TOWARDS ONTOLOGY BASED E-BUSINESS STANDARDS

Bahareh Rahmanzadeh Heravi, David Bell, Mark Lycett
Department of Information Systems and Computing, Brunel University, Uxbridge, London, UB8 3PH, U.K.
{Bahareh.Heravi, David.Bell, Mark.Lycett}@brunel.ac.uk

Stephen D. Green
Document Engineering Services, Cambridgeshire, CB6 2AP, U.K.
stephen.green@documentengineeringservices.com

David Snelling
Fujitsu Laboratories of Europe Ltd., Hayes Park Central, Hayes, Middlesex, UB4 8FE, U.K.
david.snelling@uk.fujitsu.com

Keywords: e-Business Standards, B2B Process, Ontology, Semantic Web, Semantic Standards, Standard Development.

Abstract: e-Business standards are recognised as one of the most important drivers of Business to Business Integration. These standards seek to provide unambiguous specifications for error-free exchange of documents and information between trading partners. These standards are however, syntax based and do not guarantee semantic interoperability between partners. This paper proposes the utilisation of semantic web technologies in the standards development process, aiming at developing more robust and at the same time flexible e-Business standard. In order to extract the requirements of an ontology based standard, a combined top down and bottom up approach has been adopted. This resulted in developing two ontologies: one for e-Business standards in general and one for ebXML Business Process Specification Schema (ebBP) as a specific e-Business standard. The challenge is to address the distance between these two ontologies and explore how ontologies can be utilised in developing next generation e-Business standards. It is believed that ontology based e-Business standards will enhance interoperability between organisations involved in value networks and also may facilitate the standard development process itself.

1 INTRODUCTION

Inter-organisational collaborations are effective means of gaining competitive advantage and improving effectiveness for today's organisations. In such an environment, collaborating parties' business processes and their associated documents need to be understood and aligned across organisational boundaries. E-business standards are traditionally used for achieving interoperability between trading partners and aimed at error-free exchange of documents and information. E-business standards, however, only provide syntactic and not semantic interoperation, since they are mainly based on XML, whose provision for semantic knowledge sharing is particularly restricted.

Singh, Iyer and Salam (2005a) provide a vision for Semantic e-Business which is based on Tim Berners-Lee's Semantic Web vision (Berners-Lee, Hendler & Lassila, 2001). In this vision, semantic e-Business is introduced as an approach to managing knowledge for the coordination of e-Business processes through the systematic application of Semantic Web technologies (Singh, Iyer & Salam, 2005b). They argue that Semantic e-Business will be enhanced through more rigorous information and knowledge exchange. Ontologies can capture the definitions and interrelationships of concepts in a variety of domains, resulting in a shared understanding of the domain, which is indeed the ultimate goal of e-Business standards.

This paper explores the intersection of the e-Business standards and the ontologies, with the aim of improving e-Business standards, which in turn better facilitate B2B integration. This can have a significant effect on research community as well as practitioners, who are involved in value networks.

The remainder of this paper is structured as follows: Section 2 provides a background on e-Business standards and the structure of standards in general. Section 3 explores the use of ontologies in eBusiness standards. Section 4 introduces the concept of ontology based e-Business standards and its benefits, provides a methodology for deriving an ontology for e-Business standards and presents a work in progress ontology on that basis. Section 5 presents the challenges associated with utilising ontologies as a basis for e-Business standards, followed by a discussion on the next steps of the research and a set of research questions. Section 6 concludes the paper.

2 E-BUSINESS STANDARDS

A standard is a technical specification approved by a recognised standardisation body, which is designed to be used consistently, as a rule, a guideline, or a definition across particular communities of interest, to achieve mutual benefit (ETSI, 2010). Acquiring 'standard' status may take several years. During this time a specification may be implemented if it receives sufficient public review and achieves a certain level of approval. The specification's use may be widespread even without full standardisation. Openness of standards / specifications is usually considered as an important factor in achieving consensus and widespread adoption. When agreed as a 'standard', it may only be the status of the specification which changes.

Each specification / standard is composed of a set of Normative Statements, often with a Conformance Clause and associated Test Assertions.

A Normative Statement defines the prescriptive requirements on a conformance target (Green, Kostovarov, 2009). In the standardisation terminology conformance refers to the fulfilment of specified requirements by an implementation of the standard. This is verified with the use of Conformance Clauses, which must, directly or indirectly, reference one or more Normative Statements and may also refer to another Conformance Clause (Green, Kostovarov, 2009).

Furthermore, a Test Assertion is an independent, complete, testable or measurable statement for evaluating the adherence of part of an implementation to a Normative Statement in a specification (OASIS TAG TC, 2010)(Durand, Green, Kulvatunyou, Rutt, 2009).

E-Business standards seek to establish Interoperability between trading partners by defining standard interfaces specifying one or more common Business Processes, elements of the Business Documents and / or Messaging details. Figure 1 presents an Interoperability Stack for e-Business standards and specifications. E-business specifications may cover one or more of the layers in the stack.

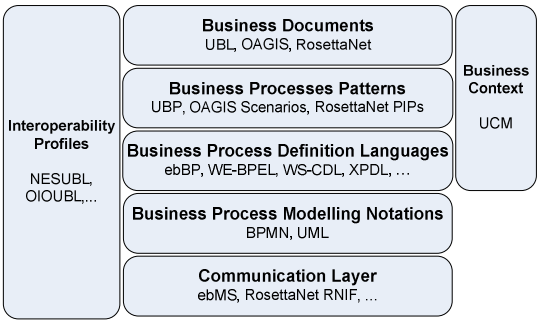

Figure 1: e-Business Interoperability Stack.

The Communication layer provides specifications for packaging, security and transport of messages to be used within business interactions. ebXML Messaging Service (ebMS) and RosettaNet Implementation Framework (RNIF) are examples of specifications from this layer.

Business Process Modelling Notations are specifications which are used for graphical representation of processes and do not have XML representation. Business Process Modelling Notation (BPMN) and UML Activity diagrams are examples from this layer.

Business Process Definition Languages provide specifications for XML based representation of business processes. These languages can have different targets. For example they might be suitable for public choreographies, such as ebXML Business Process Specification Schema (ebBP), for business process execution, such as WS-BPEL or for private workflows such as XPDL. These processes may be visualised by Business Process Modelling Notations.

The next level, Business Process Patterns, provide specifications for repeatable processes which need to be agreed between trading partners, such as procurement processes. These processes can be industry neutral or industry specific depending on the target of the specification. UBP (Universal Business Process) and OAGIS (Open Applications Group Integration Specification) Scenarios are examples of industry neutral processes and RosettaNet PIPs are examples of industry specific business processes. These processes may be represented by Business Process Definition Languages and / or visualised by Business Process Modelling Notations.

B2B transactions are composed of Business Document exchanges, within the steps of Business Processes. Therefore, the next layer represents Business Document specifications, such as UBL (Universal Business Language) and xCBL (XML Common Business Library. Business Document standards can also be industry specific or industry neutral.

Business Context is another layer in the e-Business Interoperability stack and provides contextual information to be used in Business Documents and Business Process specifications. Unified Context Methodology (UCM) is an example from this layer, which is a UN/CEFACT specification and aims at facilitating context-sensitive modelling of e-Business transactions.

Interoperability Profiles are subsets of standard specifications which focus on specific business processes or industries. Northern European Section UBL (NESUBL) is an example from this layer.

Currently e-Business standards are mainly based on XML. Built upon W3C standards, XML based e-Business standards, such as ebXML and RosettaNet, provide a good basis for a common syntactical understanding between trading partners. XML based e-Business standards are a big step towards B2B integration and have been quite successful in providing general and well utilised syntactic standards. However, they cannot facilitate semantic integration between business partners as XML can only cover syntax and not the semantics of the transactions.

Ontologies, on the other hand, are an appropriate means of unambiguously capturing the definitions and interrelationships of concepts in a formal, unambiguous and machine interpretable manner, with the aim of a shared understanding of a domain, which is indeed the ultimate goal of e-Business standards. Therefore, utilising ontologies seems an appropriate approach for defining more expressive, stable and interoperable e-Business standards.

3 E-BUSINESS STANDARDS AND ONTOLOGIES

A considerable number of publications emphasise on the importance of semantic web technologies and ontologies in B2B transactions (Legner, Wende, 2007)(Kajan, Stoimenov, 2005)(Wu, Li & Yang, 2006)(Gong, Ning, Chen, O'Sullivan, 2006)(Höfferer, 2007)(Liegl, Huemer & Zapletal 2009)(Vujasinovic et al., 2010). There are also a growing number of ontologies developed for e-Business related standards in the literature. Examples are oXPDL, an ontology for XPDL (Haller, Gaaloul & Marmolowski, 2008), an ontology for WS-BPEL (Nitzsche, Wutke & Van Lessen, 2007), ebXML Registry Profile for OWL (OASIS ebXML Registry TC, 2006), which provides specifications for publishing and discovering OWL ontologies in the ebXML Registry/Repository and OntologUBL, which provides an ontology for Universal Business Language (The Ontolog Forum, 2002).

There are also a few works focusing on utilising ontologies in conjunction with e-Business standards. Vujasinovic, Ivezic, Kulvatunyou, Barkmeyer, Missikof, Marjanovic and Miletic (2010) provide a semantic mediation architecture for standard based B2B interoperability. This work emphasises the importance of Standard Development Organisations in achieving standard based semantic B2B integration and thus highlights the importance of ontologies in relation with e-Business standards. OASIS may be considered as the first Standard Development Organisation to address ontologies and semantic web technologies and their synergy with standards. The first ontology related initiative in OASIS is the Semantic Support for Electronic Business Document Interoperability Technical Committee (OASIS SET TC, 2009), which aims at developing specifications for machine processable semantic content of the Electronic Business Documents based on the UN/CEFACT Core Components Technical Specification (CCTS). Another relevant TC in OASIS, which may be considered as the first official ontology based standard Technical Committee, is called OASIS Quantities and Units of Measure Ontology Standard (QUOMOS) Technical Committee (OASIS QUOMOS TC, 2010). Ontolog forum (The Ontolog Community, 2010) is another relevant initiative which addresses the importance of ontologies for standard community and therefore had 'Toward Ontology-based Standards' as their 2009 ontology summit theme. In fact OASIS QUOMOS was the result of discussions in the ontolog forum, which ended up as an OASIS TC. These efforts emphasise on the significance of ontologies and semantic web technologies in the standards world and imply that it is time for the intersection of these two communities.

Nevertheless, almost no effort has yet been taken to utilising ontologies for developing, authoring or improving e-Business standards. It is believed that this is an important gap, which needs to be explored extensively.

4 ONTOLOGY BASED E-BUSINESS STANDARDS

Ontologies have the potential to facilitate both the creation and utilisation of standards (The Ontolog Community, 2010). They may also be used to improve the quality of standards, leading to more robust implementations as well as the semantic integration of different standards.

Ontologies may contribute to the development, extension and improvement of e-Business standards specifications in the following ways:

1. *Formalise concepts within existing e-Business standards*, such as ebXML and RosettaNet. This would result in a more stable definition of semantics in the standard and allow the writing expressions based on clear, unambiguous terms and categories. In this approach, specifications serve as a foundation for developed ontologies and therefore the ontologies can be evaluated against the standards specifications and their XML Schemas. (The Ontolog Community, 2010)

2. *Reengineering of existing standards based on ontological analysis*, identifying their potential problems and semantic ambiguities and improving them. (The Ontolog Community, 2010)

3. *Facilitate integration between different standards*, which are already defined using ontologies.

4. *Development of standards*, wherein ontologies are used throughout the standard development phases, from start to finish, realising the benefits of the semantic vision outlined in Section 1. This approach can be taken where appropriate in developing new e-Business standards or new versions of existing standards.

The latest of the above is the proposition of this paper and will be further discussed in the remainder of the paper.

In order to study the domain under discussion, two approaches have been adopted: top down and bottom up. The top down approach is done in collaboration with standards developers and experts in the field of standardisation and also taking into account various relevant specifications. The purpose of this approach is to formalise the structure of e-Business standards in a robust and unambiguous way. The output of this approach is an ontology for e-Business standards, which represents the building blocks of standards and their relationships in general and e-Business standards in particular. This ontology may further be utilised as a basis for developing ontology based e-Business standards and possibly other information systems related standards.

The Bottom up approach is taken as an experiment for developing an ontology for a specific e-Business standard, OASIS ebXML Business Process Specification Schema (ebBP). The purpose of the bottom up approach is to explore the requirement of an e-Business standard, in particular, and challenges associated with that. The result of the bottom up approach can also be used to reflect on the top down approach and its resulting ontology.

While conducting the top down approach, a methodology comprising nine steps was developed. Steps 1 to 4 have already been taken and steps 5 to 9 are to be done in the future. The steps are as follows:

Step 1. Brainstorming for developing a domain model.

Step 2. Turning the model into a concrete ontology.

Step 3. Identifying those parts of the model related to the artefacts which are wished to be standardise.

Step 4. Adding related properties to flesh out those parts of the ontology identified in step 3.

Figure 2 depicts a snapshot of the ontology resulting from the methodology up to step 4. It is important to note that this ontology is a work in progress and is solely provided as an introduction of the domain under study. Furthermore, figure 2 depicts a part of the ontology and doesn't include all classes and properties of the ontology.

Steps 5 to 9 will be addressed in future to enhance the ontology are as follows:

Step 5. Add rules to turn the parts of the ontology identified in step 3 into artefacts such as mark-up wished to be standardise.

Step 6. Express the above rules as subject and predicate with identifiers.

Step 7. Use the aforementioned rules to generate the artefacts needed, such as a schema for a mark-up representation of the ontological model.

Step 8. Add test assertions based on the model in step 4 and statements in step 6.

Step 9. Publish the ontology including the model and its representational artefacts, possibly in separate specifications for modularity.

For the bottom up approach an ontology for ebBP is developed. Figure 3 presents a snapshot of a set of classes in the ebBP ontology.

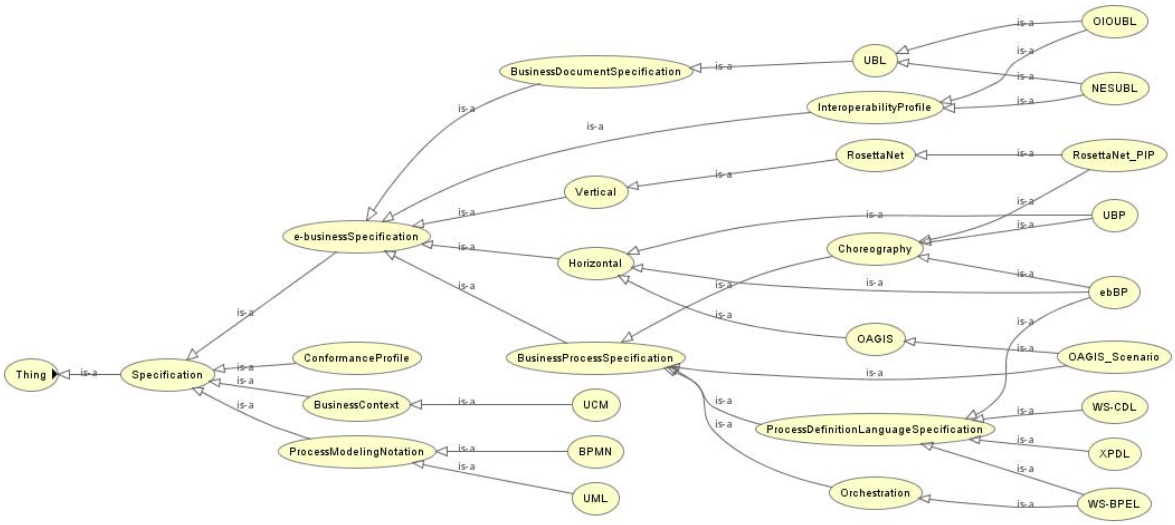

Figure 2: e-Business Specifications Ontology.

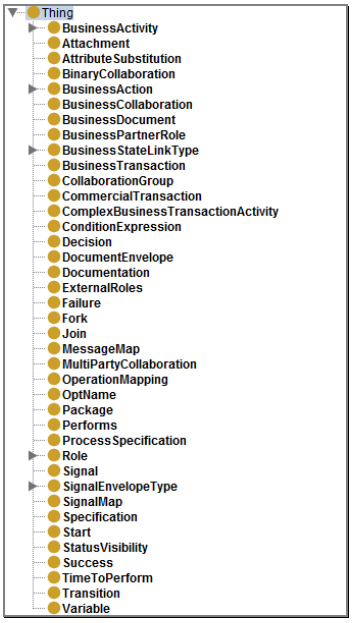

Figure 3: ebXML Business Process Specification Schema Ontology.

In combining the two approaches it seems that there is not a clear correspondence between the classes in the e-Business Specifications ontology and the ebBP ontology. These ambiguities imply that future work is needed in harmonising these two levels on standard ontologies.

This paper suggests that ontologies can be used for defining new e-Business specifications or new version of existing standards in various extents, including their conformance clause, test assertions and normative statements. They can also be used for conformance checking of the implementations of standards. To achieve this however, a consistent standard development methodology, which utilises ontologies in the whole standard development process, is required.

Using these ontologies in this way, a basis for specifying standards is provided. All or part of a standard may thus be developed from beginning to end making full use of ontologies and also domain-specific ontologies to achieve the benefits of reduced ambiguity and vagueness and to allow the development of complex and dynamic standards with context-dependant rules.

5 CHALLENGES AND FUTURE RESEARCH

5.1 Challenges

There remains the need for the standards technical committee or working group to consider how the use of ontologies as a basis for their specifications affects the implementers and, in some cases, even the end users of their standard. It may be that XML Schema files or other artefacts are to be generated using specialised tools from the ontologies and that such a schema is to define an XML instance for use in a particular context, as specified in context-specific information in the ontologies. It might be necessary to deduce certain requirements by the introduction of values for variables included in the ontologies, normative statements or test assertions; values not known until this stage but accounted for in the standard. These techniques allow for greater

flexibility and wider scope in defining a standard for implementation in a variety of situations. In some cases it may be expected that implementations or end user software will include knowledge bases and other ontology-aware technologies to make full use of the ontology basis of the standard. Test cases may be stored and retrieved dynamically from a database or repository according to results obtained running previous tests and according to complex rules based on ontology-based test assertions.

Challenges abound as the benefits do not offer themselves without a struggle. The obvious but often neglected challenge is to provide change management and version control facilities both for the standard and for the implementations of the standard.

Nevertheless, despite the complexities and stringent requirements on both standard developer and standard implementer, ontologies are becoming more and more a common sight in standards committees as their benefits are recognised for their potential to improve quality or implementation and interoperability.

5.2 Next Steps and Research Questions

As mentioned in section 4, the top down ontology provided in this paper is a works in progress, which needs to be extended and fully tested in different cases and in relation with different standards. In the next steps of these research steps 5 to 9 explained in section 4 will be taken to complete the e-Business standards ontology. The plan is to test the resulting ontology with a number of ontologies for ebXML standards, which will be defined using the bottom up approach, and explore the outcome of the test.

When considering utilising ontologies as a basis for e-Business standard development a number of research question require consideration:

- How normative statements can be defined using an ontology based e-Business standard?
- How test assertions can be addressed in an ontology based e-Business standard?
- How conformance clauses can be defined and represented in the ontology based e-Business standards and how they can be queried for conformance checking of a specific implementation?
- How existing standards can be included in the ontology based framework?
- How different versions of a standard can be managed using this approach?
- How to relate a model to its representations and how to relate the representation ontology classes to external representation definitions such as those in a schema?

6 CONCLUSIONS

This paper proposes a novel approach in developing e-Business standards and suggests that ontologies should be used in the process of e-Business standards development in order to fully realise the semantic e-Business vision. To explore this idea a current state of the art is provided followed by a combined top down and bottom up approach adopted to develop an ontology for e-Business standards in general and an ontology for a specific e-Business standard, respectively. Analysing the state of the art and comparison between top down and bottom up approaches suggest that more research is required in this field and therefore the paper is concluded with a research agenda and relevant research questions to be addressed in the future. To conclude, it is argued that development of standards, which are based on ontologies, would enhance their stability and usability, as well as facilitating standard based integration and interoperation in value chains.

ACKNOWLEDGEMENTS

The research leading to the work as published in this paper has been sponsored in part by Fujitsu Laboratories of Europe Limited.

REFERENCES

Berners-Lee, T., Hendler, J. & Lassila, O. 2001, "The Semantic Web", vol. 284(5), pp. 34-43.

Durand, J., Green, S.D., Kulvatunyou, S. & Rutt, T. "Test Assertions on steroids for XML artifacts", *In Proceedings of Balisage: The Markup Conference 2009. Balisage Series on Markup Technologies, vol. 3 (2009).*

European Telecommunications Standards Institute (ETSI). Retrieved February 26, 2010, from http://www.etsi.org

Gong, R., Li, Q., Ning, K., Chen, Y. & O'Sullivan, D. 2006, *Business process collaboration using semantic interoperability: Review and framewor*k.

Green, S.D. & Kostovarov, D. "Test Assertions Guidelines Version 1.0", 2009.

Haller, A., Gaaloul, W. & Marmolowski, M. 2008, "Towards an XPDL compliant process ontology", pp. 83.

Ho fferer, P. 2007, "Achieving Business Process Model Interoperability Using Metamodels amd Ontologies",

Proc.of the 15th European Conference on Information Systems (ECIS2007), , pp. 1620-1631.

Kajan, E. & Stoimenov, L. 2005, "Toward an ontology-driven architectural framework for B2B", *Communications of the ACM,* vol. 48, no. 12, pp. 60-66.

Legner, C. & Wende, K. 2007, "The Challenges of inter-organizational Business Process Design - A research Agenda", *15th European Conference on Information Systems* , pp. 106-118.

Liegl, P., Huemer, C. & Zapletal, M. 2009, "Towards a global business document reference ontology", pp. 355.

Nitzsche, J., Wutke, D. & Van Lessen, T. 2007, "An ontology for executable business processes", *Workshop SBPM,* vol. 251, pp. 52-63.

OASIS ebXML Registry TC, 2006, *ebXML Registry Profile for Web Ontology Language (OWL) Version 1.*5. Retrieved February 26, 2010, from http://xml.coverpages.org/OASIS-regrepOWL-Profile-22611.pdf

OASIS QUOMOS TC (2010). Retrieved February 26, 2010, from http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=quomos.

OASIS SET TC. (2009). Retrieved February 26, 2010, from http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=set.

OASIS TAG TC. (2010). Retrieved February 26, 2010, from http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=tag

Singh R., Iyer L.R., Salam A.F. 2005a, "The semantic E-business vision", *Communications of the ACM,* vol. 48, no. 12, pp. 38-41.

Singh, R., Iyer, L.S. & Salam, A.F. 2005b, "Semantic eBusiness", *International Journal on Semantic Web & Information Systems,* vol. 1, no. 1, pp. 19-35.

The British Standards Institution. (2010). Retrieved February 26, 2010, from http://www.bsigroup.com

The Ontolog Community. (2010). Retrieved February 26, 2010, from http://ontolog.cim3.net/.

The Ontolog Forum , *UBL Ontology*, (2002). Retrieved February 26, 2010, from http://ontolog.cim3.net/cgi-bin/wiki.pl?UblOntology

Vujasinovic, M., Ivezic, N., Kulvatunyou, B., Barkmeyer, E., Missikoff, M., Taglino, F., Marjanovic, Z. & Miletic, I. 2010, "Semantic mediation for standard-based B2B interoperability", *IEEE Internet Computing,* vol. 14, no. 1, pp. 52-63.

Wu, B., Li, L. & Yang, Y. 2006, "Ontological approach towards E-business process automation", pp. 154.