD. Thus, every concept defined by BCOnt can be related to the equivalent concept defined by some other external ontology, such as DBpedia [13] and FOAF [13]. This is achieved by the LOD connection techniques, such as *owl:sameAs* property, as shown in the example in Fig. 3.

We implement BCOnt model by the Protégé modeling tool. It is a free, open-source ontology editor and knowledge base framework. We have chosen Protégé due to its support to the OWL languages, plug in extension possibilities, built in reasoners, excellent documentation, user friendly interface and its ease of use. A screenshot of the BCOnt modeling by Protégé

```
<owl:NamedIndividual rdf:about="http://isicontology.owl#Austria">
      <rdf:type rdf:resource="http://isicontology.owl#Europe" />
      <owl:sameAs rdf:resource="http://dbpedia.org/page/Austria" />
      <owl:sameAs rdf:resource="http://data.nytimes.com/66221058161318373601" />
      <foaf:homepage rdf:resource="http://www.bundeskanzleramt.at/" />
      <foaf:name>Republic of Austria</foaf:name>
      ...
</owl:NamedIndividual>
```

Figure 3: BCOnt ontology and Linked Open Data.

is shown in Fig. 4.

D. BC Reasoning

The reasoning capabilities are essential benefits of the ontology based modeling. Thereby, in our research we try to harness them in order to derive new implicit business contextual knowledge. We apply two types of reasoning: (i) ontology based and (ii) rule based reasoning. Both of these techniques are implemented by the reasoning rules which are expressed using the Description Logic (DL) [16] syntax.

The ontology based reasoning mechanism is applied to acquire an implicit business contextual knowledge by following the existing reasoning rules. These rules are integrated in respect to the semantics of the used OWL language, for example: subclass relation (*rdfs:subClassOf*), equality relation (*owl:sameAs*), and functional property (*owl:FunctionalProperty*). In our work we use ontology based reasoning to build class taxonomy and check consistency of the concepts. For example, if Austria is a subclass of the European Union and the European Union is a subclass of the World Trade Organization, the ontology based reasoning mechanism can infer that Austria is also the subclass of the Word Trade Organization. This can be formally expressed by the following rule: *(?A rdfs:subClassOf ?B)* $\sqcap$ *(?B rdfs:subClassOf ?C)* $\Longrightarrow$ *(?A rdfs:subClassOf ?C)*.

The rule based reasoning follows the reasoning rules which are not included by the OWL semantics. These rules are explicitly defined by users. In our work we use this approach to infer a high level information from the low level information which holds in a specific BC. For example, if Austria is a subclass of the European Union and if there is the rule that the standard VAT rate in the European Union is 20%, the reasoning mechanism can infer that the standard VAT rate in Austria is also 20%. This is formally expressed by the following rule: *(?A rdfs:subClassOf ?B)* $\sqcap$ *(?B owl:hasStandVAT ?C)* $\Longrightarrow$ *(?A owl:hasStandVAT ?C)*.

Generally speaking, one of the most important shortcomings of the ontology based modeling approach is that reasoning involves calculation intense tasks. In particular, the performances of reasoning strictly depend on the size of the ontology knowledge base and CPU power. In our work we do not search for a new solution for better utilization of the CPU performances. However, we undermine the first obstacle in the following way. As already explained, BCOnt comprises the three level model structure which consists of the domain specific subontologies. These subontologies can be interwoven with the dynamically pluggable LOD elements. Thereby, BCOnt contains only those conceptual elements which are relevant to the current business scenario. Thus, during runtime the BC knowledge database covers only the domain which is necessary for applying reasoning restricted to the particular business processes.

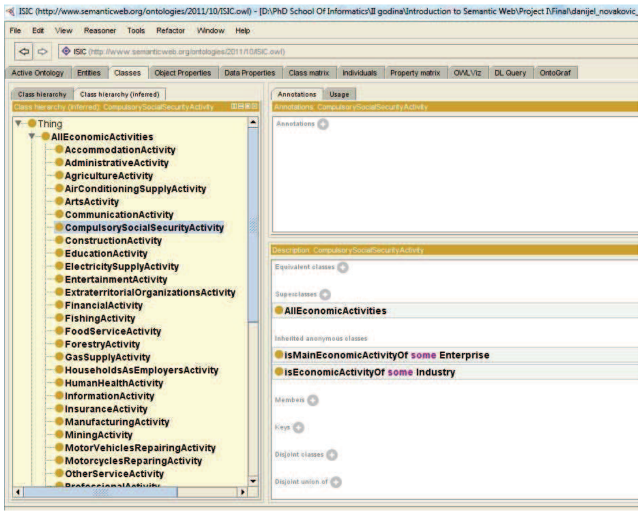

Figure 4: Protégé - BCOnt modeling screenshot.

IV. Application Example

We show the application of the BCOnt model on the CCTS entities (ABIEs, BBIEs and ASBIEs) in the following. For reasons of simplicity, we discard the activity BC category and consider only the location and industry categories. The specific BC values are expressed using the DL syntax. The runtime BC of a BIE very often is not the same as the assigned BC. Thereby, in the following we refer to runtime BC as overall BC. The used BIEs are already introduced in our previous example described in Fig. 1.

As illustrated in Fig. 5, Mark 1, BBIE1 and BBIE2 are given. The BBIE1 is a piece of information which refers to the type of a tire valid in the European Union. The BBIE2 is a piece of information which refers to the size of a tire valid in Japan. Thus, the BBIE1 has the assigned BC $(\equiv EU) \sqcup (\equiv Automotive)$ and the BBIE2 has the assigned BC $(\equiv Japan) \sqcup (\equiv Automotive)$.

In the next step, Fig. 5, Mark 2, the BBIE1 and BBIE2 are covered by the ABIE1. The ABIE1 comprises the pieces of information which specify a tire product. Generally speaking, an ABIE does not have an assigned BC. The overall BC of an ABIE is dependent and, thus, calculated based on the union of the overall BCs of the included BBIEs and ASBIEs. Hence, the calculated BC of the ABIE1 is expressed as: $((\equiv EU) \sqcup (\equiv Japan)) \sqcup (\equiv Automotive)$.

As illustrated in Fig. 5, Mark 3, the ABIE1 is associated by the ASBIE1 and ASBIE2. They relate the group of tire products with the specific tire products. However, in our case the ASBIE1 and ASBIE2 are valid in different geopolitical regions (Europe and Asia, respectively). Thereby, the ASBIE1 has the assigned BC $(\sqsubset Europe)) \sqcup (\equiv Automotive)$ and the ASBIE2 has the assigned BC $(\sqsubset Asia)) \sqcup (\equiv Automotive)$. Generally speaking, the overall BC of an ASBIE is dependent, and, thus, calculated based on the intersection of its assigned BC and the overall BC of the associated ABIE. Hence, the

❶ BBIEs
BBIE1 = BBIE_EU_Tire_Type
$BBIE1_{assignedBC}$ = (≡ EU) ⊔ (≡ Automotive)
BBIE2 = BBIE_Japan_Tire_Size
$BBIE2_{assignedBC}$ = (≡ Japan) ⊔ (≡ Automotive)

❷ ABIE
ABIE1 = ABIE_Tire_Product
$ABIE1_{overallBC}$ = $BBIE1_{assignedBC}$ ⊔ $BBIE2_{assignedBCs}$
= ((≡ EU) ⊔ (≡ Japan)) ⊔ (≡ Automotive)

ABIE1	ABIE_ Tire_Product	
	(overall) BC = ((≡ EU) ⊔ (≡ Japan)) ⊔ (≡ Automotive)	
	BBIE1	BBIE_EU_Tire_Type
		(assigned) BC = (≡ EU) ⊔ (≡ Automotive)
	BBIE2	BBIE_Japan_Tire_Size
		(assigned) BC = (≡ Japan) ⊔ (≡ Automotive)

❸ ASBIEs
ASBIE1 = ASBIE_Europe_Tire_ProductGroupMember
$ASBIE1_{assignedBC}$ = (⊏ Europe) ⊔ (≡ Automotive)
$ASBIE1_{overallBC}$ = $ASBIE1_{assignedBC}$ ⊓ $ABIE1_{overallBC}$ = (⊑ EU) ⊔ (≡ Automotive)
ASBIE2 = ASBIE_Asia_Tire_ProductGroupMember
$ASBIE2_{assignedBC}$ = (⊏ Asia) ⊔ (≡ Automotive)
$ASBIE2_{overallBC}$ = $ASBIE2_{assignedBC}$ ⊓ $ABIE1_{overallBC}$ = (⊑ Japan) ⊔ (≡ Automotive)

ASBIE1	ASBIE_Europe_Tire_ProductGroupMember		
	(assigned) BC = (⊏ Europe) ⊔ (≡ Automotive)		
	(overall) BC = (⊑ EU) ⊔ (≡ Automotive)		
	ABIE1a	ABIE_ Tire_Product	
		(overall) BC = ((≡ EU) ⊔ (≡ Japan)) ⊔ (≡ Automotive)	
		(effective) BC = (⊑ EU) ⊔ (≡ Automotive) ❹	
		BBIE1a	BBIE_EU_Tire_Type
			(assigned) BC = (≡ EU) ⊔ (≡ Automotive)
			(effective) BC = (⊑ EU) ⊔ (≡ Automotive) ❹
		BBIE2a	BBIE_Japan_Tire_Size
			(assigned) BC = (≡ Japan) ⊔ (≡ Automotive)
			(effective) BC = ⊥ ❹
ASBIE2	ASBIE_Asia_Tire_ProductGroupMember		
	(assigned) BC = (⊏ Asia) ⊔ (≡ Automotive)		
	(overall) BC = (⊑ Japan) ⊔ (≡ Automotive)		
	ABIE1b	ABIE_ Tire_Product	
		(overall) BC = ((≡ EU) ⊔ (≡ Japan)) ⊔ (≡ Automotive)	
		(effective) BC = (⊑ Japan) ⊔ (≡ Automotive) ❹	
		BBIE1b	BBIE_EU_Tire_Type
			(assigned) BC = (≡ EU) ⊔ (≡ Automotive)
			(effective) BC = ⊥ ❹
		BBIE2b	BBIE_Japan_Tire_Size
			(assigned) BC = (≡ Japan) ⊔ (≡ Automotive)
			(effective) BC = (⊑ Japan) ⊔ (≡ Automotive) ❹

Figure 5: BCOnt applied on a CCTS based business document.

ASBIE1 has the overall BC $(\sqsubseteq EU)) \sqcup (\equiv Automotive)$ and ASBIE2 has the overall BC $(\sqsubseteq Japan)) \sqcup (\equiv Automotive)$. Consequently, the overall BC of the ABIE1 and the overall BCs of its BBIEs are effectively narrowed. This is illustrated by the effective BCs shown in Fig. 5, Mark 4. In particular, the effective BC of some BBIE may be null (indicated by $\perp$ in the example). Thereby, these BBIEs are not relevant in the particular business scenario and, thus, they should be excluded from the corresponding business documents.

V. Conclusion and Future Work

In this paper we described our BCOnt model to formally represent BC of the electronic business documents. These documents conform to the CCTS document standard. They are exchanged between business partners in the course of inter-organizational business processes.

BCOnt is the extensible OWL based BC model enabling the automatic classification of concepts, reasoning (ontology based reasoning and rule based reasoning) and knowledge sharing. It is based on the three level subontology structure. Thus, it is possible to extend the model with the external pluggable elements. These elements can be defined in different ontologies located in the scope of LOD. Thereby, during runtime BCOnt covers only those concepts which are necessary to specify the particular BC domains of the current business scenario.

The example in Section IV shows how business contextual information can be applied on the Core Components. This serves as a basis for the next steps of our research. In particular, we apply the contextual knowledge for extracting only those BIEs from existing documents which are relevant in a given BC. Consequently, these entities are re-used for generating new context-specific and customized business document models. The described research is financially supported by the Vienna PhD School of Informatics [17].

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