

# GeoXBRL: Integration Standard between Geographical and Business Data

Marcelo Cerqueira<sup>a\*</sup>, Paulo Caetano<sup>b</sup>, Márcio Alexandre<sup>c</sup>

<sup>a</sup>Universidade Cesumar, Praça Conselheiro Almeida Couto 374, Curitiba-PR 40050-405, Brazil

<sup>b</sup>Universidade Salvador, R. Dr. José Peroba 251 Salvador-BA 41770-235, Brazil

<sup>c</sup>Universidade Federal de Pernambuco, Av. Prof. Moraes Rego, 1235, Recife-PE 50670-901

<sup>a</sup>Email: [marcelo.cerqueira@icloud.com](mailto:marcelo.cerqueira@icloud.com)

<sup>b</sup>Email: [paulo.caetano@unifacs.br](mailto:paulo.caetano@unifacs.br)

<sup>c</sup>Email: [marcio.alexandre83@gmail.com](mailto:marcio.alexandre83@gmail.com)

## Abstract

Context: The usage of geographic data and geovisualization in financial auditing and analytics is increasing among auditors and accountants. Business information systems can process and analyze data through geographic approaches (e.g. financial insight on a virtual geographic map). Although many business information systems have been developed considering geographic data as one of data sources, there is no a standard for modeling both kind of data together (i.e. business and geographical). Conversely, it is also known that Geographic Markup Language (GML) and eXtensible Business Reporting Language (XBRL) are W3C technologies worldwide used for representing geographic and business data, respectively. Given this absence of standardization to represent geospatial data within business taxonomies, this paper proposes the GeoXBRL to fill this gap. This paper specifies an integration between geographic and business/financial data. For this, W3C technologies such as XLink, XML schema, GML and XBRL have been used to make the data structure of this integration. As an assessment, a XML-based representation and a Java-based web application have been developed on a real-world business taxonomy (available on US-SEC website). A comparison is shown between previous business data scenario and the new one proposed in this paper. Finally, this proposal allows to explain how to use the GeoXBRL. Some comparisons with current tools and technologies are shown in order to illustrate the GeoXBRL features and contributions.

**Keywords:** GeoXBRL; Geographic XBRL; Geographic Business Data; GML; XBRL.

---

\* Corresponding author.

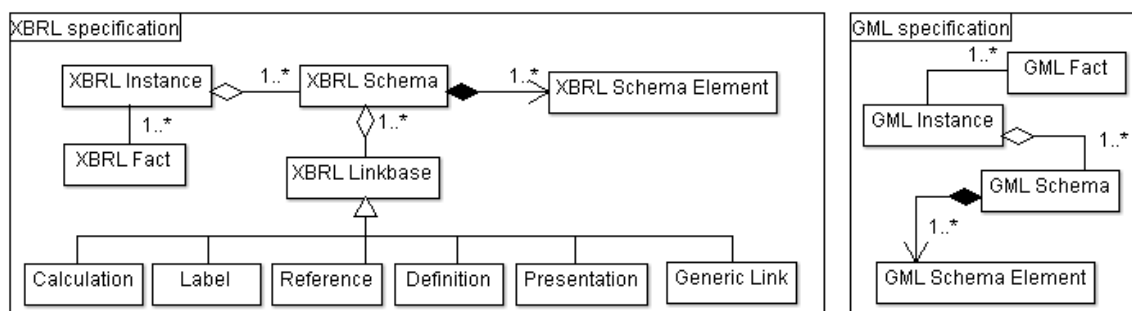
## **1. Introduction**

Business information systems have been considering the geographic (geospatial) data as a data source, which are used in some business processing stage [1,2,3,4,5,6,7,8,9,10,11]. Two free and open source technologies are widely used in information systems for business and geographic domains representation: XBRL [12] and GML [13]. Both are standards recommended by World Wide Web Consortium [14]. The XBRL adherence may be seen by the quantity of member that composes the XBRL consortium [15] and by the 8 million of filers distributed over 20 countries [16]. Conversely, the large adhesion and interest in Geographic Information System (GIS) can be measured by the hundreds of corporations, governments, institutes, associations, commissions and universities that support the Open Geospatial Consortium (OGC) [17]. OGC is an international consortium that standardizes the geospatial data (geodata) representation through Geography Markup Language (GML) [13]. Although geographic and business domains have been approached together in the information system, there is no a technology that proposes the representation of them together in the same technological infrastructure (or taxonomy), neither a technology that proposes a linking between them [8,9]. This scenery means that companies have adopted ad-hoc and non-standardized solutions to use geodata within financial business systems. This makes it difficult to develop uniform solutions (by the software manufacturers), whose development and deployment of software become costlier. According to International Organization for Standardization (ISO) [18], international standards bring technological, economic and societal benefits, reduce the cost of data interchange, reduce the delay in converting non-standard coding structures in preparation for interchange by providing advance knowledge of the standard interchange format, also harmonize products and services technical specifications, making industry more efficient and breaking down barriers to international trade. Thinking about GML and XBRL, even though both are vastly used worldwide, there is no a standard that regulates a linking between them. This is the main motivation of this paper. Thus, we propose the GeoXBRL, which provides a linking between GML and XBRL domains. GeoXBRL structure is based on W3C standards, such as XML linking language (XLink) [19], GML and XBRL definitions. This paper is organized as follows. Section 2 presents an overview about XBRL and GML technologies. Section 3 shows related works, based on tools and academic researches. Section 4 enunciates a concept modeling of GeoXBRL and its representation based on XML technology. Section 5 discusses an example of how to use the GeoXBRL standard in a real-world XBRL-based business taxonomy; describes a Java web application based on GeoXBRL and points some comparisons, features and contributions of the GeoXBRL (among tools and other technologies). Finally, Section 6 brings the conclusion, some limitations and some future works.

## **2. XBRL and GML**

XBRL International Consortium [16] defines all XBRL specification based on W3C technologies [14]. As illustrated in Figure 1, XBRL 2.1 [12] is structured in three parts: instance, schemas and linkbases. XBRL schema is an XML Schema document (XSD) that defines the business concepts (or elements) contained in the business reporting. XBRL instance represents the own business reporting, in which are contained the XBRL Facts [20]. XBRL Linkbases is a document that contains the representation of the relationships among business concepts. All XBRL Linkbases contain collections of inbound, outbound and third-party Extended Links [21], which are represented in its own kind of linkbase: Calculation, for establishing a sum expression; Label, for

labeling a business concept; Reference, for associating a concept to its authoritative documentation; Definition, in order to define another conceptual definition to some business concept, for example, for multidimensional relations between concepts; Presentation, for presenting the concepts in a specific order; and Generic Link, that allows provides others different kinds of linking among the business concepts [12], as illustrated in Figure 1. Generic Link [22] generalizes the relationships expressed in a taxonomy and allows that XBRL taxonomists express new semantics (not provided in the XBRL 2.1). GML is a language maintained by Open Spatial Initiative [13] mostly used to represent geospatial semantics. GML is another XML-based technology which represents and stores geospatial features that is processed through GIS, which provides geodata-based outputs, such as virtual spatial maps [23,24]. As also illustrated in Figure 1, GML is structured in two parts: (i) GML Schema which is composed by geographic concepts (or elements), and (ii) GML Instance in which is contained the geographical facts, i.e. GML elements associated to their respective values (e.g. latitude is 37.4834075) [13].



**Figure 1:** XBRL and GML Specifications represented in UML notation.

Geodata describes real-world objects in different approaches, such as: (i) Geographical Location relates a position according to geographic coordinate system (latitude, longitude and altitude); (ii) Topography defines the spatial relationship among an object set; (iii) Mapping Algebra allows the representation of geospatial data through measured and observed properties [23]. The geometric features (e.g. point, line and polygon) have been used for not only representing geographic objects but also establishing the topographic relationship among them [24]. Thus, the geometry figures have been integrated into GML definitions, for which have been specified a XSD file based on geometric features [25].

### 3. Literature Review

The using of XBRL and GML have attracted huge interest from the business industry and Geospatial information system. Addition to, the number of systematic literature review related to XBRL and/or GML integration with continuous auditing or audit processes that has previously been published is small. This systematic literature review will be useful to identify the current research related to XBRL and GML integration with continuous auditing.

The review goal is to answer the following research question:

Research Question: “What is currently known about the using of XBRL and/or GML integration with continuous auditing or audit processes?”

We undertook this review in three stages: (1) the development of review protocol, identify relevant studies, search databases and conference proceedings; (2) exclude studies on basis of title, and abstract, exclude studies on basis exclusion criteria or was not about the focus paper; (3) critical appraisal, data extraction and synthesis. In the rest of this sections, we describe each stage and the methods used. We developed a protocol for systematic literature review by following the guidelines and procedures of Kitchenham and Brereton [1]. We applied the protocol template from Kitchenham, Budgen, and Brereton [2].

**The strings used for searching are shown below:**

- 1) ("XBRL" AND "GML");
- 2) ("XBRL" AND ("geographical data" OR "geographics data");
- 3) ("XBRL" OR "GML" OR "geographical data" OR "geographics data") AND ("audit" OR "auditing" OR "continuous audit" OR "continuous auditing").

### ***3.1. The Inclusion and Exclusion Criteria***

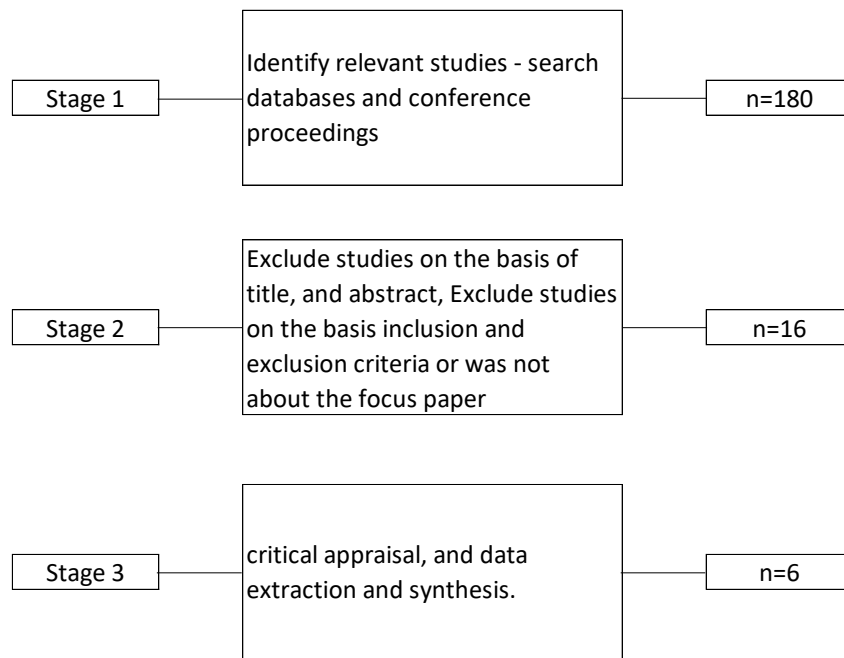
The studies were eligible for inclusion in the review if they applied empirical data on the using XBRL and/or GML integration with continuous auditing and passed the minimum quality threshold. Studies of students, researchers and business professionals were considered like an inclusion criterion. This systematic review included qualitative and quantitative research studies, published between 2005 and 2020. Only studies written in Portuguese and English were included. Studies were excluded if wasn't focus on XBRL and GML integration or papers merely based on expert opinion.

### ***3.2. Data Sources and Search Strategy***

The search included electronic databases and hand searches. Addition to, we used snowballing technique on the papers returned from electronic databases [2]. The following electronic databases were searched:

- ACM Digital Library
- IEEE Xplore;
- IJBIS;
- ScienceDirect – Elsevier
- SpringerLink

Figure 2 shows the systematic review process and the number of papers identified at each stage. (1) The titles, abstracts, and keywords of the articles in the electronic databases and conference proceedings were entered and sorted with the aid of Mendeley (Elsevier). They were imported to Microsoft Excel, where we recorded. (2) the authors went through the titles of all studies that resulted from stage 1, to determine their relevance to the systematic review, and studies were excluded if their focus, or main focus, was not about the XBRL and/or GML integration with continuous auditing. After this, we applied the exclusion and inclusion criteria. (3) after stage 1 and 2, we realized a critical appraisal, and data extraction and synthesis.



**Figure 2:** Stages of the study select process

At the stage 2, we divided the abstract among ourselves and a third researcher in such a way that each abstract was reviewed by two researchers. The Kappa coefficient was applied for stage 2 assessments [3,4], and this value is 0.798, which is characterized as “substantial agreement”.

### 3.3. Data Extraction

At this stage, data was extracted from each of the 16 studies included in this literature review. We recorded full details of the articles under review and to be specific about how each of them addresses our research question. At the synthesize stage, we identify the main concepts from each study that were organized in tabular comparison. We identified 12 studies related to the using XBRL and GML integration with continuous auditing that were full read and synthesized into a Microsoft Excel Sheet.

### 3.4. Results and Discussion

We identified six studies on XBRL and/or GML with continuous auditing. Two studies covered the research questions. We organized these studies (1) into an Excel sheet that provided the answer of research questions. In the next paragraph, we describe characteristics of studies and describe the research methods applied. Efendi and his colleagues investigate the using of XBRL reporting and its impact on the capital market, regarding informational efficiency [5]. Was found in this research that XBRL eliminate costly manual collection, aid processing of financial information, facilitate information analysis, and audit processes. They used a sample of 7619 firm-quarter observations from 474 firms. The audit processes are facilitating with XBRL using because XBRL has a well-structured information that facilitate the analysis processes. Henderson and his colleagues examined organizational adoption of inter-organizational information technology using the Technological Organizational-Environmental Framework [6]. They considered XBRL as an inter-organizational information

technology that could be used inter-organizationally or internally. They interviewed managers and found that adopting XBRL increasing the transparency of financial reporting, which improving audit processes. Gambetta and his colleagues investigated the benefits of implementing an enterprise resource planning (ERP) system and using eXtensible Business Reporting Language (XBRL) format to report in the banking industry [7]. They found the using of ERP and XBRL can enhance audit processes in banks. Their findings are useful for banks because they indicated bank management the potential benefits of using ERP and XBRL reporting to audit processes and to auditors, because the results show the potential use of data analytics. Abdolmohammadi and his colleagues examined the relationships of national legal system, company size, and governance quality with eXtensible Business Reporting Language (XBRL) implementation in public companies [8]. They realized a worldwide survey with 692 internal auditors that include eight countries. They discovered that XBRL allows internal auditors to access companies' financial data in a timelier manner and reuse data across different platforms to more effectively and improving internal control quality. They concluded that XBRL implementation benefits internal and external information users and audit processes. Troshani and his colleagues collected data from the Thomson One Banker database that include all firms listed on the NYSE and NASDAQ for eight-year period from 2005 to 2012 [9]. They found that XBRL enhance the transparency of financial reports and could enhancing auditing costs reduced. Addition to, XBRL enhances transparency of financial reporting, which facilitates external auditing functions. Moreover, XBRL can also facilitate auditing because allowing auditors to integrate the appraisal of internal controls over financial reporting, and XBRL improves auditors' access to and analysis of financial information. Escobar and his colleagues have conducted in-depth interviews with four of the Spanish innovators in XBRL [10]. The structure of interviews is based on a set of eleven open questions which aim to construct the innovators' views on XBRL. The questions have been formulated from the literature reviewed and in terms of their research goals. They found that XBRL contributes to minimizing errors, failures and frauds. Addition to, XBRL brings innovation for both accounting and auditing processes. Theses above studies reveal that the adoption of XBRL with integration with geographic data reduces costs in the processing of financial information, facilitates the process of analyzing financial information, and improves the auditing process, due to the standardization of information. In addition, XBRL with the integration of geographic data improves the transparency of financial reports and the performance of external and internal audits.

### **3.5. Limitations of This Review**

The key limitations of this job are bias in the selection of publications and inaccuracy in data extraction. To mitigate this issue, we developed a research protocol that defined the research question and research databases. Addition to, we followed recommendations suggested by [4].

## **4. Related Work**

GeoXBRL is based on Generic Links [22], which permits that any other semantic not foreseen in XBRL 2.1 can be represented in XBRL taxonomies. Some XBRL data semantics are already specified based on Generic Links, such as XBRL Formula [26], Generic Label [27] and Generic Reference [28]. XBRL Formula was specified to represent complex arithmetic expressions, due to Calculation Linkbase just represents sum expressions. Generic

Label can be used for associating a label with any element contained in XBRL taxonomy, extending the Label Linkbase that is just used for labeling the business concepts contained in XBRL schema. Generic Reference specifies syntax to associate an authoritative documentation with any element contained in XBRL taxonomy, not only with business concepts from XBRL schema, as proposed by Reference Linkbase [12]. There is some works that proposes the integration among business and geospatial data. The next two related works are previous researches about this proposal, which has been done by the same authors of this paper. Silva and his colleagues (2013) [8] approach the integration between XBRL and GML documents through a Simple XLink [19]. This proposal is represented by a link that contains an URI [29] of a GML instance. This representation is made within XBRL instance. Silva and his colleagues (2015) propose to integrate business and geospatial taxonomy through the linking of data schemas, not only within instance documents, i.e. the document containing the data. The aim of this work is to import the geospatial schema into XBRL taxonomy. Thus, it proposes that both schemas (XBRL and GML) can work in the same taxonomy. This work makes a theoretical proposal, and there is no any computer-based encoding. These works [8,9] propose GML and XBRL technologies integration. However, they do not specify how to handle the data of business and geospatial schema together. These works were the conceptual base for GeoXBRL. A comparison among business tools and technologies is shown to clarify how the GeoXBRL can evolve the XBRL tools to another kind of analysis (i.e. geographical analysis or geoanalysis). XBRL consortium [16] publishes XBRL tools and services to support the XBRL community. As illustrated in Table 1, seventeen tools have been developed to support the business domain and XBRL data. However, all of them have no support to geospatial data and cannot output data in geovisualization format.

**Table 1:** Comparison among XBRL tools and GeoXBRL-based App.

Software	Open Source	Business Domain	XBRL data support	Financial Analysis	Geodata support	Geovisualization of Financial Data
Arelle [30]	Yes	Yes	Yes	No	No	No
XWand [31]	No	Yes	Yes	No	No	No
Vizor [32]	No	Yes	Yes	Yes	No	No
Batavia [33]	No	Yes	Yes	Yes	No	No
SQL Power [34]	No	Yes	Yes	Yes	No	No
EdgarSuite [35]	No	Yes	Yes	No	No	No
Bearing Point [36]	No	Yes	Yes	Yes	No	No
Addactis [37]	No	Yes	Yes	Yes	No	No
Calbench [38]	No	Yes	Yes	Yes	No	No
Litix [39]	No	Yes	Yes	Yes	No	No
Raportado [40]	No	Yes	Yes	Yes	No	No
RegulatorWorks [41]	No	Yes	Yes	No	No	No
Workiva [42]	No	Yes	Yes	Yes	No	No
XBRL Analyst [43]	No	Yes	Yes	Yes	No	No
XKubed [44]	No	Yes	Yes	Yes	No	No

We did a search to find GIS Tools that support XBRL. There were 24 tools, 13 open source tools and 11 proprietary tools. As shown in Table 2, none of them has support for the XBRL technology use. Both types of tools, i.e. XBRL tools and tools for geographic information, do not integrate these domains. Also, no academic

work was found that proposed the integration of business data with geographic data. This limits data analysis, since business information needs to be linked to its location for accurate decision making. To fill this gap is proposed GeoXBRL.

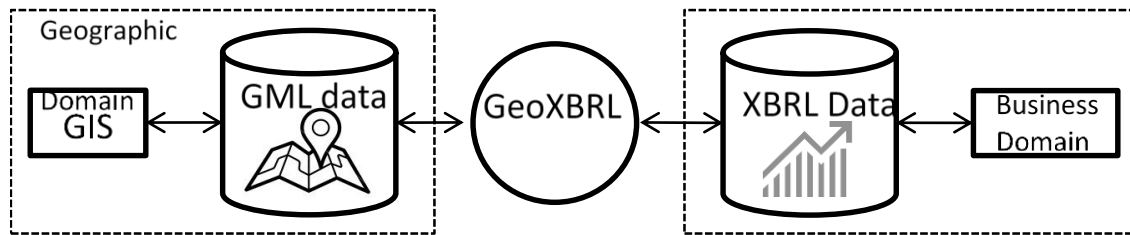
**Table 2:** GIS Tools that support XBRL.

Software	Open Source	Business Domain	XBRL data support	Financial Analysis	Geodata support	Geovisualization of Financial Data
QGIS [45]	yes	No	No	No	yes	No
gVSIg [46]	yes	No	No	No	yes	No
SAGA GIS [47]	yes	No	No	No	yes	No
GRASS GIS [48]	yes	No	No	No	yes	No
MapWindow [49]	yes	yes	No	No	yes	No
ILWIS [50]	yes	No	No	No	yes	No
GeoDa [51]	yes	No	No	No	yes	No
uDig [52]	yes	No	No	No	yes	No
OpenJump [53]	yes	No	No	No	yes	No
Diva GIS [54]	yes	No	No	No	yes	No
Falcon View [55]	yes	No	No	No	yes	No
OrbisGIS [56]	yes	yes	No	No	yes	No
ArcGIS (Esri) [57]	No	yes	No	No	yes	No
Geomedia [58]	No	No	No	No	yes	No
MapInfo Pro [59]	No	yes	No	No	yes	No
Global Mapper [60]	No	No	No	No	yes	No
Manifold GIS [61]	No	yes	No	No	yes	No
Smallworld [62]	No	yes	No	No	yes	No
Bantley Map [63]	No	yes	No	No	yes	No
MapViewSurfer [64]	No	No	No	No	yes	No
Maptitude [65]	No	yes	No	No	yes	No
SuperGIS [66]	No	No	No	No	yes	No
IDRISI [67]	No	yes	No	No	yes	No

## 5. GeoXBRL

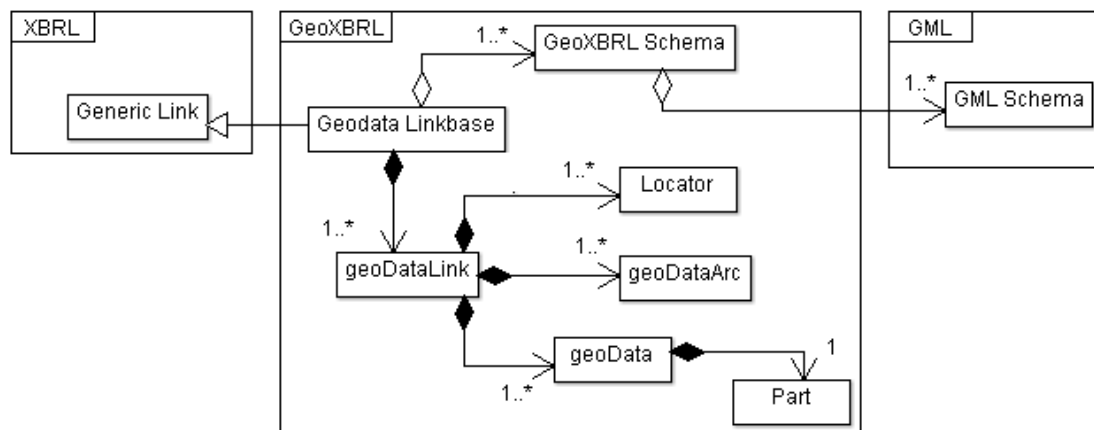
XBRL standard has not specified geodata to be part of its taxonomy. Hence, geodata cannot be represented in business taxonomies based on XBRL data. This is a problem for the auditing and financial analysis which demand business data processing and intend to analyze them through geovisualization. As illustrated in Figure 3, GeoXBRL integrates GML and XBRL data, with which the business data processing through GIS and vice versa (i.e. geodata processing through business systems) could be done by standards.





**Figure 3:** GeoXBRL: An integration between geographic and business data.

Figure 4 illustrates a GeoXBRL modeling based on UML notation, all elements are explained in the following. Geodata Linkbase is derived from Generics Link (explained in Section 2), for this reason it inherits all elements from XBRL Schema(s). Geodata Linkbase is also composed by elements from GeoXBRL Schema(s), which is composed by elements based on GML Schema(s). The element geoDataLink is a container for other elements: Locator, geoDataArc e geoData. Locator is an element already specified in XBRL 2.1, whose role is to locate any element from XBRL taxonomy. The geoDataArc is an element specified in GeoXBRL, whose role is to establish a linking between Locator and geoData. The element geoData serves as a common ancestor of all geodata types in GeoXBRL proposal. Part is a specialization element (sub-element) of GeoData that represents any fragment of geoinformation, in which is possible to represent any kind of geodata.



**Figure 4:** UML modeling of GeoXBRL.

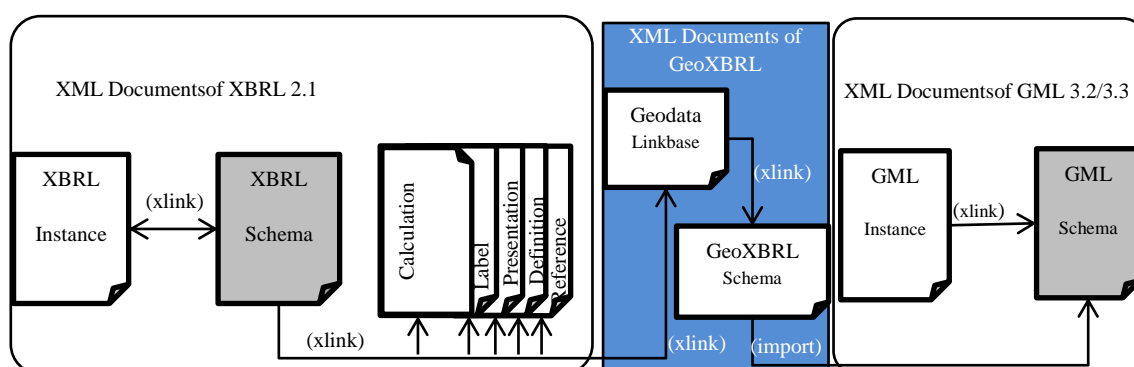
Thus, GeoXBRL represents geodata on XBRL-based business reporting, allowing that information systems can make financial business data processing through GIS and vice versa. In the following, each GeoXBRL element and their XML representation are shown.

### 5.1. GeoXBRL Specification Based on XML Technology

To implement the GeoXBRL we have proposed a specification based on XML, which is a common technology between XBRL and GML. In the following, it is explained the Geodata linkbase, GeoXBRL schema, geoDataLink, geoData, geoDataArc.

➤ GeoXBRL Documents: Geodata Linkbase and GeoXBRL Schema

As illustrated in Figure 5, GeoXBRL is based on two documents, i.e. Geodata Linkbase and GeoXBRL Schema. In the Geodata Linkbase document, all geographic semantic about XBRL elements is represented. According to XBRL 2.1, XBRL Schema must reference all linkbases that is used in taxonomy. GeoXBRL Schema document specifies and defines all geographic elements that can be used in Geodata Linkbase. GeoXBRL schema imports the GML schema to follow the suggestion of using GML-based elements, which are widely used in GIS. As a XML-based representation, the xlink attribute (from XLink definition) and the import element (from XML Schema definition) are used to link the documents and its elements.



**Figure 5:** GeoXBRL overview based on XML technology.

A schema (shown in Appendix 1) has been built to regulate the creation of Geodata Linkbase documents. In the following, we discuss about all GeoXBRL elements that must be contained in Geodata Linkbase documents.

#### The <geoDataLink> element

The <geoDataLink> element has been specified as an XBRL Extended Link to represent all geographic linking in the XBRL taxonomy. Geodata Linkbase is derived from Generic Link definitions, as illustrated in Figure 4. Thus, as illustrated in Figure 1, to represent this hierarchy in XML syntax, <geoDataLink> is defined as a generic link type (i.e. type="gen:link") and also belong to XBRL extended link group (i.e. substitutionGroup = "xl:extended"). In this way, <geoDataLink> are from the same group of those already-specified extended links [12], and can represent generic data type which was not foreseen by XBRL 2.1 specification (e.g. in this work is approached the linking with geospatial type). There are two others sub-elements specified to documentations finalities (i.e. <annotation> and <documentation>).

```

<element name="geoDataLink" type="gen:link" substitutionGroup="xl:extended">

  <annotation>

    <documentation>

      "geoDataLink" is the extended and Generic link that contains all elements that
      participate of

      the geolocation. See: http://www.xbrl.org/2008/generic-link.xsd.

    </documentation>

  </annotation>

</element>

```

**Figure 10:** XSD Fragment of <geoDataLink> Element.

According to the concept modeling shown in Figure 4, there are two more elements: geoData and geoDataArc, which are shown through the XML syntax, as follows.

#### The <geoData> Element

As illustrated in Figure 2, The <geoData> element is defined as a XBRL resource (i.e. substitutionGroup="xl:resource"). Many elements from XML technology are used for building the <geodata> element (i.e. <xsd:complexType>, <xsd:complexContent>, <extension>, <sequence>, <xsd:attribute> and <xsd:anyAttribute>) [68]. To represent any geospatial data, the part element (i.e. <element ref="link:part">) is specified as a composition element of <geoData>, in which any XML fragment (including that GML-based ones) can be expressed.

```

<element name="geoData" substitutionGroup="xl:resource">

    <annotation>

        <documentation>

            Definition of the geodata resource element.

        </documentation>

    </annotation>

    <complexType mixed="true">

        <complexContent mixed="true">

            <extension base="xl:resourceType">

                <sequence>

                    <element ref="link:part" minOccurs="0"
maxOccurs="unbounded"/>

                </sequence>

            </extension>

        </complexContent>

    </complexType>

    <xsd:attribute name="id" type="ID" use="optional"/>

    <xsd:anyAttribute namespace="http://www.w3.org/XML/1998/namespace"
processContents="lax"/>

</element>

```

**Figure 11:** XSD Fragment of <geoData> Element.

To represent a relationship between <geoData> and XBRL locators elements, an arc based on Generic Links definitions must be defined in order to link them, as explained in the following.

### The <geoDataArc> Element

Each extended Link defined in XBRL 2.1 has an element whose type is arc type (i.e. labelArc, calculationArc, presentationArc, referenceArc and definitionArc) [12]. This occurs to represent a linking arc between two XBRL elements or concepts [12]. The Generic Links specification has defined a linking type, called genericArcType [69]. As shown in Figure 3, <geoDataArc> has been specified to create a relationship between those elements contained in Geodata Linkbase, of which at least one is a geodata. As XBRL 2.1 has not foreseen geospatial data in its specification, <geoDataArc> has been defined as a genericArcType type, a generic arc from the Generic Link specification (i.e. type="gen:genericArcType"). Thus, the <geoDataArc> element fit with XBRL definitions and can be used in XBRL taxonomies. So, it can define a relationship arc between two elements, even though if one of them is a geospatial data.

```
<element name="geoDataArc" type="gen:genericArcType" >

    <annotation>

        <documentation>

            Linking Arc between a XBRL locator and a Geodata.

            See: http://www.xbrl.org/2008/generic-link.xsd.

        </documentation>

    </annotation>

</element>
```

**Figure 12:** XSD Fragment of <geoDataArc> Element.

Geodata Linkbase has been specified in order to relate geospatial and business concepts in a same taxonomy based on W3C standards. Geodata Linkbase storages geographic data related to any business concepts belong to any XBRL taxonomy. This linkbase extends those already specified by XBRL 2.1. Thus, this work brings the possibilities of geospatial data representation into XBRL-based business reporting, allowing interoperability among information systems that supports the business and geographic domains. This XML-based infrastructure (presented in this section) is based on acknowledged international standards, avoiding the plurality of data formats, meaning it is possible to adapt this standard in business taxonomies that are used in worldwide, as shown in following section.

### 6. GeoXBRL: An Example of Its Use

In this section the GeoXBRL use is shown. Firstly, an extension of Facebook taxonomy, downloaded at the US-SEC XBRL website [70], is built included the geographic data by the GeoXBRL features. After that, an

application was developed and an example using the extended taxonomy is showed.

### 6.1. GeoXBRL in a Real-World XBRL Taxonomy

A Geospatial XBRL schema has been built to help the initial stage of a geographic representation on XBRL taxonomy, as illustrate in Figure 4. Six elements have been specified to represent a real-world geographic position: Geometry, Point, Coordinates, Latitude, Longitude and Altitude. All these elements are based on GML specification, as it is also shown in Figure 4 through namespace “gml:” in the ref attributes. The first three elements are XBRL tuple (i.e. substitutionGroup = “xbrli:tuple”), which means they can contained other elements. The other elements are simple, i.e., XBRL item (cannot contain other elements). Three steps are necessary to adapt the GeoXBRL documents in some XBRL taxonomy, as illustrated in Figure 6. Firstly, a Geodata Linkbase document must be built based on GeoXBRL specification, in which is presented all company geolocation. Secondly, this GeoData Linkbase document must be added in same other documents directory of the respective XBRL taxonomy (as a good practice, not mandatory). Finally, this Geodata Linkbase document must be referenced within schema document (e.g. XBRL taxonomy).

```
<schema
  targetNamespace="http://www.xbrl.org/2006/ref"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified"
  xmlns:ref="http://www.xbrl.org/2006/ref"
  xmlns:link="http://www.xbrl.org/2003/linkbase"
  xmlns="http://www.w3.org/2001/XMLSchema">

  <import namespace="http://www.opengis.net/gml/3.2"
    schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd" />

  <import namespace="http://www.opengis.net/gml/3.3"
    schemaLocation="http://schemas.opengis.net/gml/3.3" />

  <element name="Geometry" ref="gml:_Geometry" substitutionGroup="xbrli:tuple"
```

```

id="geo_Geometry" />

<element name="Point" ref="gml:Point" substitutionGroup="xbrli:tuple" id="geo_Point" />

<element name="Coordinates" ref="gml:coord" substitutionGroup="xbrli:tuple"

id="geo_Coordinates" />

<element name="Latitude" ref="gml:x" substitutionGroup="xbrli:item" id="geo_Latitude" />

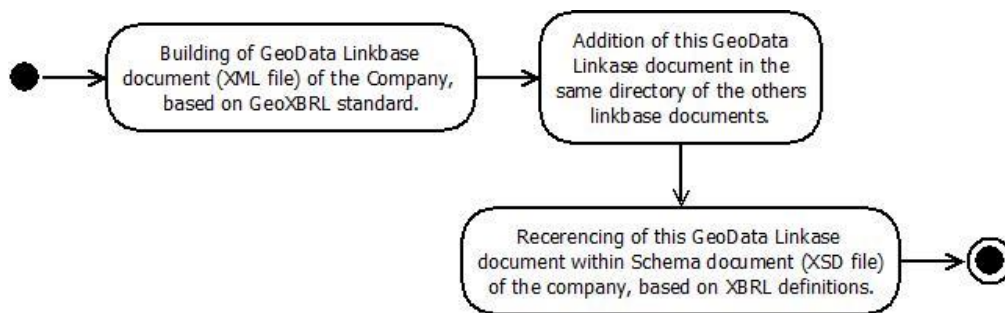
<element name="Longitude" ref="gml:y" substitutionGroup="xbrli:item" id="geo_Longitude" />

<element name="Altitude" ref="gml:z" substitutionGroup="xbrli:item" id="geo_Altitude" />

</schema>

```

**Figure 13:** Example of a GeoXBRL Schema Document that Contains some Geospatial-XBRL Elements.



**Figure 6:** Activity diagram of how to adapt the GeoXBRL standard in a XBRL taxonomy.

To exemplify a usage of GeoXBRL specification, a new Geodata Linkbase document has been developed in this work and integrated in real-world business reporting of the Facebook company (2016). This business reporting is available on U.S. Securities and Exchange Commission website [70]. This Geodata Linkbase is illustrated in Figure 5, in which the link, xlink, xsi and geoxbrl namespace attributes define the prefixes that can be utilized in Geodata Linkbase as a pointer to their respective data schema. GeoXBRL namespace has pointed to an URL, in which there are all GeoXBRL XSD files (i.e. <https://xbrlframework.wordpress.com/wiki/geoxbrl>). The <roleRef> element references the URI of the Generic Link and how it works can be seen at the XBRL 2.1 specification. The element <geoxbrl:geoDataLink> is defined as an extended type. According to Section 4 (and as illustrated in Figure 4), <geoxbrl:geoDataLink> contains other three sub elements: an Locator element <link:loc>, <geoData> and <geoDataArc>.

- (i) <link:loc> element is defined as a locator (i.e. xlink:type="locator"), which in this example has located the company that sends the business report (i.e., its href attribute is "http://xbrl.sec.gov/dei/2014/dei-

2014-01-31.xsd#dei\_EntityRegistrantName"). The label attribute defines an identifier label to <xlink:loc> element (i.e. xlink:label="dei\_EntityRegistrantName").

- (ii) <geoxbrl:geoData> element is represented with label and id attributes equal to "fb\_geodata". All attribute values must be defined by XBRL developer. The taxonomist can use all those elements that have already been specified, i.e. Geometry, Point, Coordinate, Latitude, Longitude and Altitude (as illustrated in Figure 4). However, the taxonomist can use other geographic elements contained in other schema, in this case it is necessary to import the schema into the document.
- (iii) <geoxbrl:geoDataArc> element represent the linking between the previous two elements, through the attributes From and To, which say the start and the end point of the linking, respectively.

As illustrated in Figure 5, the Geodata Linkbase document of the Facebook company has numeric data related to geographic coordinate system (composed by latitude, longitude and altitude). In this example, Facebook coordinates have been presented with latitude equals to 37.4834075, longitude equals to -122.1517019,17 and altitude is zero.

```
<?xml version='1.0' encoding='iso-8859-1'?>

<link:linkbase

  xsi:schemaLocation="http://www.xbrl.org/2003/linkbase http://www.xbrl.org/2003/xbrl-linkbase-2003-12-31.xsd"

  xmlns:link="http://www.xbrl.org/2003/linkbase" xmlns:xlink="http://www.w3.org/1999/xlink"

  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"

  xmlns:geoxbrl="https://xbrlframework.wordpress.com/wiki/geoxbrl">

  <link:roleRef          xlink:href="http://www.xbrl.org/2008/generic-link.xsd#standard-link-role"
xlink:type="simple"

  roleURI="http://www.xbrl.org/2008/role/link"/>

  <geoxbrl:geoDataLink xlink:type="extended">

          <link:loc      xlink:type="locator"      xlink:href="http://xbrl.sec.gov/dei/2014/dei-2014-01-31.xsd#dei:dei_EntityRegistrantName" xlink:label="dei_EntityRegistrantName"/>
```



```

    <geoxbrl:geoData xlink:type='resource' xlink:label="fb_geodata" id="fb_geodata">

        <geoxbrl:Geometry xlink:label="fb_geometry" id="fb_CompanyGeometry">

            <geoxbrl:Point xlink:label="fb_point" id="fb_point">

                <geoxbrl:Coordinate                                xlink:label="fb_coordinates"
id="fb_coordinates">

                    <geoxbrl:Latitude                                xlink:label="fb_latitude"
id="fb_latitude">37.4834075</geoxbrl:Latitude>

                    <geoxbrl:Longitude                                xlink:label="fb_longitude"
id="fb_longitude">

                        -122.1517019,17

                    </geoxbrl:Longitude>

                    <geoxbrl:Altitude                                xlink:label="fb_altitude"
id="fb_altitude">0</geoxbrl:Altitude>

                </geoxbrl:Coordinate>

            </geoxbrl:Point>

        </geoxbrl:Geometry>

    </geoxbrl:geoData>

    <geoxbrl:geoDataArc      xlink:type="arc"      xlink:from="dei_EntityRegistrantName"
xlink:to="fb_geodata" />

</geoxbrl:geoDataLink>

</link:linkbase>

```

**Figure 14:** Facebook Geodata Linkbase with its Location in the USA.

According to XBRL 2.1 specification, each company must describe all linkbases that are parts of its XBRL taxonomies, through the tag-element `link:linkbaseRef` in XSD file [12]. As shown in Figure 6, the first four `<link:linkbaseRef>` tag-elements reference linkbases that have already been specified in XBRL 2.1 (i.e. Calculation, Definition, Label and Presentation), which are parts of Facebook taxonomy (2016). To add the Geodata Linkbase in this taxonomy, a new tag-element `link:linkbaseRef` must be created, whose `xlink:href` have to contain the name of the Geodata Linkbase document (i.e. `fb-20160331_geo.xml`), as shown in bold part in Figure 6. Its arc role is defined as a linkbase (i.e. `xlink:arcRole="http://www.w3.org/1999/xlink/properties/linkbase"`), and the attribute `Type` defines it as a simple link, both directives are provided by XBRL 2.1 specification. The creation of Geodata Linkbase document - and its integration in the Facebook taxonomy - is doable and follows all needed steps to create any other linkbase document specified in XBRL 2.1. In this example shown in this section, it has been done (i) the representation of the Facebook geolocation in the United States of America within XBRL taxonomy, (ii) the construction of a new XBRL linkbase based on geospatial concepts and, finally, (iii) the integration of this linkbase in the business data schema of company Facebook. In following section is shown a web application based on GeoXBRL files.

```
<link:linkbaseRef xlink:arcrole="http://www.w3.org/1999/xlink/properties/linkbase" xlink:href="fb-
  20160331_cal.xml" xlink:role="http://www.xbrl.org/2003/role/calculationLinkbaseRef" xlink:type="simple"
/>

<link:linkbaseRef xlink:arcrole="http://www.w3.org/1999/xlink/properties/linkbase" xlink:href="fb-
  20160331_def.xml" xlink:role="http://www.xbrl.org/2003/role/definitionLinkbaseRef" xlink:type="simple" />

<link:linkbaseRef xlink:arcrole="http://www.w3.org/1999/xlink/properties/linkbase" xlink:href="fb-
  20160331_lab.xml" xlink:role="http://www.xbrl.org/2003/role/labelLinkbaseRef" xlink:type="simple" />

<link:linkbaseRef xlink:arcrole="http://www.w3.org/1999/xlink/properties/linkbase" xlink:href="fb-
  20160331_pre.xml" xlink:role="http://www.xbrl.org/2003/role/presentationLinkbaseRef" xlink:type="simple"
/>

<link:linkbaseRef xlink:arcrole="http://www.w3.org/1999/xlink/properties/linkbase"
  xlink:href="fb-20160331_geo.xml" xlink:type="simple" />
```

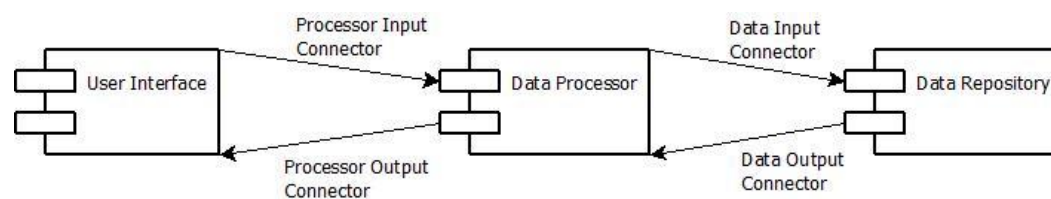
**Figure 15:** Fragment of Facebook XSD file.

## 6.2. A GeoXBRL-Based Web Application

A Java-based web application has been built to show how data from GeoXBRL specification can be used for providing new geodata inputs and outputs for the financial auditing and analysis.

### ➤ Architecture of GeoXBRL Systems

As illustrated in Figure 7, GeoXBRL systems must have three layers: (i) User Interface, in where the user can insert and read data (input and output); (ii) Data Processor, layer that processes user queries and XBRL and GeoXBRL data; and (iii) Data Repository, in where XBRL and GeoXBRL documents (files) are stored.



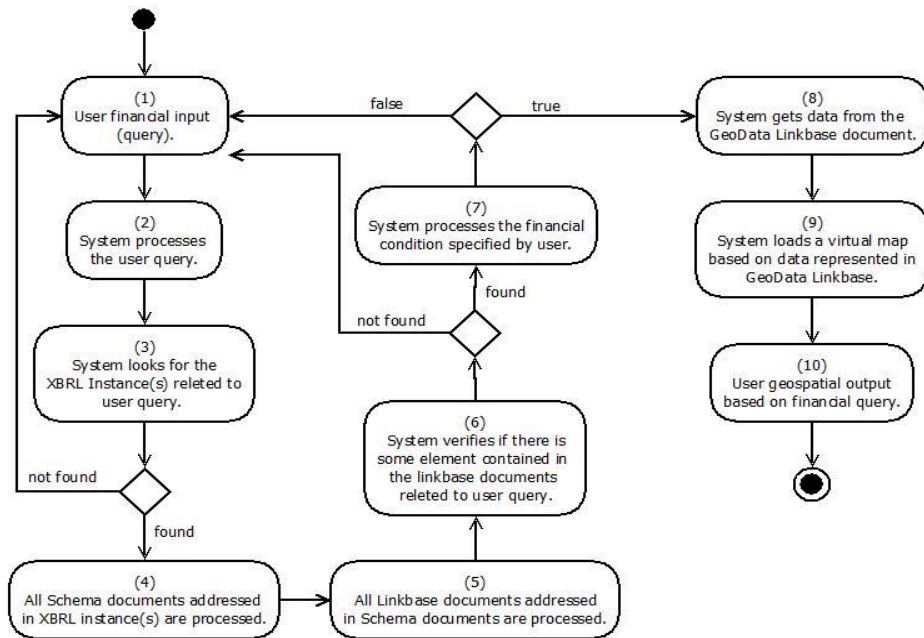
**Figure 7:** Layers of a GeoXBRL-based Application.

As illustrated in Figure 8, an UML activity diagram illustrates how to build a GeoXBRL-bases application, whose steps are explained as follows:

1. User inputs, whose financial query can be done via web form, web service or any other way.
2. User financial query is processed by the system, based on which a set of XBRL files are selected in the database.
3. The system processes the XBRL Instance(s) related to user query, in order to – for example - find the element name specified by the user in the query. If the XBRL Instance is not found, an error message is show to the user, which must redo the query.
4. The system processes the XBRL Schema files that are presented in XBRL Instances. In the schema files are the names of the Linkbase documents, in which are stored other information related to the elements specified in the user query (e.g. other labels, some calculations).
5. The system verifies the names of the Linkbase documents referenced in the Schema document.
6. The user can use some information in the financial query, which can be contained in some Linkbase document (e.g. another label for a financial element). However, if this information is not found a message is shown to user.
7. System verifies the financial conditional defined by the user (in the financial query). All financial elements and their numeric value are stored in the XBRL Instance file. Thus, application must process this file (i.e. XBRL instance) in order to verify whether the financial conditional is true or false. If this verification result is false, the system shows a message to the user, which has to redo the query. If it is true, the system moves to the next step.
8. System looks for the Geodata Linkbase in the database and retrieves all geodata that are defined in the

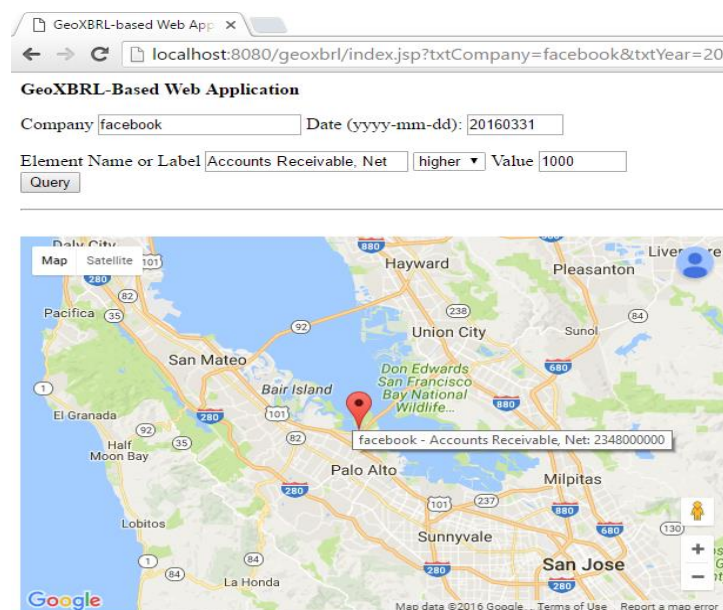
relationships within it.

9. System processes the geodata and loads them in a virtual map (the better virtual map is not defined in this work, this concerns to the companies that are developing their GeoXBRL-based solution).
10. Finally, the geospatial output based on financial query is shown to user.



**Figure 8:** Activity diagram (UML) of building a GeoXBRL-based Application.

As illustrated in Figure 9, a web form has been built to interact with users. Thus, according to the data showed in image, the user intends to locate geospatially the company Facebook only if its XBRL documents are from the date 2016/03/31, whose financial element named “Accounts Receivable, Net” is higher than 1000.



**Figure 9:** A Financial Query and its Geovisualization-based Output.

This sample is an initial development to test how a web application works on a repository composed by SEC XBRL files and their Geodata linkbases. It is proven that GeoXBRL specification standardly integrates the linking between business data (designed through XBRL technology) and geospatial data (GML technology). In addition, GeoXBRL works without problems with XBRL taxonomies that are already in use. This GeoXBRL-based web application brings to XBRL community support to geospatial data and output data in geovisualization format. This is the main feature geoXBRL, i.e. supporting geodata and generating outputs based on geovisualization. In next section, a comparison is done among this GeoXBRL-based application – built in this work - and others XBRL tools.

### **6.3. Technology Comparisons**

Some technological features are presented in Table 3 to compare the GeoXBRL with other specifications that have already been described in Section 2 (i.e. XBRL Formula, Generic Label, Generic Reference, XBRL GIS, Geographic XBRL). These features are related to aspects of implementation based on XBRL and GML standard, i.e. what technological advantage and resource the GeoXBRL gives us in the representation of business data. Each feature is explained below:

- a) **Adaptable in Current XBRL Taxonomies:** it means the adaptability of the GeoXBRL with older XBRL taxonomies. Thus, any XBRL taxonomies can use the GeoXBRL standard without problem with unfixable technology;
- b) **XBRL Instance:** it provides the possibility of geographic modeling in XBRL instance document, providing more flexibility for developers choose where they intend to put the data within taxonomy.
- c) **XBRL Schema:** developers can reference and locate data from XBRL schema;
- d) **XBRL Linkbase:** it means the possibility of using Linkbase documents to storage the extended links, in which any GML-based geospatial and XBRL-based business data can be interconnected in a freely way;
- e) **XBRL Generic Links:** it implies in the usage of the Generic Links specification to represent linking that were not foreseen in the XBRL specification 2.1;
- f) **GML Instance:** it is the possibility of using the GML Instance document in some solution, giving more flexibility for developers choose in where they intend to catch the data from GML taxonomy;
- g) **GML Schema:** it means the use of any geospatial concepts from the GML schema, and it does not matter how complex is this data.
- h) **Some contributions of GeoXBRL are presented which are related to representation and handling of geospatial data in XBRL business taxonomies:** (a) **Geospatial Representation in XBRL Context:** it is possible to represent geospatial data within XBRL taxonomy; (b) **Specification for Geospatial and Business Data Integration:** it means a way based on W3C standards of representing the relationships among geospatial and business data; and (c) **Handling of Concepts from GML Schema within XBRL Taxonomy:** it is the definition of geospatial elements in XBRL schema, even though all elements are based on GML schema. Thus, it can be stated that GeoXBRL supports all the features analyzed in Table 1, i.e., it is an Open Source solution, supports XBRL and geographic data, does financial analysis based on geographic data and provides mechanism to develop a geo-visualization of financial data. In next

section, conclusions, limitations and future works are discussed to guide other researchers on relevant points of the GeoXBRL specification.

**Table 3:** GeoXBRL Technological Features.

		<b>Related Work</b>					
		XBRL Formula [71]	Generic Label [15]	Generic Reference [71]	XBRL GIS [11]	Geographic XBRL [70]	GeoXBRL
<b>Features</b>	a) Adaptable in Current XBRL Taxonomies	YES	YES	YES	YES	YES	YES
	b) XBRL Instance	YES	YES	YES	YES	NO	YES
	c) XBRL Schema	YES	YES	YES	NO	YES	YES
	d) XBRL Linkbase	YES	YES	YES	NO	NO	YES
	e) Generic Links	YES	YES	YES	NO	NO	YES
	f) GML Instance	NO	NO	NO	YES	NO	YES
	g) GML Schema	NO	NO	NO	NO	YES	YES

## 7. Conclusion, Limitations and Future Work

Two sceneries explicit the need of a standard for geographic data representation in business taxonomies: (i) international technology consortiums and acknowledged organizations (such as ISO) have been announcing the importance of the data standardization, worldwide; (ii) the increasing of continuous auditing and financial analysis techniques based on geospatial data resource. GeoXBRL allows that developers define geospatial concepts within XBRL business taxonomies, providing a standardized information technology (IT) infrastructure on which GIS and business systems can process data from both domains. This allows, for example, the decision-making and the detection of some financial index (e.g. fraud) through virtual map observation on the computer screen. GeoXBRL brings to business processing world this feature of supporting geodata based on standardized representation, whose financial analytics can be through geovisualization. Due to wide use of GML and XBRL in geographic and business system respectively, this work has proposed a representation based on this both languages. It is relevant to point that GeoXBRL has adopted W3C technologies (such as GML, XBRL and XLink) in its specification, which avoid the plurality of data format and support the interoperability among GIS and business systems. This paper shown that GeoXBRL can be applied on current XBRL reporting (based on version 2.1), even though this version does not support geodata. An example of integration and a Java web system have shown this possibility through a joint processing of a real-world XBRL reporting (available on US SEC website) and an XML-based GeoXBRL representation. Thus, there is no problem in using GeoXBRL in business taxonomies already in use by financial market regulators. It means the GeoXBRL does not affect the processing of those XBRL reporting already in use in current business

information systems. A limitation of GeoXBRL representation (presented in this paper) is the use of XLink technology. This is an investigation issues for others technologies that do not have this kind of linking technologies in their specification, such as JavaScript Object Notation (JSON) [72], Object Data Instance Notation (ODIN) [73] and Lightweight Markup Language (LML) [74], and must be investigated how the best way to represent it. GeoXBRL is the initial step to integrate GIS and business systems in a standardized way, and gives rise to new fields of research, which can support continuous auditing and other financial analysis based on financial business geovisualization. This paper has presented a GIS that processes XBRL-based business data, a future work is to develop a business system that processes geodata. Other future works also are encouraged, as follows: (i) the representation of complex geodata types, which ones can build more complex virtual maps, evolving the financial business analysis to another level of observation; (ii) the use of geospatial concepts from other specifications (e.g. KML and from Open Source Geospatial Foundation); (iii) the representation of GeoXBRL through other representation technologies, such as JSON, ODIN and LML; (iv) compression, clustering and pattern discovery on XBRL data, through spatial OLAP tools and geospatial mining techniques; (v) the development of applications for geovisualization of sustainability data, considering that the GRI's sustainability taxonomy are based on XBRL [75,76] (vi) geospatial mapping of crime data, which are structured through XBRL in India [77]; and, finally, (vii) extend a GeoXBRL-based solution for mobile devices [71].

## References

- [1]. M. V. A. Alawadhi, The Application of Data Visualization in Auditing, PhD Thesis, Program in Management- Continuous Auditing & Reporting Lab, USA, Rutgers University, 2014.
- [2]. Esri, GIS for Banking – Overview, 2016.
- [3]. H. B. S. H. S. Jouida, The Effects of Activity and Geographic Diversification on Performance: Evidence from French Financial Institutions, Research in International Business and Finance, Elsevier, 2016.
- [4]. M. V. Q. Liu, The Application of Exploratory Data Analysis in Auditing, USA: , Program in Management - Continuous Auditing & Reporting Lab, Rutgers University, 2014.
- [5]. P. Lutu, Progressive Usage of Business and Spatial Intelligence for Decision Support in the Delivery of Educational Services in Developing Countries, Knowledge Management for Development, Springer, 2013.
- [6]. K. Nielsen, An Interactive Geospatial Tool for Financial Inclusion Analysis., Spatial Development, 2013.
- [7]. C. Reed, Integrating Geospatial Standards and Standards Strategies Into Business Process, 2014.
- [8]. P. d. S. J. C. M.A.P. da Silva, XBRL GIS - Integrating Geographic Information in XBRL Documents,

São Paulo: 10th Contecsi, USP, 2013.

- [9]. P. d. S. M. V. M.A.P. da Silva, Geographic XBRL: An Approach for Financial Reporting and Analysis, Sao Paulo: 34th WCARS, 2015.
- [10].D. Taylor, FinAccess geospatial mapping survey: analysis and use cases, Kenya: FSD Kenya, 2015.
- [11].US-DOI, Geospatial Services Model: Serving the Geographic Business Needs of the U.S, Department of the Interior, 2016.
- [12].X. Inc., "XBRL Specification 2.1," 2013. [Online]. Available: <http://specifications.xbrl.org/work-product-index-group-base-spec-base-spec.html>. [Accessed 01 05 2017].
- [13].OGC, "Geography Markup Language," 2016. [Online]. Available: <http://www.opengeospatial.org/standards/gml>. [Accessed 30 08 2017].
- [14].W3C, "WWW Consortium," 2017. [Online]. Available: <https://www.w3.org>. [Accessed 14 09 2017].
- [15].X. Inc., "Membership List," 2016. [Online]. Available: <https://www.xbrl.org/the-consortium/about/membership-list>. [Accessed 23 05 2017].
- [16].X. Inc., "XBRL Consortium," 2016. [Online]. Available: <http://xbrl.org/>. [Accessed 06 05 2017].
- [17].OGC, "Open Geospatial Consortium," 2016. [Online]. Available: <http://www.opengeospatial.org>. [Accessed 29 08 2017].
- [18].ISO, Benefits of International Standards, 2016.
- [19]. W3C, "XML Linking Language (XLink) Version 1.0," 2001. [Online]. Available: <https://www.w3.org/TR/xlink>. [Accessed 29 08 2017].
- [20].X. Inc., "XBRL Essentials," 2016. [Online]. Available: <http://specifications.xbrl.org/xbrl-essentials.html>. [Accessed 04 05 2017].
- [21].X. Inc., "XBRL simple and extended links," 2003. [Online]. Available: <http://www.xbrl.org/2003/xbrl-linkbase-2003-12-31.xsd>. [Accessed 15 08 2017].
- [22].X. Inc., "XBRL Generic Links 1.0," 2009. [Online]. Available: <http://www.xbrl.org/Specification/gnl/rec-2009-06-22/gnl-rec-2009-06-22.html>. [Accessed 02 08 2017].
- [23].C. Barbosa, Map Algebra and its Applications in Remote Sensing and GIS., Brazil, 1997.



- [24].R. M. P.A. Burrough, Principles of Geographical Information Systems, Oxford University Press, 1998.
- [25].OGC, "Geometry data," 2010. [Online]. Available: <http://schemas.opengis.net/gml/2.1.2/geometry.xsd>. [Accessed 20 08 2017].
- [26].X. Inc., "XBRL Formula 1.0," 2011. [Online]. Available: <http://www.xbrl.org/wgn/xbrl-formula-overview>. [Accessed 03 01 2017].
- [27].X. Inc., "Generic labels 1.0," 2009. [Online]. Available: <http://www.xbrl.org/Specification/genericLabels/REC-2009-06-22>. [Accessed 15 07 2017].
- [28].X. Inc., "Generic References 1.0," 2011. [Online]. Available: <http://www.xbrl.org/specification/genericreferences/rec-2009-06-22>. [Accessed 26 05 2017].
- [29].W3C, "Universal Resource Identifier (URI)," 2015. [Online]. Available: <https://www.w3.org/wiki/URI>. [Accessed 01 09 2017].
- [30].Arelle, "Arelle," 2017. [Online]. Available: <http://arelle.org>. [Accessed 09 09 2017].
- [31].XWand, "XWand," 2017. [Online]. Available: <http://www.fujitsu.com/global/products/software/middleware/application-infrastructure/interstage/solutions/xbrl>. [Accessed 09 09 2017].
- [32].Vizor, "Vizor," 2017. [Online]. Available: <https://vizorsoftware.com>. [Accessed 09 09 2017].
- [33].Batavia, "Batavia," 2017. [Online]. Available: <http://www.batavia-xbrl.com>. [Accessed 09 09 2017].
- [34].S. Group, "SQLPower Group," 2017. [Online]. Available: <https://www.sqlpower.ca>. [Accessed 09 09 2017].
- [35].EDGARSuite, "EDGARSuite," 2017. [Online]. Available: <http://sec-edgar-filing.com/edgsuite.htm>. [Accessed 09 09 2017].
- [36].B. Point, "Bearing Point," 2017. [Online]. Available: <https://reg.tech/en>. [Accessed 09 09 2017].
- [37].Addactis, "Addactis," 2017. [Online]. Available: <http://www.addactis.com>. [Accessed 09 09 2017].
- [38].Calbench, "Calbench," 2017. [Online]. Available: <https://www.calcbench.com>. [Accessed 09 09 2017].
- [39].Litix, "Litix," 2017. [Online]. Available: <http://br-ag.eu>. [Accessed 09 09 2017].
- [40].Reporting, "Business Reporting," 2017. [Online]. Available: <http://www.fujitsu.com/global/solutions/industry/financial/business-reporting>. [Accessed 09 09 2017].

- [41].R. Works, "Regulator Works," 2017. [Online]. Available: <http://www.xbrlworks.com> . [Accessed 09 09 2017].
- [42].Workiva, "Workiva," 2017. [Online]. Available: <https://www.workiva.com>. [Accessed 09 09 2017].
- [43].XBRLAnalyst, "XBRLAnalyst," 2017. [Online]. Available: <https://findynamics.com> . [Accessed 09 09 2017].
- [44].XKubed, "XKubed," 2017. [Online]. Available: <http://xkubed.com> . [Accessed 09 09 2017].
- [45].QGIS, "Formerly Quantum GIS," 2018. [Online]. Available: <https://www.qgis.org/en/site> . [Accessed 01 08 2018].
- [46].gVSIG, "gVSIG," 2018. [Online]. Available: <http://www.gvsig.com>. [Accessed 01 08 2018].
- [47].S. GIS, "SAGA GIS," 2018. [Online]. Available: <http://www.saga-gis.org>. [Accessed 01 08 2018].
- [48].G. GIS, "GRASS GIS," 2018. [Online]. Available: <http://www.grass-osgeo.org>. [Accessed 01 08 2018].
- [49].MapWindow, "MapWindow," 2018. [Online]. Available: <http://www.mapwindow.org>. [Accessed 01 08 2018].
- [50].ILWIS, "ILWIS," 2018. [Online]. Available: <http://52north.org/communities/ilwis>. [Accessed 01 08 2018].
- [51].GeoDa, "GeoDa," 2018. [Online]. Available: <http://geodacenter.asu.edu/software/downloads> . [Accessed 01 08 2018].
- [52].uDig, "uDig," 2018. [Online]. Available: <http://udig.refractory.net>. [Accessed 01 08 2018].
- [53].OpenJump, "OpenJump," 2018. [Online]. Available: <http://www.openjump.org>. [Accessed 01 08 2018].
- [54].DivaGIS, "DivaGIS," 2018. [Online]. Available: <http://www.diva-gis.org>. [Accessed 01 08 2018].
- [55].FalconView, "FalconView," 2018. [Online]. Available: <http://www.nga.mil/ProductsServices/Pages/-FalconView.aspx> . [Accessed 01 08 2018].
- [56].OrbisGIS, "OrbisGIS," 2018. [Online]. Available: <http://www.orisgis.org> . [Accessed 01 08 2018].
- [57].ArcGIS, "ArcGIS - Esri," [Online]. Available: <http://www.esri.com>.

- [58].Geomadia, "Geomadia," [Online]. Available: <http://www.hexagongeospatial.com>.
- [59].MapInfo, "MapInfo," 2018. [Online]. Available: <http://www.pitneybows.com/us/location-intelligence/geographic-information-systems/mapinfo-pro.html> . [Accessed 01 08 2018].
- [60].G. Mapper, "Global Mapper," 2018. [Online]. Available: <http://www.blumarmblegeo.com/products/global-mapper.php>. [Accessed 01 08 2018].
- [61].M. GIS, "Manifold GIS," 2018. [Online]. Available: <http://www.manifold.net> (. [Accessed 01 08 2018].
- [62].Smallworld, "Smallworld," 2018. [Online]. Available: <http://www.gegridsolutions.com> . [Accessed 01 08 2018].
- [63].B. Map, "Bentley Map," 2018. [Online]. Available: <http://www.bentley.com> . [Accessed 01 08 2018].
- [64].M. Viewer, "Map Viewer and Surfer," 2018. [Online]. Available: <http://www.goldensoftware.com>. [Accessed 01 08 2018].
- [65].Maptitude, "Maptitude," 2018. [Online]. Available: <http://www.caliper.com/maptovu.htm>. [Accessed 01 08 2018].
- [66].SuperGIS, "SuperGIS," 2018. [Online]. Available: <http://www.supergeotek.com>. [Accessed 01 08 2018].
- [67].IDRISI, "IDRISI," 2018. [Online]. Available: <http://www.clarklabs.org>. [Accessed 01 08 2018].
- [68].W3C, "XML Schema," 2016. [Online]. Available: <https://www.w3.org/XML/Schema>. [Accessed 11 09 2017].
- [69].X. Inc., "Generic arcs," 2009. [Online]. Available: <http://www.xbrl.org/specification/gnl/rec-2009-06-22/gnl-rec-2009-06-22.html#sec-gen-arc>. [Accessed 23 07 2017].
- [70].US-SEC, "U.S. Securities and Exchange Commission," 2016. [Online]. Available: <http://www.sec.gov>. [Accessed 06 06 2017].
- [71].G. Inc, "The best of Google Maps for every Android app," 2016. [Online]. Available: <https://developers.google.com/maps/documentation/android-api/>. [Accessed 26 07 2017].
- [72].Json, "Json," 2017. [Online]. Available: <http://www.json.org>. [Accessed 13 09 2017].
- [73].OpenEHR, "Object Data Instance Notation," 2017. [Online]. Available: <http://www.openehr.org/releases/trunk/architecture/syntaxes/ODIN.pdf> . [Accessed 13 09 2017].

- [74].C. Tomer, "Lightweight Markup Languages,," 2017. [Online]. Available: <http://d-scholarship.pitt.edu/28131>. [Accessed 23 09 2017].
- [75].D. Costa and P. S. (. M.A.P. Silva, OLAP-based Sustainability Report Auditing., Valencia: The Eleventh International Conference on Internet and Web Applications and Services, 2016.
- [76].M. S. P. S. D. Costa, A Service Framework to Audit Sustainability Reporting Based on GRI Rules, São Paulo: In: 13° CONTECSI - International Conference on Information Systems and Technology Management, 2016.
- [77].X. Inc., "Indian State Uses Structured Data to Report Crime Statistics," 2016. [Online]. Available: <https://www.xbrl.org/news/indian-state-uses-structured-data-to-report-crime-statistics/>. [Accessed 06 07 2017].
- [78].J. S. C. T. E.Y. Peng, XBRL and Accruals: Empirical Evidence from China, Canada: Canadian Academic Accounting Association, 2011.
- [79].WhiteGAT, "WhiteGAT," 2018. [Online]. Available: <http://www.uogelph.ca/~hydrogeo/Whitebox>. [Accessed 01 08 2018].
- [80].J. S. P. Fu, Web GIS: Principles and Applications, USA: ESRI Press, 2010.
- [81].X. Inc., "Tools and Services," 2017. [Online]. Available: <https://www.xbrl.org/the-standard/how/tools-and-services/> . [Accessed 09 09 2017].
- [82].W3C, "The XML Data Model,," 2005. [Online]. Available: <https://www.w3.org/XML/Datamodel.html>. [Accessed 05 01 2017].
- [83].M. S. F. T. Z. Bai, The Impact of XBRL Adoption on the Information Environment: Evidence from Japan, IPRC, 2012.
- [84].R. S. V. K. D.J. Maguire, The Business Benefits of GIS: An ROI Approach, Redlands, 2008.
- [85].StopFraud.Gov, "StopFraud.Gov," 2016. [Online]. Available: <http://www.stopfraud.gov>. [Accessed 04 07 2017].
- [86].G. Inc., "Maps JavaScript API," 2016. [Online]. Available: <https://developers.google.com/maps/>. [Accessed 23 07 2017].
- [87].I. FinX, "Iris FinX," 2017. [Online]. Available: <http://irisbusiness.com> . [Accessed 09 09 2017].
- [88].V. S. O. C. L.M. Vilches-Blázquez, Interlinking Geospatial Information in The Web of Data, Bridging the Geographic Information Sciences, 2012.

- [89].T. S. A. S. A. Khan, Implement credit card fraudulent detection system using observation probabilistic in hidden Markov model, Nirma University International Conference on Engineering (NUiCONE), IEEE, 2012.
- [90].H. W. T. Z. Z. G. Z. L. L. Y. S. S. J. Z. J. G. K. Q. W. Y. Z. L. & J. Y. J. Gong, Geospatial Service Web: towards integrated cyberinfrastructure for GIScience, Geo-spatial Information Science, 2012.
- [91].V. T. J. Silva, GEOMDQL: A Geographic Multidimensional Query Language, UFPE, 2008.
- [92].Z. R. R. R. J. U. V. C.E. Hogan, Financial Statement Fraud: Insights from the Academic Literature., A Journal of Practice and Theory, 2008.
- [93].W3C, "Extensible Markup Language (XML)," 2017. [Online]. Available: <https://www.w3.org/XML/>. [Accessed 10 09 2017].
- [94].P. d. Silva, Exploring Markup Languages for representing Financial Information Reports, Salvador: Unifacs, 2003.
- [95].O. N. C. L. Y. Li, Does XBRL Adoption Reduce the Cost of Equity Capital?, National University of Singapore, 2013.
- [96].R. Clark, Corporate Governance Changes in the Wake of the Sarbanes-Oxley Act: A Morality Tale for Policymakers, Harvard Law and Economics , 2005.
- [97].W3C, "Complex Type Definitions," 2014. [Online]. Available: [https://www.w3.org/TR/xmlschema-1/#Complex\\_](https://www.w3.org/TR/xmlschema-1/#Complex_). [Accessed 09 09 2017].
- [98].M. A. H. H. M. J. E. Hormozi, Accuracy evaluation of a credit card fraud detection system on Hadoop MapReduce, 5th Conference onInformation and Knowledge Technology (IKT), 2013.
- [99].28msec, "28msec," 2017. [Online]. Available: <http://www.28msec.com>. [Accessed 09 09 2017].
- [100].Microsoft, <xsd:import> Element, 2012.

## Appendix 1

GeoXBRL Specification Schema based on XML technology

```
<?xml version="1.0" encoding="US-ASCII"?>

<schema

xmlns:link="http://www.xbrl.org/2003/linkbase" xmlns="http://www.w3.org/2001/XMLSchema"

xmlns:gen="http://xbrl.org/2008/generic"

xmlns:geoxbrl="http://xbrlframework.wordpress/wiki/geoxbrl"

targetNamespace="http://www.xbrl.org/2003/linkbase" elementFormDefault="qualified">

<annotation>

<documentation> GeoXBRL Specification version 1.0 </documentation>

</annotation>

<!-- XML imports -->

<import                                namespace="http://www.w3.org/XML/1998/namespace"
    schemaLocation="http://www.w3.org/2001/xml.xsd"/>

<import namespace="http://www.w3.org/1999/xlink" schemaLocation="xlink-2003-12-31.xsd"/>

<import                                namespace="http://www.w3.org/1999/xsd"
    schemaLocation="https://www.w3.org/2009/XMLSchema/XMLSchema.xsd" />

<!-- XBRL imports -->

<import                                namespace="http://www.xbrl.org/2003/instance"
    schemaLocation="http://www.xbrl.org/2003/xbrl-instance-2003-12-31.xsd"/>

<import                                namespace="http://www.xbrl.org/2003/linkbase"
    schemaLocation="http://www.xbrl.org/2003/xbrl-linkbase-2003-12-31.xsd"/>

<import namespace="http://www.xbrl.org/2003/XLink" schemaLocation="xl-2003-12-31.xsd"/>

<import                                namespace="http://xbrl.org/2008/generic"
    schemaLocation="http://www.xbrl.org/2008/generic-link.xsd"/>
```

<!-- Geodata Element -->

<element name="geoData" substitutionGroup="xl:resource">

<annotation>

<documentation value="Definition of the geoData Resource Element." />

</annotation>

<complexType mixed="true">

<complexContent mixed="true">

<extension base="xl:resourceType">

<sequence>

<element ref="link:part" minOccurs="0"

maxOccurs="unbounded"/>

</sequence>

</extension>

</complexContent>

</complexType>

<xsd:attribute name="id" type="ID" use="optional"/>

<xsd:anyAttribute namespace="http://www.w3.org/XML/1998/namespace" processContents="lax"/>

</element>

<!-- geodataArc Element -->

<element name="geoDataArc" type="gen:genericArcType" >

<annotation>

<documentation value="Linking element, an arc between Locator and geoData element." />

```
</annotation>

</element>

<!-- geoDataLink Element -->

<element name="geoDataLink" type="gen:link" substitutionGroup="xl:extended">

    <annotation>

        <documentation value="GeoDataLink contains all geographic references." />

    </annotation>

    <complexType>

        <complexContent>

            <restriction base="xl:extendedType">

                <choice minOccurs="0" maxOccurs="unbounded">

                    <element ref="link:loc"/>

                    <element ref="geoxbrl:geoDataArc"/>

                    <element ref="geoxbrl:geoData"/>

                </choice>

                <anyAttribute
namespace="http://www.w3.org/XML/1998/namespace" processContents="lax"/>

            </restriction>

        </complexContent>

    </complexType>

</element>

</schema>
```