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Knowledge management via ontology development in accounting

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Abstract

Purpose – This paper seeks to develop an ontological approach, in order to make it possible to share a common understanding of accounting theory, in this case, the specific structure of the profit and loss account among people or software agents.

Design/methodology/approach – This paper presents an ontology methodology (the Net technique) which represents a semi-structured element in the domain knowledge of accounting. More specifically, ontology will be used to explain the profit and loss account as a representation of the potential use of this methodology.

Findings – To support ontology effectively, a strong accounting information support system in the organization is necessary. The ontology may be used by employees to navigate the information repository of an organization for the effective coordination. In addition, it might be possible for the WWW to be used to generate data, information and knowledge in the accounting domain.

Practical implications – Software agents could extract and aggregate accounting information from numerous web sites, which in turn might answer research questions or be used as input data for other applications.

Originality/value – The development of ontology expands the researcher's ability to generate information by using search methods beyond simple keywords. If only keywords are used in internet searches, then information that is retrieved will often lack the precision necessary for generating quality information. Therefore, in order to retrieve quality information more quickly and accurately, a broader and more extensive ontology development is required.

Keywords Cybernetics, Knowledge management, Accounting procedures

Paper type Research paper

Introduction

The internet has provided the means to collect information from an infinite number of sources (web sites). By creating formal explicit descriptions of concepts in terms of ontological statements that relate to a domain, knowledge management, along with knowledge sharing, knowledge reuse, and knowledge creation becomes possible. Ontology defines vocabularies that represent domain knowledge and provides the means to share information within that domain (Fuchs and Hofkirchner, 2005). People or software agents can make use and reuse of ontology when researching the internet

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(Hult, 2003). The development of ontology expands the researcher's ability to generate information by using search methods beyond simple keywords. If only keywords are used in internet searches, then information that is retrieved will often lack the precision necessary for generating quality information. Therefore, in order to retrieve quality information more quickly and accurately, a broader and more extensive ontology development is required.

The main purpose of this paper is to develop a methodology which will demonstrate the use of Microsoft's.NET software to construct an accounting ontology map to illustrate its use. This framework may also be used to implement ontology in other domains such as customer's Q&A, travel planning, etc. The next section provides a literature review of knowledge management and ontology development. Followed by the section, that proposes a methodology for constructing an accounting ontology. The next section that provides a specific illustration of the profit and loss account. In the penultimate section, the primary stages of specifically building the profit and loss ontology are discussed. The final section summarizes the paper and makes several concluding comments.

Literatures review

In this section, the knowledge management and ontology methodology literature will be reviewed. A specific emphasis will be focused on methodological considerations that shed light on how one might construct an ontology process that could be used in the business environment.

Knowledge may be defined as reliable information which is accumulated by knowledge workers. For an organization to be successful, it must have a structure to manage these invisible assets (Rowe, 2005; Johannessen *et al.*, 2002). From a decision science perspective, knowledge management may be viewed as the transformation of data to information and then information into knowledge (Hult, 2003; Wang and Ariguzo, 2004; Yim *et al.*, 2004; Johannessen *et al.*, 2002; Gottschalk, 2007). There are several processes and objectives that comprise the knowledge management function in all types of organizations. Figure 1 shows the subsystems that comprise knowledge management. Knowledge management involves the internal management of data and information flows into, through, and out of the organization. These activities include the following: generating information, disseminating information, selecting knowledge, deploying knowledge, creating unique value, and organizing information.

In recent years, the development of ontology has been recognized in artificial intelligence, software reuse, and information technology. Many researchers believe that the use of ontology will dramatically change the way systems will be designed (Sugumaran and Storey, 2002; Noy and McGuinness, 2001; Poli, 2002; Ami and Sommer, 2007; Gabbar, 2007). Before discussing the methodology for the construction of ontology, various definitions of the term "ontology" will be examined.

There has been much debate among philosophers, mathematicians, and artificial intelligence experts over how to define ontology. Sugumaran and Storey (2002) have stated that ontology may be viewed as an important and natural means of representing reality. Other often-cited definitions are:

- "An ontology is an explicit specification of a conceptualization" claimed by Gruber (1993).

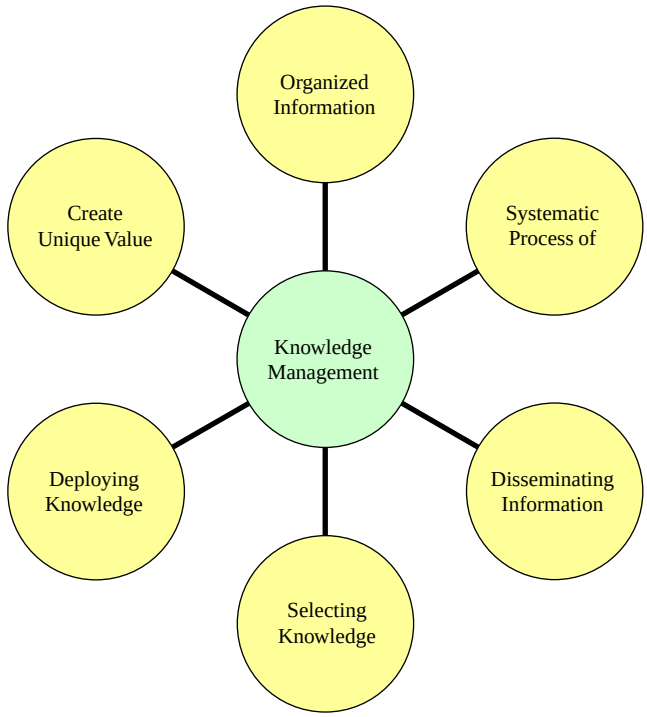

Figure 1.
The categorization of knowledge management

- "An (AI-) ontology is a theory of what entities can exist in the mind of a knowledgeable agent" (Wielinga and Schreiber, 1993).
- "Ontologies are agreements about shared conceptualizations. Shared conceptualizations include conceptual frameworks for modeling domain knowledge; content-specific protocols for communication among inter-operating agents; and agreements about the representation of particular domain theories. In the knowledge sharing context, ontologies are specified in the form of definitions of representational vocabulary. A very simple case would be a type hierarchy, specifying classes and their subsumption relationships. Relational database schemata also serve as ontologies by specifying the relations that can exist in some shared database and the integrity constraints that must hold for them" (Gruber, 1994).
- An ontology is an explicit knowledge level specification of a conceptualization which may be affected by the particular domain and task it is intended for (van Heijst *et al.*, 1996).
- "An ontology for a body of knowledge concerning a particular task or domain describes taxonomy of concepts for that task or domain that define the semantic interpretation of the knowledge" (Alberts, 1993).

Noy and McGuinness (2001) note that the artificial intelligence literature contains many definitions such as those quoted above and that many of these attempts at

defining the term contradicts each other. For purposes of this paper, Noy and McGuinness' definition will be used. They define ontology as:

> ... a formal explicit description of concepts (sometimes called classes) in a domain of discourse, properties of each concept describing various features and attributes of the concept, and restrictions on slots or facets (Noy and McGuinness, 2001).

They further state that a knowledge base may be created by defining individual instances of the classes filling in specific slot value information and additional slot restriction.

Poli (2002) and Guarino (1997) have divided ontology into three categories: descriptive, formal, and formalized. Each of these three categories may contain two aspects: domain-dependent and domain-independent. Descriptive ontology collects information about many entities. Formal ontology will filter, codify, and organize the results of the descriptive ontology process. The final category, formalized ontology is concerned with an evaluation of the adequacy of the various formalisms and the problems related to their reciprocal translation (Poli, 2002). Therefore, the taxonomy of ontology can be shown in Figure 2.

Various approaches have been proposed to study ontology issues and the current major research in ontology development has moved from the academic halls of universities, where philosophers and other academic specialist reside to the desks to practitioners in the functional areas of businesses such as marketing, accounting, human resources management, etc. as well as the top-strategic levels of the corporation (Seng and Lin, 2007). One of the main reasons for this shift has been the development of the WWW and the need for ontology development which will allow for the full potential of the web to be realized (Tung *et al.*, 2007). The ability to generate vast amounts of data, information, and knowledge by an organization will be greatly enhanced when ontology development occurs in all domains of study. McGuinness believes that ontologies in the future will be used as central controlled vocabularies that are integrated into catalogues, databases, web publications, knowledge management applications, etc. Further, she observes that large ontologies are essential components in many online applications including search (such as Yahoo and Lycos), e-commerce (such as Amazon and eBay), configuration (such as Dell and PC-Order), etc. She also envisions seeing ontologies that have long life spans, sometimes in multiple projects (such as UMLS, SIC codes, etc.) (McGuinness, 2001).

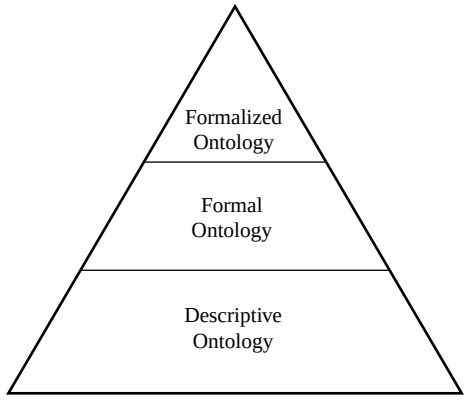

Figure 2.
Taxonomy of ontology

This study will hopefully contribute to this evolving process of building ontology that will reflect a part of the overall map that will have to be developed to represent accounting theory. Uschold and Gruninger (1996) believes that there are several possible approaches in developing a class hierarchy; a top-down process which starts with the definition of the most general concepts in the domain and then subsequent specialization of the concepts, a bottom-up approach which starts with the definition of the most specific classes followed then by a grouping of the classes into more general concepts and a combination of the first two processes.

To summarize those definitions of ontology, it can be treated as conceptual, knowledgeable, and taxonomy methodology. Ontology is also agreement of knowledge sharing. The recent usage of ontology represents a conceptual model that is embedded in many information systems (Smith, 2003; Leonard, 2000; Seng and Lin, 2007). Ontology is sometimes structured with hierarchies of real environmental objects and is not just limited to conservative object definitions. Prior to specifying a conceptual model one needs to state axioms that limit the possible interpretations for the defined terms.

Theresa *et al.* (2004) adopted the ontology to development project at Intel Corporation and used the result to build a semantic web. Corcho *et al.* (2003) has listed the methodologies, tools, and languages for building ontology. In Corcho *et al.* survey, most of ontology methods are discussed more complicated and these methods cannot support the customized for our research purposes. In the IT technology aspect, Sugumaran and Storey, 2002 used database design methodologies to create and integrate ontology. Hence, this research adopts self-development to facilitate process of building ontology and generates ontology map in the accounting theory.

Table I summarizes the comparison of the ontology and discusses the relevant research on knowledge management and ontology.

Proposing framework in this research

Knowledge ontology is a set of rules with vocabularies, semantic interconnection inference, and logic. It also represents domain knowledge (such as accounting) in ontology, and the ontology has properties of taxonomy and lexicon which become the knowledge base. Ontology development involves the following steps:

(1) defining classes in the ontology;

(2) arranging the classes in a taxonomic (subclass-superclass) hierarchy;

(3) defining slots and describing allowed values for these slots; and

(4) filling in the values for slots for instances.

After the ontology is developed, a knowledge base may be created by defining individual instances of these classes by filling in specific slot value information and additional slot restrictions (Noy and McGuinness, 2002; Steele *et al.*, 2007).

There are many ontology tools capable of building ontology such as Ontolingua, WebOnto, Protégé OntoSaurus, ODE and KADS22. However, these tools do not have the capability of presenting the operational relationship among the attributes in the ontology. Hence, one of the objectives of this research is to integrate accounting theory along with a database; based upon this objective and the tools available which could facilitate achieving this objective, it was decided that Microsoft's.NET software was the best option to implement the system.

Relevant research	Features
Ontology theories (Poli, 2002; Sugumaran and Storey, 2002; Guarino, 1997; Smith, 2003; Uschold and Gruninger, 1996)	Introduce ontology from the philosophy aspect Discuss the boundaries, types and structures of ontology Propose the development of database designs and a methodology for creating and managing domain ontology Discuss how the principles of formal ontology and ontological engineering can be used for the knowledge engineering in the real world Introduce the emerging field concerned with the design and use of ontology
Ontology development (Noy and McGuinness, 2001; Corcho *et al.*, 2003; van Heijst *et al.*, 1996; Alberts, 1993)	Demonstrate how to use Protégé to develop ontology Review and compare the main methodologies, tools and languages for building ontology Describe a number of ways in which ontologies – schematic descriptions of the contents of domain knowledge
The examples of ontology application (McGuinness, 2001; Seng and Lin, 2007)	Use ontology-assisted schema and semantic resolution in the business process alignment Describe some desirable properties of ontologies, how both simple and complex ontologies are being and may be used to support varied applications
Knowledge management and engineering (Hult, 2003; Wang and Ariguzo, 2004; Yim *et al.*, 2004; Wielinga and Schreiber, 1993; Leonard, 2000; Fuchs and Hofkirchner, 2005; Rowe, 2005; Johannessen *et al.*, 2002)	Transformed social facts into data, data into information, and information into knowledge Knowledge is a process and relationship between humans Using the viable system model to make an assessment of knowledge management Develop a metaphor to explain knowledge Invent a method to facilitate the linkage between knowledge management initiatives and achieve strategic goals and objectives of organization
The conversion of ontology and knowledge (Edgington *et al.*, 2004; Gruber, 1993)	Use a case study of Intel to describe how to adopt ontology to facilitate knowledge management Discuss how the translation method to portability addresses several technology issues

Table I.
The research of knowledge management and ontology

In order to generate an accounting ontology, the following process was followed. The processes can be shown in Figure 3.

The process of constructing the accounting ontology, as shown in Figure 3, consists of five stages, from Stage 1 to Stage 5. The following is a more detailed explanation of each stage:

(1) *Stage 1: collect accounting information.* In this stage, the accounting information is collected from a corporation accounting information system or other data sources such as stock exchange center. Then each item is assigned a number.

(2) *Stage 2: analyze accounting items.* After collecting each accounting item, they are then divided or classified based upon the following three definitions:

- the meaning of item;
- the relationship between items; and
- the operations of items.

(3) *Stage 3: accounting item taxonomy.* In this stage, using the results of Stage 2, an operational taxonomy is used to construct the interrelated items.

(4) *Stage 4: import accounting items into DB.* In this stage, items are imported into the DB schema where the relationship is built between the items. The DB schema records the basic information and relationship among the accounting items.

(5) *Stage 5: generate ontology for accounting.* In the final stage, this research generates an accounting is developed to demonstrate the accounting's architecture.

This technique presents a framework for building accounting knowledge and may also serve as an excellent learning tool for accounting students by demonstrating the relationships among the various accounts that are studied.

An illustration: the case of the profit and loss account

All accounting information is designed to provide a particular user with relevant and period data to make sound business decisions (Lea, 2007). There are several reports and sheets in accounting theory; they are the balance sheet, the profit and loss account, the cash flow statement and so on. The balance sheet records the relationship between assets and liabilities, and is expressed by the equation as below:

$$\text{Assets} = \text{liabilities}$$

The profit and loss account describes business behaviors of income and expense in the company. These income and expense items are a summary of a company's trading transactions from its customers and suppliers. The equation of profit and loss account may be illustrated as follows:

$$\text{Profit or loss} = \text{income} - \text{expenses}$$

A cash flow statement is a statement of the amounts of cash flowing into and out of the company during their annual reporting period; it also summaries where cash came from and how cash was spent during the year. This research will focus on profit and loss account. In the following paragraph, the taxonomy of items that make up the profit and loss account will be explained.

Figure 4 shows the profit and loss account and how the items may be divided into two parts. One of the categories is expenses, and the other is income. More detail information is shown in Figure 4.

Each item in the profit and loss account may be defined as an equation as is shown in Figure 5. The profit and loss account is also composed by these equations.

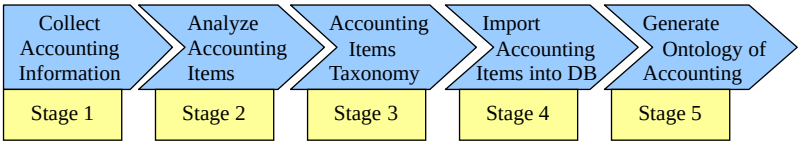

Figure 3.
The constructing processes in the research

	Expenses	Income
Sales revenue		10,000
-Sales return and sales allowances	(2,000)	
Gross profit of sales revenue		8,000
-Cost of goods sold	(1,000)	
Net profit of sales		7,000
Operating costs		
Marketing expense	(100)	
Administrative expense	(600)	
Research and development expense	(300)	
Operating profit		6,000
Non-operating revenue and profit		1,500
Non-operating expense and loss	(500)	
Gain from operating profit (before tax)		7,000
-Income tax expense	(1,000)	
Gain from operating profit		6,000

Figure 4.
Illustration of profit and loss account

A. Gross profit of sales revenue = Sales revenue - Sales return and sales allowances

B. Net profit ofsales = Gross profit of sales revenue - Cost of goods sold

C. Operating profit = Net profit of sales - Operating costs

D. Gain from operating profit(before tax) = Operating profit + Non-operating revenue and profit - Non-operating expense and loss

E. Gain from operating profit = Gain from operating profit (before tax) - Income tax expense

Figure 5.
The equations of the profit and loss account

The system implementation

This section demonstrates the detailed operations necessary to develop the accounting ontology; then it will be implemented by using the.Net software tools. The profit and loss account's subject characteristics are used to construct its ontology and to draw a graph to represent the relationships between these subjects. Next, based upon standardized accounting practice the profit or loss of the firm has generated is calculated. The following section defines the steps required to build the profit and loss account's ontology.

The data schema of the profit and loss account's ontology

According to the illustration in Figure 4, it is composed of three properties. The first property is the characteristic of the item; each item has the mean of itself. The second property is the attribute in each item such as expense subject or income subject. Finally, the third property is the relationship among items. The following formula is composed to present the relationships among the items.

Single item:
Item A (Attr1, Attr2, …).

The relationship of items:
Item C (Attri1, Attri2, ...) = Item A (Attr1, Attr2, ...) *operator* Item B (Attr1, Attr2, ...).
**The Attr means the attribute of each item such as item name, item amount, ... and so on.*

Hence, database technology is utilized to facilitate these formulas and to transform these items into a database schema.

Figure 6 shows the data schema of the profit and loss account and uses a relational model to illustrate these items' inter-relationships. There are three tables in this model and each of them describes each item's different functionality.

The *Basic_Information* table is used to describe each item's information in the profit and loss account such as item_id, item_name and amount. Item_id is the primary key in the Basic_Information table and is used to identify the unique item in the database. Then the item_name and amount is used to record the account information of profit and loss. The *Operation_Relation* table is used to define the relationship among these items. The operator records the algebraic relationship among the items by recording all of relevant items with item_id (item_id is located in the Basic_Information table). After building all of relationships for each item, the *Tree_Information* table is then used to construct the map of ontology as shown in Figure 6.

The system operations of constructing the profit and loss account's ontology

In this section, the specific methodology for building ontology of the profit and loss account will be outlined. In order to construct the profit and loss account's ontology, a unique approach has been created to construct it. The following is a listing of the steps used to construct the profit and loss account's ontology.

First at all, the user needs to create items of the profit and loss account in Figure 7 by using "Create Item" button, and then he uses "Operation Setting" button to setup the operational relationships. For example, the creation of sales revenue item can be created in following steps:

- *Step 1.* Naming the unique id of item that cannot repeat with other item.
- *Step 2.* Filling out the Item_Name and checking the item belong with which item.
- *Step 3.* Click "Create Item" button to verify your input.

All of these steps are shown in Figure 7.

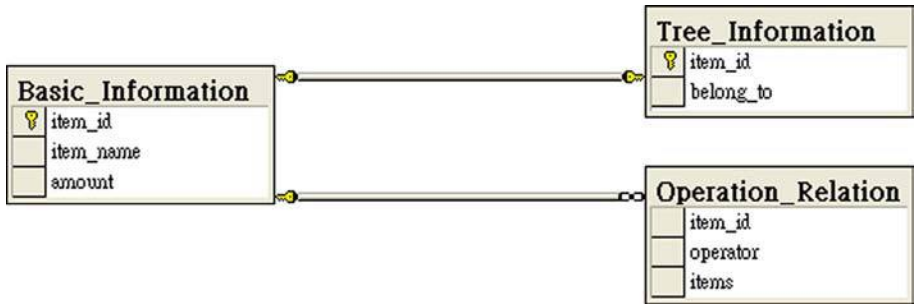

Figure 6.
The data schema of profit and loss account

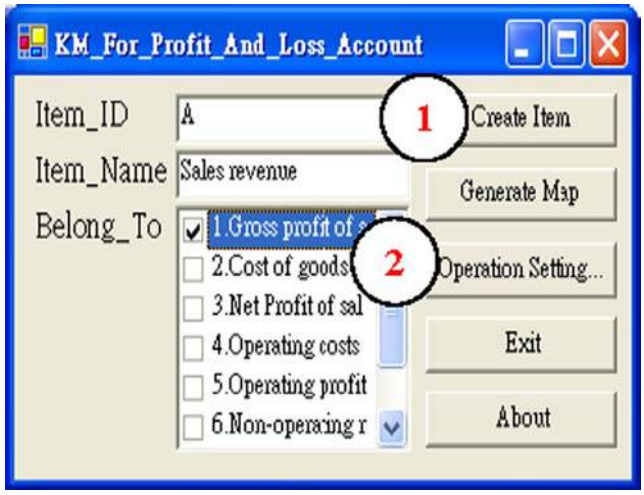

Figure 7.
Creating items steps

And the setting of item of *Net profit of sales* is expressed in equation B of Figure 5 which is also described as below:

- *Step 1.* Click "Operation Setting" button to setting the item.
- *Step 2.* Then, Choice an Item_Name that you want to set.
- *Step 3.* Choice an operator that you want to express in equations of Figure 5.
- *Step 4.* Click how many items are related to this Item_Name with Step 3's operator.

The operation setting also can be shown in Figure 8.

While the user has accomplished all setting of these items, this research provides a "Generate Map" button to construct the ontology of the profit and loss account automatically and the result can be shown in Figure 9.

Conclusion

The overall objective of this research is to construct an ontology concept model of the profit and loss account. In order to achieve this objective, a tool was devised to create this knowledge ontology by using a database technique.

This ontology will express the relationships between several items of the profit and loss account. The basic objectives of this research were as follows:

- analyze the relationships of items in the profit and loss account;
- propose a conceptual ontology for the profit and loss account; and
- develop a tool to express the conceptual ontology.

To support ontology effectively, a strong accounting information support system in the organization is necessary. The ontology may be used by employees to navigate the information repository of an organization for the effective coordination. In addition, it also might be possible for the WWW to also be used to generate data, information and knowledge in the accounting domain. Therefore, the potential to use internet as well as

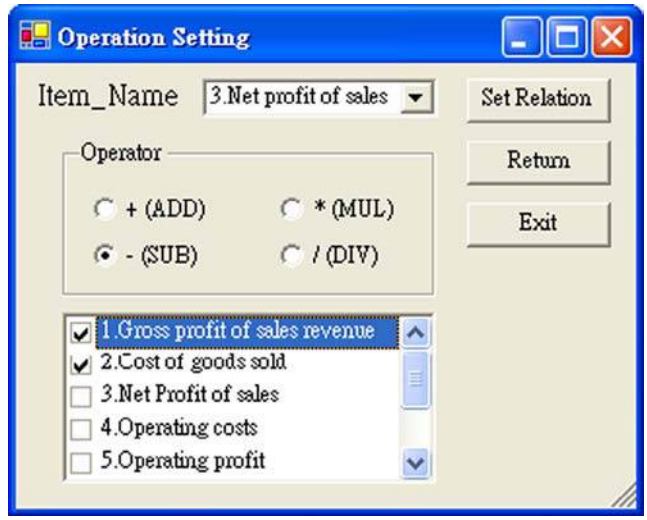

Figure 8.
Setup items steps

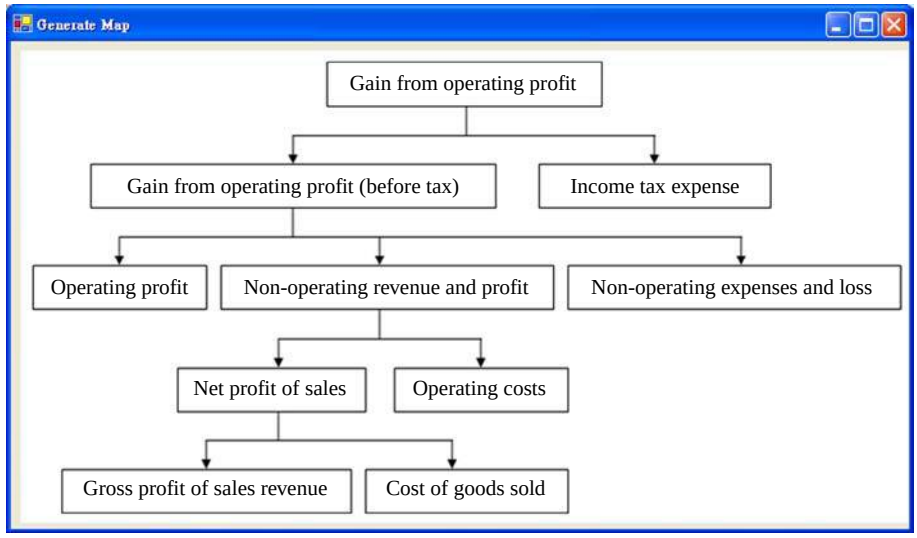

Figure 9.
The ontology of profit and loss account: an example

the intranet exist with the development of an accounting ontology. Hence, this paper develops a conceptual model of ontology and implements it by the software.

In the future, it is envisioned that this research may move in two directions. The first direction is in developing other functionalities in the accounting theory realm. The other direction may be to use this tool to develop ontology in other domains such as marketing or human resources management. This methodological research may also develop applications with other technologies such as AI, data mining and semantic web, and then search out tacit knowledge from the ontology map.

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