OLAP-based Sustainability Report Auditing

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***Abstract* — In the last decades, companies have adopted environmental control and protection systems and have also been encouraged to demonstrate their results through the use of indicators in which the efforts made are presented. The adoption of XBRL by the Global Reporting Initiative (GRI) in the disclosure of sustainability reports contributes to the increase of their quality. However, the great heterogeneity of enterprise information systems is an obstacle to the use of the GRI guidelines in the corporate setting and for efficient auditing. In this paper, a service framework to audit sustainability reports based on the GRI rules is proposed. We also present operators that are called GRI operators and are implemented in an OLAP server, which aims to conduct analytical processing of sustainability reports to validate their compliance with the GRI guidelines.**

Keywords: Sustainability Report Auditing; OLAP; Global Report Initiative; SOA; XBRL.

I. INTRODUCTION

For decades, sustainable development has been an important topic in companies, mainly for those that are market leaders. Each company establishes its own sustainability approaches, seeking to develop better practices in order to create competitive advantages. Therefore, the disclosure of non-financial data has gained great importance for company success and sustainability reports have become a divulgation tool for acquiring competitive advantages and increasing the organizational image. Many companies use a specific model for building sustainability reports; however, the proposed standard by Global Reporting Initiative (GRI) has relevant and acceptable representation worldwide. According to GRI, the elaboration of Sustainability Reports is a measuring and divulgation practice, which is a responsibility of each company, whose results must be sent to stakeholders so they may analyze its performance in environmental, social and economic terms.

Although the adoption of GRI guidelines has contributed to the standardization of sustainability data, companies have been facing challenges, such as (a) diversity of computer systems and (b) the difficulty to perform an audit that is able to monitor data continuously, given it may not be trivial to capture large data in different systems and formats. In this context, the adoption of a Service Oriented Architecture (SOA) is a solution to mitigate flexibility and integration problems in software applications. SOA should be considered to improve (i) company productivity, (ii) alignment with business, (iii) agility for attending new demands, and (iv) service reuse [9].

Continuous Auditing is a technology innovation of the traditional audit, which is based on automation and, though its concepts have been established for almost two decades, in practice it is still something new [4]. Currently, technologies allow continuous auditing; however, some challenges must still be overcome, such as data acquisition in real time, as well as the scope and flexibility of audits. To solve this problem, a service-based framework is proposed in this work, in which analytical processing can be executed on eXtensible Business Reporting Language (XBRL) documents, allowing continuous auditing based on GRI sustainability guidelines.

After the introduction, this paper is structured as follows: Section II introduces a review of related literature; in Section III, the proposed model based on SOA is discussed; Section IV presents an analysis of the compliance of sustainability reports with GRI guidelines; Section V discusses Link Based Multidimensional Query Language (LMDQL) [19]-[23] operators (based on GRI rules), which can perform analytical processing on XBRL/GRI data; Section VI includes the conclusions and future work and, finally, the references are presented.

II. LITERATURE REVIEW

A model for continuous auditing is proposed to help stakeholders in decision-making processes in companies [25]. The integrity of data in financial reports is currently questionable; however, continuous auditing is an effective way to ensure safety and to facilitate early detection of fraud in financial reporting [14].

A study about integration on information systems and auditing which revealed several future challenges for audits due to business information systems is shown in Kanellou and Spathis [13]. These authors also state that continuous audit and monitoring can help stakeholders in the detection of errors and financial fraud.

A model is proposed for auditing through software systems called Continuous Auditing Web Service (CAWS), which is based on Web Service and XML technologies [16]. This model has been developed in order to reduce complexity in the transmission of data and to aggregate security to software systems, and for that the following technologies have been used: XML, WS-BPEL (for the composition of new services) and Web Service (for avoiding incompatibility in data access and exchange).

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A collaborative model based on SOA for audit systems is proposed, which uses XML standards and data transformation applications (developed by companies and software vendors) [6].

The adoption of XBRL by GRI provides greater facility in the collection and analysis of sustainability data, besides significantly influencing the improvement of quality of data that composes the report is discussed in Leibs [24].

Recent advances in information technology have encouraged the search for means which are able to verify the integrity of transactional data, which brings many benefits to auditing particularly through continuous monitoring, in order to guarantee operations are made in an environment where information technology is intensively used [1].

Regarding the standardization of sustainability reporting, GRI has strong representation, to be considered an international standard widely accepted, which allows organizations to inform their sustainable practices in relation to environmental, social and economic dimensions. Many organizations use the GRI standard; however, studies show that although organizations declare themselves strategically sustainable, there are attempts to camouflage the indicators that are disclosed in sustainability reports, as well as the omission of relevant negative information, which puts at risk the interpretation of corporate performance and the impact of the company's programs. Therefore, this article seeks to fill a gap that previous studies have left, with regard to the lack of automated controls that allow the audit of reports issued by organizations. Then, it is also intended to verify if the reports are in compliance with the guidelines proposed by the GRI. To address this issue, a service framework is presented to audit sustainability reports with operators that evaluate the compliance of sustainability reports to the GRI guidelines, which can be seen in section V.

III. A SERVICE FRAMEWORK FOR SUSTAINABILITY REPORTS

The framework proposed in this paper is divided into two conceptual layers: (1) integration infrastructure, which is intended promote the access and retrieval of data within the informational structure of the company. In this layer we can find the corporative environment, extraction services and standardization services; and (2) Global Reporting Initiative, whose function is to integrate the architecture proposed by the GRI to the informational scenario of the organization. In this layer we can find persistence, auditing and distribution services. The services are materialized in the form of Web Services to meet the necessary integration in order to design the collection environment and the recovery of sustainability data. Thus, all adjacent layers of the model can consume this data. Figure 1 illustrates the framework proposed using SOA, XBRL, GRI and Continuous Auditing.

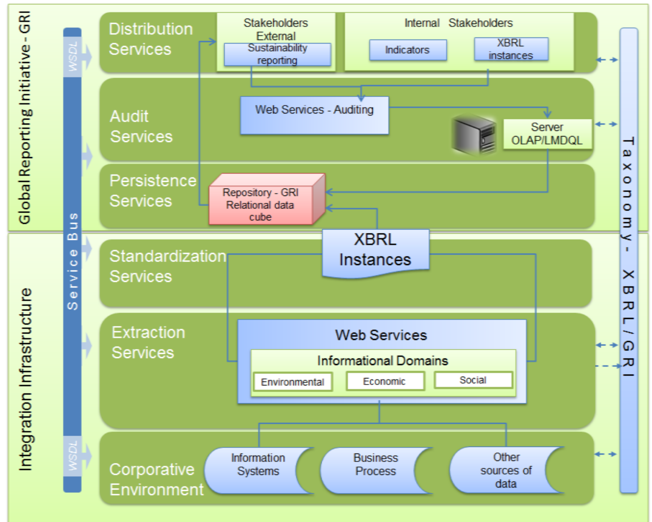

Figure 1. Service Framework for Sustainability Report. [5]

A physical and logical infrastructure is proposed to provide effective communication among the many layers of the model. The physical one is based on a service bus and the logical one is responsible for the representation of data using XBRL technology.

- *Service Bus XBRL:* Enterprise Service Bus (ESB) has the function of granting access to resources provided among the layers, which allows the exchange of messages. The implementation of service bus enables the connection of software systems developed on different platforms, integrating them as services. The communication interface of the services on the bus is made through their WSDL documents. In ESB, through the SOAP protocol, the consumption and provision of services of all layers of the framework are allowed.
- *XBRL-GRI Taxonomy*: The XBRL-GRI taxonomy standardizes the representation of data, as well as how to perform its exchange, which facilitates the connection of all layers in the proposed model. This allows all layers to have the necessary infrastructure to use the facts reported in XBRL instances [12].

From this physical and logical communication infrastructure, six layers are defined.

- *Corporate Environment*: The corporate environment layer is composed of information systems that store data related to the scope of sustainability. It is understood as the scope of sustainability the set of data required according to the GRI guidelines.
- *Extraction Services*: The extraction services layer gathers the necessary services for the integration of data. These services are responsible for collecting the data that is available in the corporate environment to be converted into XBRL format, according to the guidelines proposed by the GRI.
- *Standardization Services*: This layer is intended to standardize the form of the representation of data in the

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Extraction Services and *Corporate Environment* layers through the XBRL-GRI taxonomy. This layer is connected to extraction services layer through Enterprise Service Bus (ESB), where data is retrieved and organized, creating the XBRL instance with the data related to sustainability performance.

- *Persistence Services*: The function of this layer is to store the sustainability reports of the organization through a data repository. This will allow retrieving and analyzing data of specific reports. From the several XBRL instances stored, queries can be executed, providing the use of analysis techniques and knowledge discovery (e.g., OLAP, data mining, trend analysis) to support decision-making related to sustainability.
- *Audit Services*: the Audit Services layer consists of two components: Web Services Auditing and OLAP/LMDQL Server. In the former, are the services that are designed to audit the sustainability reports based on the GRI guidelines. The latter is a tool that will allow stakeholders to generate queries for the analysis of sustainability data [20].
- *Distribution Services*: In this layer, the sustainability data of the organization is made available. It is conceptually subdivided into two categories: (1) internal stakeholders, whose function is to carry out a continuous monitoring of sustainability indicators and (2) external stakeholders, who1ª avaliação11se focus is on the use of reports in order to know the sustainable practices of the organization. Thus, the distribution layer is of fundamental importance in the process of engagement and performance maintenance of the organization sustainability, benefiting all stakeholders, since it is an important feature to track the organization's sustainability initiatives.

It is expected that through this architecture it will be possible to provide the necessary means to mitigate problems of access and standardization of data on the sustainable performance of organizations. In the next section the analysis of sustainability reporting compliance is presented.

IV. Analysis of Sustainability Reports Compliance

This section presents three analytical levels of compliance of reports based on GRI guidelines, which are GAPIE (Degree of Full Compliance), GEE (Degree of Effective Disclosure) and GRIConformity (Degree of Compliance). Through these indices it is expected to evaluate the level of disclosure of sustainability data in organizational reports issued based on the GRI guidelines.

The GRI guidelines are developed through a process that involves a network of stakeholders, including company representatives, workers, financial markets, auditors and specialists in several areas. One of the main aspirations of GRI is that sustainability reporting reaches the same level of accuracy, comparability, credibility and verifiability expected of a financial report. To define the content of reports, GRI uses three main principles called Indicators, Aspects and Categories to describe two types of content: general and specific [2].

The "Core" option contains the essential elements of a sustainability report. It provides grants for the organization to report the impact of their economic, environmental, social and governance performance, requiring a report of at least one indicator related to each material aspect identified. The "comprehensive" option requires disclosure of additional information about the strategy, analysis, governance, ethics and integrity of the organization.

According to the GRI, indicators are qualitative or quantitative information associated with the organization. This provides information about the performance or economic, environmental and social impacts of the organization related to material aspects; Aspects relate to topics that each Category covers; and Categories represent each of the three macro-elements that comprise the GRI guidelines, which represent the dimensions of sustainability [12]. From these definitions, two are the types of GRI reports: General Standard Disclosure and Specific Standard Disclosure. Based on the GRI guidelines, the authors Dias [7] and Carvalho and Siqueira [3] propose two indices for the analysis of compliance of sustainability reports: the degree of effective disclosure (GEE) and the degree of full compliance (GAPIE). The degree of effective disclosure (GEE) is intended to measure the percentage of the amount of data reported by the organization in relation to all data according to the GRI guidelines [3]. The degree of full compliance allows establishing the percentage of compliance of each company in relation to what was required by GRI [3]. For the treatment of data, first the data that organizations report on sustainability reports are classified according to the information required by the essential indicators of GRI; then, the calculations of GAPIE and GEE are made. For this classification, the criteria defined by Dias [7] and Carvalho and Siqueira [3] are followed, as shown in Table I and II.

TABLE I. BASIS FOR INFORMATION CLASSIFICATION

CATEGORY: SHOWN		
CLASSIFICATION	***ABREVIATION***	***DEFINITION***
FULL COMPLIANCE	FC	When all the data required by the GRI-G4 guidelines is provided by the organization.
PARTIAL COMPLIANCE	PC	When only part of the data required by the GRI-G4 guidelines is provided by the organization.
DUBIOUS	D	When the data provided is not enough for the user to evaluate if the compliance is full or partial.
INCONSISTENT	I	When the data provided by the organization is different from that required by GRI-G4 guidelines.

TABLE II. BASIS FOR INFORMATION CLASSIFICATION

CATEGORY: NOT SHOWN		
NOT AVAILABLE	NA	When the organization recognizes that the data required is relevant to its activities, but it still does not have conditions to provide it.
NOT APPLICABLE	NAP	When the organization recognizes that the data required is not relevant to its activities or business field.
OMITTED WITH A REASON	OR	When the organization omits the data required by GRI-G4 guidelines, presenting a reason for such omission.
OMITTED	O	When nothing is commented about the indicator, as if it did not exist.

To calculate GAPIE, the total number of Full Compliance indicators ("FC"), i.e., the total indicators that had their content reported according to what is required by the GRI guidelines, is added to the total number of indicators omitted with a reason ("OR"), i.e., the indicators that the organization omitted from its report, but presented a reason for the omission, and divided by the total number of Core indicators (which are essential indicators for sustainability reporting) subtracted by the total number of indicators that are Not Applicable, "NAP", i.e. indicators that do not apply to the organization. Figure 2 shows the formula for the calculation of this index.

$$GAPIE = \frac{\text{TOTAL INDICATORS "FC"} + \text{TOTAL INDICATORS "OR"}}{\text{TOTAL INDICATORS ESSENTIAL} - \text{TOTAL INDICATORS "NAP"}}$$

Figure 2. GAPIE Formula.

To calculate GEE, the total number of Full Compliance indicators ("FC") is divided by the total number of Core indicators subtracted by the total number of Not Applicable indicators "NAP", as shown in Figure 3.

$$GEE = \frac{\text{TOTAL INDICATORS "FC"}}{\text{TOTAL INDICATORS ESSENTIAL} - \text{TOTAL INDICATORS "NAP"}}$$

Figure 3. GEE Formula.

Another way of assessing compliance is through the use of the GRIConformity index. This index is intended to compare the data reported by organizations to the data required by the GRI guidelines. Through the use of this index, the analyst/auditor can analyze and assess whether organizations disclose sustainability data in accordance with the guidelines.

The next section presents the analytical processing operators based on these three indices, which will allow the auditing of sustainability reports based on the guidelines proposed by the GRI and the studies proposed by Dias [7] and Carvalho and Siqueira [3].

V. OPERATORS FOR THE ASSESSMENT OF COMPLIANCE

The use of tools for the analytical processing of data (OLAP) to perform strategic analyses of an organization allows assisting stakeholders in identifying trends and patterns in order to better conduct their business.

A language called LMDQL was proposed and aims to conduct analytical processing of multidimensional data expressed in XML documents connected by links [20].

LMDQL is a language derived from Multidimensional Expression (MDX) [15][26] and executes OLAP queries on relational databases and XML-based documents. OLAP queries executed in the Mondrian server generate SQL queries, which are translated into XQuery with the Sql2Xquery driver [20]. The Sql2Xquery driver enables the suitability of relational OLAP servers to XML environments. LMDQL is designed to run on a data cube, i.e. a multidimensional structure of data representation [20] - constructed from a relational database or an XML database, defined by XBRL Dimensions documents [27].

Therefore, the Audit Services layer was designed to perform analytical processing (OLAP) on sustainability reports [20]. This paper proposes the use of Mondrian server to execute OLAP queries through an extension of LMDQL language, in order to manipulate sustainability data issued in GRI/XBRL reports. To make this possible, a Web Service to access the Mondrian server is proposed [18].

LMDQL has financial analytical operators, which allow (a) the acquisition of data in linkbases, which is a characteristic of XBRL taxonomies; (b) to execute analytical queries in a set of XML documents; (c) to execute queries based on the value or structure of the XML document; (d) to create operators based on other operators created at run time, (e) to perform horizontal, vertical and separatrix analyses and also analyses based on the proximity of data values [19] [20] and (f) fraud analysis (i.e. forensic analysis) in financial reports based on Benford's Law, 3-Sigma Rule, Z Test and Chi-Square [22] [23].

For the analytical processing of a sustainability document, considering the GRI guidelines and GAPIE, GEE and GRIConformity indices, three operators were specified: GRIConformity, GRIGapie and GRIGee. The LMDQL operators for sustainability auditing are presented In Figure 4. The three operators (i.e. GRIConformity, GRIGapie and GRIGee) have a MemberSet type as a parameter, which refers to a member set of a data cube, according to the specifications of LMDQL operators.

GRIConformity (*<MemberSet>*)
GRIGapie(*<MemberSet>*)
GRIGee(*<MemberSet>*)

Figure 4. LMDQL Operators for Sustainability Auditing.

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To execute an LMDQL query based on these operators, a parameter is provided referring to the sustainability element (or a set of elements) contained in the sustainability report to be assessed, that we call Element. To analyze the chosen operator, a specific element can be used according to the needs of the analyst/auditor, such as [Element].[Aspect BoundaryLimitationOutsideOrganizationDescription]). If the auditor/analyst wishes to make the analysis of a set of elements, the keyword "children" must be used (which is native to the Mondrian server [18]), referencing all children members of the "Element" dimension (contained in the database), i.e. "[Element].children". In the tests carried out in this paper, the following dimensions were specified: (i) Entity, which refers to the name of the companies that issue sustainability reports; (ii) Document, which corresponds to sustainability documents that the company issues; (iii) Element, which refers to the elements that correspond to the sustainability indicators contained in these documents and (iv) Time, the time period to which the document belongs. An example of an LMDQL query is shown in Figure 5.

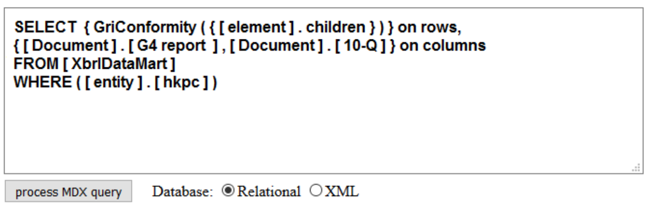
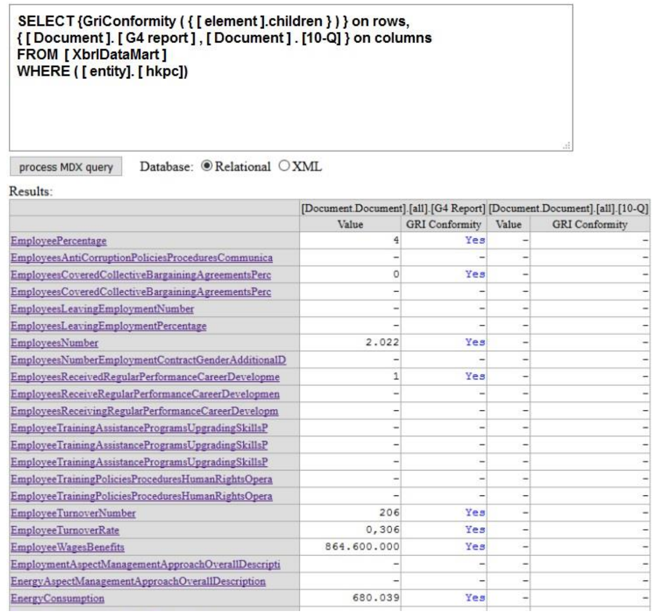


Figure 5. OLAP query using an LMDQL operator for sustainability auditing

In this query, the auditor informs which document he aims to analyze, which is specified in the Document dimension. Two types of documents have been defined, i.e. G4 Report and 10-Q, which refer to a sustainability and financial report, respectively. It is also necessary to specify the company that issued the financial report (e.g. [Entity].[hkpc], which is the company Hong Kong Productivity Council). The options "relational" and "XML" are attributes of the extension of the Mondrian server, which implements LMDQL, with which the analyst chooses on which database paradigm he wishes to execute the query [20] [22] [23].

To illustrate the use of operators in relational and XML environments, two databases are used to store sustainability reports: MySql [17], a relational database, and Exist [8], a native XML database; both were chosen for being open source and free. The logical model schema stored in the database must be informed in a mandatory XML configuration file of the Mondrian server [18].

In this example, in Figure 5, the GRIConformity operator executes a query to assess the compliance of the sustainability elements contained in XBRL/GRI documents with the elements specified by GRI as important indices for enterprise sustainability issues [10]-[12]. After executing the query, the operator classifies the elements as "yes" if they are in compliance, and "no" if they are not, as shown in Figures 6 and 7, which respectively show the result of the compliance of the documents contained in the database which belongs to the company Hong Kong Productivity Council, and the non-compliance of the documents of Facebook company. Fields containing the character "-" indicate that there are no results for the query executed by the GRIConformity operator.



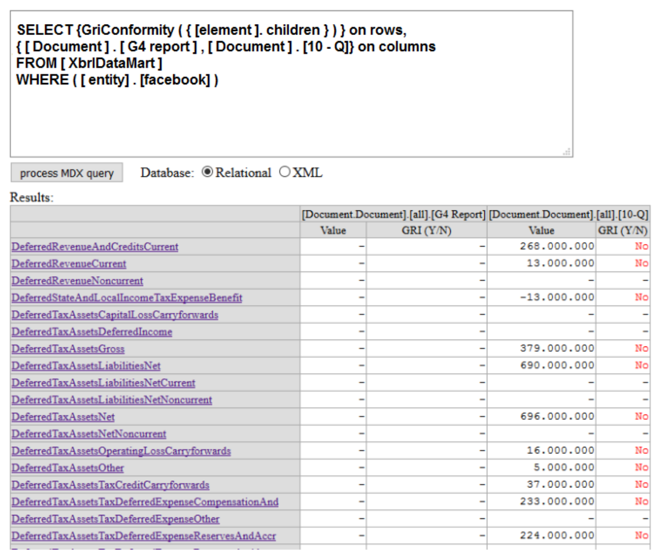
```
SELECT {GriConformity ( { [ element ].children } ) } on rows,
{ [ Document ]. [ G4 report ] , [ Document ] . [10-Q] } on columns
FROM [ XbrlDataMart ]
WHERE ( [ entity]. [ hkpc])
```

process MDX query Database: Relational XML

Results:

	[Document.Document].[all].[G4 Report]		[Document.Document].[all].[10-Q]	
	Value	GRI Conformity	Value	GRI Conformity
EmployeePercentage	4	Yes	-	-
EmployeesAntiCorruptionPoliciesProceduresCommunica	-	-	-	-
EmployeesCoveredCollectiveBargainingAgreementsPerc	0	Yes	-	-
EmployeesCoveredCollectiveBargainingAgreementsPerc	-	-	-	-
EmployeesLeavingEmploymentNumber	-	-	-	-
EmployeesLeavingEmploymentPercentage	-	-	-	-
EmployeesNumber	2.022	Yes	-	-
EmployeesNumberEmploymentContractGenderAdditionalD	-	-	-	-
EmployeesReceivedRegularPerformanceCareerDevelopme	1	Yes	-	-
EmployeesReceiveRegularPerformanceCareerDevelopmen	-	-	-	-
EmployeesReceivingRegularPerformanceCareerDevelopm	-	-	-	-
EmployeeTrainingAssistanceProgramsUpgradingSkillsP	-	-	-	-
EmployeeTrainingAssistanceProgramsUpgradingSkillsP	-	-	-	-
EmployeeTrainingAssistanceProgramsUpgradingSkillsP	-	-	-	-
EmployeeTrainingPoliciesProceduresHumanRightsOpera	-	-	-	-
EmployeeTrainingPoliciesProceduresHumanRightsOpera	-	-	-	-
EmployeeTurnoverNumber	206	Yes	-	-
EmployeeTurnoverRate	0,306	Yes	-	-
EmployeeWagesBenefits	864.600.000	Yes	-	-
EmploymentAspectManagementApproachOverallDescripti	-	-	-	-
EnergyAspectManagementApproachOverallDescription	-	-	-	-
EnergyConsumption	680.039	Yes	-	-

Figure 6. Example of compliance of an LMDQL query with the GRIConformity operator



```
SELECT {GriConformity ( { [element ]. children } ) } on rows,
{ [ Document ] . [ G4 report ] , [ Document ] . [10 - Q]} on columns
FROM [ XbrlDataMart ]
WHERE ( [ entity] . [facebook] )
```

process MDX query Database: Relational XML

Results:

	[Document.Document].[all].[G4 Report]		[Document.Document].[all].[10-Q]	
	Value	GRI (Y/N)	Value	GRI (Y/N)
DeferredRevenueAndCreditsCurrent	-	-	268.000.000	No
DeferredRevenueCurrent	-	-	13.000.000	No
DeferredRevenueNoncurrent	-	-	-	-
DeferredStateAndLocalIncomeTaxExpenseBenefit	-	-	-13.000.000	No
DeferredTaxAssetsCapitalLossCarryforwards	-	-	-	-
DeferredTaxAssetsDeferredIncome	-	-	-	-
DeferredTaxAssetsGross	-	-	379.000.000	No
DeferredTaxAssetsLiabilitiesNet	-	-	690.000.000	No
DeferredTaxAssetsLiabilitiesNetCurrent	-	-	-	-
DeferredTaxAssetsLiabilitiesNetNoncurrent	-	-	-	-
DeferredTaxAssetsNet	-	-	696.000.000	No
DeferredTaxAssetsNetNoncurrent	-	-	-	-
DeferredTaxAssetsOperatingLossCarryforwards	-	-	16.000.000	No
DeferredTaxAssetsOther	-	-	5.000.000	No
DeferredTaxAssetsTaxCreditCarryforwards	-	-	37.000.000	No
DeferredTaxAssetsTaxDeferredExpenseCompensationAnd	-	-	233.000.000	No
DeferredTaxAssetsTaxDeferredExpenseOther	-	-	-	-
DeferredTaxAssetsTaxDeferredExpenseReservesAndAccr	-	-	224.000.000	No

Figure 7. Example of noncompliance of an LMDQL query with the GRIConformity operator.

From the presented operators, it is possible to perform analytical processing of sustainability reports based on the XBRL-GRI taxonomy. They are therefore expected to assist in the continuous audit process of those reports, which will provide stakeholders with greater integrity of the organization's sustainability information.

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VI. CONCLUSIONS AND FUTURE WORK

In this work, we presented a service framework to audit sustainability reports based on the GRI rules. This framework can contribute to the development of a model that is able to simplify the collection, analysis, comparison and disclosure of data related to the sustainability performance of organizations. For the analysis of reports an OLAP tool was presented, an extension of the Mondrian server [18] and LMDQL language [20], which allows the audit of XBRL reports based on the GRI guidelines, assessing their compliance, that is, if they meet the guidelines proposed. Continuous monitoring of sustainability reports of organizations can be performed with this tool. It is expected that through this work and the use of technology involving SOA and XBRL, the framework can bring greater reliability and security to stakeholders in decision-making, with regard to the fundamental dimensions of corporate sustainability that are: social, environmental and economic. This framework is a scale model that grows as the organization establishes excellence in sustainability, internationalization and standardization of data. For future work, we intend to raise the level of detail of the framework presented, in addition to implementing the GRIGapie and GRIGee operators.

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