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**ABSTRACT**

An e-Business standard is a technical specification which provides a shared understanding and agreement on the shared information and data among trading partners. Standards are usually developed in a standards development organisation, where a guideline for the process of developing standards is provided. However, these guidelines are mainly concerned about the administrative aspect of the standardisation process and there is a lack of practical technological support for developing the content of a standard specification. This chapter reviews the characteristics of e-Business standards and their development process and presents OntoStanD, a novel, comprehensive, ontology-based collaborative standards development methodology. OntoStanD is then applied on ebXML Business Process Specification Schema to demonstrate the application of OntoStanD.

**INTRODUCTION**

In today’s global business environment business values and competitive advantage lie beyond the boundaries of any one enterprise. In such an environment companies’ business processes need to be understood and aligned across organisational boundaries. E-Business standards are considered as an important facilitators for B2B interoperability and provide a shared understanding and agreement on what information to share, when and how among trading partners. Standard development organisations usually provide a guideline for the process of developing standards. These guidelines are however more concerned with administrative aspect of the process and there is a lack of practical technological supports for developing the content of a standard specification.

Semantic interoperability on the other hand is considered to be an essential factor for effective interoperation. This implies that the meaning of terms, their relationships and also the restrictions and rules in the standards should be clearly defined in the early stages of standard development and act as a basis for the latter stages. Furthermore, XML based standards can only cover syntax and not the semantics of transactions. Therefore there is a need for a
semantic approach for capturing and the semantics of e-Business standards. Fırat, Madnick & Manola (2005) state that applying ontologies in practical semantic interoperability problems has proven to reduce the amount of work needed to agree on a shared model based on the assumptions made by different parties. Ontologies are therefore considered as an appropriate means for capturing the definitions and interrelationships of concepts in a domain, resulting in a robust shared understanding of the domain, which is indeed the ultimate goal of e-Business standards.

This chapter proposes utilisation of ontologies in the process of standards development and presents OntoStanD, a comprehensive ontology-based standards development methodology, which takes into account the collaborative nature of standard development and is developed and refined in collaboration with standards developers and stakeholders. Using ontologies as a basis for standards also facilitates transparent flow of semantically enriched information and knowledge in order to enhance B2B collaborations (Rebstock, Fengel & Paulheim, 2008). This chapter also provides a summative view on standards and their creation process.

The remainder of this chapter is organised as follows: Second section provides a background on standards, their structure and creation methods. Third section discusses ontologies and their importance and relevance for standards development. Fourth section introduces OntoStanD, an ontology based standards development methodology, the constructed methodology, followed by applying OntoStanD to the ebXML Business Process Specification Schema (ebBP). The sixth section discusses future research directions and the final section concludes the chapter.

BACKGROUND

Standards are important facilitators for achieving B2B interoperability. 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 (ETSI, 2010). The aim of standards is to provide unambiguous specifications for error-free exchange of documents and information to achieve mutual benefit.

Different types of Standards

Although there are a significant number of standardisation bodies in the e-Business and information systems domain, relevant standards can be grouped in a number of categories. The most important of these are:

• Formal standards, which are normative documents from formal standards bodies and have passed through a full and open consensus process. Formal standards normally have a legal basis and can be made mandatory to conform to for a certain group of users (W3C COPRAS, 2007).

• Technical or industry specifications, which are based on consensus among members of standards bodies, consortia or trade organisations. Comparing to formal standards, they require less time to produce and do not have a formal character or legal basis. However, when widely accepted and used they can become de facto standards (W3C COPRAS, 2007). Technical specifications can become formal standards if passed through a formal approval process.

Openness of standards is usually considered as an important factor in achieving consensus and widespread adoption. Bird (1998, p. 76) defines an open standard as “a publicly available specification that is developed and maintained by an open, public consensus process and that is consistent with international standards, where relevant”. Tim Berners-Lee in his recent article (Berners-Lee, 2010) defines open standards as “standards that can have any committed expert involved in the design, that have been widely reviewed as acceptable, that are available for free on the Web, and that are royalty-free (no need to pay) for developers and users”. The purpose of open standards is to support common agreements that enable communications
between parties who conform to the standard (Krechmer, 2005). Both formal standards and technical specifications that are developed in an open process can be regarded as open standards (W3C COPRAS, 2007).

Standards are usually developed by standardisation bodies. Standards bodies can be classified in different categories based on different perspectives. From geographic perspective, there are international, regional, and national standards bodies. From technology or industry perspective, there are standards developing organisations (SDOs) and also standards setting organisations (SSOs) also known as consortia.

**Structure of Standards**

A standard specification is usually composed of a set of *normative statements*, often with a *conformance clause*, all inline in the text, and optionally associated *test assertions*. The descriptive text provides background and contextual information, description and examples (OASIS TAG TC, 2010).

Normative statements, which are usually inline in the descriptive text, define the prescriptive requirements of a specification (Green & Kostovarov, 2009) and form its core. 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 (OASIS TAG TC, 2010). 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 et al., 2009).

Normative statements are distinguished by the use of the reserved keywords as explained in Table 1, while descriptive text does not use these reserved words as keywords. The keywords in Table 1 are mainly based on the OASIS guidelines and may be slightly different in other standards bodies.

<table>
<thead>
<tr>
<th><strong>MUST</strong></th>
<th>The requirement is an absolute requirement of the specification.</th>
</tr>
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<tbody>
<tr>
<td><strong>MUST NOT</strong></td>
<td>The requirement is an absolute prohibition of the specification</td>
</tr>
<tr>
<td><strong>SHOULD</strong></td>
<td>There may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.</td>
</tr>
<tr>
<td><strong>SHOULD NOT</strong></td>
<td>There may exist valid reasons in particular circumstances when the particular behaviour is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behaviour described with this label.</td>
</tr>
<tr>
<td><strong>MAY</strong></td>
<td>This item is truly optional.</td>
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</tbody>
</table>

*Table 1. Restriction keywords in normative statements - adopted from (OASIS, 2007)*

**Standards Creation Processes**

Standards bodies usually provide a guideline for the process of creating standards. Table 2 provides an overview of the standards creation process of six influential standards development organisations in information systems/e-Business domain.

Analysing the processes of different standards bodies, as depicted in Table 2, it is learnt that although not all standardisation processes follow exactly the same development process, a set of commonalities can be identified in their processes, which may be considered as a typical standards creation process, as follows:

1. **Identifying needs for a new standard:** Standardisation efforts are initiated when there is a need for an idea or concept to be standardised (IEEE, 2011). A market need for a new standard or standardisation effort has to be identified and expressed by an interested party and a set of requirement for the new standard has to be drafted to be published as the proposal.
2. **TC Formation**: Standards development is a collaborative work and a Technical Committee (TC), also called Working Group, in a standardisation body is normally responsible for developing standards. At this stage TCs are usually open to any interested party to participate based on the terms of each SDO: some need membership of the SDO. They may be individuals or representatives of public or private organisations, who are interested in the proposal and have knowledge and expertise in the technology/concept being standardised. At this stage the TC has to be formed based on the drafted requirement in the first stage. In other words, any party who is interested in the published proposal may participate in the TC.

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<tbody>
<tr>
<td>TC discussion</td>
<td>Proposal stage</td>
<td>Identifying needs for standardisation</td>
<td>Proposal</td>
<td>Initiate the project</td>
<td>Proposal and assessment of new work</td>
</tr>
<tr>
<td>TC formation</td>
<td>Preparatory stage</td>
<td>Defining the technical committee</td>
<td>Acceptance</td>
<td>Mobilising the working group</td>
<td></td>
</tr>
<tr>
<td>Drafting</td>
<td>Committee stage</td>
<td>Identification, definition, approval and adoption of work items</td>
<td>Drafting</td>
<td>Drafting the standard</td>
<td>Preparation of draft</td>
</tr>
<tr>
<td>Approval of a committee draft</td>
<td>Enquiry stage</td>
<td>Drafting, editing and publication.</td>
<td>CEN Enquiry</td>
<td>Ballot the draft</td>
<td>Public enquiry</td>
</tr>
<tr>
<td>Public review of a committee draft</td>
<td>Approval stage</td>
<td>Adoption by weighted vote</td>
<td>Gaining final approval</td>
<td>Preparation of draft standard for formal vote</td>
<td></td>
</tr>
<tr>
<td>Approval of a committee specification</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Approval of an OASIS standard</td>
<td>Publication</td>
<td></td>
<td>Publication</td>
<td></td>
<td>Publication</td>
</tr>
<tr>
<td>Errata</td>
<td>N/A</td>
<td>N/A</td>
<td>Review</td>
<td>Maintenance</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*Table 2. Summary of various standard creation processes*

3. **Specification Drafting**: The specification is drafted by the members of the TC.

4. **Approval Process**: Formal approval process is conducted when the specification draft is ready. This process is usually composed of one or more rounds of technical committee reviews followed by public review, which may vary depending on the type of standard. At the end of this step the standard specification may be submitted to be considered for achieving ‘standard’ status. 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.

5. **Publication**: The standard is published at this stage if accepted as a ‘standard’, otherwise it might be published as a technical specification.

6. **Maintenance**: This phase in concerned with the validity and deprecation of standards and also revisions, amendments, modifications, reaffirmation or withdrawal. The details of each of these stages may vary in each standardisation body depending on the type and scope of the standard and the standardisation body.

Although the standards creation process, as seen in Table 1, is usually defined by standards bodies, the technical aspect of developing/drafting the standards themselves, step 3 of the typical process above, hasn’t received much attention either by the standards bodies or in the literature. It is believed that a robust standards development process would be of great value for standards developers and organisations. This chapter proposes a comprehensive standards
development methodology which has a formal basis and utilises ontologies as an appropriate
means for capturing knowledge in a domain in the process of standards development.

ONTOLOGY BASED STANDARDS

Semantic interoperability is considered to be an essential factor for effective interoperation. This implies that the meaning of terms, their relationships and also the restrictions and rules in the standards should be clearly defined in the early stages of standard development and act as a basis for the latter stages. Therefore, this aspect should be considered in the whole process of standard development, in particular in the conceptual modelling phase, which is the starting point of standards development.

An ontology is “an explicit specification of a conceptualisation” (Gruber 1995, p. 1). Ontologies provide a formal description of concepts and their relationships within a domain which result in a shared understanding of a domain which is the ultimate goal of e-Business Standards. Ontologies may contribute to the development, extension and improvement of standards specifications in *formalising concepts within existing standards*, *reengineering of existing standards based on ontological analysis* (The Ontolog Community, 2010) and *development of standards*, wherein ontologies are used throughout the standard development phases (Heravi et al., 2010b). The latter approach can be taken where appropriate in developing new standards or new versions of existing standards.

When a standard makes use of ontologies, it results in comprehensive, clear, unambiguous and robust e-Business standards. Ontology based standards make it clearer how conformance to individual normative requirements relates to overall conformance to a particular conformance profile. Another benefit of having ontology based standards is the possibility of deriving (semi) automatic textual/HTML specifications from the ontology itself. This requires annotating the concepts, relationships, restrictions and rules in the standard’s ontology. Furthermore, when an ontology exist for a standard, such as ebBP, it allows the architects to write expressions and normative statements based on clear, unambiguous terms.

Ontology Engineering Methods

Ontology engineering is referred to a set of activities that concern the ontology development process, its lifecycle and creation methods (Corcho, Fernández-López, & Gómez-Pérez, 2007). There exist various ontology development methods, providing methodological guidelines for developing ontologies, in the literature. Grüninger and Fox methodology (Grüninger & Fox, 1995), METHONDOLOGY (López et al., 1999) are examples of traditional methodologies. More recent ontology engineering methodologies take into account several soft aspects of the ontology development process, such as the aspect of community and evolution. Example of more recent methodologies are Developing Ontology-grounded Methods and Applications (DOGMA) (Spyns, Tang & Meersman, 2008), Ontology-based Knowledge Management method (OTKM) (Sure & Staab, 2003), the method for supporting Meaning Evolution Support Systems (MESS) (De Leenheer, 2008), OntoEng (Al-Debei & Fitzgerald, 2009) and the method of Ontology-based Obstacle and Prevention and Solution (OOPS) (Sasajima, Kitamura & Mizoguchi, 2010). Surveys on ontology engineering methods can be found in (Jones, Bench-Capon & Visser, 1998; Simperl & Tempich, 2006).

Amongst the above ontology engineering methods, DOGMA is the one which contains the best practises of older ontology creation methods, is also grounded in natural language facts analysis and is a community-based approach. Since standards development is a community based process and almost all the exchanged information in the community is in natural language, the above characteristics make DOGMA a suitable choice to be used in the ontology development process of OntoStanD.
Ontologies and Standards in the literature

Using ontologies as a means of formalising e-Business standards’ structure has gained momentum in the last few years. There are a growing number of ontologies developed for various standards and specifications. 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, 2006), ebXML ebBP (Business Process Specification Schema) (Haller, Gaaloul & Marmolowski, 2008), OntologUBL, which provides an ontology for Universal Business Language (The Ontolog Forum, 2005).

OASIS may be considered as the first standard development organisation to address ontologies 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, 2010), 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 oriented standard Technical Committee, is called OASIS Quantities and Units of Measure Ontology Standard (QUOMOS) Technical Committee (OASIS QUOMOS TC, 2011), which aims at developing an ontology to specify the basic concepts and systems of quantities, measurement units and scales, metric prefixes, rules for constructing various derived units, and designations of the most common derived units to be used across multiple industries. Ontolog forum (The Ontolog Community, 2010) is another relevant initiative which addressed the importance of ontologies for standard community in their 2009 summit theme: “Toward Ontology-based Standards”. In fact OASIS QUOMOS TC was a consequence of discussions in the Ontolog forum. Above efforts show the significance of ontologies in the standards world and imply that it is time for the intersection of these two communities.

Nevertheless, almost no effort has yet been expended on utilising ontologies for developing, authoring or improving e-Business Standards. With the current trend in utilisation of ontologies in conjunction with standards efforts, it is believed that using ontologies in the process of standards development is an important area of research for the future of standards development which deserves to be explored extensively.

ONTOSTAND

OntoStanD is a systematic design methodology, utilising ontologies to assists standard development process and/or refining standards specifications. This methodology may be used for developing new standards specifications from scratch or new versions of existing standards, re-engineering existing standards and also formalising concept in existing standards. The potential value of OntoStanD is in providing a comprehensive, clear and unambiguous method for developing more robust standards. It also facilitates standards conformance check and change management and potentially improves interoperability.

Figure 1 depicts the overview of OntoStanD. Each round-cornered rectangle is either a phase or an activity. A phase is a collection of activities, which themselves can be a composition of several other activities. The phases and activities in OntoStanD are designed with respect to the typical standardisation process presented earlier. The phases concerning capturing domain semantics, namely preparation & scoping and domain conceptualisation, are mainly designed based on the DOGMA methodology (Spyns, Tang & Meersman, 2008).

Formulate Vision and Feasibility Study

A vision is a compelling view of a standard that is going to be built. In this phase a usually small group of interested parties develop a proposal for a new standardisation effort to be submitted to a standardisation body. The standardisation body takes the decision on whether it is feasible to create the proposed standard or not. The proposal would then be published on-
line for comments after the initial acceptance of the standardisation body. The process of submitting a proposal to a standardisation body and its acceptance may vary in different standardisation bodies.

Figure 1. Overview of the OntoStanD methodology

Technical Committee Formation
Depending on the standardisation body, a TC may be composed of various roles. OntoStanD’s minimum role requirement is to have one knowledge engineer, who may be one of the TC members, one key domain expert, who may be the TC chair and several domain experts, who are the TC members. A domain expert, a stakeholder in the TC, has good insights in the discussed sub-domain, which reflects the interests from his/her organisation. The key domain expert holds an overview of the knowledge in the domain and knows the overlapping interests of these organisations and is responsible for scoping the problem, defining knowledge resources and helping the knowledge engineer. The knowledge engineer is responsible to run OntoStanD, in collaboration with other TC members, and needs to know how to model/formalise the information. In this phase, the TC would be established and the members are appointed to their roles.

Preparation & Scoping
There are two activities in this phase: define knowledge resources and select relevant passages, which are explained in the following two subsections.

Define Knowledge Resources
The knowledge resources need to be defined according to the vision/proposal defined earlier and the requirements of the standards. The knowledge resources will be further used in the phases of domain conceptualisation, axiomatisation and specification reification.

Select relevant Passages
At this stage the knowledge engineer and the key domain expert need to categorise the knowledge resources in the following categories:

- Core texts and explanatory texts/resources.
- Application specification resources.

Other Structured and unstructured resources, such as XML files or a piece of news.
Domain Conceptualisation

This phase of the standard development is when the conceptual model of a standard is defined. This is a significant phase since it forms the core of a standard. There is no clear guideline in standardisation bodies for domain conceptualisation of standards. OntoStanD uses theories of ontologies for formalising conceptual model of a standard. Domain Conceptualisation starts by considering if there are any existing specifications or other material to be re-used. If this is the case, the Knowledge Breakdown activity should be followed, otherwise Knowledge Elicitation phase is conducted.

Knowledge Breakdown

In this activity the domain of interests is decomposed into a number of smaller, more manageable topics. The knowledge breakdown activity is performed when there exist any specifications, earlier versions, or a set of passages are selected in the preparation & scoping phase. Otherwise this activity is omitted and the knowledge elicitation activity is performed straightaway.

Narratological Schema (Spyns, Tang & Meersman, 2008) is used in OntoStanD to break down the knowledge in the domain. Narratological Schema (NS) has its root in stories (or storytelling), which are considered as one of the best ways to scope knowledge. NS allows tracing/logging changes, supports the communications between technical and non-technical domain experts and articulates tacit knowledge. Using NS, the knowledge engineer focuses easily on smaller but well scoped relevant passages. An NS contains the following items:

- Scenarios: a scenario describes how a potential application will use the concepts of the ontology that is going to be built.
- Settings: which show the background knowledge of the elements in the NS.
- Characters: defines the actors in the NS.
- Episodes: a scenario normally contains a set of episode in a chronological sequence.

An empty NS form is presented in Table 3.

<table>
<thead>
<tr>
<th>Narratological Schema (NS) Form</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
<td>&lt;title of this narratological schema&gt;</td>
</tr>
<tr>
<td><strong>Author</strong></td>
<td>&lt;the author name of this NS and optionally his/her contact information&gt;</td>
</tr>
<tr>
<td><strong>ID</strong></td>
<td>&lt;ID of this document&gt;</td>
</tr>
<tr>
<td><strong>Date</strong></td>
<td>&lt;creation date of this NS&gt;</td>
</tr>
<tr>
<td><strong>Theme</strong></td>
<td>&lt;theme of this NS&gt;</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>&lt;short description of the purpose&gt;</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>&lt;the reference to the ontology scoping form (the resource which the NS is being built from)&gt;</td>
</tr>
<tr>
<td><strong>Settings</strong></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>&lt;setting of the NS&gt;</td>
</tr>
<tr>
<td>S2</td>
<td>&lt;setting of the NS&gt;</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td><strong>Characters</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ID</strong></td>
<td>Role</td>
</tr>
<tr>
<td>C1</td>
<td>&lt;character of the NS&gt;</td>
</tr>
<tr>
<td>C2</td>
<td>&lt;character of the NS&gt;</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td><strong>Episodes</strong></td>
<td></td>
</tr>
<tr>
<td>E1</td>
<td>&lt;episode or scenario of the NS&gt;</td>
</tr>
<tr>
<td>E2</td>
<td>&lt;episode or scenario of the NS&gt;</td>
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<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

*Table 3. An empty Narratological Schema (NS) form, adopted from (Spyns, Tang & Meersman, 2008)*

Segmentation and Highlighting: The goal of segmentation (Zhao & Meersman, 2005) is to detect atomic textual segments, which are stored as a scenario, an episode or a paragraph in the NSs and to partition long sentences into Subject-Verb-Object style, atomic sentences.
During highlighting (Zhao, 2004) important concepts, relations and possible axioms are discovered and highlighted. As proposed in Spyns, Tang & Meersman (2008), three types of phrases are mostly highlighted: noun phrases, verbal phrases and prepositional phrases. Restriction keywords, such as ‘MUST’, ‘SHOULD’ and ‘MAY’ (refer to Table 1), also need to be highlighted since they are very important for defining axioms in the ontology.

**Knowledge Elicitation (Conceptualisation)**

This phase is concerned with the process of conceptual modelling, which leads to the baseline taxonomy of a standard. This phase is composed of three sequential activities and the brainstorming parallel with the other three as follows:

**Abstraction:** Abstraction is to create a set of proper binary fact types, which can be formalised as lexons (Spyns, Meersman & Jarrar, 2002). A lexon is defined as \((t_1, r_1, r_2, t_2)\), where \(t_1\) and \(t_2\) represent two concepts and \(r_1\) and \(r_2\) represent the relationship between \(t_1\) and \(t_2\). An example of a lexon is \((\text{Student}, \text{studies}, \text{isStudiedBy}, \text{Book})\), which contains a fact that a student studies a book and a book is studied by a student.

**Compile baseline Taxonomy:** Based on the output from of abstraction activity, a taxonomy of terms in the domain will be compiled at this stage. A baseline taxonomy contains super types and subtypes relation, which are defined by domain experts. In this activity the relationships which are defined as \((\text{is}-\text{a}, \text{supertypeOf})\) in the lexon table would be used for forming the taxonomy. Brainstorming and negotiation techniques also support this activity.

**Define Relationships:** At this activity, the following cross-domain relations would be added to the model:
- Mereology relations: the part-whole relations.
- Domain relationships: already defined as roles \((r_1, r_2)\).
- Annotation relationships.

**Brainstorming & Negotiation:** Given the collaborative nature of standards development, brainstorming and negotiation is an inseparable part of the process, which usually take place during the teleconferences and face to face meetings. A brainstorming and negotiation cycle of capturing concepts for building an ontology is suggested in (De Moor, De Leenheer & Meersman, 2006).

**Axiomatisation**

This phase aims at defining the normative statements of a standard and consequently modelling them in a formal, ontological manner. The first activity in this phase is brainstorming and negotiation, which iteratively feeds its following activity as described bellow.

**Define Textual Normative Statements**

Normative statements form the core of a specification and it is essential that each statement be clear, concise, and unambiguous (OASIS, 2007). In this activity the normative statements of the specification are defined in a textual basis. Brainstorming and negotiation would be an integral part of this activity and these two activities would repeat until the final agreement on the normative statements between the members of a TC is reached.

**Define Test Assertions**

Test assertions are a way of formulating the normative statements, which would facilitate developing test cases and automatic conformance testing (OASIS TAG TC, 2010). This activity is an optional step in OntoStanD, which facilitates defining axioms and/or developing test suits.
Define Axioms
OntoStanD suggests modelling normative statements in a formal/ontological manner so that they would benefit from greater stability and also better connection to the conceptual model of a standard. Normative statements can be considered as logical statements with a prescription level. In the ontological terms they can be considered as restrictions and rules. OntoStanD suggests utilising a combination of ontological axioms and semantic rules for modelling normative statements of a standard specification. OWL proposes to use the following semantic constraints for defining axioms (Motik & Patel-Schneider, P. F., Parsia, B., 2009):

- **Existential constraint**: which describe classes of individuals that participate in at least one relationship along a specific property to individuals of a specific class (Horridge, 2011). For example if an Existential constraint is applied on the lexon (University, has student, is registered in, PG_Student), it means that each University has at least one PG_Student or each University MUST have a PG_Student. Open World Assumption of OWL however affects such an expression to be used as an integrity constraint and an OWL reasoner would not infer a statement to be fault on the basis that in cannot be proved to be true. This means that if there is no student assigned to a university via the hasStudent relationship, the reasoner would assume there is a student but we don’t know about it. In order for us to be able to use OWL for data validation and constraint check, we would need to close the part of the world we need not behave under OWA, but Closed World Assumption. Sirin and Tao (2009) propos Integrity Constraint Check for OWL in order to overcome this problem and therefore to be able to use OWL for constraint checks in addition to its strong modelling reasoning capabilities. This is out of the scope of this chapter and will be further discussed in the future work.

- **Universal constraint**: which describe classes of individuals that for a given property only have relationships along this property to individuals that are members of a specific class (Horridge, 2011). For example if a Universal constraint is applied on the above lexon, it means for all Universities, if they have any Students, all the students should be PG_Students.

- **Cardinality constraints**, which describe the class of individuals that have at least, at most or exactly a specified number of relationships with other individuals or datatype values (Horridge, 2011).

- **Other constraints**, which can be used to model axioms, such subclass, disjoint, equivalentClass and logical constraints such as Intersection, Union and Complement.

For more information of OWL class and property constraints please refer to (Motik & Patel-Schneider, P. F., Parsia, B., 2009).

Define Semantic Rules
In OntoStanD, Semantic rules may be used to formalise more complex normative statements in the ontology. OntoStanD suggests using axioms for defining normative statement when possible and use semantic rules when it is required to model the normative statements which include conditional statements or when Open World Assumption is causing a problem for conformance checking.

Ontology Validation and Verification
After the axioms and semantic rules are defined, the consistency of the model should be checked. Ontology evaluation is composed of two activities of ontology verification and validation (Gomez-Perez, 2001). Ontology verification is mainly concerned with the syntactic correctness of the model, while ontology validation refers to the process of ensuring that an ontology corresponds to the part of the real word that it is supposed to represent.

Specification Reification
The purpose of this phase is to develop the textual specifications either manually or (semi) automatically.

**Create Textual Specification**
In this phase the textual specification of a standard is developed. The specification should include all the normative statements and supporting informative material. The textual specifications of a standard can either be created manually, as it is being done currently, or (semi) automatically.

**Annotate the Ontology**
(Semi) automatic specification creation is an optional activity in OntoStanD which may or may not be required in a standards development process. However, it has the potential to greatly facilitate specification development and also change management. Furthermore the specification, if created in this manner, would be tightly bound to the conceptual model of a standard and its normative statements. For this to be done, annotating the ontology is required.

**Gap Analysis & Consistency Check of the Specification**
In the case where the ontology annotation and (semi) automatic specification creation is performed the generated specification should be checked and finalised manually. In case there already exist a specification which is defined in a manual manner, it would be a good practice to generate a (semi) automatic specification from the annotated ontology and compare it to the one which is created manually. The gaps would show whether the ontology is lacking any concepts or relationships or the specification is inconsistent.

**Approval & Publication**
At this stage the specification is submitted for the formal approval process, as it is defined in any standards organisation. There may be a number of iterations back to Axiomatisation phase until consensus is reached on both the ontology and the specifications.

**Maintenance**
When the standard and its ontology is approved and published, they need to be maintained for future changes and deprecation.

**APPLICATION OF ONTOSTAND: THE CASE OF EBBP**
To demonstrate the application and practical adequacy of OntoStanD, it is applied to an existing specification of the ebBP standard, resulting in a complete ontology for the ebBP specification, its related axioms and rules. This section demonstrates a small part of the developed ontology by providing a step by step guideline for its development, with the aim of providing a better understanding of OntoStanD methodology.

EbBP is an XML based B2B process standards which may be used to clearly define the public aspects of B2B processes (OASIS, 2006). EbBP is one of five components of ebXML (Electronic Business using eXtensible Markup Language) framework (Van der Eijk et al., 2001). EbXML is a modular suite of XML based specifications, sponsored by OASIS and UN/CEFACT (United Nations Centre for Trade Facilitation and Electronic Business). EbXML’s mission is to provide an open, XML based infrastructure that enables the global use of electronic business information in an interoperable, secure, and consistent manner. The other four components of the ebXML framework are as follows:

- ebXML Core Components, which provide basic and reusable building blocks for Business Documents.
• ebXML Registry/Repository (ebReg/Rep), which are as follows: EbXML Repository manages and maintains the shared information as objects in a repository. EbXML registry is an interface for accessing and discovering shared business semantics.

• Collaboration Protocol Profiles and Agreements (CPP/A), which are as follows: The CPP describes the specific capabilities that a trading partner supports. A CPA is a document that represents the intersection of two CPP’s and is mutually agreed upon by both trading partners.

• ebXML Messaging Service (ebMS), which is designed for the secure, reliable exchange of e-Business information.

The ebXML framework is designed in a way that specifications of each component can be used independently, composed as desired, or integrated with other evolving technologies (OASIS, 2006).

**Formulate vision and Feasibility Study in ebXML Standards**

The ebXML Business Process TC started its work by publishing its Call for Participation in September 2003. Prior to that, a group of interested parties had identified a need for such a standard and worked together to prepare the call for participation. The call for participation could be found at http://lists.oasis-open.org/archives/ebxml-bp/200309/msg00000.html, where the ebBP vision is clearly stated.

**Technical Committee Formation in ebBP**

Following publishing the Call for Participation, a meeting was scheduled for the group so that interested parties would discuss their interest. The initial TC was formed on the day of the teleconference.

**Preparation & Scoping in ebBP**

As explained above, the ebXML specifications are composed of five core components, each of which discussed in their own specialised TC. Therefore, the scope of the ebBP TC was on the Business Process aspect of the ebXML.

**Define knowledge resources**

In the scope of this chapter, and since there is already a complete standard defined, the selected knowledge resources are: a) the specifications, b) the XML Schema, c) a set of available ebBP instances. However, where a new standard or a new version of a standard is planned to be developed, other knowledge resources may need to be considered. In addition to the specification and the XML Schema, and based on them, a UML diagram was drawn, which gives an overview of the top level view of the elements and their basic relationships in ebBP. This diagram was later used in the Domain Conceptualisation phase.

**Select relevant passages from existing knowledge repositories**

This activity is to choose relevant passages from selected knowledge resource to develop the standard. However, since the ebBP specification is already completed and due to space limit, one section of the specification is selected to be formalised in OntoStanD way in this chapter. The section to be explored in this chapter is Section 3.4.2 of the ebBP specifications, entitled ‘Business Transactions’. The ebBP specification is a text based document and also have an XML specification. Therefore both structured and non-structured knowledge resources are available in this case.

**Domain Conceptualisation**

Since there is existing specification for ebBP, the Knowledge Breakdown activity should be followed as follows.
**Knowledge Breakdown**

On the basis of DOGMA guidelines, OntoStanD suggests using Narratological Schema (NS) at this stage with the aim of scoping the knowledge in the domain. Table 4 shows an example of an NS, which contains basic settings and a set of episodes for the selected part of the ebBP specification.

**Segmentation and Highlighting:** The ebBP specification has a relatively formal structure and therefore the selected relevant passages are already in the form of segmented text and therefore we can move to the highlighting activity straightaway. However, in cases that the text is not structured enough, Segmentation activity should be conducted. Table 5 shows an example of highlighting of episodes E1 which already defined in the previous activity, with the aim of discovering important concepts in the segmented passages.

<table>
<thead>
<tr>
<th>Title</th>
<th>ebXML Business Process Specification’s Business Transactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Bahareh R. Heravi</td>
</tr>
<tr>
<td>ID</td>
<td>ebBP.Section.3.4.2</td>
</tr>
<tr>
<td>Date</td>
<td>16/03/2011</td>
</tr>
<tr>
<td>Theme</td>
<td>ebXML Business Process Specification Schema 3 Technical Specification v2.0.4 / Language Overview / Key Concepts of This Technical Specifications / Business Transactions</td>
</tr>
<tr>
<td>Purpose</td>
<td>to articulate more fully the Business Transactions, rather than primarily focusing on their relationship to trading arrangements between business partners.</td>
</tr>
</tbody>
</table>

**Settings**

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>A Business Transaction represents an atomic unit of work that may be associated with a trading arrangement between two business partners.</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
</tbody>
</table>

**Characters**

<table>
<thead>
<tr>
<th>ID</th>
<th>Role</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Business Partner</td>
<td>A Business Transaction is conducted between two parties playing opposite abstract roles in that transaction.</td>
</tr>
<tr>
<td>C2</td>
<td>Requesting Role</td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>Responding Role</td>
<td></td>
</tr>
</tbody>
</table>

**Episodes**

<table>
<thead>
<tr>
<th>E1</th>
<th>A Business Transaction MUST succeed or fail from both a technical and business protocol perspective.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• If it succeeds from both perspectives it MAY be designated as having shared intent between the two business partners, or otherwise govern their collaborative activity.</td>
</tr>
<tr>
<td></td>
<td>• If it fails then it is null and void, and each partner MUST terminate and release any shared statement established by the transaction.</td>
</tr>
<tr>
<td></td>
<td>• If it fails from protocol perspective, each party MUST synchronize their state to the state prior to the start of the transaction.</td>
</tr>
</tbody>
</table>

| E2 | A Business Failure is any Failure that is identified by an application or service during the processing of the Business Document(s) and based on information not available in or part of the ebBP instance. |

<table>
<thead>
<tr>
<th>E3</th>
<th>The Business Transaction is defined as an abstract super class. It is associated with the six concrete Business Transaction patterns defined in the UMM:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Commercial Transaction</td>
</tr>
<tr>
<td></td>
<td>• Information Distribution</td>
</tr>
<tr>
<td></td>
<td>• Notification: Note, the Notification of Failure business transaction is based on the Notification pattern.</td>
</tr>
<tr>
<td></td>
<td>• Query Response</td>
</tr>
<tr>
<td></td>
<td>• Request Confirm</td>
</tr>
<tr>
<td></td>
<td>• Request Response</td>
</tr>
</tbody>
</table>

*Table 4. An example of a Narratological Schema*
A Business Transaction **MUST** succeed or fail from both a technical and business protocol perspective.

- If it succeeds from both perspectives it **MAY** be designated as having shared intent between the two business partners, or otherwise govern their collaborative activity.
- If it fails then it is null and void, and each partner **MUST** terminate and release any shared statement established by the transaction.
- If it fails from protocol perspective, each party **MUST** synchronize their state to the state prior to the start of the transaction.

Table 5. Highlighted phrases for the episode E1 in Table 4

**Brainstorming & Negotiation**: Brainstorming is an integral part of standards development in OASIS which normally takes place during the teleconferences. However, the TC’s mailing lists are also a common place for brainstorming.

**Knowledge Elicitation (Conceptualisation)**

**Abstraction**: In this activity a set of lexons are created. Following the same example shown in Table 4 and Table 5, the lexons shown in Table 6 are abstracted. In the case of ebBP, the lexons are mainly derived from both the specifications text later completed based on the existing XML schema.

<table>
<thead>
<tr>
<th>t1</th>
<th>r1</th>
<th>r2</th>
<th>t2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Transaction</td>
<td>hasRespondingRole</td>
<td>isRespondingRoleOf</td>
<td>RespondingRole</td>
</tr>
<tr>
<td>Business Transaction</td>
<td>hasRequestingRole</td>
<td>isRequestingRoleOf</td>
<td>RequestingRole</td>
</tr>
<tr>
<td>Business Transaction</td>
<td>hasState</td>
<td>is include by</td>
<td>BusinessSuccess</td>
</tr>
<tr>
<td>Business Transaction</td>
<td>hasState</td>
<td>isStateOf</td>
<td>ProtocolSuccess</td>
</tr>
<tr>
<td>Business Transaction</td>
<td>hasState</td>
<td>isStateOf</td>
<td>BusinessFailure</td>
</tr>
<tr>
<td>Business Transaction</td>
<td>hasState</td>
<td>isStateOf</td>
<td>ProtocolFailure</td>
</tr>
<tr>
<td>RespondingRole</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Role</td>
</tr>
<tr>
<td>RespondingRole</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Role</td>
</tr>
<tr>
<td>Commercial Transaction</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Business Transaction</td>
</tr>
<tr>
<td>Information Distribution</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Business Transaction</td>
</tr>
<tr>
<td>Notification</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Business Transaction</td>
</tr>
<tr>
<td>Query Response</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Business Transaction</td>
</tr>
<tr>
<td>Request Confirm</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Business Transaction</td>
</tr>
<tr>
<td>Request Response</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Business Transaction</td>
</tr>
<tr>
<td>Success</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>State</td>
</tr>
<tr>
<td>Failure</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>State</td>
</tr>
<tr>
<td>BusinessSuccess</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Success</td>
</tr>
<tr>
<td>ProtocolSuccess</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Success</td>
</tr>
<tr>
<td>BusinessFailure</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Failure</td>
</tr>
<tr>
<td>ProtocolFailure</td>
<td>is-a</td>
<td>supertypeOf</td>
<td>Failure</td>
</tr>
</tbody>
</table>

Table 6. A lexon table which contains lexons abstracted from Table 4

**Compile baseline Taxonomy**: Figure 2 shows a part of the baseline taxonomy of the ebBP specifications, which is derived based on the lexons defined earlier in Table 6. The types highlighted in grey eclipses are the ones which are extracted from lexons in Table 6 and the others are the ones which are related to the Business Transaction, which are not mentioned in the selected subsection, but are included in other parts of the specification, XML Schema, or are defined to categorise some related concept during the brainstorming sessions. All the relationships at this stage are ‘is-a’ relationships.

**Define Relationships**: At this stage other relationships, which are defined as r1 and r2 in Table 6, and are not of type ‘is-a’ relationships, should be added to the ontology. An example of such relationship, extracted from Table 6, is as follows:

(BusinessTransaction, hasRespondingRole, isRespondingRoleOf, RespondingRole)
**Axiomatisation**

**Define Textual Normative Statements**

In the case of ebBP, the normative statements are already defined in the specification and therefore we proceed to the next activity. In the cases when the standard is being developed from scratch, this activity should be conducted in conjunction with brainstorming.

**Define Test Assertions**

The following is a test assertion defined for one of the normative statement defined in episode E1:

- **Normative Source:** E1 - A Business Transaction MUST succeed or fail from both a technical and business protocol perspective
- **Target:** Business Transaction
- **Prerequisite:** (Business Transaction is executed)
- **Predicate:** Succeed OR Fail
- **Prescription Level:** mandatory

**Define Axioms**

As mentioned earlier, normative statements are distinguished by their prescription level keywords, which are also reflected in their test assertions. There is already a lexon defined for the concepts taking part in the above test assertion/normative statement as (Business Transaction, hasState, isStateOf, Success). This normative statement is a mandatory statement and an Existential constraint is suitable to formalise this normative statement as follows:

```
BusinessTransaction ((hasState some Failure) or (hasState some Success)) and (hasState some CompletionState)
```

This above normative statement is formalised in OWL Manchester syntax and implies that a Business Transaction has to have either at least one ‘Failure’ or at least one ‘Success’ and that it has to have a ‘CompletionState’, which itself is a union of classes ‘Success’ and ‘Failure’. In addition it is necessary to define that ‘Failure’ and ‘Success’ are disjoint.

**Define Semantic Rules**

As mentioned earlier, OntoStanD suggests minimum use of semantic web rules while possible. The selected section of the ebBP specification doesn’t include any complex normative statements and therefore no need for using semantic web rules at this stage. This is to keep the ontology as simple and lightweight as possible.

![Figure 2. An example of type hierarchy for selected part of ebBP specification](image-url)
Ontology Validation and Verification
The ontology derived in this case study was developed in OWL and verified using Protégé 4.0.2. It is also under further validation by the domain experts in the ebCore TC.

Specification Reification
At this stage of the project the specification is developed in a traditional manner. Therefore ontology annotation activity was not performed at this stage but might be considered for the next versions of the same standard.

Approval and Publication
Approval of the ebBP specifications followed the OASIS approval process and ebBP is accepted as an OASIS standard in December 2006. EbBP is now focused on a submission to ISO for the ISO-15000. Furthermore the ebBP ontology is currently submitted to be reviewed in the OASIS ebCore TC for future development and integration purposes and/or publication as a deliverable of the TC.

Maintenance
EbBP specifications are now maintained under ebCore TC, which is currently responsible for maintaining all ebXML standards.

FUTURE RESEARCH DIRECTIONS
The following research areas are considered to be important for future of ontology based e-Business standards development:

- Normative statements of standards specifications are not of the same type and do not follow the same patterns. For example there is a type of normative statement which only addresses the implementation of a specification and not their conceptual models. This type is not easy to model in an ontological manner and also do not add any value to the conceptual model of a standard. With this in mind, a clear categorisation system and a set of patterns should be defined for specifying normative statements. This would facilitate their ontological modelling since they need to be treated appropriately.

- More work on integrating Closed World Assumption and Integrity Constraints with OntoStanD is needed and is in the agenda for further improvements of the methodology.

- There is the need for the standards technical committees to consider how the use of ontologies as a basis for their specifications affects the development of the standards, conformance check and the implementers and end users of their standard.

- The economic benefits of using ontologies as a basis for standards development should be further analysed and studied.

CONCLUSION
Standards development is a community based activity where consensus on the conceptual model of the standard is crucial. Standards organisations normally provide a guideline for standards development. These guidelines however, are not comprehensive enough and there is lack of practical and technological support for developing the conceptual model and content of a standards specification. This chapter reviews the characteristics of e-Business standards and their development process and presents OntoStanD methodology to addresses the shortcomings of current standards development processes. OntoStanD is a comprehensive, clear and unambiguous methodology for developing and formalising ontology-based standards. OntoStanD utilises DOGMA methodology for ontological modelling. DOGMA is a community based ontology engineering methodology and pays good attention to natural language processing in ontology development, which are important factors in standards
development. OntoStanD is then applied to the ebBP standard to demonstrate application of OntoStanD. This, not only formalised the ebBP specification and its conceptual model in a rigorous manner but also revealed a number of minor mistakes in the ebBP specification as explained in (Heravi et al., 2010a). The ebBP ontology is currently submitted to be reviewed in the OASIS ebCore TC for future development and integration purposes and/or publication as a deliverable of the TC.

In general terms OntoStanD provides an illustration of how ontology-based standards can impact on the standards development community and improve the quality of standards. Furthermore ontology-based standards would facilitate conformance testing, standards change management and facilitates interoperability between standards which are developed in OntoStanD way.

ACKNOWLEDGMENT
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REFERENCES


KEY TERMS & DEFINITIONS

OntoStanD: A comprehensive ontology-based standards development methodology, which takes into account the collaborative nature of standard development.

Ontology Engineering: A set of activities that concern the ontology development process, its lifecycle and creation methods.

E-Business Standard: A technical specification which provides a common understanding and agreement on the shared information and data among trading partners.

Standards Development Process: A set of guidelines for the process of developing standards.

Normative Statement: Define the prescriptive requirements of a specification and are distinguished by the use of the reserved keywords such as MUST, SHOULD and MAY.

DOGMA: A collaborative ontology engineering framework which has its roots in database semantics and model theory and natural language semantics.

ebBP: A standard process definition language for defining and monitoring e-Business collaborations. It is one of the five key components of ebXML framework.