An Ontological Model for Corporate Social Responsibility (CSR) Reporting Based on Global Reporting Initiative GRI G4

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Abstract

The aim of this research is to develop a Model for CSR Reporting based on the Global Reporting initiative, GRI Sustainability Reporting Guidelines G4, using an ontological approach. This Model can be used as a shared vocabulary and knowledge base. This research adopts a combination of methodologies to develop the CSR reporting ontology. This includes four phases: specification, conceptualization, formalization, and implementation. The specification phase defines the purpose and the scope. Conceptualization identifies the Conceptual Model. Formalization transforms the Conceptual Model using a Unified Modeling Language (UML) by following a top-down hierarchy approach. Implementation encodes the formalized Model using OWL. The resulting ontological Model for CSR Reporting users is based on GRI G4 and can be automatically processed.

Keywords

CSR Reporting, GRI Sustainability Reporting Guidelines G4, Ontology, Conceptual Model, Stakeholders.

INTRODUCTION

In today's business world, the responsibility of organizations has greatly extended beyond the profitability and returns to shareholders to include social and environmental impacts (Deegan 2012). These three dimensions of responsibilities are known as Corporate Social Responsibility (CSR). CSR largely comprises theories, approaches and terminologies that describe the phenomena related to corporate responsibility in society (Garriga and Melé 2004). CSR has become important to businesses since 1980s as people became more aware of the impacts of organisations' business activities on society and the environment.

Regarding environmental and social reporting, several major issues need to be addressed; these include: a lack of consistent measures to capture CSR activities; absence of regulatory requirements; disclosure is voluntary; different report forms; and environmental and social costs and benefits have been ignored (Deegan 2012; Jones and Jonas 2011). To resolve these issues, several national and international bodies promote and provide guidance on sustainability reporting. The GRI guidelines are generally accepted as "best practice" reporting and are widely used by organizations around the world as the basis for their environmental and social reporting (Deegan 2012).

Gray and J.Bebbington (Gray and J.Bebbington 2002) commented that the traditional accounting information system does not provide adequate support for managing social and environmental concerns. Thus, a new information system for reporting CSR is required to ensure high quality of information. Church and Smith (2007) argued that an ontology methodology plays an important role in an information system design. It provides a formal specification for the concepts within a domain and the relationship between those concepts (Gruber 1993). The use of ontology in the accounting domain is relatively recent as in other diverse domains, and therefore the number of ontologies in existence is tiny (Stevens et al. 2000). A literature review reveals that there is no ontology for CSR reporting based on GRI G4 Sustainability Reporting Guidelines.

The aim of this research is to develop a model for knowledge domain CSR reporting using an ontological approach based on GRI G4. As it can be seen In Figure 1, in a real-world use scenario of CSR reporting, the small, medium or large enterprises engage in this reporting process by following Sustainability Reporting Guidelines. There is a lack of a common accounting understanding of the regulation about social and environmental performance disclosure. In addition, in current accounting practices, there is no generally accepted accounting standard and reporting framework for reporting CSR. Ontology can be used to resolve this issue for the following reasons: firstly, ontology can be used as a shared vocabulary to disambiguate terminology for sustainability reporting among multiple organizations; secondly, ontology can be used as a knowledge base to enable computer software to automatically generate sustainability reports.

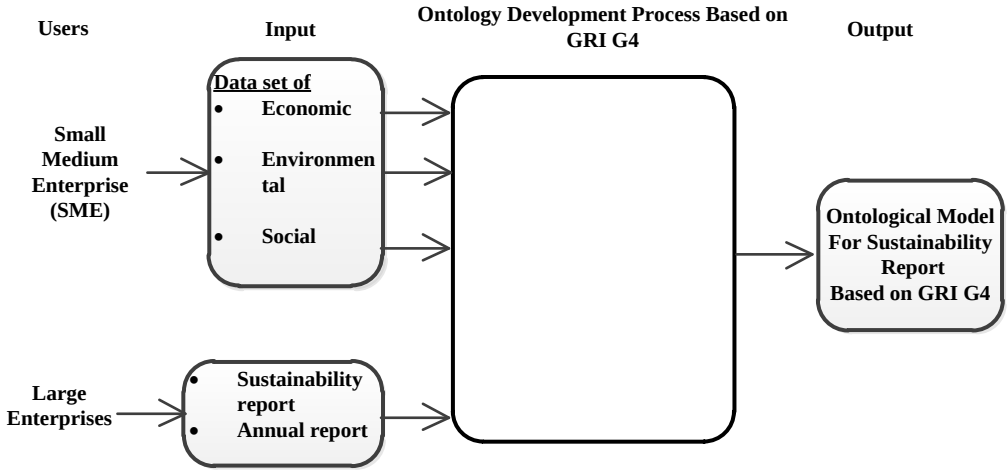

Figure 1: A methodology to develop ontology for CSR Reporting based on GRI G4

The research question is: What are the most appropriate techniques and methodology for the development of an Ontological Model for knowledge domain CSR Reporting?

The paper is structured as follows: after an introduction, the background, definition and components of GRI G4 and ontology are presented. The existing methodologies for building ontology from scratch are presented in the subsequent section and followed by the approach of this research which is ontology development process for CSR Reporting which comprises four phases: specification, conceptualization, formalization, and implementation of GRI G4. The conclusion summarises the paper and describes the intended future work.

BACKGROUND

GRI G4

A comprehensive Sustainability Reporting Framework that is the most widely used around the world has been established and improved by GRI. A sustainability report is a report issued by organizations (private, public, or non-profit) that reports the economic, environmental, and social impacts and performance of their activities, products and services. Such reporting takes a Triple Bottom Line (TBL) approach. GRI considers an organization's impacts and performance not only on its local economy but also on sustainable global economy. Organizations, regardless of their type, size, sector or location, voluntarily use GRI's Framework to measure and report on their performance based on specific principles and indicators. There are two types of principles: principles defining report content and principles for defining report quality. This framework is a reporting system which includes the Reporting Guidelines, "the core document" or the "cornerstone" of this framework providing guidance on how organizations can disclose their sustainability performance and increase their accountability (Moneva et al. 2006); Sector Guidance; and other resources. G4 is the newest version of GRI's Sustainability Reporting Guidelines released in May 2013 after several versions of Guidelines: the first version in 2000; the second generation known G2 in 2002; the third generation G3 in 2006; in 2011, GRI updated and completed and published the G3.1. GRI's Reporting Framework is developed through a consensus-seeking, multi-stakeholder process. There are various forms of Sustainability Reporting which are web-based or print, stand alone or combined with annual or financial reports[1].

G4 Guidelines describe the preparation of a sustainability report as an "iterative process" and the core of this process is "identifying material Aspects". Material Aspects are those that reflect the significance to the organization's economic, environmental and social impacts, and the influence on stakeholder assessments and decisions. There Guidelines offer two options to organizations when preparing the sustainability report: "Core" and "Comprehensive" options. In addition, there is a third option whereby organizations use the standards but do not report "in accordance" with these Guidelines. The GRI describes the sustainability reporting as a process. The inputs of this process are principles and guidance and the outputs are Standard Disclosures. There are two different types of Standard Disclosure: General Standard Disclosure and Specific Standard Disclosure. The General Standard Disclosure is divided into: Strategy and Analysis, Organizational Profile, Identified Material Aspect and Boundary, Stakeholder Engagement, Report Profile, Governance, and Ethic and Integrity. Specific Standard Disclosure includes Disclosure On Management Approach (DMA) and Indicators. Specific Standard

[1] https://www.globalreporting.org/information/about-gri/what-is-GRI/Pages/default.aspx

Disclosures are organized into three Categories: Economic, Environmental, and Social. In addition, the sub-categories of Social Category are divided into Labour Practices and Decent Work, Human Rights, Society and Product Responsibility. Furthermore, each Category consists of "Aspects". Organizations' sustainability reports disclose Aspects after identifying sustainability impacts that are material. Then, information for each identified material Aspect can be reported as DMA and as Indicators. DMA are divided into two types: "Generic and Aspect-specific". Generic DMA is used with any material Aspect. It refers to for the application of any material Aspect. Aspect-specific DMA is intended to give additional details to report on a specific Aspect. G4 developed only 23 Aspect-specific DMA of the 46 Aspects in the Guidelines. Indicators present "qualitative or quantitative information on the economic, environmental and social performance or impacts of an organization in regard to its material Aspect for a certain reporting period". G4 comprises ninety-one indicators. Sector disclosures are required if they are available (Initiative 2013a; Initiative 2013b).

Ontology

There are many existing definitions of ontology, arguments about what the definition of ontology is or ought to be (Uschold and Tate 1998), and debates regarding the best definition (Borst 1997) . The definition introduced by Studer (1998) that ontology is "a formal, explicit specification of a shared conceptualisation" is one of the most comprehensive definitions from those available in the literature (Corcho et al. 2007). This research is based on this definition.

- Components of ontology: Researchers in the ontology field agree that concepts, relations, properties, instances, and axioms are the main components or basic and typical elements of ontology. Because of different ontology languages, the exact specification of these elements may vary according to the underlying knowledge model (Gomez-Perez and Corcho 2002; Weller 2010). The following subsection will introduce the main components of ontology. Concepts are also known as classes of objects. Classes have been defined as "abstract or concrete, elementary or composite, real or fictitious; in short, a concept can be anything about which something is said, and, therefore, could also be the description of a task, function, action, strategy, reasoning process, and so on" (Gomez-Perez and Corcho 2002). For example, classes in Sustainability Reporting Guidelines G4 are 'Standard Disclosure' class, 'General Standard Disclosure' class, 'Specific Standard Disclosure' class, 'Strategy And Analysis' class, ' Indicator' class, etc. (Initiative 2013a). Taxonomies are tree structures of concepts, where concepts are divided into super and sub classes.
- Relations represent "a type of association between concepts of the domain" (Corcho et al. 2007). Binary relation refers to the relation that links two concepts, and inverse relation refers to a subtype of binary relation that links two concepts in the opposite direction. There are three types of relationships: association relationship, inheritance relationship, and composition relationship as presented in Figure 4.
- Properties are relationships that describe various features and attributes of concepts (Noy and McGuinness 2001). Object properties and datatype properties are the two main types of properties. Object properties are relationships between two individuals and they use "vocabulary" and "semantics" to describe this relationship. For example, object properties that are used in this research are: 'generates', 'hasTypeOf' 'isDividedInTo' and 'includes' as can be found in Figure 5. Corcho et al. used 'attributes' to describe 'properties'. They distinguished between 'instance attributes' and 'class attributes'. Instance attributes describe concept instances in terms of values. Class attributes describe concepts without using values. Class attributes are neither inherited by the subclasses nor by the instances (Corcho et al. 2005).
- Instances represent "real-world individuals" or are used to represent elements or individuals in ontologies (Corcho et al. 2005). Horridge defined individuals, also known as instances as "objects in the interested domain". Individuals can be defined as being "instances of classes" (Horridge 2011) . For example, an instance of the class 'revenue' is 100,000 AUD$.
- Axioms refers to "constraints used on values for classes or instances"; the properties of relations are types of axioms and they include more general rules (Noy and McGuinness 2001; Stevens et al. 2000).

EXISTING METHODOLOGIES FOR BUILDING ONTOLOGY FROM SCRATCH

Many methodologies and methods have been proposed in the literature for the development of ontology from scratch. These methodologies and methods are related to the ontology lifecycle which includes different activities for the design and evaluation of ontologies. Until the mid-1990s, this process was an art rather an engineering activity. Then, ontology development became a branch of engineering due to the development of principles, methods, methodologies and technologies related to ontology processes and the ontology lifecycles (Corcho et al. 2007) . The role of ontologies in the knowledge engineering process is to facilitate the construction of a domain

model (Weller 2010). It provides a vocabulary of terms and relations with which to model the domain (Studer et al. 1998).

Casellas defined an ontology development methodology as "an organized set of procedures and guidelines for aiding and guiding the development of ontology during its lifecycle or some parts of it" (Casellas 2011). Fernandez-Lopez et al. state that certain activities should be performed in the ontology development process, although no details are provided concerning the ordering or complexity of these activities (Fernández-López et al. 1997; Gomez-Perez 1998).

It is not easy to build ontology as an engineering artefact. It requires methods, tools and guidelines to perform their activities (de Almeida Falbo 2004; Gruninger and Lee 2002). Uschold and Gruninger (Silva et al. 2012) stated that "there are no standardised methodologies for building ontologies". Uschold and Gruninger (1996) proposed a solution to address the perceived lack of a standard ontology construction by suggesting a methodological approach based on theoretical and methodological principles that scientifically support the ontology-building process.

ONTOLOGY DEVELOPMENT PROCESS FOR CSR REPORTING

This research uses a combination of the methodologies from (Uschold 1996), (Fernández-López et al. 1997; Lopez et al. 1999), and (Noy and McGuinness 2001). For the METHONTOLOGY methodology, three activities are described in detail which are specification, conceptualization, and implementation, whereas the formalization is described based on activities. For the Noy and McGuinness methodology, the only activities that are described in detail are conceptualization and implementation. Uschold described in detail the specification and implementation activities. In addition, he stated general and specific guidelines. The general guidelines pertain to clarity, consistency, coherence, extensibility, and reusability, while the specific guidelines are go middle-out and handling ambiguity (Uschold and Gruninger 1996).

This research will adopt the methodology used for developing the CSR reporting ontology. The process includes four phases: specification, conceptualization, formalization, and implementation as shown in Figure 2.

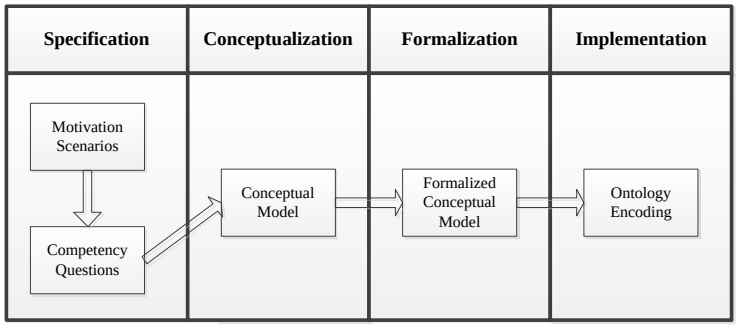

Figure 2: Tasks in each phase for the methodology adopted for developing the CSR Reporting ontology.

Each phase includes one or more tasks as shown in Figure 2. The motivation scenarios and competency questions need to be described. In the conceptualization phase, the conceptual model needs to be defined. In the formalization phase, the conceptual model is formalized. In the implementation phase, the ontology will be built by encoding (Fernández-López et al. 1997; Grüninger and Fox 1995a; Lopez et al. 1999; Noy and McGuinness 2001; Staab et al. 2001; Uschold 1996).

Specification Phase

The first phase of ontology development is specification in terms of description ontology (usually in natural language). The aim of this phase is to "capture knowledge of a given domain and to develop a requirement specification document" (Gómez-Pérez et al. 1996). Gruninger and Fox charactered an ontology with the use of competency questions (Grüninger and Fox 1995b) . Uschold and King proposed to identify the purpose of the ontology by determining "why the ontology is being built", "what its intended uses are" ; it is also necessary "to identify and characterise the range of intended users of the ontology" and "to identify motivating scenarios and competency questions" (Uschold 1996; Uschold and King 1995). Noy and McGuinness suggested that an ontology should be developed by defining its domain and scope; the use of competency questions is one of the ways to determine the scope of the ontology (Noy and McGuinness 2001). In a real-world use scenario of CSR Reporting, the small, medium or large enterprises engage in this reporting process by following Sustainability Reporting Guidelines. Because there is no standard model for the generation of the report, ontology is used to solve this problem by generating an Ontological Model for Sustainability Reporting. This enables organizations

to share, communicate and reuse this Model for Sustainability Reporting. Then, the second step in this phase is to develop the "Competency Questions" which are "a set of natural language questions used to determine the scope of the ontology. These questions and their answers are both used to extract the main concepts and their properties, relations, and formal axioms of the ontology" (Gomez-Perez et al. 2004). Therefore, the specification phase for the CSR Reporting ontology is defined as follows:

- Domain: CSR Reporting based on GRI Sustainability Reporting Guidelines G4.
- Purpose: To develop a CSR Reporting ontology-based knowledge base for software to automatically create GRI reports for the following reasons (Chandrasekaran et al. 1998; Duineveld et al. 2000; Gruninger and Lee 2002; Noy and McGuinness 2001; Stevens et al. 2000; Uschold and Gruninger 1996):

– To enable knowledge sharing among people, organizations, and software systems

– To enable the reuse of knowledge. The proposed ontology can be reused by organizations; the ontology can also be updated to adapt to new generations of GRI.

- End users: Organization that is engaged in sustainability reporting. In addition, this includes relevant stakeholder groups such as community groups, customers, employees, other workers and their trade unions, local communities, shareholders and providers of capital, and suppliers (Initiative 2000-2011 GRI Version 3.1).
- Level of formality of the implemented ontology: Semi-formal. This refers to the formality that will be used to codify the terms and their meaning in a language between natural language and a rigorous formal language (Fernández-López et al. 1997). Uschold and Gruninger (1996) classify the level of formality as: highly informal, semi-informal, semi-formal or rigorously formal ontologies.
- Scope: All components of CSR Reporting defined in GRI Sustainability Reporting Guidelines G4.
- Sources of knowledge: The following reports:

– GRI Sustainability Reporting Guidelines G4: Reporting Principles and Standard Disclosures (Initiative 2013a).

– GRI Sustainability Reporting Guidelines G4: Implementation Manual (Initiative 2013b).

Table 1 shows a sample of competency questions for organizations involved in Sustainability Reporting G4.

Table 1. Sample Competency Questions for Organizations Involved in Sustainability Reporting G4

CQ	Competency questions	Concepts/Classes	Relations
CQ-1	What is an output class name of GRI G4 reporting process?	Standard Disclosure	generates
CQ-2	What are types of Standard Disclosure?	General Standard Disclosure, Specific Standard Disclosure	hasTypeOf
CQ-3	What are the divisions of General Standard Disclosure class?	Strategy And Analysis, Organizational Profile, Identified Material Aspect And Boundary, Stakeholder Engagement, Report Profile, Governance, Ethic And Integrity,	isDividedInTo
CQ-4	What does Specific Standard Disclosure include?	Disclosure On Management Approach, Indicator	Includes
CQ-5	……..		

Conceptualization phase

The second phase of ontology development is conceptualization. The aim of this activity is to structure the domain knowledge in a conceptual model in terms of the domain vocabulary identified in the ontology specification activity (Fernández-López et al. 1997). Weber (2003) defines conceptual modelling as an "activity undertaken during information systems development to build a representation of selected semantics about some real- world domain". The requirements of the conceptualization phase are:

- Identification of the terminologies in the GRI G4 Guidelines; and

- Defining the classes, relations, functions, instances, and formal axioms identified in GRI G4 Guidelines.

To identify and define all the elements of Sustainability Reporting ontology, Table 2 depicts the definitions for high level classes. Note: It should be noted that each class listed below consists of classes and consequently there is sub-ontology for each one.

Table 2. Definitions for Some Classes of Sustainability Reporting for GRI G4

Name	Ontology Entity	Definitions	Reference
General Standard Disclosure	Concept	"Central element of both 'in accordance' options and should be disclosed for both Core option and Comprehensive option".	(Initiative 2013a)
Strategy and Analysis	Concept	A plan that studies, not summarizes, the considered organization's sustainability report topics.	(Initiative 2013a)
Organization Profile	Concept	A short description of the organization's identity that gives useful information about it.	(Initiative 2013a)
Identified Material Aspect and Boundary	Concept	It refers to the process of defining Report Content, identifying material Aspects, reporting Aspect Boundary within and outside the organization, and reporting for any restatements of information provided in previous reports.	(Initiative 2013a)
Stakeholder Engagement	Concept	"An individual or group having a legitimate claim on the firm-someone who can affect or is affected by the firm's activities".	(Tilt 2007)
Report Profile	Concept	It focuses on three main points: information about report in regard to reporting period, date of most recent previous report, reporting cycle, and contact for any questions for the report or its contents; GRI Content Index; and the organization's policy and current practice of seeking external assurance for the report.	(Initiative 2013a)
Governance	Concept	It relates in a general sense to "the exercise of control and authority" thus, corporate governance is about the "process and content of decision making in business organizations".	(McAlister 2003)
Ethics and Integrity	Concept	It refers to moral behaviour and the quality of being honest and having strong moral principles, standards, and values that govern an organization's behaviour or the conduct of its activities.	(Initiative 2013a)
Specific Standard Disclosure	Concept	It is organized into three categories: economic, environmental and social. It includes two classes: 'Disclosure On Management Approach' (DMA) class and 'Indicator' class.	(Initiative 2013a)
Disclosure on Management Approach	Concept	It explains the way in which the organization managed the material Aspects of economic, environmental and social impacts. In addition, it must report specific management practices in terms of: policies, commitments, goals and targets, responsibilities, resources, and specific actions.	(Initiative 2013a)

Formalization Phase

The formalization phase is the core of an ontology development process. It refers to the transformation of a conceptual model into a formalized model or semi-computable model (Corcho et al. 2007; Corcho et al. 2005; Weller 2010). Thus, for the development of the CSR Reporting ontology, the formalization requires a notation system to formalize the CSR Reporting ontology conceptual model. An object-oriented modelling language can be used for ontology modelling. Unified Modeling Language (UML), "represents a unification of the concepts and notations presented by the three amigos" (Booch 1994) . The UML as a static modelling notation, can be used to model the "formal semantics" of ontologies, as suggested by (Cranefield and Purvis 1999). The UML class diagram can be used to represent the classes in the domain within a model (Martin 1997; Schmuller 2002). In the UML class diagram, a rectangle represents a class. This rectangle contains three parts: the name of class,

the attributes of the class (name, type, and visibility of attributes), and the operations of the class, as shown in Figure (3) (a). Taking into account the characteristics of ontology, only classes and attributes of classes are required for modelling the CSR ontology. The class diagram for the development of ontologies is shown in Figure (3) (b). In this research, three types of relationships are identified between classes, which are graphically represented in Figure (4). A high-level overview of the Sustainability Reporting GRI G4 ontology is shown in Figure (5).

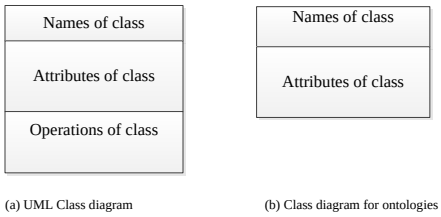

Figure 3: UML class diagram for ontology modelling

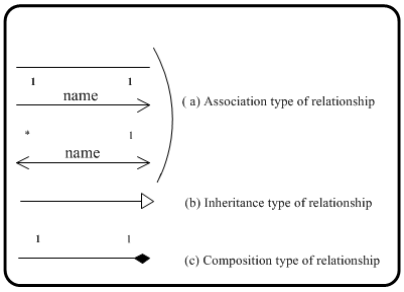

Figure 4: Three types of relationship in UML

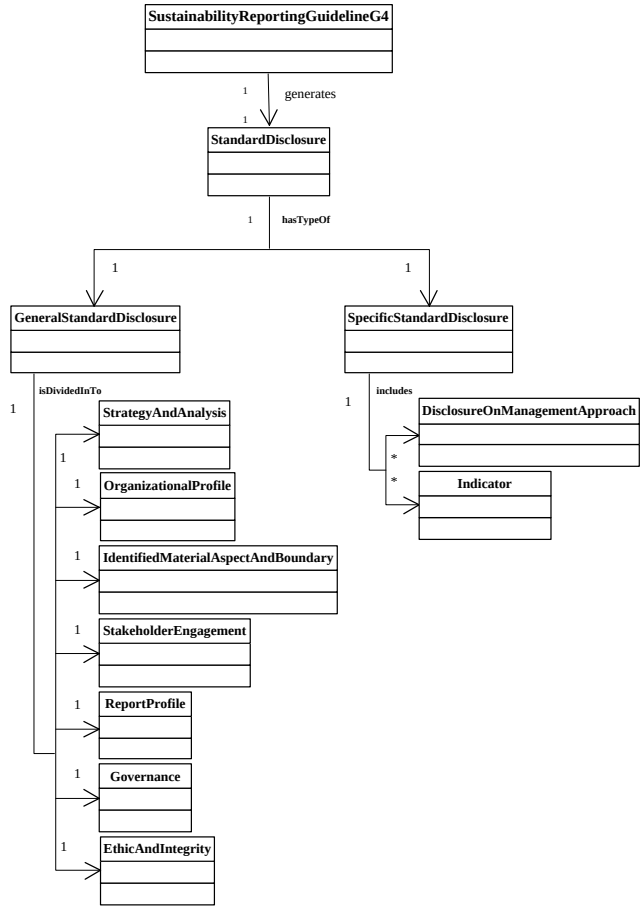

Figure 5: Ontology formalization for the 'Sustainability Reporting Guidelines GRI G4' class

Implementation phase

This phase builds computable models in a formal language or representation of conceptual models by using an ontology language (Stevens et al. 2000). The requirements of the implementation phase are:

- A formal language that can be used to encode the ontology; and
- A tool that supports the ontology development activities.

In this research, Web Ontology Language OWL will be used since it is a standard and broadly acceptable ontology language which provides classes, properties, individuals, and data values. Protégé_5.0_beta

(protégé.standford.edu) will be used as a tool to represent ontology in a machine-readable format. Ontologies are stored as Semantic Web documents (W3C OWL Working Group, 2012). Figure 6 shows a screenshot in Protégé_5.0_beta of the ontology for GRI G4.

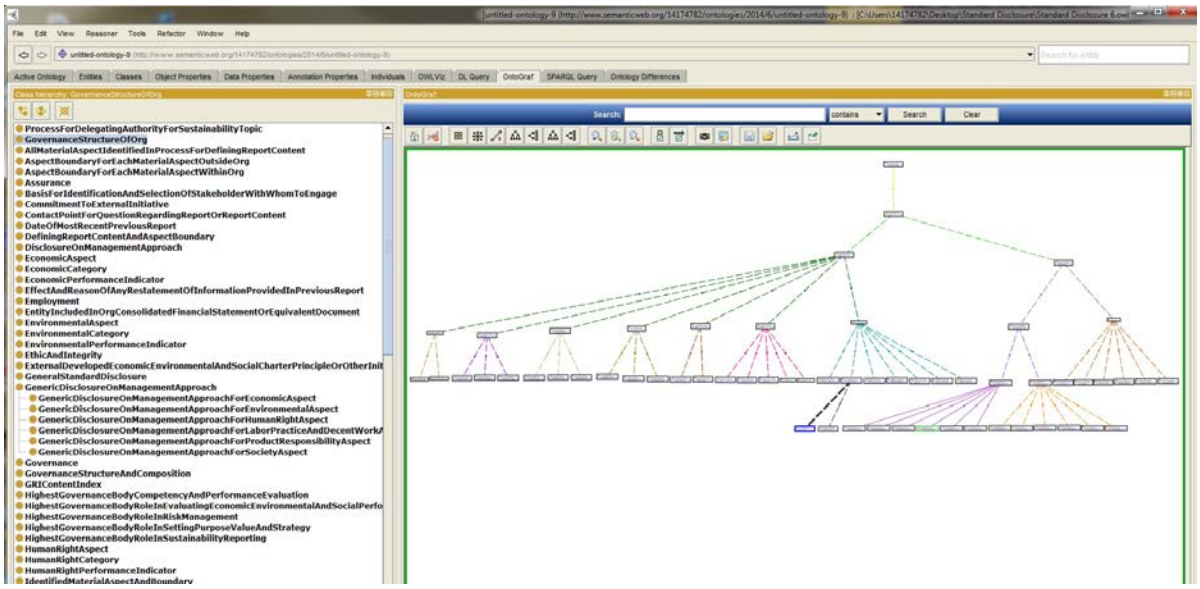

Figure 6: A screenshot for the class hierarchy and ontology graph of several levels for classes of GRI G4 in protégé _5.0_beta.

VERIFICATION AND VALIDATION OF ONTOLOGY

In this phase, a comprehensive test is required to verify and validate the ontology developed by applying it to one Australian company (mining industry); the online data can be the annual report and sustainability report. All concepts, data properties, object properties, and relationships that are identified from GRI G4 and presented in UML to formalize the CSR Reporting ontology conceptual model are structured using the OWL language and Protégé_5.0_beta tool. Then, the ontological values or individuals will be found from the sustainability report and annual report for the BHP BILLITON LIMITED Company, applying the GRI G4 to ascertain that the reported data are instantiated and correctly describe all relationships between the data.

CONCLUSION

In this paper, the adapted methodology as an engineering knowledge to develop ontology for the domain CSR reporting based on GRI G4 is presented. The motivation scenarios and competency questions are described. In the conceptualization phase, the conceptual model is defined. In the formalization phase, the conceptual model is formalized by using UML as an ontology modelling language. In the implementation phase, the ontology is built by encoding. OWL is used to implement the conceptual models by using Protégé as a tool. In the future, work will concentrate on a detailed search of the ontology implementation as well as on the verification and validation of the CSR Reporting ontology for BHP BILLITON LIMITED.

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