Life Cycle of Software Development Design in European Structured Economic Reports

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Abstract: This proposal presents the complete life cycle of software development for semantic economic reports using the MDA paradigm. A panoramic view of the development of these reports using the MDM and the DPM in Europe is shown. Stock market, financial institutions and others are using these reports. Companies, organizations and agencies need to exchange accounting reports. A very high percentage of reports are published and transmitted through the internet. These reports are structured and semantic. In general, the XBRL specification, based on XML, is used as a de facto standard. This research work examines the evolution of this design and analyses the Conceptual Model in detail. Regulators through different Central Banks and European Agencies have established a modelling tool in the context of the European Union (EU), the DPM, which is a European standard. Moreover, a minimum set of consistent definitions and rules based on the MDM using the MDA will be proposed. This paper will analyse the DPM methodology. Finally, it is hoped that this study will help to make the design of reports easier.

1 INTRODUCTION

The world's main economic/financial institutions and agencies, as well as many companies and state or local agencies, actively use semantic reports using the XBRL specification. In the USA, Canada, Europe, China, etc. all financial entities and companies quoted on the stock market have to report compulsorily to the supervisory and regulatory authority using the XBRL specification. Financial statements are regulated by strict requirements, such as the International Financial Reporting Standard (IFRS, 2020) or Generally Accepted Accounting Principles (GAAP). XBRL is actively used by the Board of Governors of the Federal Reserve System (FED), the Securities and Exchange Commission (SEC), the ShenZhen Stock Exchange (SZSE), the Shanghai Stock Exchange (SSE) (JiMei et al., 2012; Jimei et al., 2013), the European Central Bank (ECB), the European Banking Authority (EBA), the European Insurance and Occupational Pensions Authority (EIOPA), the Deutsche Börse, the Deutsche Bundesbank, Companies House and HM Revenue & Customs (UK) and the Australian Prudential Regulation Authority (APRA), among many other institutions and agencies. Recently, in the EU, the European Securities and Markets Authority (ESMA, 2020) began using structured reports.

The authors of this paper show the application of the Model Driven Architecture (MDA) that belongs to Object Management Group (OMG, 2020) and analyse the software development life cycle of this type of document, (Santos et al. 2016). OMG is a common portable and interoperable object model with methods and data that works using all types of development environments on all types of platforms. To do this it is very important to understand the design of semantic reports in relation to the real world

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and away from its physical implementation, because this will help with understanding the difficulties presented. When a financial institution, company, etc. fills out a report, before sending this to another entity, agency, etc., it has to be validated (at origin), to ensure that it is syntactically correct (Debreceny et al., 2010).

This paper shows a metadata design for semantic economic reports. Moreover, the approach of European Regulators to the Data Point Model (DPM) is studied. The MDA provides a good framework for the automatic generation of code for application development (MDA, 2020). The MDA focuses on using models as approaches to cover the life cycle of software development. Heterogeneity and interoperability problems between systems with different implementation platforms are resolved by using this approach. The MDA stratifies the design into three phases or levels to allow for easier development. The levels of the MDA are:

- Computation Independent Model (CIM). The business or domain model. In this level, the real world is analysed, including concepts, data and rules.
- Platform Independent Model (PIM). This focuses on high-level business logic without considering the features of the implementation technology of the system. In this level, the real world is mapped to a conceptual model, using a star model of the MDM.
- Platform Specific Model (PSM). This represents the detail of using a specific platform for a system. In this level, the DPM is used, because at the end, the implementation is in an XML-based format (XBRL, iXBRL (an HTTP of an XBRL).

The MDM is a model for databases (Kimball, 1996-2004; Inmon, 2005; Jarke et al., 2003). Dimensional modelling defines the concepts of facts (measures), and dimensions (contexts), and the authors and the European regulators believe that it is a concept model perfectly adapted to this modelling in Europe (Boixo and Flores, 2005; Felden, 2007; Santos, 2013; Santos and Castro, 2010, 2011, 2011a, 2011b; Santos et al., 2013). The DPM was originally proposed and led by the Bank of Spain. This model started using the taxonomies of Balance Sheet Items and Interest Rates Monetary Financial Institutions (BSI-MIR 2010) and they were implemented by the Polish financial software company, BR-AG (2020). After, with this model was developed COREP (it focuses on the consolidated, sub-consolidated and solo reporting of capital requirements and capital and reserves based on EU directives) and FINREP (consolidated and sub-consolidated financial reporting for supervisory purposes based on IAS (International Accounting Standards)/IFRS) taxonomies (Eurofiling 2020). The DPM was developed using two taxonomies for respectively Cayman Islands Monetary Authority and Bermuda Monetary Authority.

The next section studies the use and necessity of this type of report, and its historical evolution. Section 3 is divided into five subsections. In 3.1 the CIM is analysed. In the next subsection, 3.2, the rules and definitions in the PIM are shown. The metadata design in the PIM and its validation is shown in section 3.3. The PSM is presented in subsection 3.4. In 3.5 a complete example is displayed. Finally, section 4 presents the conclusion of this research and explores future works.

2 BACKGROUND

In a company, organization or agency, there is always an exchange of accounting reports. Since the late 1990s, this exchange of reports has started to increase. Companies needed to know the status of their orders as soon as possible, and to perform a calculation of presales, sales and future product availability (Lee et al., 1997). If these reports are not semantic, they cannot be directly automated in the internal or external processes of the company through Information Systems (IS) (Wagenhofer, 2003; Williams et al., 2006).

Following the bankruptcy of Enron Corporation in December 2001, stock market regulators began to demand the reporting of much more business information and reduce the amount of time in which this reporting had to be processed. In April 1998 the automation of the exchange of financial information through XBRL was proposed (Hamscher and Kannon, 2000). XBRL is an XML-based standard for semantic financial reporting (Engel et al., 2008). The financial statements of credit institutions, for example, are specific statements defined by one or more taxonomies, including their structures and semantics. As accounting directives are subject to continuous modification, versioning and changes of location (e.g. of a country, state or region), problems often arise. There are three important groups of semantic reports in Europe: COREP (Common Reporting Framework), FINREP (Financial Reports), both of the EBA, and Solvency II of the EIOPA. In the U.S.A. and Canada one of the main taxonomies is the US-Generally Accepted Accounting Principles (US-GAAP). Another specification for semantic reports is the Statistical Data and Metadata Exchange (SDMX, 2020). This is often used by the ECB and the Bank for International Settlements (BIS), among other agencies and institutions.

In 2008, the European regulator had the necessity of developing reports for each country or jurisdiction. In the first meetings, each national regulator presented a set of spreadsheets with a heap of cells that gathered data from the supervised entities. Moreover, a unification of criteria was necessary. Where originally they were just a small set of countries, presently there are almost 30. The main problem was that these data (Data Points) didn't match with each other. Firstly, IS analysts and expert users looked for data points with the same dimensions. Many cells coincided with the dimensions of the time period, the currency and/or the entity. Then IS and expert users obtained more dimensions, such as liabilities, assets, etc. From these meetings the related data points were gathered, using dimensions. The question remains, when these dimensions are not commons, whether each expert user can use different dimensions for defining the same data point or measure.

3 DESCRIPTION OF THE DESIGN AND PROPOSAL

In this section the metadata model drivel engineering approach in accounting semantic reports will be analysed using the authors' approach (Ñustes et al., 2016). The first step is to define an economic semantic report (Figure 1). However, this approach is different of the Semantic Web, is a definition economic. This figure 1 just it is only an example, it is not a real example. Nevertheless, we use real names, because so the example could be more pedagogic. In this example, the Financial Assets in a period in a country is shown. With specific rules, such as that the real estate loans of the bank must be equal to the sum of the real estate loans to the bank itself and other banks (Santos, I., 2016).

Germany — Financial assets, period: 1st quarter, 2019 — Euros

Financial institution	Type of Loan	Type of Asset	Value
BNP Paribas	The bank itself	Real Estate	10,000.00
BNP Paribas	To other banks	Real Estate	20,000.00
ING Group	The bank itself	Real Estate	10,000.00
ING Group	To other bank	Real Estate	15,000.00
BNP Paribas	To bank itself and other banks	Real Estate	30,000.00

Figure 1: Example of financial sematic report.

Firstly, the following definition of an economic semantic report is proposed: An economic/financial report is semantic if it is composed of a set of interconnected concepts, and values are assigned to these concepts or groups of concepts. Also, the values must comply with certain rules and/or constraints among other values and concepts.

Figure 2 diplays the design of sematic reports using the MA paradigm. The regulators, agencies, etc. need to gather a series of data. These expert users, with the help of IS, build a set of templates, through

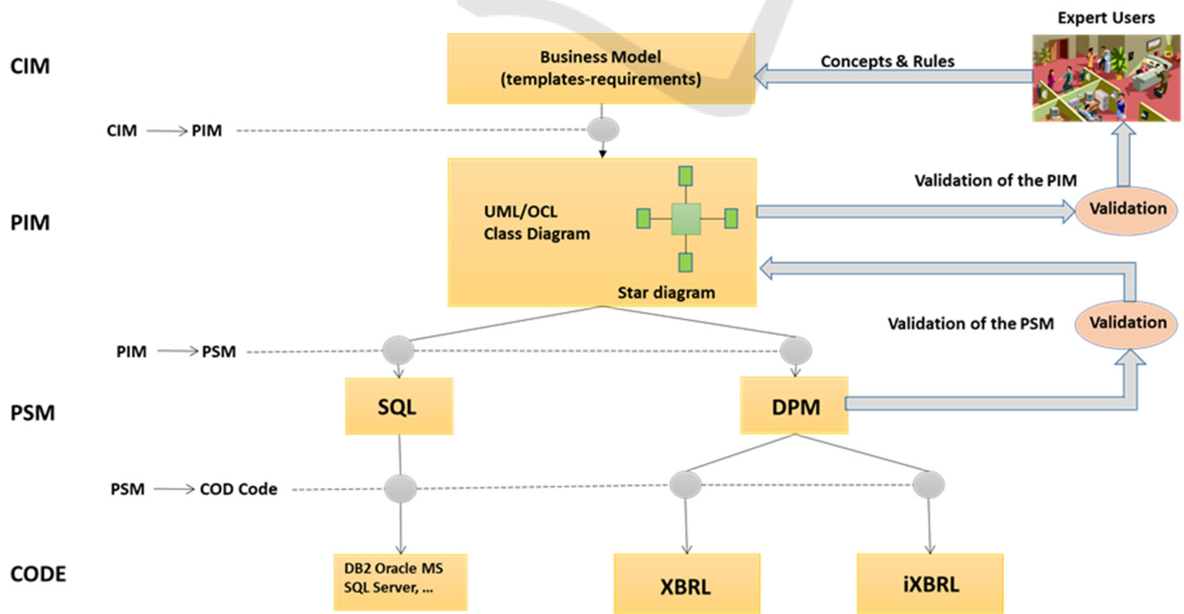


Figure 2: Design of sematic reports using the MDA paradigm.

one or more spreadsheets. Therefore, the real world consists of a set of accounting rules, laws, directives, etc., defined by a set of required data in a report (the CIM), through templates. According to the MDA paradigm, the PIM is obtained from the CIM. In the PIM, the set of definitions and user rules are analysed. A mapping from the CIM to the PIM is shown. The model used in the MDM is the star model that is used by European regulators. The PSM (in this case the DPM) consists of a set of definitions, rules and transformations.

In Europe the design makes extensive use of dimensions (Boixo and Flores, 2005; Felden, 2007). This use of dimensions makes the design process easier, since if the number of dimensions in the conceptual model is high, it is semantically richer, and the mapping to a database is easier.

This section has been divided into five subsections in order to explain the definition of the CIM, the analysis of the PIM, its rules and definitions, the design of the metadata in the PIM, the PSM and a complete example.

3.1 The Computation Independent Model (CIM)

An economist-accountant wants only to obtain a set of data (Santos, 2016). In certain cases, these specialists design a report as in Figure 1. However, in most cases, they want to collect data independently of its presentation. A generalized method is to generate one or more spreadsheets or templates with the data that are needed. In this way, the presentation of the data is separated from its definition. According to the business logic, the user will create one or more spreadsheets, each sheet having a group of cells. Figure 3 shows a simplified example with three cells, based on the report of Figure 1, where F(5.1.1) shows row 1 in Figure 1, F(5,1,2) shows row 2 and F(5, 1, 3) could be row 5.

From these templates or sheets, the IT analyst, together with the business user, extracts the metadata. In these templates, the business users show the data they need to gather. The analyst may find a set of Excel sheets with a large number of cells unconnected with each other and with a high degree of redundancy. Each template has a different meaning for the business user. The template will consist of a set of cells where each cell is a fact to be gathered, this being determined by a set of dimensions and dimension attributes, among other things. For example, F5 (5, 1, 1) is real estate assets, with a loan from the bank, for an entity, in euros. In this figure 3, if the fields are crossed out, they are considered not allowed by the business user. On the other hand, a fact can be represented by more than one triplet (template, row, column), because a fact can be in more than one template. The proofs of concepts (hereinafter POCs) of this paper are based on the reports that must be sent from financial institutions to European regulators (Openfiling, 2020). These POCs use the draft of the FINREP 2012 taxonomy (EBA, 2011; Eurofiling, 2012; Eurofiling, 2020), published on the internet, with extensive use of dimensions.

3.2 The Platform Independent Model (PIM): Rules and Definitions

This subsection analyses the PIM of this model. UML is used to show all necessary definitions and rules of this platform (the PIM). The star model of the MDM is used in this level. Table 1 summarises the set of definitions. Column 1 defines the name of the concept in the MDM and column 2 its description. However, these definitions are based on the XBRL Data Model (XBRLDM).

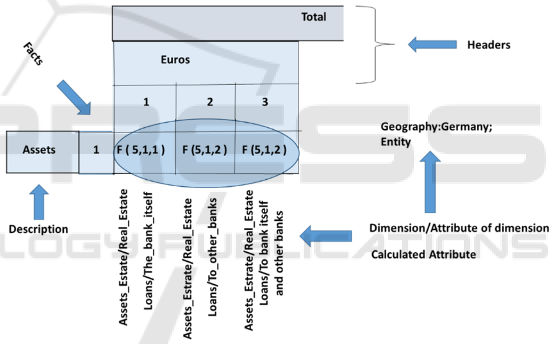


Figure 3: Star model in the PIM.

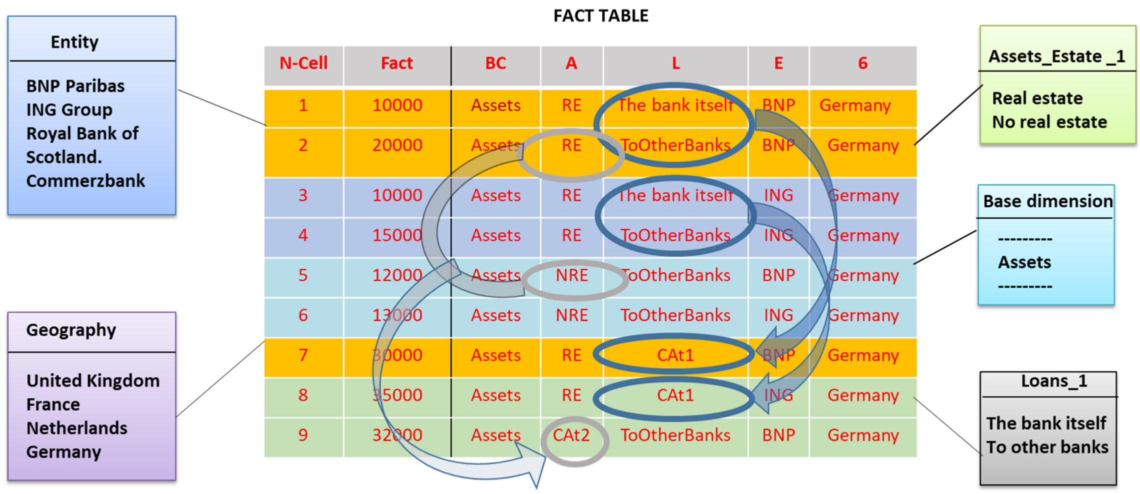
The first definition, according to Table 1, is the definition of a business *concept* or item. In the Figure 1, the concepts are {*'Entity_Financial', 'BNP Paribas', 'ING Group', 'Royal Bank of Scotland', Commerzbank, 'Real estate', 'No real estate', 'Real estate and no real estate', Assets, Liabilities*, …}. A *basic concept* is a *primary item*, in the XBRLDM (Hernández-Ros and Wallis, 2006; Santos and Castro, 2011a, b). All concepts of a domain have the same type of time period. A domain is formed of a set of concepts, and each concept belongs to a single domain. In this example the basic concepts are *Type of Asset: Real Estate*, *No Real Estate* and *'Real estate and no real estate'*. As will be seen later, 'Real estate and no real estate' is a hierarchy within a dimension, and is specific to this type of report. They have type *monetary*, their period is *instant* and they can be *positive* or *negative* (*balance*). All concepts of a domain have the same type of time period. In the example the set of domains are *DEntity, DAssets_Estate, DLoans,* and *DGeography*. The domain *DEntity* consists of the next concepts {'*Entity_Financial*', 'BNP *Paribas', 'ING Group', 'Royal Bank of Scotland', Commerzbank*} and so on.

Table 1: Definitions and rules in the MDM (the PIM).

Name in the MDM	Description
Concept	The definition of a business concept or item. Each concept is associated with a time period type attribute (*Instant, Period,* and *Forever*).
Basic Concept	A special concept that has an associated data type, time period type, and balance type (if it is monetary).
Domain	A group of concepts belonging to a field or scope of knowledge or activity. In this model a domain can contain basic concepts or non-basic concepts but not both.
Base Dimension	A domain with only basic concepts.
Dimension	A set of concepts of a domain. These concepts have a tree-like structure.
Dimension (explicit / implicit)	This is **explicit** if the attributes are defined. It is **implicit** if they are not defined. Dimension → Domain. Domain → → Dimension.
Dimension Group	Group of dimensions of a domain.
Calculated attribute	An aggregate of dimension attributes of a dimension, and/or calculated attributes.
Attribute of dimensions	Not an aggregate.
Attribute by default	Each domain has a concept by default.
Hierarchical Constraint	Concepts in a dimension have a tree-like structure. Validation is between a leaf and its leaves below, that is to say, it is used for the calculated attributes.
References	References to directives or laws of the concepts.
Fact::=<Dimension/Dimension attribute>-Basic concept-Calculated attribute	A fact is a value representing a particular measurement provided by the reporting entity.
Allowed fact	User constraint.
Forbidden fact	User constraint.

In the MDM or the XBRL specification one cannot have more than one dimension attribute of a dimension that refers to a fact. However, in the real world there can be more than one concept for a domain that makes references to a fact. The solution in the XBRLDM is to create as many dimensions of the same domain as is possible, so that each fact has a dimension attribute (member-domain in XBRLDM), without overlapping dimension attributes of a dimension in a fact. Dimensions of a domain with overlapped are created in the MDM. This means, a dimension determines a domain. Then, in the example it is possible to define the domain *DLoans*, the dimension *Loans_1={'The bank itself'+'To other banks'},* etc. A calculated attribute determines a domain and a dimension. For example, in the domain *DLoans* the concept *'The bank itself and other banks'* is a calculated attribute of *Loans_1*, where *'The bank itself and other banks'='The bank itself'+'To other banks'*. A dimension attribute determines a single concept from a domain, but dimension attributes determine from 1 to n dimensions. In XBRLDM a dimension consists of domain-member, and does not differentiate between dimension attributes and calculated attributes. On the other hand, in the XBRLDM, all defined domains must have a concept by default with semantic content (Hernández-Ros and Wallis, 2006; Eurofiling, 2011). Also in this data model, every dimension should have a concept by default of the domain to which the dimension belongs.

In the XBRLDM a domain consists of dimensions and these dimensions consist of domain-members. In the MDM a domain consists of dimension attributes and the calculated attributes or measures of dimensions belong to a domain. These concepts are hierarchical (Hernández-Ros and Wallis, 2006; Schmehl, 2009). In this data model, the hierarchies can be used for different validations of the concepts, and with a business perspective for IS. This means, that in the MDM the concepts (dimension attributes and measures) of a dimension are organized into an interconnected hierarchy tree. In the example the concept *'Real estate and no real estate'* of the domain *DAssets_Estate* is a root of the concepts *'Real estate'* and *'No real estate'*. Each concept can have an associated a comparison operation (the root) and an operation, *"+"* or *"-"*(the leaves). Unlike the XBRLDM, the MDM uses calculated attributes to obtain a fact, but the XBRLDM does not calculate the facts, only their validations. Therefore, to obtain a mapping between the two models, a fact must carry out a certain validation rule defined with respect to a calculated attribute. The validations from the XBRLDM hierarchies are used to take advantage of the *Linkbase calculation* (operation in the XBRL specification with only one dimension) (Engel et al.,



N-Cell	Fact	BC	A	L	E	6
1	10000	Assets	RE	The bank itself	BNP	Germany
2	20000	Assets	RE	ToOtherBanks	BNP	Germany
3	10000	Assets	RE	The bank itself	ING	Germany
4	15000	Assets	RE	ToOtherBanks	ING	Germany
5	12000	Assets	NRE	ToOtherBanks	BNP	Germany
6	13000	Assets	NRE	ToOtherBanks	ING	Germany
7	30000	Assets	RE	CAt1	BNP	Germany
8	35000	Assets	RE	CAt1	ING	Germany
9	32000	Assets	CAt2	ToOtherBanks	BNP	Germany

Figure 4: Example of fact table with calculated attributes, from Figure 1.

2008; Santos and Castro, 2011, b). However, the Eurofiling group in its guide of best practices recommends the use of the XBRL formula Linkbase (Morilla, 2008; XBRL International, 2009; Fischer, 2011).

The XBRLDM Dimension Taxonomy (XDT) defines two types of dimensions (Hernández-Ros and Wallis, 2006; Schmehl, 2009). The dimensions can be explicit or implicit. Explicit dimension attributes of a dimension are defined in an explicit way in the metadata model. Dimension attributes are implicit (according to XBRLDM) when they are not explicitly defined in the metadata model, however they belong to a particular domain. In the MDM an implicit dimension's dimension attributes will be defined at run-time. Each concept is associated with 0 or an unknown number of references. The references are indications of legal texts (Engel et al., 2008; Santos and Castro, 2011, b). In the XBRL specification, tuples or arrays of data are allowed. However, the best practices guide developed by the Eurofiling group does not recommend them (CEN, 2013; Eurofiling, 2020; Santos et al., 2016). In the MDM an array is considered as another dimension.

In the XBRLDM, a fact is defined as a set of pairs (dimension / domain-member) and a basic concept (primary item). In the MDM a table of facts consists of a set of facts, and these facts are determined by a set of pairs <dimension/dimension attributes>, including the base domain as an additional dimension, and with or without calculated attributes. For example, if in Figure 1 *"BNP Paribas - The bank itself - Real Estate - 10,000.00"* is chosen, this is equivalent to F(5,1,1) in Figure 3. Then, the fact F(5, 1,1) is the union of <Entity, *"BNP Paribas"*>, <Assets_Estate_1,*"Real estate"*>, <Loans_1, *"The bank itself"*>, <Geography, *Germany*> and <Base dimension, *Assets*>. The hypercubes in the XBRLDM are constraints on facts in the XDT (XBRL Dimensional Taxonomies), which indicate the valid combinations of pairs <dimension, attributes of dimension>. A hypercube in MDM is a set of pairs <dimension, attributes of dimension> and calculated attributes defining one or more facts.

An allowed hypercube is defined as a hypercube associated with a basic concept that determines a fact. A forbidden hypercube is defined as a hypercube associated with a basic concept that cannot determine any fact, because the expert user considers this fact to be impossible or erroneous. Figure 4 shows the MDM of this example.

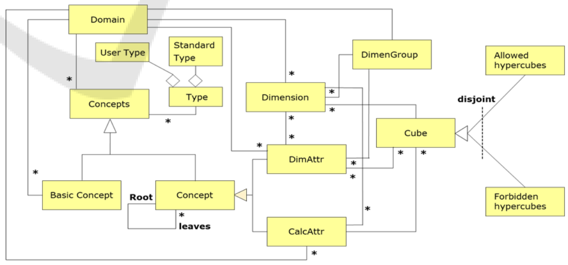


Figure 5: UML summary of the artefacts of the data model in the PIM.

As it is explained in Figure 4, in this model there are two calculated attributes. *CAt1=('To bank itself'+ 'To other banks'),* dimension *Loans_1, CAt2=('Real Estate' + 'No Real Estate'),* dimension *Assets Estate_1* . Finally, it is possible to analyse that Fact 7 is correct, and 8 is wrong. Moreover, it is possible to see an allowed hypercube as Fact 7 that is defined as {(BD, Assets), (Assets Estate_1, Real Estate), CAt1, (Entity, BNP), (Geography, Germany)}.

So far the structure, definitions and user constraints of the PIM have been shown. In the next subsection, it is necessary to validate some constraints of the design in this platform.

3.3 Design of Metadata in the PIM

In this section, it is ensured that the transformation of the CIM to PIM is correctly performed. In this phase the result of this transformation is validated, i.e., if the resulting PIM (or UML star model) is correct. According to Gogolla et al. (2007), the validation of conceptual models at early phases of their development can help correct faults in the design at a point where they may still be corrected with relative ease.

The validation involves testing that the data obtained in the development of this research work match up with expert users' requirements. In this validation FINREP (Eurofiling 2012) and Solvency II is used. The number of concepts to gather is so large (there were only 4500 in FINREP in 2012 and 45000 in 2015 (Weller, 2015)), with COREP presently 95742 (EBA, 2018) that it makes it impossible to work directly with the report of Figure 1. In the initial development (in the CIM) these templates have a large number of unconnected cells and a high level of redundancy. In the first phase, according to Algorithm 1, the different elements of the original templates (Figure 3) are entered into the relational model of Figure 5. By applying this algorithm repeatedly, the unconnected and redundant cells are analysed.

Algorithm 1 uses the definitions and rules from the above sections. It is this process that really makes the structural validation (Santos and Nieto, 2014, 2015), verifying if hierarchies of concepts are valid in a domain, with regard to dimensions, dimension attributes and calculated attributes (if dimension attributes belong to one domain rather than two at a time, etc.).

Algorithm 1: Extraction of the metadata model.

```
start
    read data type, domains, concepts,
basic concepts;
    read dimensions, dimension groups;
    verify the hierarchies of the
concepts and dimensions;
    obtain dimension attributes,
calculated attributes;
    obtain allowed cubes, forbidden
cubes;
    obtain UML star model
    create dimension tables from
dimensions and dimension attributes in
the star model;
    create stored procedure with
calculated attributes;
    create base dimension;
    create facts from allowed cubes;
end
```

Next, the UML star model is obtained, as in Figure 5. To achieve the transformation in the Proof of Concept (POC), this paper uses SQL Server Integration Services (SSIS), an ETL (Extract, Transform and Load data) product of Microsoft (Openfiling, 2020a). Table 2 shows, after which, it is verified whether the output is as expected. This process is based on the EBA and EIOPA taxonomies (more than 20 modules), in that each concept is analysed, for example, as to whether the hierarchy of the concepts in a domain is correct.

Table 2 verifies a set of validation tests for the proposal, only a summary, due to lack of space, more information in Santos (2016) and Santos and Nieto (2014, 2015). Column 1 shows the test number. Column 2 shows the test to validate. This column shows the test case, for example, test number 1: "3 repeated concepts" means that it is impossible to repeat 3 concepts. Columns 3, 4 and 5 are inputs to the test. These columns display the set of correct objects and the set of incorrect objects to test. For example, test number 1 shows 187 concepts + 3 repeated concepts. Finally, the last column gives the test output. In test number 1, in the three samples

Table 2: Validation tests belonging to the UML star model.

n	Test to validate	Input FINREP 2014	Input Solvency II	Test output
1	3 concepts repeated	1632 concepts+3 concepts repeated	145 concepts+ 3 concepts repeated	3 conce pts repeat,
2	2 domains repeated	35 domains+2 repeated domains	1 domain+2 repeated domains	2 repeat. Dom.
9	Creation of calcul. attrib.	4 dimen., 18 calcul. attributes+1 incorrect dimension attribute	2 dimen., 2 calcul. attributes+ 1 incorrect dimension attribute	1 incorr. dim. attribu te
10	The concepts of a dim. has 1 only root	92 dimen., 1632 concepts. 2 roots in a dimension	2 dimen., 4 concepts. 2 roots in a dimen.	2 roots in a dim.

(FINREP 2014 and Solvency II) three repeated concepts are inserted, respectively, so the test output is three errors with three repeated concepts, respectively.

The validation in the POCs in the PIM performed on each sample (FINREP 2014, Solvency II) depicts all structural validations in a 95%.

This proposal produces well-built metadata for semantic economic reports because it is a structural validation. However, it is necessary to continue the validation with expert users, in order to validate the semantically-complete design. To achieve this, an economic study of the concept domains, hierarchies, etc. is necessary, and that is left for future work.

3.4 Design of Metadata in the PSM

This section analyses the transformation from PIM to PSM, using UML/MDM as the PIM and the DPM used in the financial supervision as the PSM.

The Data Point Metamodel is a way to help to design the reports for financial regulators (Weber et al., 2013). Table 3 shows the mapping between both levels:

Table 3: Mapping between the MDM and DPM models.

MDM	DPM	Comments
Domain	Domain	
Dimension	Dimension	
Dimension attribute	*DomainMember*	
Dimension attribute by default	*DefaultMember*	Assertion
Set of dimension attributes	*EnumerableDimension*	Defined values
Set of dimension attributes	*NonEnumerable Dimension*	Defined in run time
Group of dimensions belonging to the same domain.	*Family of dimensions*	Assertion
Dimension attribute with data type and time	*Basic concept* or *primary item*	
Base Dimension	Set of *Primary Items*	Assertion
Calculated attributes	*Hierarchy and/or validation of domain-member*	Assertion
Set of <dimension / dimension attributes>	*Context*	
Metric or Fact	*Data Point*	
Schema	*Taxonomy*	

```xml
<xbrli:xbrl xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="ht
  <link:schemaRef xlink:type="simple" xlink:href="entry.xsd"/>
  <xbrli:context id="Ctxt1">
    <xbrli:entity>
      <xbrli:identifier scheme="http://scheme">abc</xbrli:identifier>
    </xbrli:entity>
    <xbrli:period>
      <xbrli:instant>2019-06-12</xbrli:instant>
    </xbrli:period>
    <xbrli:scenario>
      <xbrldi:explicitMember dimension="dim:Entity">BNP_Paribas</xbrldi:explicitMember>
      <xbrldi:explicitMember dimension="dim:A_E_1">RE</xbrldi:explicitMember>
      <xbrldi:explicitMember dimension="dim:Loans1">TBI</xbrldi:explicitMember>
      <xbrldi:explicitMember dimension="dim:Geography">Germany</xbrldi:explicitMember>
    </xbrli:scenario>
  </xbrli:context>
  <xbrli:context id="Ctxt2">
    <xbrli:entity>
      <xbrli:identifier scheme="http://scheme">abc</xbrli:identifier>
    </xbrli:entity>
    <xbrli:period>
      <xbrli:instant>2011-06-12</xbrli:instant>
    </xbrli:period>
    <xbrli:scenario>
      <xbrldi:explicitMember dimension="dim:Entity">BNP_Paribas</xbrldi:explicitMember>
      <xbrldi:explicitMember dimension="dim:A_E_1">RE</xbrldi:explicitMember>
      <xbrldi:explicitMember dimension="dim:Loans1">ToOtherBanks</xbrldi:explicitMember>
      <xbrldi:explicitMember dimension="dim:Geography">Germany</xbrldi:explicitMember>
    </xbrli:scenario>
```

Figure 6: Context in XBRL, from Figures 1,3 and 4.

A *Domain Member* is an element that belongs to a domain and it can be in 0..n dimensions. A *dimension attribute by default* in a dimension is used when a program does not select the dimension attribute of a dimension. An example of *NonEnumerableDimension* is *Entity,* that at one instant in the time its values can be *Bank A, Bank B* and *Bank C* but one year after, there are *Bank A, Bank C* and *Bank D*. A *Base Dimension* in the DPM is the set of Basic concepts or *Primary Items* (defined in the XBRL specification). *Hierarchy* used in dimensions is a set of relationships parent-child; in the MDM these are *calculated attributes*. The Context is not defined in the DPM, because it is more associated with the presentation of the report. However, the authors of this paper think that it is better to include it here. The context is the set of dimension attributes without a *Base dimension* that allow the existence of a fact or measure.

A *Metric* or *Fact* is a is a real world measurement and the Data Point is a cell in a table of a spreadsheet that is measuring some aspect of economic data in the report to gather it for the regulator. A Fact in the DPM is associated with a *Base Dimension*. The *Data Point* is associated with a period and a type of data. Then, this is associated with a Primary Item or Basic Concept (dimension attribute of the Base Domain). It consists of the cell identifier or Data Point, the decimal precision, the identifier of the context, the *unitRef*, and the value of the Data Point (the fact or thing measured). A Schema is a description of the model.

From here a taxonomy is built, but this topic will be analysed in future work due to lack of space in this paper.

3.5 Example

This section shows the example of Figure 1 to present this methodology in an easily understandable way. From the PIM (Figure 3) Table 1 is filled out as can be seen in Figure 4, although this is only a summary. In the PIM, the constraints, allowed facts with its contexts are defined. Table 3 has to be resolved. In Table 4 only a small set of contexts from Figure 3 are shown.

Table 4: Contexts of figures 1, 3 and 4.

Ctx	Description
Ctxt1	<Entity/ BNP Paribas>+ <Assets_Estate _1(A_E_1)/Real estate(RE)> +< Loans_1(Loans1) /The bank itself (TBI)> +< Geography/Germany>
Ctxt2	<Entity/ BNP Paribas>+ <Assets_Estate _1(A_E_1)/Real estate(RE)> +< Loans_1(Loans1)/To other banks (Tootherbanks)>+< Geography/Germany>
Ctxt3	<Entity/ ING Group>+ <Assets_Estate _1(A_E_1)/ Real estate(RE)> +< Loans_1(Loans1) /The bank itself (TBI)> +< Geography/Germany>
…	…

The *Base dimension* = {*Assets* (Monetary (credit), Instant),…} In this example, the basic concept is *Assets*, the data type is monetary and positive (credit), and its value at an instant in time is defined. Until here the metadata (data set required) of the reports are defined. If the report is defined, the facts or values are gathered and next the Instance Document is obtained, Figures 6 and 7.

Figures 6 and 7 show an XBRL Instance Document, that is to say, the economic report that, for example, a financial entity sends to a regulator. In Figure 5 the contexts or allowed hypercubes used in this report are defined. The Figure 6, at the end, the facts or Data Points are presented. These three facts are equivalent to the first three lines of the report in Figure 1.

```xml
<xbrli:context id="Ctxt3">
  <xbrli:entity>
    <xbrli:identifier scheme="http://scheme">abc</xbrli:identifier>
  </xbrli:entity>
  <xbrli:period>
    <xbrli:instant>2011-06-12</xbrli:instant>
  </xbrli:period>
  <xbrli:scenario>
    <xbrldi:explicitMember dimension="dim:Entity">ING_Group</xbrldi:explicitMember>
    <xbrldi:explicitMember dimension="dim:A_E_1">RE</xbrldi:explicitMember>
    <xbrldi:explicitMember dimension="dim:Loans1">TBI</xbrldi:explicitMember>
    <xbrldi:explicitMember dimension="dim:Geography">Germany</xbrldi:explicitMember>
  </xbrli:scenario>
</xbrli:context>
<xbrli:unit id="EUR">
  <xbrli:measure>iso4217:EUR</xbrli:measure>
</xbrli:unit>
<base:Assets decimals="0" contextRef="Ctxt1" unitRef="EUR">10000</base:Assets>
<base:Assets decimals="0" contextRef="Ctxt2" unitRef="EUR">20000</base:Assets>
<base:Assets decimals="0" contextRef="Ctxt3" unitRef="EUR">10000</base:Assets>
</xbrli:xbrl>
```

Figure 7: Data Points or Facts.in XBRL, from Figures 1,3 and 4.

4 CONCLUSIONS

This paper analyses and shows a panoramic view of the development stages of the creation of economic report metadata using the XBRL specification. In this paper the MDA paradigm is proposed. The MDM is chosen as the PIM, because this model is adapted to the development of European metadata. The DPM is used as the PSM, because it is used in European regulation (not only financial), for its implementation in XML, XBRL or iXBRL. By means of the MDM the definitions and rules are formalised and the semantics of the XBRL Data Model (XBRLDM) are audited. The automation of this mapping is also proposed and implemented in the DPM Architect (Morales, 2017). The aim of this research is to clarify the XBRL and multidimensional data models, as well as the mapping from XBRL to the MDM and vice versa.

The DPM is the logical model used in Europe (EBA, ECB, EIOPA, etc.) and a CEN standard (2013). This is very close to end-user applications, and is oriented exclusively to development using the XBRL specification (Díaz, 2012; DPM, 2020). At present, the IS departments of regulatory bodies with very large taxonomies have an important challenge, because taxonomies and their validations are created without public test cases. The approach of this paper provides a way forward for the generation of these test sets.

The DPM is a logical model very adapted to the expert user and the design is presently almost automated. In Europe it is very widely used, and a group that specialises in the modelling of this type of report wish it to become an ISO standard (Piechocki, 2014). The DPM is very extended for the EBA, SRB (Single Resolution Board), ECB and EIOPA. An example of the EBA is the Reporting framework 2.10, 31/12/2020 https://eba.europa.eu/risk-analysis-and-data/reporting-frameworks/reporting-framework-2.10, with 74726 concepts, 259 dimensions, 49 domains, etc. Another example is the SRB v.4.0.3 31/12/2019, https://srb.europa.eu/en/content/2020-resolution-reporting. EIOPA, for example v2.6.0, 15/7/2021, https://www.eiopa.europa.eu/tools-and-data/supervisory-reporting-dpm-and-xbrl_en. The European Agencies provide all the definitions of their DPMs and detail the taxonomy that forms them, including its mapping. However, since they are real taxonomies, they are much more complex than the example shown in this article. The DPM methodology has remained practically stable since its first iteration/formalization at CEN (2013). However, it is in mind by users, its evolution in the short/medium term, incorporating it as an ISO (International Organization for Standardization) standard and with some revision. In particular, the review should improve certain aspects such as the best coverage of different use cases, both to better cover certain financial cases (statistical and transactional) and non-financial cases.

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