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Abstract

Ontology is a formal explicit specification of shared conceptualisation. Ontology revision refers to revising the ontology as a result of learning or when new knowledge is gained. This paper discusses the possibility of using the concept of belief revision as a basis for ontology revision. Belief revision is concerned with the approach of updating and revising a belief set so that it remains consistent when new information is received. The consistency issue is important to ensure that it does not cause inconsistent beliefs or contradicts with existing beliefs. We propose to use the expansion, revision and contraction operators of belief revision to revise ontology. The conceptual framework of these operations will be presented.

Keywords: Ontology Revision, Belief Revision, Ontology, the Semantic Web

1. INTRODUCTION

Ontology is an emerging research area that extends to the Semantic Web. One of the problems identified in the evolution of ontology is that it is difficult to maintain ontology when there is a change in knowledge or perhaps a change in the perception about things within the community of practice. When the system faces these changes, the adjustments made as a result of change in knowledge or perception may contradict with what was initially defined in the ontology and could also contradict with the conceptualisation of that initially agreed by the community of practice. Examples of change of perceptions about things could be in the form of changes in the definitions of terms, phrases or statements.

One may argue that conceptualisation in ontology should be well planned and defined in the designing phase of the ontology. However learning can occur as intelligent agents roam in the Semantic Web environment. When learning takes place, there is a higher chance for new knowledge and greater understanding of perceptions about things. When such situations arise, ontology revision is required. Questions can also be asked whether reference to a concept should remain valid in the ontology if there is a partial change of existing relationship? This paper will present an approach of using the concept of belief revision as a way to revise ontology in the Semantic Web environment.

The paper is organised as follows. Section 2 discusses background literature on ontology and motivation of ontology revision. Section 3 discusses the concept of belief revision. Section 4 discusses an example to illustrate the application of belief revision approach to revise ontology. Finally, conclusion and future research direction are presented.

2. BACKGROUND AND MOTIVATION

2.1 THE SEMANTIC WEB

The distributed nature of the World Wide Web (WWW) means that it is of heterogeneous structure (Heflin 2001). This characteristic of the WWW has resulted in current proliferation and widespread usage of the Web, which also results in the lack of structure when information needs to be retrieved. Stuckenschmidt (2003) explains the structure can be seen as a set of named relations (schemas) and information semantics can be captured in that structure. Providentially, ontology can be used as a way of representing the semantics of the web documents and enabling it to be used by web applications and agents (W3C 2002). It provides a very useful way to structure and define the meaning of the metadata of the web documents. For example, Dorai and Yacoob (2001) facilitate the Semantic Web search with embedded grammar tags for speech recognition engines, the Semantic Web page representation and speech output generation. In particular, the embedded grammar tags are marked up in a way that give "meaning" of information. A meaning of information is closely related to the requirement that explicitly represents the meaning of the content of Web resources.

The Semantic Web is defined by the WWW Consortium (W3C) as "the representation of data on the World Wide Web" (W3C 2000). Berners-Lee et al (2001a) define the Semantic Web as "an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation". It allows agents to be able to communicate with each other, and it can be achieved by sharing terms that are presented in ontology. Tim Burners-Lee drew the Semantic Web as a "layer cake" in terms of knowledge terms, ontology vocabularies, logics and rules as shown in Figure 1 (Berners-Lee et al. 2001b).

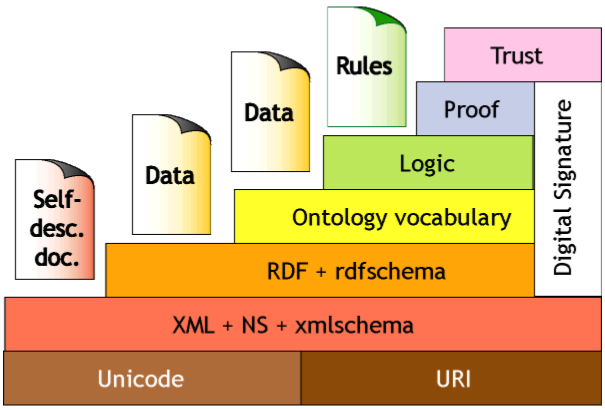


Figure 1. The Semantic Web as a "layer cake" (Source: Berners-Lee et al. 2001b).

The feature of the Semantic Web can be seen as bringing a structure to the meaningful content of web pages so that machine-centred initiatives can be achieved. The machine-centred initiatives refer to access of agents to the meaningful content of web is more systematic and knowledge-rich on the standard platform. The purpose of such an approach can be seen as an effort to improvement of knowledge acquisition (Benjamins & Fensel 1998; Fensel et al. 2002) or simply for information retrieval of a system (Aitken & Reid 2000; Farquhar et al. 1995; Wache et al. 2001). More importantly, the emergence of the Semantic Web provides a way to bring structure to the content of Web pages and create an environment that allows agents to be used and deployed to perform tasks for the users (Berners-Lee et al 2001).

2.2 ONTOLOGY

McCarthy and Hayes (1969) point out that in order for the computer program to function intelligently, it must have a general representation of the world in which its input can be interpreted. Similarly, in the WWW in order for agents to function autonomously and intelligently in the distributed environment, agents must know or be able to interpret the meaning of the terms referenced. Thus, agents can prudently communicate, and perform jobs either autonomously or in response to the user request. Ideally, agents can perform better if they can communicate through sharing a commonly agreed term of reference over the Semantic Web.

There are various definitions of ontology in the literature, commonly used definitions include: "ontology is a science or study of being" (Hornby 1995); "ontology is a particular theory of the nature of being or existence" (Russell & Norvig 2003 p.261); "ontology is a formal explicit specification of a shared conceptualisation" (Gruber 1993). In addition, Zúniga (2001) points out that the term ontology is derived from cognitive semantics which relate to expressions of conceptual structures. Gärdenfors (1995 p.11) elaborates the relationship of cognitive semantics as follows: "meanings are not in the head of a single individual, but they emerge from the conceptual schemes in the heads of the language users together with the semantic power structure." Gomez-Perez (1999) points out that ontology should aim at capturing domain knowledge in a generic way so that it provides a commonly agreed understanding of domain that can be reused and shared. Ontology has been widely used and engaged in development of the Semantic Web.

James Hendler (2001) forecasts a vision of the Semantic Web Ontology. The first vision of its use is to create web pages with ontological information (Hendler 2001). This means logic experts and/or individuals will develop decentralised small size ontology. In addition, one or more ontologies will be linked to other ontologies to share repositories. The second vision of the Semantic Web Ontology is the definition of services in a machine-readable form (Hendler 2001). This refers to using ontology to agree on terms and/or constraints for web services. For example, software agents or e-commerce programs are able to share and reuse B2B e-commerce transactions based on machine-readable ontology. The final vision of the Semantic Web Ontology is the use of logic and agents (Hendler 2001). Logic and rules are being used to improve the description of software agents' services. Software agents are communicating with other agents using the terms in ontology, exchanging portion of other agents' ontology, and merging with other agents' ontology.

Most recently, the visions of the Semantic Web and the Semantic Web Ontology have been implemented in many ways. One of the most important outcomes of these efforts is the development of Ontology Web Language (OWL). OWL is a language for defining and instantiating Web ontologies recommended by the W3C (Smith et al. 2002). In the last few years, a number of research groups have been focussing on ontology languages in terms of standardising knowledge representation language for the Semantic Web. For example, both DAML (DARPA Agent Markup Language) and OWL are developed to bring communicating bridge among agents and building its equivalent machine-readable and understandable mechanism over the web.

2.3 MOTIVATION

The Online Computer Library Center (OCLC) reported that there were about 9 millions unique websites in 2002 compared to 2.8 millions in 1998 (OCLC 2003). We can see that websites evolve and change over time and the number of websites will increase in future. Therefore, it is not surprise to see that ontology evolves over time as well. Ontology may have changed as a result of extension from previous ontology or as a result of revision over time. When this happens, issues such as ontology inter-operability and handling of multiple ontologies need to be addressed. A possible approach to tackle the ontology maintenance matters has been discussed in the literature in the area of ontology versioning or ontology library system. The concept of ontology versioning has been used to reduce the inter-operability problem caused by the evolution of ontology (Klein & Fensel 2001). The ontology versioning system allows comparability issues to be taking into consideration when new knowledge is added to the system over time. On the other hand, ontology library, which is described as “a system capable of offering various functions for managing, adapting and standardizing groups of ontologies” (Ding & Fensel 2001 p.1), has also been used to address the ontology maintenance issue.

The idea of ontology revision is introduced by Heflin and Hendler (2000). Their idea of ontology revision closely relates to the concept of belief revision. They define an ontology revision as a change in the components of ontology, which can involve addition or removal of categories, relations, and/or axioms. Literature review shows it is necessary to consider ontology revision. Foo (1995) uses the dynamic concept set as a way of ontology revision. OWL resolves the ontology versioning problem by using a standard tag to provide consistency in terms of version control. The aim of our research is to investigate approaches that can be used for ontology revision.

As discussed earlier, in order to effectively deploy ontology, it has to be published and broadly agreed among interest groups. Our proposition is that even though ontology is carefully developed and used, ontology may still need to be revised over time as a result of new knowledge gained. Thus, ontology will continually be evolved over time. When an individual or the community of practice learns something new or the system accepts new information, then a change of knowledge can occur through some form of belief changes. This issue is akin to the concept of representation adjustment and presentation adjustment, which is a concept formation in knowledge representation. If that is the case, revision of ontology representation is an answer to reflect those belief changes.

3. BELIEF REVISION

In general, belief revision deals with approaches of changing belief, particularly when new information is received or added to the system. It ensures that new information does not cause inconsistent beliefs and contradict with the existing beliefs (Gärdenfors 1992). There are two approaches to describing belief revision: the foundation theory and the coherence theory.

The foundation theory focuses on keeping track of justifications (a proof for logical representation) for one’s belief (Gärdenfors 1990; 1992). An example of the foundation theory is a Truth Maintenance System (TMS). The TMS aims to detect inconsistencies during the reasoning process, and it will revise its knowledge base if any inconsistency is detected. In addition, it is able to provide justifications for conclusions in the problem solving process. A proposition α is accepted (or believed) in the foundation theory of justification if and only if: α is self-evident, or α can be derived from a set of accepted propositions. McAllester (1978 p.1) notes that the TMS "is designed to be used by deductive systems to maintain the logical relations among the beliefs which those systems to maintain the logical relations among the beliefs which those systems manipulate". The assumption-based TMS allows the system to decide on their actions based on available information and revise their beliefs when new information invalidates previous assumptions or observations about the physical world (Doyle, 1979). The logic-based TMS allows the system to justify their actions based on logical consequences of foundational beliefs.

On the other hand, the coherence theory highlights the logical structure of the things in a "world" which are semantics in a form of logically consistent structure: if α is believed in a belief set K and β follows logically from α, then β is believed in the belief set K too. Gärdenfors (1990 p.5) notes that "the beliefs are justified just as they are" in the coherence theory. The AGM model proposed by Alchourrón, Gärdenfors and Makinson is an example that based on the coherence theory. This model deals with modelling and analysing the belief revision process based on epistemic states. The difference between justification theory and that of the coherence theory is as follows. In the justification theory, the belief needs to be removed from the belief set if the justification is no longer valid. On the other hand, the coherence theory allows the belief to be remained in the belief set as long as it is coherent with the rest of the new belief set. The coherence theory of belief revision deals with minimal changes of epistemic states.

We will briefly discuss three types of belief revision operators proposed by the AGM model. Let a belief set K be represented by a set of sentences in the logical language L. A set of all sentences represented in L is believed to be true. Assume that the language L contains the standard logical connectives: negation ($\neg$), conjunction ($\wedge$), disjunction ($\vee$) implication ($\Rightarrow$), and two truth-values of truth ($\top$) and falsity ($\bot$). In a consistent belief set, a sentence α exists in one of three possible epistemic states: accepted, rejected and unknown.

α is accepted ($\alpha \in K$)

α is rejected ($\neg\alpha \in K$)

α is unknown ($\alpha \notin K$ and $\neg\alpha \notin K$)

Note that we cannot accept both α and $\neg\alpha$ at the same time because it leads to inconsistency in the belief set. Thus, modelling that epistemic state is not allowed.

Consider the following set of sentences in a belief set:

A: All birds fly with wings.

B: The bird in the cage has wings.

C: The bird in the cage is a parrot.

D: A parrot is a bird.

E: A parrot can fly.

Reasoning can be applied to spawn new knowledge based on given knowledge if the given proposition is true (Hoffmann, 1998, p.25). In this example, a new sentence Z is generated:

Z: The bird in the cage can fly with wings.

Together with its logical consequence, *Z* is added to the belief set *K*, then it is said that the belief set is expanded by the sentence *Z*. As a result of *expansion* of the sentence *Z*, the following set of sentences now exists in the belief set:

A: All birds fly with wings.

B: The bird in the cage has wings.

C: The bird in the cage is a parrot.

D: A parrot is a bird.

E: A parrot can fly.

Z: The bird in the cage can fly with wings.

Assume that the following new sentences are learned and introduced to the belief system.

F: The bird in the cage turns out to be Tweety.

G: Tweety has wings.

H: Tweety cannot fly.

I: Tweety is a penguin.

Then, the sentences *D* and *Z* are no longer consistent in the belief set due to the added new sentences *F*, *G*, *H*, and *I*. This means that there is a need to add negations of *D* ($\neg D$), and *Z* ($\neg Z$) to the belief set. Let the new sentences ($\neg D$ and $\neg Z$) be denoted to *Y* and *X* accordingly. As a result of the expansion, the belief set becomes:

A: All birds fly with wings.

B: The bird in the cage has wings.

C: The bird in the cage is a parrot.

D: A parrot is a bird.

E: A parrot can fly.

Z: The bird in the cage can fly with wings.

F: The bird in the cage turns out to be Tweety.

G: Tweety has wings.

H: Tweety cannot fly.

I: Tweety is a penguin.

Y: $\neg D$

X: $\neg$Z

Now consider the following scenario to describe the *revision* operator. This occurs when a new sentences *X* and *Y* that are inconsistent with a belief set *K* are added. In order to maintain consistency in the belief set *K*, some of the old sentences may need to be revised. Then, it is said that the belief set is revised by that sentence. In other words, the belief state for that particular belief changed from "rejected" to "accepted" or from "accepted" "rejected". In this instance, we do not want to lose valuable information that describes "*B*: The bird in the cage has wings" and "*E*: A parrot can fly". However, it still requires us to revise our belief based on the given evidence that it contradicts with what we had previously agreed to accept. The following shows the revised belief set as a result of revision:

A: All birds fly with wings.

B: The bird in the cage has wings.

C: The bird in the cage is a parrot.

D: A parrot is a bird.

E: A parrot can fly.

Z: The bird in the cage can fly with wings.

F: The bird in the cage turns out to be Tweety.

G: Tweety has wings.

H: Tweety cannot fly.

I: Tweety is a penguin.

Y: $\neg D$

X: ¬Z

B′: The Bird can fly with wings except the one in the cage.

The third example illustrates the case when some beliefs are found to be invalid. That is, propositions for those beliefs turned out to be false. When this occurs the belief is to be given up (*contract*) to allow new beliefs to be accepted. In order words, the belief state of that particular belief to be "unknown" from "accepted" or "rejected". Contraction is defined as when some sentences in the belief set *K* is removed without any new sentences are added (Gärdenfors 1990). Using the same example, a result in contraction can be shown as follows (we use "strikethrough" to show the sentence that has been given up):

A: All birds fly with wings.

B: The bird in the cage has wings.

C: The bird in the cage is a parrot.

~~*D*: A parrot is a bird.~~

E: A parrot can fly.

~~*Z*: The bird in the cage can fly with wings.~~

F: The bird in the cage turns out to be Tweety.

G: Tweety has wings.

H: Tweety cannot fly.

I: Tweety is a penguin.

Y: $\neg D$

X: ¬Z

B′: The Bird can fly with wings except the one in the cage.

One of the concerns of the underlying idea of revision and contraction methods is removing potentially useful information in the process of removing conflicting beliefs (McAllester

1990; Segal 1994). Segal (1994 p.9) explains "removing all beliefs in a candidate is the simplest way to insure no conflicts occur, but it has the cost of removing potentially useful information." In fact, there is no formal way to decide what to remove or modify in belief set. Gärdenfors (1990 p.13) notes that "what is needed here is a computationally well defined method of determining the revision"

4. ILLUSTRATED EXAMPLE

Ontology representation begins with conceptualisation of one's domain of interest in the community of practice. In our research, the conceptualisation is represented as the belief set which is made up of a set of sentences in the ontology. We propose to use the concept of belief revision to support ontology revision when the need to revise ontology arises. The three belief revision operators of expansion, revision and contraction will be used for this purpose. Figure 2 shows an agent roams between the Semantic Web environments, A and B. We assume that the agent has access to its own ontology and may not share the same ontology. An agent can learn new information from the Semantic Web environment through interaction and communication channel. When an agent learns new information, the agent's belief changes as a result of learning that can lead to changes in perception. For instance, this proposition change has either *true* or *false* value. Thus, it leads to agent's belief change about a particular concept. When this happens, the agent needs to update or revise its own belief sets currently stored in the ontology.

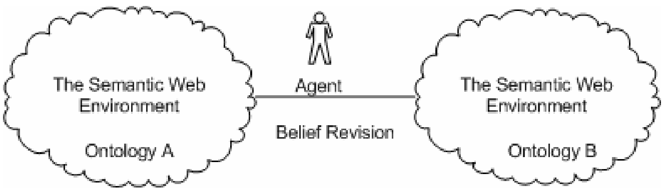


Figure 2 An agent roaming between two Semantic Web environments

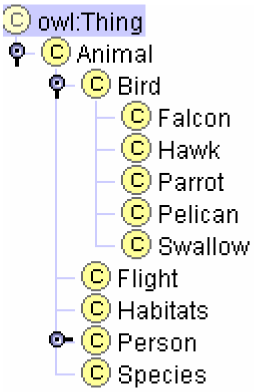
We will explain the operations of ontology revision based on the three operators of expansion, revision and contraction using the following example. We have used a software tool Protégé-2000, which is developed by Stanford Medical Informatics, to design and develop an example of animal ontology to explain our example. Visualisations of the concepts described here are representation of the Protégé-2000 in OWL (See Figure 3). The scenario is that an agent has to update its knowledge about "birds" as a result of learning. In this example, ontology A and B represent initial knowledge about animals, in this case the birds. Concepts of birds such as "a bird is an animal", "a bird has wings" "a bird lays eggs", and others related concepts and relations are stored in the ontology (See Figure 3). In figure 3, the first four concepts (hasWings, canFly, layEggs, and cannotFly) are properties of the concept of *bird* itself; whereas the others are inherited from the parent concept of *animal*.

Figure 3 A partial property of the concept birds.

For purpose of simplicity, we will only discuss the characteristics of aerial flight that belongs to the concept of *bird*. Assume that agent A is capable of accessing its own ontology A, and another agent B allows agent A to access its ontology. Based on the ontology stored in A, agent A knows that "a parrot is a bird". The property value of the parrot *canfly* has a value truth (Boolean). That is, the parrot can fly. The concept B*ird* is part of the concept *Animal*. The following shows the partial codes of the concept *Bird* in OWL format.

```
<?xml version="1.0"?>
<rdf:RDF
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns="http://myhost.com/ontology#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
  xml:base="http://myhost.com/ontology">
  <owl:Ontology rdf:about=""/>
...
  <owl:Class rdf:ID="Bird">
    <rdfs:subClassOf>
      <owl:Class rdf:ID="Animal"/>
    </rdfs:subClassOf>
  </owl:Class>
  <owl:DatatypeProperty rdf:ID="hasWings">
    <rdfs:domain rdf:resource="#Bird"/>
    <rdfs:range rdf:resource="http://www.w3.org/2001/XMLSchema#boolean"/>
  </owl:DatatypeProperty>
...
</rdf:RDF>
```

To depict the conceptual relationship in our example, a concept hierarchy is presented in the diagram (See Figures 4 & 5). Thus using the ontology agent A knows what a *parrot* is; that is, it is a *bird* that *can fly*. However, when agent A reads the ontology of agent B, it is not able to recognise or understand the concept of *Penguin, Ostrich*, and *Emu* and their relation to *cannot-fly* because it is not included in its own ontology A. If agent B can provide information about *cannot-fly* as the opposite of the relation *can-fly*, then agent A can revise its own ontology to learn that "*not all birds can fly*", "*some birds such as a penguin cannot fly*".



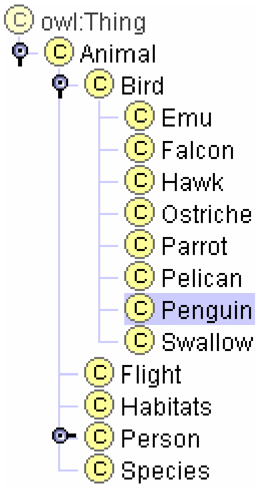


Figure 4 An example of ontology of agent A.

Figure 5 An example of ontology of agent B.

The first step of the ontology revision starts with a process that represents the conceptualisations from ontology to a set of beliefs. Some integrity constraints are considered in this process. Beliefs in ontology have logical consequences. For example, the concept *Bird* has logical consequences to the concept *Animal*. Assume that all propositions for sentences of ontology always be true in initial stage unless certain propositions found to be false with given new information. That is, when a sentence "a bird is an animal" is believed by an agent, all propositions are true for that particular sentence. This means the agent believes that sentence is true. New information should give consistent propositions that change agent's beliefs. Agent A's belief are denoted as α, β, γ, δ, etc., and Agent B's beliefs are denoted as *A*, *B*, *C*, *D*, etc.,

α: A bird is a subclass of an animal.

β: A parrot has wings.

γ: A parrot can fly.

δ: All birds fly.

…

A: A bird is a subclass of an animal.

B: A penguin has wings

C: A penguin cannot fly.

D: A penguin is a bird.

…

Figure 6 An example of Agent A's & B's beliefs

We use the expansion operator of the AGM model to allow this ontology revision to happen. Two types of ontology expansions can be considered: lower expansion and upper expansion. Firstly, the notion of upper expansion refers to the expansion of an upper level concept. An upper level concept is eligible to be a candidate of expansion to the current concept hierarchy only if it shares the same concept. Assume that the concept *Animal* shares the same meanings, and is used in both ontology A and B. If a concept *Seabird* exists over the concept Bird and it is a sub-concept of the animal which shares the same meanings, the concept of *Seabird* can be a candidate of upper expansion. This kind of expansion does not exist in our example illustrated here.

Lower expansion means that a lower level of concept is only eligible to be a candidate for expansion of the belief set. It is eligible to be a candidate of expansion to the current concept hierarchy if and only if it shares the same concept. Assume that the concept *birds* shares the same meanings (i.e α and *A* are the same). Then the concept of *Penguin* can be a candidate of lower expansion as well as the relation *cannot-fly* and the default value of *canswim.* As a result of lower expansion the following sentences are now included in ontology A:

α: A bird is a subclass of an animal.

β: A parrot has wings.

γ: A parrot can fly.

δ: All birds fly.

B: A penguin has wings

C: A penguin cannot fly.

D: A penguin is a bird.

Another integrity constraint that needs to be considered is if new information has truth propositions that are consistent with existing beliefs then those beliefs should be included in the ontology.

When the sentences *B*, *C*, and *D* are added to the existing ontology as a result of ontology expansion above it may results in inconsistency. In this instance, δ and *C* become inconsistent because both concepts are inconsistent in the belief set of agent A. Thus it is necessary to operate revision function so that agent's beliefs become consistent. One way to do this is to introduce a restriction so that the amount of information lost in a belief change can be kept to be minimal. In this case δ *is* revised to δ'

δ': All birds fly except the penguin.

When the assertion of negation $\neg\delta$ is considered, a sentence *C* (A penguin cannot fly) became contracted. Thus, it is necessary to operate contraction of agent's beliefs so that inconsistencies can be removed. In this example, the insertion of revised δ' might be more useful.

A default rule needs to be considered as a way that identifies a default choice when contraction or revision occurs. A default rule for *Birds* may looks like this:

R1: Birds (*x*) : *flies* (*x*) / *flies* (*x*)

This rule means that if *Birds* (*x*) is true, and if *flies* (*x*) is consistent within the belief set, then *flies* (*x*) may be deduced by default. One of guidelines for this default rule can be found in the Semantic Web layers such as fact, rules, logic and proof that exist over ontology vocabularies. Ideally, these factors of the layers may provide sufficient information to identify integrity constraints to decide which beliefs we choose to give up or retain. The default rule *R1* shows that if *Birds (x)* is true, and if *flies (x)* is consistent within ontology, then *flies (x)* can be concluded by default. This means that there is an assumption that *all birds flies* has only default status unless it is contracted by more specific information.

A default value is used "to specify a default choice for the value of some quantity. This choice is made with the intent of overriding it if either a good reason is found for using some other value, or if making the default choice leads to an inconsistency" (Doyle 1979 p.234). Russell and Norvig (2003) note that default values for categories, in our case the concepts in ontology, are one of the most important aspect of semantic networks. The default value here refers to overriding an inheritance concept. For example, a *Penguin* has a default truth-value of *canswim*. Thus, if Tweedy is a bird and a penguin, it overrides the default value *flies* with a specific value such as *swims*. This presents a simple and natural way to override default values.

5. CONCLUSION AND FUTURE RESEARCH

We have shown that the concept of belief revision can be applied as an approach for ontology revision. As discussed in the literature, a support of ontology is fundamental in terms of carrying out the Semantic Web vision. However there is a perceived difficulty in maintaining ontologies, in particular ontology revision. There is a need to make adjustment of new concepts, rules and relations as agent learns or as perception changes in the community of practice. In this paper we have attempted to present our approach from the conceptual perspective. We have not discussed the implementation issues, which need further investigation. Another issue that worth further investigation is the concern of maintaining the ontology versioning system and ontology library to enable management and handling of comparability issues in ontology as a result of ontology revision. Thus the need of ontology revision is motivated by ontology evolution that needs a way to adjust new concepts, rules and relations when belief changes occur.

In addition, future research should be conducted on ways to handle comparability issues in ontologies. The investigation may include how to limit the ability of belief revision by an agent, or what types of relationships are allowed to revise and whether only some parts of ontology are allowed to be revised and so on. Further research also includes a proposed framework so that the belief revision operators can be implemented in an operational level so that testable propositions will be evaluated and tested.

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