An ontology modelling perspective on business reporting languages

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Next generation Business intelligence

- BI is a fast growing sector of enterprise IT applications
- BI involves advanced data, information and even knowledge modelling
- BI requires massive data processing like in data warehouses
- new dimension of BI is needed due to regulatory compliance requirements (Basel II etc)
- in addition, new big free trade areas in EU, America, Asia create new administrative requirements for massive information integration and intelligence
The EU MUSING integrated project

- MUlti-industry, Semantic-based next generation business INtelliGence
- EU IP project for advanced decision support in several risk assessment and risk management areas
- with partners from
  - relevant industry sectors
    - financial risk management  Banca di Monte dei Paschi di Siena
    - IT operational risk management  risk management consultancies Ci3 and KPA
    - internationalization consulting  SKOY
  - financial business registry and enterprise intelligence institutions –
The EU MUSING integrated project II

- European Business Registry,
- Verband der Vereine Creditreform
- software and IT services / managed operations houses (Metaware, KPA)
- academic research (UPV, DFKI, USFD, DERI, UPI)
  - data and knowledge mining (U Pisa)
  - applied econometrics / statistics departments (U Pavia)
  - natural language processing (DFKI, U Sheffield)
- and semantic technology institutes (DERI, DFKI)
Business reporting standards

**data definition and structure standards** – implement standard data formats for reporting across industry sectors and countries

**reporting indicator standards** – implement standard indicator definitions for assessment of financial and other risks aiming at worldwide comparability,

**reporting metadata standards** – provide structures for international business data warehousing
XBRL – the eXtensible Business Reporting Language – overall structure

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## Indicator standards – example from Basel II Credit Risk Assessment Template

<table>
<thead>
<tr>
<th>ID</th>
<th>Label</th>
<th>Amount (a)</th>
<th>Legal References &amp; Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TOTAL OWN FUNDS FOR SOLVENCY PURPOSES</td>
<td>$1.1+1.2+1.3+1.6+1.7$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$1.4+1.5+1.6+1.7$</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>ORIGINAL OWN FUNDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.1</td>
<td>Eligible Capital</td>
<td>$1.1.1+1.1.2+1.1.3+1.1.4$</td>
<td>Eligible Tier I capital</td>
</tr>
<tr>
<td>1.1.1*</td>
<td>Of which: Non- Innovative instruments subject to limit</td>
<td>$1.1.1.1+1.1.1.2+1.1.1.3+1.1.1.4$</td>
<td>See Item 1.1.5.2</td>
</tr>
<tr>
<td>1.1.1**</td>
<td>Of which: Innovative instruments subject to limit</td>
<td></td>
<td>Corresponds to the type of instruments referred to in the Basel Committee on Banking Supervision’s press release (Sydney, October 1999). See Item 1.1.5.3</td>
</tr>
<tr>
<td>1.1.1.1</td>
<td>Paid up capital</td>
<td>Article 57, sentence 1 lit.(a) of Directive 2006/48/EC.</td>
<td>≈ FINREP: Paid in capital</td>
</tr>
<tr>
<td>1.1.1.2</td>
<td>(-) Own shares</td>
<td>Article 57, sentence 2 lit. (i) of Directive 2006/48/EC</td>
<td>≈ FINREP: Treasury shares</td>
</tr>
<tr>
<td>1.1.1.3</td>
<td>Share premium</td>
<td>Article 57, sentence 1 lit. (a) of Directive 2006/48/EC</td>
<td>≈ FINREP: Share premium</td>
</tr>
</tbody>
</table>
| 1.1.1.4 | Other instruments eligible as capital        | Article 57, sentence 1 lit.(a) of Directive 2006/48/EC | See also Guidelines on Prudential Filters for Regulatory Capital (CEBS, 21.12.2004) due to the application of IAS-type accounting rules. This item includes the instruments eligible as own funds but classed as debt under the IAS-type accounting rules ≈ FINREP: Includes amongst others the item "Other equity:other" and "share capital repayable on demand (e.g. cooperative shares)"
| 1.1.2 | Eligible Reserves                            | $1.1.2.1+1.1.2.2+1.1.2.3+1.1.2.4a+1.1.2.4b+1.1.2.5+1.1.2.6 |                                                                                                           |
| 1.1.2.1 | Reserves                                     | Article 57 sentence 1 lit.(b) of Directive 2006/48/EC, including profit and losses brought forward as a result of the application of the final profit or loss. Article 65 (1) lit. (b), (c) and (d) and (2) of Directive 2006/48/EC. ≈ FINREP: Reserve+Revaluation reserves (excludes the valuation differences included in 1.1.2.6) |
| 1.1.2.2 | Minority interest                            | Article 65 (1) lit. (a) and (2) of Directive 2006/48/EC. ≈ FINREP: Minority interest (excludes the valuation differences included in 1.1.2.6) |
| 1.1.2.2*| Of which: Non- Innovative instruments subject to limit | See Item 1.1.5.2 |                                                                                                           |
| 1.1.2.2**| Of which: Innovative instruments subject to limit | $1.1.2.3.01+1.1.2.3.02. | Corresponds to the type of instruments referred to Basel Committee on Banking Supervision’s press release (Sydney, October 1998). See Item 1.1.5.3 |
| 1.1.2.3 | Interim profits                              |                                  |                                                                                                           |

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XBRL General Ledger for data integration in administrations

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An ontology modelling perspective on business reporting languages
Why ontologies?

**Taxonomy representation** – reporting elements are organized in definitional taxonomies

**Taxonomy integration** – different taxonomy standards prevail (e.g., BACH database)

**Aggregation rules separation** – reporting elements are aggregated to provide critical indicators, again this is subject to change by legislation

**Unstructured (e.g., legal) references management** –
Purpose in the EU Multi-industry semantic based next generation business intelligence project I

- MUSING will deliver next generation analytical applications integrating quantitative and qualitative analysis for advanced decision support
- reporting data are used for MUSING applications on the basis of ontology representations of the reporting languages –

**balance sheet data spotting from pdf documents** –
pdf2xbrl tool of DFKI Saarbrücken uses RDF-labels
Purpose

Purpose in the EU Multi-industry semantic based next generation business intelligence project II

- **text mining for balance sheet relevant information** – GATE tool (Sheffield university) provides annotations of texts from news services serve as additional data source for next generation business intelligence

- **probabilistic analysis of reporting data** – Bayesian analysis of expected risks etc (extension of Bayesian networks – forthcoming work of Innsbruck and Pavia universities)

- ontologies will support all these applications based on a repository with database backend and web services interface
Methodology for ontology engineering

- Development methodology – use expert communication, concentrate on competency questions – NOT main focus here
- Logical design principles – long time neglected in ontology construction, but crucial for large ontologies to work
- Here, we concentrate on the OMG ontology definition metamodel (ODM) that ensures compatibility of ontologies with other business object models
Associations in XML vs. OWL

- XBRL uses in XML a context complex type as an element of an XBRL balance sheet instance.
- The context complex type is subtype of another more general context entity type.
- Translating this to OWL leads to an OWL full ontology. OWL description logic does not allow property types.
- OWL full is rarely used in applications because of undecidability (even if this is only worst case behaviour).
OWL full representation of XBRL context property type

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UML / OWL mappings for associations I

**Associations**

**UML** modeling element in class diagrams specializing classifiers and relationships

**OWL** object property with domain and range classes (NOT owned by a given class).

**Association Classes**

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An ontology modelling perspective on business reporting languages
**UML / OWL mappings for associations II**

**UML**  A class owning an association specializing associations and classes

**OWL**  A class with functional properties with range on the classes participating in the association

Consequence – Can have attributes of associations and association classes participating in further associations
Item structures

Example – Representation of an association class in OWL

this allows an improved ontology representation of the XBRL XML schema describing items and their contexts on the OWL DL level.
suppose, an ontology must contain individuals for companies and a taxonomy of business activity codes (like NACE in Europe) to be used for each company

add classification from a taxonomy to an individual – but how?

**object property** – requires individuals representing classes of the taxonomy – we lose the subclass relationship for representing the taxonomy itself

make the taxonomy classes accessible as individuals – use OWL full, running into undecidability
A simple(?) task in ontology construction II

- express taxonomy hierarchy as property associating individuals and use a property for immediate sub-individuals – can lead to spaghetti code in the ontology and makes inferencing complex

**subproperty** – leads to values of subproperties aggregated for higher taxonomy elements – that would make representing companies acting in a sector with no apparent specialization impossible
A simple(?) task in ontology construction III

**subclassing** – make individual element of suitable taxonomy class – leads to multiple inheritance in most applications BUT – this is the correct choice in accordance with a general business object modelling approach
Taxonomies in business reporting languages

- document hierarchy of balance sheet section structure (structure perspective)
- presentation functionality for balance sheet data (layout perspective)
- selection and aggregation regulations for capital requirements and risk analysis (content perspective)
- taxonomy implies definitions for aggregation dimensions in data warehousing
eXtensible Business Reporting Language – example of balance sheet item taxonomy

Note the taxonomy is not an XML element hierarchy – the hierarchy is conceptual and can be visualized only on the presentation layer.
Ontology interpretations of Reporting Item Classes

- A common interpretation of business taxonomies in terms of ontologies consists of mapping a given taxonomy hierarchy to a subclass hierarchy.
- E.g., unpaid capital items can be seen as a subset of asset items etc.
- The little problem with this interpretation is that assets (the total) is a balance sheet item itself derived from aggregating lower level item data.
- Therefore, an interpretation in terms of part-of relationships, or a mereology seems more appropriate.
- The parts of a balance sheet mereology are relations. This is common in data warehousing.
relationship class in OWL is an ordinary OWL class given specific functional properties for each attribute of the n-ary relationship.

Logically, these functional properties correspond to the projections of the multi-attribute relationship to one particular attribute.

The domain of each such property is the set of possible instances of the relationship class in question.

The range of each such property is the domain of the respective attribute.

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ODM for n-ary relationships

Example of an ODM compliant ontology representation of an XBRL accounting relational hierarchy
mapping reporting languages structures to ontologies is important for next generation business intelligence

however, the ontology representations need guidance from engineering principles applied elsewhere in business object modelling

we saw that ODM provides a very useful set of representation primitives that greatly facilitates ontology construction

in particular, taxonomies should not be taken automatically as class hierarchies, mereologies and other upper ontologies are important (in MUSING, we additionally use a time ontology to represent time-sliced economic data)