The SemanticXBRL Dataset, Semantic Financial Data from XBRL Filings

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Abstract. One of the main ways of populating the Web of Data is by translating existing data sources. One interesting candidate for this approach is data based on the XML Business Reporting Language (XBRL), a standard for business and financial reporting. Many regulation agencies require financial reports based on this format, e.g. the United States Securities and Exchange Commission (US SEC). However, despite its proliferation, XBRL data is loosely interconnected and thus it is difficult to mix and query beyond the per-report context. Our contribution is an automatic translation from XBRL filings to Semantic Web technologies, which we have applied to almost 30000 filings by USA companies to the US SEC obtaining more than 125 million triples. The resulting semantic data is easier to integrate and cross query as some preliminary applications have shown. Moreover, it can be interconnected with the rest of the Web of Data in order to extract its full potential.

Keywords: Business, Semantic Web, Linked Data, accounting, finance, interoperability.

1. Introduction

The main way to populate the Web of Data is by translating existing data sources. The motivation to do so is that usually this data is not offering its full potential because it is isolated, i.e. not connected to other external pieces of data that enrich them. It might even be the case that the data is loosely interconnected internally. Most of the time this is due to the fact that the technological solutions used to publish that data do not make it easy to interconnect it internally and to other external data sources.

Business reporting is a domain where the need for a common data format for reports has already been identified. XBRL (eXtensible Business Reporting Language) is an XML language intended for modelling, exchanging and automatically processing business and financial information. XBRL is being deployed in many different scenarios, especially thanks to the support of regulators and government agencies. For instance, there is the EDGAR[1] program promoted by the U.S. Securities and Exchange Commission (SEC). It is based on the automated collection, validation, indexing, acceptance and forwarding of submissions by companies and others who are required by law to file forms with the SEC.

However, thought it great inpact in relation with data collection, it has been observed the limited support for cross analysis of XBRL financial information [1]. This is not just among data based on different accounting principles, which are represented in XBRL using taxonomies. It even happens when comparing filings for different companies based on the same taxonomies or those for the same company but based on different versions of the taxonomies.

We argue that this limitation is inherited from the technologies underlying XBRL, especially XML. XML takes a document oriented approach, where each document has a tree structure. This makes it difficult for XML-based tools to provide functionalities that blur this separation into documents and that overcome the limitations of a tree structure when mashing-up data from different sources. Moreover, XBRL does not provide formal semantics that might help to integrate different taxonomies.

In any case, the integration of XBRL data into comparable information is a strong requirement for the analysis of business and financial information at the global level. This might increase the efficiency and effectiveness of the decision making processes relying on this kind of information. For instance, bankruptcy prediction and other tasks related to the

[1] Electronic Data Gathering, Analysis, and Retrieval system, http://www.sec.gov/edgar.shtml

assessment of the solvency of a firm, a business sector or set of interrelated companies.

Many have already pointed to this issue and propose Semantic Web technologies as a natural choice for XBRL data integration [2]. However, this is not enough, the Semantic Web provides the technologies for data integration but some principles are required that facilitate Web-wide deployment of highly interlinked XBRL data. Linked Data [3] provides these principles to publish data in the World Wide Web in a way that helps making it easily discoverable through the links that connect it to other pieces of data.

Despite these benefits, currently, financial and business data is being produced using XBRL and it seems that more and more XBRL data is going to be available in the future. XBRL is been promoted by regulators and government agencies like the SEC, as it has been shown before, but also other bodies like the European Union or the Spanish securities commission [4].

Consequently, our opinion is that the best short and mid-term approach to get financial and business data to the Semantic Web is not to propose and alternative language based on Semantic Web technologies, but to apply methods to map existing XBRL to semantic metadata.

The rest of this paper is organised as follows. The next Introduction subsections present the XBRL standard. In Section 2, we present our approach, which is based o the XML Semantics Reuse Methodology. The first step is to map the XML Schemas that structure XBRL data to OWL ontologies using the XSD2OWL mapping detailed in Section 2.1. Then, the second step is to map XBRL XML data to RDF using the XML2RDF mapping, which is described in Section 2.2.

The results of the previous mappings, as detailed in Section 3, are a set of OWL ontologies for the main XBRL taxonomies used by the US SEC. Based on these ontologies, it has been possible to map all XBRL instance documents from XML based on these taxonomies to RDF based on the resulting ontologies.

From these ontologies and semantic data, it has been possible to establish some mechanisms, facilitated by Semantic Web technologies, that enrich the dataset with additional links. First, some links to external datasets of the Web of Linked Data as detailed in Section 3.1. Second, internal links that integrate different filings by aligning the ontologies they use, as shown in Section 4. To conclude the paper, the conclusions and future work are presented in Section 5.

1.1. XBRL

XBRL is based on two kinds of documents, instance documents and taxonomies. Instance documents report business facts and point to a set of taxonomies, which define the meaning of these facts, e.g. under what accounting principles they hold, what other facts they related to or what kind of things do they refer to.

1.1.1. Instances

An XBRL instance document contains business facts, for instance “sales in the last quarter”. If the fact has a simple value, like “the long term debt is 350,000” whose value is just a number, it is called Item. Items are represented in XBRL as a single XML element with the value as its content.

However, facts are not isolated entities and it is not enough to provide their values, it is also necessary to contextualize them. Consequently, four more entities are introduced in the XBRL model:

- **Context**: it defines the entity (e.g. company or individual) to which the fact applies, the period of time the fact is relevant and an optional scenario. Scenarios provide further contextual information about the facts, such as whether the business values reported are actual, projected or budgeted. Contexts are referenced from Facts using the “contextRef” attribute, which specifies that the given Fact is valid for the entity, period and scenario defined in the Context.
- **Unit**: it defines a unit of measure, such as “USD” or “shares”. They are referenced from Facts using the “unitRef” attribute, which specifies that the numeric or fractional value of the Fact is based on that unit of measure. Complex units can also be defined, like “USD per share”.
- **Reference**: The kinds of facts under consideration are defined by taxonomies, which specify their meaning in the context of some accounting principles or purpose. These kinds of facts are then used in instance documents in order to specify actual values for them. They are linked to their definition in the taxonomies, typically through schema references.
- **Footnote**: it contains some additional support content and it is associated to a fact using XLink.

Table 1 shows part of an instance document that contains a Context element which defines a company, a time period and the scenario “unaudited”. Then, there is a fact that holds in that context.

Table 1. Context and facts examples from an EDGAR filing

```
…
<context id="From20080301-To20080530_Unaudited">
  <entity>
    <identifier scheme="http://www.sec.gov/CIK">
      796343
    </identifier>
    &lt;segment&gt;<adbe:EnterpriseSolutions/>&lt;/segment&gt;
  </entity>
  <period>
    <startDate>2008-03-01</startDate>
    <endDate>2008-05-30</endDate>
  </period>
  <scenario><adbe:Unaudited/></scenario>
</context>
…
<adbe:EnterpriseSolutionsRevenue decimals="-6"
  contextRef="From20080301-To20080530_Unaudited"
  unitRef="USD">
    54400000
</adbe:EnterpriseSolutionsRevenue>
…
```

1.1.2. Taxonomies

Taxonomies are the other kind of XBRL document. A taxonomy defines a hierarchy of concepts, basically kinds of facts, and captures part of their intended meaning. In XBRL there is a set of base taxonomies that define the core concepts and other ones that extend them in order to particularize these concepts for concrete accounting principles, application domains, etc. Additionally, it is possible to extend existing taxonomies and accommodate them to particular needs.

Taxonomies are based on XML Schemas, which provide the taxonomy building primitives and the extension mechanisms.

2. Approach

The proposed approach is to transform XBRL data to RDF but also to map the associated XBRL taxonomies to capture also part of the intended semantics of the mapped facts.

The relations among facts defined in the taxonomies capture part of the meaning intended by the schema developer that, though XML Schema does not provide a way to encode semantics, is recorded in the way XML Schema constructs are used.

For instance, by modeling that element “father” is a *subtitutionGroup* for element “parent”, it is possible to interpret that “parent” is more general than “father” and that “father” can appear where “parent” appears. More details about the implicit semantics of XML Schema constructs as compared to OWL ones are provided in Section 2.1.

Therefore, we have chosen the XML Semantics Reuse methodology [5] and the XML Schema to OWL and XML to RDF tools implemented in the ReDeFer project[2] as the starting point to map XBRL instance and taxonomy documents to semantic data.

This methodology combines an XML Schema to web ontology mapping, called XSD2OWL, with a mapping from XML to RDF, XML2RDF. The ontologies generated by XSD2OWL are used during the XML to RDF step in order to generate semantic metadata that takes into account the XML Schema intended meaning.

This approach has already shown its usefulness with other quite big XML Schemas in the Digital Rights Management domain, such as MPEG-21 and ODRL [6], and also in the E-Business [7] and multimedia metadata domains [8], where it produced the more complete MPEG-7 ontology to date [9].

2.1. XSD2OWL Mapping

The XML Schema to OWL mapping is responsible for capturing the schema implicit semantics, which is determined by the combination of XML Schema constructs. The mapping is based on translating these constructs to the OWL ones that best capture their intended meaning. These translations are detailed in Table 2 and Table 3 shows an example mapping.

Table 2. XSD2OWL translations for the XML Schema constructs

XML Schema	OWL	Mapping motivation
element | attribute	rdf:Property owl:DatatypeProperty owl:ObjectProperty	Named relation between nodes or nodes and values
element@substitutionGroup	rdfs:subPropertyOf	Relation can appear in place of a more general one
element@type	rdfs:range	The relation range kind
complexType|group |attributeGroup	owl:Class	Relations and contextual restrictions package
complexType//element	owl:Restriction	Contextualised restriction of a relation
extension@base | restriction@base	rdfs:subClassOf	Package concretises the base package
@maxOccurs @minOccurs	owl:maxCardinality owl:minCardinality	Restrict the number of occurrences of a relation
sequence choice	owl:intersectionOf owl:unionOf	Combination of relations in a context

Therefore, XSD2OWL produces OWL ontologies that make explicit part of the semantics of the corresponding XML Schemas. Table 3 shows a piece

[2] ReDeFer project, http://rhizomik.net/redefer

of an XML Schema and the OWL that is generated following this approach.

Table 3. XML Schema to OWL mapping example (namespaces omitted for readability)

XML Schema	OWL (Abstract Syntax)

<complexType
 name="**OrganisationType**">
  <complexContent>
    <extension base=
     "**EntityType**">
      <sequence>
        <element name="**country**"
         type="**CountryType**"/>
      </sequence>
    </extension>
  </complexContent>
</complexType>
	Class (**OrganisationType**
	 complete
	  EntityType
	  restriction(**country**
	   allValuesFrom(
	    CountryType)
	   cardinality(1)))

2.2. XML2RDF Mapping

Once all the XBRL Schemas are mapped to OWL ontologies, it is time to map the XBRL XML instance data that instantiates them. The approach is based on structure-mapping, i.e. representing the XML tree structure using RDF.

The RDF model is based on the graph so it is easy to model a tree using it. Moreover, we do not need to worry about the semantics loose produced by structure-mapping. We have formalised the underlying semantics into the corresponding ontologies and we will attach them to RDF metadata using the instantiation relation *rdf:type* later.

The structure-mapping is based on translating XML metadata instances to RDF ones that instantiate the corresponding constructs in OWL. The more basic translation is between relation instances, from *xsd:elements* and *xsd:attributes* to *rdf:Properties*. Concretely, *owl:ObjectProperties* for node to node relations and *owl:DatatypeProperties* for node to value ones.

Values are kept during the translation as simple types and RDF blank nodes are introduced in the RDF model in order to serve as the source and destination for properties, as it is shown in Fig. 1.

The resulting RDF graph model contains all that we can obtain from the XML tree. It is already semantically enriched thanks to the *rdf:type* relation that connects each RDF property to the *owl:ObjectProperty* or *owl:DatatypeProperty* it instantiates. It can be enriched further if the blank nodes are related to the *owl:Class* that defines the package of properties and associated restrictions they contain, i.e. the corresponding *xsd:complexType*. This semantic decoration of the graph is formalised using *rdf:type* relations from blank nodes to the corresponding OWL classes.

At this point we have obtained a semantically enabled representation of the input metadata, a representation that makes the meaning intended by the XML and XML Schema modelers explicit from a computer point of view. The instantiation relations can now be used to apply OWL semantics to metadata. Therefore, the semantics derived from further enrichments of the ontologies, e.g. integration links between different ontologies or semantic rules, are automatically propagated to instance metadata thanks to inference, as it is shown in the next sections.

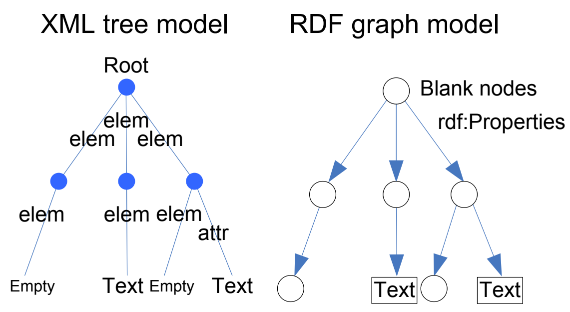

Fig. 1. Comparing the source XML tree and the resulting RDF model

3. Results

First of all, we have generated an ontological infrastructure for the XBRL core used in the context of the US SEC, currently XBRL 2.1. It is composed by the ontologies resulting from mapping the XBRL XML Schemas using the XSD2OWL mapping: XBRL Instance, XBRL Linkbase, XBRL XL and XBRL XLink.

Addtionally, the US GAAP (Generally Accepted Accounting Principles) and non-US GAAP schemas listed in Table 4 and usually found in filings to the US SEC have been also mapped to OWL ontologies using XSD2OWL.

All the previous ontologies are available from the BizOntos site[3] and the semantic data for all the processed filings can be queried and browsed from the Semantic XBRL site[4]. Currently, almost 30000 filings by USA companies to the US SEC habe been processed using XML2RDF and more than 125 million triples have been obtained. However, we

[3] BizOntos, http://rhizomik.net/ontologies/bizontos
[4] SemanticXBRL, http://rhizomik.net/semanticxbrl

have more than 100000 filings currently available so potentially the SemanticXBRL dataset might grow up to more than 400 million triples.

Table 4. XBRL Schemas commonly found in filing to the US SEC that have been mapped to OWL ontologies

- **US GAAP** (Generally Accepted Accounting Principles):
  - Primary Terms Elements (USFR-PTE)
  - Primary Terms Relationships (USFR-PTR)
  - Financial Services Terms Elements (USFR-FSTE)
  - Financial Services Terms Relationships (USFR-FSTR)
  - Investment Management Terms Relationships (USFR-IME)
  - Industry
    - Banking and Savings Institutions (US-GAAP-BASI)
    - Commercial and Industrial (US-GAAP-CI)
    - Insurance (US-GAAP-INS)
    - Investment Management (US-GAAP-IM)
- **Non-GAAP**:
  - Accountants Report (USFR-AR)
  - Management Discussion and Analysis (USFR-MDA)
  - Management Report (USFR-MR)
  - SEC Certifications (USFR-SECCERT)

Table 5 shows the RDF metadata resulting from applying the XML2RDF mapping to the XBRL context and fact shown in Table 1. The RDF metadata references classes and properties from the OWL ontologies resulting from mapping the XML Schemas used in the XML instance. This includes the XBRL schemas and also those specific for the concrete filing being processes.

For a more general view of the resulting semantic dataset, Fig. 2 shows a diagram of the resulting RDF model. At this step, it is possible to take profit from semantic web technologies in order to facilitate connecting the resulting data to other datasets, but also to improve the interconnectedness of the dataset. Both processes are detailed in the next subsections.

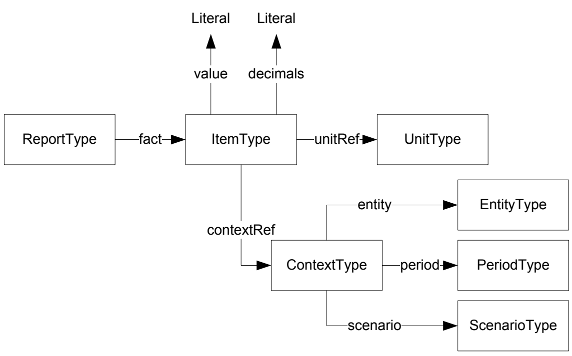

Fig. 2. RDF Model of the semantic XBRL dataset (squares: classes, arrows: properties)

Table 5. RDF mapping for the context and fact shown in Table 1

```
…
<xbrli:contextType rdf:about="&semxbrl;adbe-20080616#
      From20080301-To20080530_Unaudited">
     <xbrli:period>
       <xbrli:contextPeriodType>
         <xbrli:endDate>2008-05-30</xbrli:endDate>
         <xbrli:startDate>2008-03-
01</xbrli:startDate>
       </xbrli:contextPeriodType>
     </xbrli:period>
     <xbrli:entity>
       <xbrli:contextEntityType
           rdf:about="&semxbrl;CIK/796343">
         &lt;xbrli:segment&gt;
           <xbrli:segmentType>
             <adbe:EnterpriseSolutions
                rdf:parseType="Resource">
             </adbe:EnterpriseSolutions>
           </xbrli:segmentType>
         &lt;/xbrli:segment&gt;
       </xbrli:contextEntityType>
     </xbrli:entity>
     <xbrli:scenario>
       <xbrli:contextScenarioType>
         <adbe:Unaudited rdf:parseType="Resource">
         </adbe:Unaudited>
       </xbrli:contextScenarioType>
     </xbrli:scenario>
</xbrli:contextType>
…
<adbe:EnterpriseSolutionsRevenue>
      <xbrli:monetaryItemType>
        <xbrli:unitRef
rdf:resource="http://dbpedia.org/resource/USD"/>
        <xbrli:decimals>-6</xbrli:decimals>
        <xbrli:contextRef
rdf:resource="&semxbrl;adbe-20080616#From20080301-
To20080530_Unaudited"/>
        <rdf:value>54400000</rdf:value>
      </xbrli:monetaryItemType>
</adbe:EnterpriseSolutionsRevenue>
```

3.1. Links to External Data

In order to connect the SemanticXBRL dataset with others in the Web of Linked Data, the entities in the XBRL model have been analyzed in order to detect those also described in other datasets. The more prominent ones are companies, a kind of EntityType present in most XBRL filings. US SEC XBRL data provides an identifier for these entities, the Central Index Key (CIK) number. It is a number given to an individual or company by the US SEC and used to identify the filings of a company, person, or entity in several online databases.

However, there are some filings that do not use this identifier and use the “CompanyName” one instead. For most of them it is possible to get the corresponding CIK using CIK Lookup service[5].

[5] Search EDGAR: CIK Lookup, http://sec.gov/edgar/searchedgar/cik.htm

Even when a CIK identifier is available in the dataset, it might be impossible to directly connect it to companies in the Linked Open Data cloud[6] because the CIK is just available from a handful of company description in DBPedia. In this case, the SILK tool has been used too align companies in the dataset with companies in DBPedia based on their name. This way, it has been possible to generate 63 links from companies in the SemanticXBRL dataset to DBPedia. Fortunately, there is another dataset in the LOD cloud also proving information about companies that does use the CIK identifier. It is the SEC-RDFAbout dataset[7]. In this case 398 links have been generated.

Due to the fact that the SemanticXBRL dataset follows the Linked Open Data principles and is linked to datasets in the LOD cloud, it is now part of the LOD cloud and consequently appears in the LOD cloud diagram[8].

4. Evaluation

The proposed approach has been evaluated using two input XBRL reports for the same company but based on different accounting principles, and consequently different taxonomies. The input data is from Telefonica S.A., one of the reports was submitted to the Spanish CNMV and the other to the US SEC[9], more specifically the consolidated Balance Sheet for the years 2009 and 2008.

The elaboration of the financial statements for the CNMV has been done under the Spanish GAAP regulations[10], i.e. Plan General de Contabilidad (PGC), and the corresponding XBRL taxonomies based on IFRS[11]. Meanwhile, financial information filed to the US SEC was elaborated also using the IFRS taxonomies, but following SEC's provisions for foreign corporations.

Therefore, it could be expected that both XBRL financial reports would be the same or at least quite similar. However, there are some differences, as shown in the online demo[12], due to different fact names or levels of disaggregation.

For instance, the in the PGC balance sheet for the Spanish CNMV, the *ipp-gen:ActivoNoCorrienteNiif* fact amounts 84.311 million euros, which correspond to the *ifrs:NoncurrentAssets* fact in the IFRS balance sheet for the US SEC. An *owl:equivalentClass*[13] OWL construct has been manually defined between these two facts but, from that point, it makes it possible to query any PGC-based filing in US SEC terms facilitating thus financial information integration and comparability.

When the relation is more complex than a simple equivalence because the filings follow different leves of disaggregation, for instance when the value for a term in one vocabulary is the sum of more than one value in other vocabularies, then the approach is to use a CONSTRUCT[14] SPARQL query that computes the combined value, for instance the sum, and creates the computed fact.

For instance, the CONSTRUCT shown in computes all the *ifrs-gp:TradeAndOtherReceivablesNetCurrent* facts expected in a US SEC filing from the facts it is disaggreated in PGC filings, *ipp-gen:ClientesVentasPrestacionesServicios* and *ipp-gen:OtrosDeudores*.

Table 6. SPARQL CONSTRUCT to compute US SEC TradeAndOtherReceivablesNetCurrent facts from PGC facts ClientesVentasPrestacionesServicios and OtrosDeudores

```
CONSTRUCT {
  [] a ifrs-gp:TradeAndOtherReceivablesNetCurrent;
  xbrli:contextRef ?context; xbrli:unitRef ?unit;
  xbrli:decimals ?decimals; rdf:value ?value.
}
WHERE {
  ?cvps a ipp-gen:ClientesVentasPrestacionesServicios;
  xbrli:contextRef ?context; xbrli:unitRef ?unit;
  xbrli:decimals ?decimals; rdf:value ?cvps_value.

  ?od a ipp-gen:OtrosDeudores;
  xbrli:contextRef ?context; xbrli:unitRef ?unit;
  xbrli:decimals ?decimals; rdf:value ?od_value.

  BIND(xsd:integer(?cvps_value)+xsd:integer(?od_value)
       AS ?value)
}
```

[6] Linked Open Data cloud, http://linkeddata.org

[7] U.S. Securities and Exchange Commission Corporate Ownership RDF Data (rdfabout), http://datahub.io/dataset/sec-rdfabout

[8] Linked Open Data cloud diagram, http://lod-cloud.net

[9] Telefonica's report to the CNMV is available from http://www.cnmv.es/ipps/default.aspx and the one sent to SEC is available from http://www.sec.gov/Archives/edgar/data/814052/000095010310000881/dp16939_20f.htm

[10] Models recently modified by Ministerial Oder JUS/1698/2011 of June 13, approving the model for presentation at the Mercantile Registry of the consolidated financial statements

[11] International Financial Reporting Standards (IFRS), http://www.ifrs.org

[12] http://rhizomik.net/semanticxbrl-demo/

[13] OWL Equivalent Class, http://www.w3.org/TR/owl-ref/#equivalentClass-def

[14] SPARQL Construct, http://www.w3.org/TR/sparql11-query/#construct

5. Conclusions and Future Work

The SemanticXBRL dataset has been generated by mapping XML data for XBRL filings using the XML2RDF tool. This mapping is combined with the XSD2OWL one that maps the XML Schemas modelling the XBRL taxonomies used by the XBRL filings to OWL ontologies that capture part of the semantics of the taxonomies.

This way, it is possible to profit from Web ontology primitives in order to semantically integrate different filings following different XML Schemas, i.e. XBRL taxonomies. Once mapped to ontology concepts and relations, the XBRL contexts, facts and other resources defined for different filings can be related as more specific, more general or equivalent. It is also possible to use SPARQL CONSTRUCT queries to establish more complex equivalences among financial facts.

This approach has been put into practice with US SEC and Spanish CNMV XBRL financial data. It has been tested with almost 30000 filings generating more than 125 million triples. Moreover, the benefits of the approach have been validated in an online demo based on real data and capable of generating XBRL facts based on US SEC IFRS taxonomies from facts based on the Spanish CNMV taxonomies using semantic mappings and SPARQL queries established at the ontology level.

Future work focuses on, once we establish more semantic mappings at the conceptual level that can be reused to map instance documents for different companies, obtaining financial statement analysis ratios, taking profit from the semantic data already available.

For instance, to compute the debt ratio (equivalent to total liabilities divided by total assets) or the Return on Sales (ROS, equivalent to net income divided by sales revenue). From these ratios and the semantic mappings, it will be possible, for instance, to create a ranking showing the best-positioned international companies for each ratio mixing the data they submit to different regulators.

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References

[1] Roohani, S., Xianming, Z., Capozzoli, E.A., Lamberton, B. Analysis of XBRL Literature: A Decade of Progress and Puzzle. International Journal of Digital Accounting Research 10 (2010): 131-147.

[2] Watson, L. Industry Framework and Applications for Business Reporting Semantics. Demystifying Financial Services Semantics Conference, New York, USA. March 13th, 2012

[3] Bizer, C., Heath, T., Idehen, K., Berners-Lee, T. Linked data on the web (LDOW2008), in: Proceeding of the 17th international conference on World Wide Web, ACM, 2008, pp. 1265-1266.

[4] Núñez, S., de Andrés, J., Gayo, J. E., and Ordoñez, P. A Semantic Based Collaborative System for the Interoperability of XBRL Accounting Information, in: Emerging Technologies and Information Systems for the Knowledge Society. Lecture Notes in Computer Science Vol. 5288, Springer, Berlin, 2008, pp. 593-599.

[5] García, R. XML Semantics Reuse, Chapter 7 in: A Semantic Web Approach to Digital Rights Management, PhD Thesis, Universitat Pompeu Fabra, Barcelona, Spain, 2006. http://rhizomik.net/~roberto/thesis

[6] García, R., Gil, R., Delgado, J. A Web Ontologies Framework for Digital Rights Management, Journal of Artificial Intelligence and Law 15, 2 (2007) 137-154.

[7] García, R., Gil, R. Facilitating Business Interoperability from the Semantic Web, in: Proceedings of the 10th International Conference on Business Information Systems, BIS'07, Lecture Notes in Computer Science Vol. 4439, Springer, Berlin, 2007, pp. 220-232.

[8] García, R., Perdrix, F., Gil, R., Oliva, M. The Semantic Web as a Newspaper Media Convergence Facilitator, Journal of Web Semantics 6, 2 (2008) 151-161.

[9] García, R., Tsinaraki, C., Celma, O., Christodoulakis, S. Multimedia Content Description using Semantic Web Languages, in: Semantic Multimedia and Ontologies: Theory and Applications, Y. Kompatsiaris and P. Hobson Eds. Springer, Berlin, 2008, pp. 17-54.