



The xEBR Ontology
Transforming the XBRL Europe Business Registers Taxonomy
into an OWL Ontology: How & What For

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Overview

- ▶ Background, Goals & Benefits
- ▶ xEBR Ontology
- ▶ Showcases

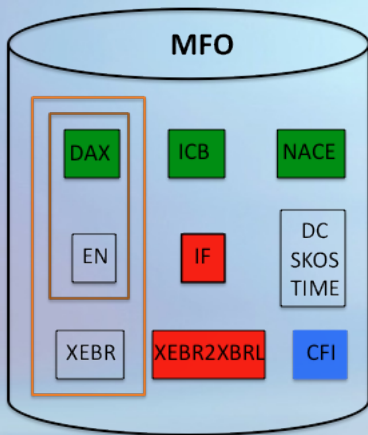
Background: The Monnet & TrendMiner Projects

- ▶ European Integrated Projects
 - ▶ Monnet (www.monnet-project.eu)
 - ▶ TrendMiner (www.trendminer-project.eu)
- ▶ information extraction from
 - ▶ stock exchange http pages
 - Deutsche Börse, NYSE Euronext, Bolsa de Madrid
 - ▶ machine-readable financial documents
 - financial reports from different XBRL jurisdictions
- ▶ record extracted data in a Semantic Repository
 - ▶ transform data into a meaningful form w.r.t. ontology
 - ▶ use well-defined standards (e.g., XSD, RDF, OWL)
 - ▶ carry out inferences and queries
 - ▶ to make implicit knowledge explicit
 - ▶ to unveil inconsistencies
- ▶ xEBR ontology mediates between different XBRL jurisdictions

xEBR—What is This ?

- ▶ international standard for financial reporting: XBRL
 - ▶ XBRL = *eXtensible Business Reporting Language*
 - ▶ free and open standard
 - ▶ makes use of usual XML technologies
 - ▶ describes important financial information for one full year
- ▶ structure of XBRL document is the same for each jurisdiction
- ▶ **but**
 - ▶ namespace and tag names differ
 - ▶ some of the tags in one jurisdiction do not exist in another one
- ▶ circumvent these issues (in part): xEBR
 - ▶ xEBR = *XBRL Europe Business Registers*
 - ▶ XBRL working group on xEBR
 - ▶ core taxonomy (\approx interlingua) for all XBRL jurisdictions
 - ▶ information that is shared by all jurisdictions
 - ▶ canonical names
 - ▶ further info: other key financial ratios, company identification

Background: Schema—The Monnet Financial Ontology



- ▶ green: industry sector classification
- ▶ orange: financial reporting
- ▶ brown: stock exchange master data
- ▶ red: interface axioms
- ▶ blue: financial instruments

Background: Instance Data—Company Snapshots

- ▶ company information is harvested from stock exchange pages
- ▶ caption-value pairs are translated into instance data compliant with the DAX & EN ontology schemata
- ▶ this includes
 - ▶ the proper use of class and property names
 - ▶ the introduction of fresh URIs for individuals of interest
 - ▶ the syntactical transformation of values
 - ▶ the combination of values from different places
- ▶ binary facts + temporal duration: quintuples
- ▶ DE000A1EWWO_1324055698213 DE000A1EWWO_1324055698213
dax:endOfBusinessYear dax:totalCapitalStock
"--12-31"^^xsd:gMonthDay "209216186EUR"^^xsd:monetary
"2011-12-21T16:24:20"^^dateTime "2011-12-21T16:24:20"^^dateTime
"2011-12-21T16:24:20"^^dateTime "2011-12-21T16:24:20"^^dateTime

Background: Instance Data—xEBR Reports

- ▶ financial facts are harvested from XBRL reports
- ▶ xEBR serves as a mediator between XBRL jurisdictions
- ▶ XML-to-N-Triples translation

```
<pfs:Assets contextRef="CurrentInstant"↔ % CurrentInstance=2007  
  decimals="INF" unitRef="U-EUR">128413</pfs:Assets>
```

```
rep42 rdf:type xebr:Report
```

```
rep42 xebr:start "2007-04-01"^^xsd:date
```

```
rep42 xebr:end "2008-03-31"^^xsd:date
```

```
rep42 xebr:hasKeyBalanceSheetFiguresReport kbsfr4711
```

```
kbsfr4711 rdf:type xebr:KeyBalanceSheetFiguresReport
```

```
kbsfr4711 xebr:hasAssetsPresentation ap217
```

```
ap217 rdf:type xebr:AssetsPresentation
```

```
ap217 xebr:hasAssetsTotal "128413EUR"^^xsd:monetary
```

- ▶ XEBR2XBRL & IF OWL axioms

```
xebr:AssetsPresentation ≡ xbrl_be:AssetsTitle
```

```
xebr:AssetsPresentation ≡ xbrl_es:ActivoPresentacion
```

```
xebr:hasAssetsTotal ≡ xbrl_be:hasAssets
```

```
xebr:hasAssetsTotal ≡ xbrl_es:hasTotalActivo
```

```
en:revenue ≡ xebr:hasNetTurnover
```

```
en:operatingProfit ≡ xebr:hasOperatingProfitLossTotal
```

Using xEBR: Benefits

- ▶ the representation of the xEBR taxonomy as an OWL ontology enables the use of semantic technologies
- ▶ short-time varying stock exchange data can be merged with long(er)-time static data found in XBRL reports
- ▶ data redundancy permits consistency checking and the generation of financial summaries
- ▶ the use of xEBR (and industry sector classification) makes it possible to compare companies across XBRL jurisdictions
- ▶ multilingual labels (e.g., English, French, German) attached to xEBR concepts ease the work of human analysts

xEBR: Version 7 XML Specification, plus further files

```
<xsd:element name="KeyBalanceSheetFiguresReport" id="xebr_KeyBalanceSheetFiguresReport"
type="xbrli:stringItemType" substitutionGroup="xbrli:item" abstract="true" nillable="true"
xbrli:periodType="instant"/>
<xsd:element name="AssetsPresentation" id="bach_AssetsPresentation" type="xbrli:stringItemType"
substitutionGroup="xbrli:item" abstract="true" nillable="true" xbrli:periodType="instant"/>
<xsd:element name="SubscribedCapitalUnpaid" id="bach_SubscribedCapitalUnpaid"
type="xbrli:monetaryItemType" substitutionGroup="xbrli:item" nillable="true"
xbrli:balance="debit" xbrli:periodType="instant"/>
<xsd:element name="FixedAssetsPresentation" id="xebr_FixedAssetsPresentation"
type="xbrli:stringItemType" substitutionGroup="xbrli:item" abstract="true" nillable="true"
xbrli:periodType="instant"/>
<xsd:element name="IntangibleFixedAssetsPresentation"
id="bach_IntangibleFixedAssetsPresentation" type="xbrli:stringItemType"
substitutionGroup="xbrli:item" abstract="true" nillable="true" xbrli:periodType="instant"/>
<xsd:element name="FormationPreliminaryExpenses" id="bach_FormationPreliminaryExpenses"
type="xbrli:monetaryItemType" substitutionGroup="xbrli:item" nillable="true"
xbrli:balance="debit" xbrli:periodType="instant"/>
<xsd:element name="OtherIntangibleFixedAssets" id="bach_OtherIntangibleFixedAssets"
type="xbrli:monetaryItemType" substitutionGroup="xbrli:item" nillable="true"
xbrli:balance="debit" xbrli:periodType="instant"/>
<xsd:element name="IntangibleFixedAssetsTotal" id="bach_IntangibleFixedAssetsTotal"
type="xbrli:monetaryItemType" substitutionGroup="xbrli:item" nillable="true"
xbrli:balance="debit" xbrli:periodType="instant"/>
<xsd:element name="TangibleFixedAssetsPresentation" id="bach_TangibleFixedAssetsPresentation"
type="xbrli:stringItemType" substitutionGroup="xbrli:item" abstract="true" nillable="true"
xbrli:periodType="instant"/>
.....
```

xEBR: Version 7 Microsoft Excel Specification

Key Balance Sheet Figures [Report]	KEY BALANCE SHEET FIGURES [Report]		role
Assets [Presentation]	Assets [Presentation]		abstract
Subscribed Capital Unpaid [Presentation]		Subscribed capital unpaid [Presentation]	abstract
Subscribed Capital Unpaid [Total]		Subscribed capital unpaid [Total]	monetary
Fixed Assets [Presentation]		Fixed assets [Presentation]	abstract
Intangible Fixed Assets [Presentation]		Intangible fixed assets [Presentation]	abstract
Formation Preliminary Expenses		Formation (preliminary) expenses	monetary
Other Intangible Fixed Assets		Other intangible fixed assets	monetary
Intangible Fixed Assets [Total]		Intangible fixed assets [Total]	monetary
Tangible Fixed Assets [Presentation]		Tangible fixed assets [Presentation]	abstract
Property Plant And Equipment [Presentation]		Property, plant, and equipment [Presentation]	abstract
Land And Buildings		Land and buildings	monetary
Plant And Machinery		Plant and machinery	monetary
Furniture Fixtures And Equipment		Furniture, fixtures, and equipment	monetary
Other Property Plant And Equipment		Other property, plant, and equipment	monetary
Other Fixtures		Other fixtures	monetary
Property Plant And Equipment [Total]		Property, plant, and equipment [Total]	monetary
Payments On Account And Assets In Construction		Payments on account and assets in construction	monetary
Other Tangible Fixed Assets		Other tangible fixed assets	monetary
Tangible Fixed Assets [Total]		Tangible fixed assets [Total]	monetary
Financial Fixed Assets [Presentation]		Financial fixed assets [Presentation]	abstract
Affiliated Enterprises		Affiliated enterprises	monetary
Other Financial Assets		Other financial assets	monetary
Financial Fixed Assets [Total]		Financial fixed assets [Total]	monetary
Fixed Assets [Total]		Fixed assets [Total]	monetary

xEBR: From a Taxonomy to an Ontology

- ▶ specification: make use of W3C standards RDF & OWL
 - ▶ declarative formalism
 - ▶ precise semantics
 - ▶ computational properties: decidable, terminating
- ▶ taxonomy is a tree, expressing meronymy (**not** hyponymy !)
- ▶ every xEBR concept in the specification comes with
 - ▶ tag (xEBR concept): OWL class and/or property
 - ▶ (multilingual) label: annotation property `rdfs:label`
 - ▶ xEBR type
 - ▶ *role*: 4 fundamental parts of an xEBR report;
example: *Key Balance Sheet Figures [Report]*
 - ▶ *abstract*: a presentation has parts;
example: *Assets [Presentation]*
 - ▶ *tuple*: like *abstract*, but parts might be instantiated multiple times; example: *Company Official [List]*
 - ▶ monetary, string, date, etc.: leaves of the taxonomy

xEBR: From a Taxonomy to an Ontology—Idea

- ▶ **whole** (indent i) \ni **part** (indent $i + 1$): xEBR types
 - ▶ role \ni abstract | tuple
 - ▶ abstract | tuple \ni abstract | tuple
 - ▶ abstract | tuple \ni atomic type
 - ▶ **no** other combinations possible, i.e., atomic type $\not\equiv$ abstract | tuple
- ▶ transformation to OWL
 - ▶ role, abstract, tuple: OWL classes
 - ▶ xEBR atomic types: XSD types
 - ▶ parthood (\ni): dedicated OWL properties
- ▶ `<whole>` has`<part>` `<part>`
 - ▶ ... \ni **abstract**: functional *object* property
 - ▶ ... \ni **tuple**: (relational) *object* property
 - ▶ ... \ni **atomic type**: functional *datatype* property

xEBR: From a Taxonomy to an Ontology—Example

- ▶ ontology schema is auto-generated by a Java program
- ▶ N-Triples file is transformed into OWL-XML using raptor
- ▶ result can be viewed and modified using ontology editors
- ▶ example: *Assets [Presentation] \supseteq Fixed Assets [Presentation]*

```
xebr:AssetsPresentation rdf:type owl:Class
xeb:AssetsPresentation rdfs:label "Assets [Presentation]"@en
xeb:AssetsPresentation rdfs:subClassOf xebr:Abstract

xeb:hasFixedAssetsPresentation rdf:type owl:FunctionalProperty
xeb:hasFixedAssetsPresentation rdf:type owl:ObjectProperty
xeb:hasFixedAssetsPresentation rdfs:domain xebr:AssetsPresentation
xeb:hasFixedAssetsPresentation rdfs:range xebr:FixedAssetsPresentation

xeb:FixedAssetsPresentation rdf:type owl:Class
xeb:FixedAssetsPresentation rdfs:label "Fixed Assets [Presentation]"@en
xeb:FixedAssetsPresentation rdfs:subClassOf xebr:Abstract
```


xEBR: Version 7 OWL Ontology—Protégé View, Cont.

The screenshot shows the Protégé 3.4.4 interface for editing the OWL class `xebr:KeyBalanceSheetFiguresReport`. The main editor area displays the following table of properties:

Property	Value	Lang
<code>rdfs:comment</code>		
<code>rdfs:label</code>	KEY BALANCE SHEET FIGURES [Report]	en
<code>xebr:version</code>	V1	

Below the table, the 'Properties and Restrictions' section lists the following restrictions:

- `xebr:hasAssetsPresentation` (single `xebr:AssetsPresentation`)
- `xebr:hasEquityAndLiabilitiesPresentation` (single `xebr:EquityAndLiabilitiesPresentation`)
- `xebr:hasIncomeStatementPresentation` (single `xebr:IncomeStatementPresentation`)

The SUBCLASS EXPLORER on the left shows the following hierarchy:

- owl:Thing
 - xebr:Class
 - xebr:Abstract
 - xebr:Role
 - xebr:CompanyHistoryReport
 - xebr:CompanyIdentificationReport
 - xebr:CompanyOfficialsReport
 - xebr:KeyBalanceSheetFiguresReport
 - xebr:Tuple
 - xebr:CompanyActivityList
 - xebr:CompanyAddressList
 - xebr:CompanyContactPointList
 - xebr:CompanyHistoryEventList
 - xebr:CompanyIdNumberList
 - xebr:CompanyIdTownOfRegistration
 - xebr:CompanyLegalFormList
 - xebr:CompanyNameList
 - xebr:CompanyOfficialList
 - xebr:OfficialFirstAndMiddleNamesList
 - xebr:OfficialFunctionList
 - xebr:OfficialIdNumberList

The bottom right of the interface shows the 'Disjoints' section, which is currently empty.

xEBR: From a Taxonomy to an Ontology—Alternative

- ▶ meronymy can **not** be expressed *intensionally* for all reports
 - ▶ OWL's TBox axiom constructors: \equiv and \sqsubseteq
 - ▶ geared towards hyponymy
 - ▶ no constructor for parthood \ni
 - ▶ our solution: individual properties for part-whole pairs
 - ▶ **but**: introduces a great number of (possibly empty) container objects over and over again during ontology population
- ▶ solution: meta-model \ni as a TBox axiom constructor
 - ▶ $\ni \sqsubseteq$ owl:Class \times owl:Class
 - ▶ no longer OWL-DL, but still RDF, accessible through SPARQL
 - ▶ requires property belongsTo to link concrete data (e.g., financial numbers) to a specific xEBR report
 - ▶ relational properties (tuple !) can **not** be modeled properly

xEBR: Problems With Hyponymy

- ▶ problem: change of xEBR type; true example:
role → tuple → abstract → tuple → string ??
- ▶ hyponymy would lead to the “inheritance” of properties
- ▶ `hasTangibleFixedAssets` defined on `FixedAssets` is valid for `TangibleFixedAssets` and `PropertyPlantAndEquipment`, given `PropPlantEquip` \sqsubseteq `TangibleFixedAssets` \sqsubseteq `FixedAssets`
- ▶ solution: local cardinality (= 0) restriction defined on classes
- ▶ more serious problem: entailment (universal instantiation) + querying (SPARQL): more than 1 value
- ▶

```
SELECT ?t WHERE {  
  ?p rdf:type xebr:FixedAssets .  
  ?p xebr:hasTotal ?t}
```

Showcases

showcases make use of *HFC*, an in-memory semantic repository and extended forward chainer, going beyond RDF & OWL

- ▶ connecting snapshots and reports
- ▶ multilingual properties and classes
- ▶ evolution of financial data
- ▶ finding competitors across borders
- ▶ financial summaries: filling missing data
- ▶ consistency checking

Showcase: Connecting Snapshots and Reports

snapshots (quintuples) and reports (triples) are not related when they are uploaded; this rule connects them through `if:hasReport` rules and queries below depend on the application of this rule

```
?comp rdf:type dax:Company ?s1 ?e1
?comp dax:isin ?isin ?s1 ?e1
?rep rdf:type xebr:Report
?rep xebr:hasCompanyIdentificationReport ?idrep
?idrep xebr:hasCompanyIdNumberList ?idlist
?idlist xebr:hasCompanyIdValue ?isin
?rep xebr:starts ?s2
?rep xebr:ends ?e2
->
?comp if:hasReport ?rep ?s2 ?e2
```

Showcase: Multilingual Properties and Classes

interface axioms and multilingual labels can ease the work of a human analyst in a specialized GUI (not shown here, only query)

```
xebr:hasAssetsTotal ≡ xbrl.be:hasAssets
xebr:hasAssetsTotal ≡ xbrl.es:hasTotalActivo
xebr:hasKeyBalanceSheetFiguresReport ≡ xbrl.es:hasBalanceSituacionPresentacion
xebr:KeyBalanceSheetFiguresReport ≡ xbrl.es:BalanceSituacionPresentacion
xebr:AssetsPresentation ≡ xbrl.es:ActivoPresentacion

xbrl.be:hasAssets rdfs:label "Summe der Aktiva"de
xbrl.be:hasAssets rdfs:label "Total assets"en
xbrl.be:hasAssets rdfs:label "Total de l'actif"fr
xbrl.be:hasAssets rdfs:label "Totaal van de activa"nl
xbrl.es:hasTotalActivo rdfs:label "Total activo"es
xebr:hasAssetsTotal rdfs:label "Assets [Total]"en
```

Showcase: Multilingual Properties and Classes, Cont.

Spanish analyst looking for FDC's total assets for 2007 (start of business year can be obtained elsewhere, viz., stock exchange)

```
SELECT ?total_assets
WHERE ?rep rdf:type xebr:Report
      ?rep xebr:hasCompanyIdentificationReport ?idrep
      ?idrep xebr:hasCompanyIdNumberList ?idlist
      ?idlist xebr:hasCompanyIdValue "BE0468567012"
      ?rep xebr:starts "2007-04-01"^^xsd:date
      ?rep xbrl_es:hasBalanceSituacionPresentacion ?kbsf
      ?kbsf xbrl_es:hasActivoPresentacion ?ap
      ?ap xbrl_es:hasTotalActivo ?total_assets
```

Showcase: Evolution of Financial Data

query tangible & intangible fixed assets for *adidas* over the years
(not listed on German DAX pages)

```
SELECT ?start2 ?end2 ?tass ?iass
WHERE ?comp rdf:type dax:Company ?start ?end
      ?comp dax:isin "DE000A1EWWO" ?start ?end
      ?comp if:hasReport ?rep ?start2 ?end2
      ?rep xebr:hasKeyBalanceSheetFiguresReport ?kbsf
      ?kbsf xebr:hasAssetsPresentation ?ap
      ?ap xebr:hasFixedAssetsPresentation ?fap
      ?fap xebr:hasTangibleFixedAssetsPresentation ?tfap
      ?tfap xebr:hasTangibleFixedAssetsTotal ?tass
      ?fap xebr:hasIntangibleFixedAssetsPresentation ?ifap
      ?ifap xebr:hasIntangibleFixedAssetsTotal ?iass
```

Showcase: Finding Competitors Across Borders

we are looking for competitors of *Deutsche Bank* and their financial numbers (xEBR reports), both on DAX & Euronext

IF interface axiom (DAX ↔ EN): financial institutions

icb:ICB8300 ≡ dax:Banks ≡ nace:nace_64.1

```
SELECT DISTINCT ?rival ?rep ?s3 ?e3
WHERE ?db dax:name "Deutsche Bank" ?s ?e
      ?db rdf:type ?type ?s ?e
      ?rival rdf:type ?type ?s2 ?e2
      ?rival if:hasReport ?rep ?s3 ?e3
FILTER ?db != ?rival
```

Showcase: Financial Summaries—Filling Missing Data

information that should be listed on DAX/EN is missing, but is available in the xEBR report for the same company (vice versa)

example: EADS' net profit for 2007-2012 on Euronext

```
?rep rdf:type xebr:Report
?rep xebr:hasCompanyIdentificationReport ?idrep
?idrep xebr:hasCompanyIdNumberList ?idlist
?idlist xebr:hasCompanyIdValue "NL0000235190"
?rep xebr:starts ?start
?rep xebr:ends ?end
?rep xebr:hasKeyBalanceSheetFiguresReport ?kbsf
?kbsf xebr:hasEquityAndLiabilitiesPresentation ?elp
?elp xebr:hasEquityPresentation ?ep
?ep xebr:hasProfitLossForThePeriodTotal ?prof
?comp if:hasReport ?rep ?start ?end
->
?comp en:netProfit ?prof ?start ?end
```


Showcase: Consistency Checking

consistency checking through rules implements conditions that should never happen (like LTL safety properties):

- ▶ leave a *memento* in the repository when things go wrong
- ▶ by marking URIs as being inconsistent (assign bottom type)

```
?p rdf:type owl:FunctionalProperty
```

```
?p rdf:type owl:DatatypeProperty
```

```
?x ?p ?y ?s1 ?e1
```

```
?x ?p ?z ?s2 ?e2
```

```
->
```

```
?x rdf:type owl:Nothing ?s ?e
```

```
@test
```

```
?y != ?z
```

```
IntersectionNotEmpty ?s1 ?e1 ?s2 ?e2
```

```
@action
```

```
?s = Max2 ?s1 ?s2
```

```
?e = Min2 ?e1 ?e2
```

Thank you!

Questions?

Translating XBRL Into Description Logic. An Approach Using Protégé, Sesame & OWL. BIS 2006.

A Temporal Extension of the Hayes/ter Horst Entailment Rules and an Alternative to W3C's N-ary Relations. FOIS 2012.

The MONNET Financial Ontology: Integrating Independent Ontologies Using OWL. KEOD 2012.

The xEBR Ontology: Transforming the XBRL Europe Business Register Taxonomy into an OWL Ontology. XBRL 2013.