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A Semantic Wiki Framework for Reconciling Conflict Collaborations Based on Selecting Consensus Choice[1]

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Abstract: Semantic wikis have been regarded as an important collaboration tool among a number of experts from multiple domains. This wiki platform can play a role of collaborative knowledge management system which can provide an efficient framework to raise social interactions between remote people synchronously. However,

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as these semantic wiki systems allow users to exploit their own semantics and backgrounds for describing their knowledge and skills, there are often semantic conflicts between knowledge (or information) published and provided by the users. Thereby, the main aims of this work are *i*) to automatically detect such conflicts by keeping track on the user semantics, and *ii*) to reasonably select consensus choice by analyzing social collaborations. In this paper, we want to note major patterns of knowledge dynamics through the social interactions on semantic wikis, and the semantic conflicts caused by the knowledge dynamics. The consensus choice has been effectively selected to be recommended for better understandability about the knowledge conflicts.

Key Words: Semantic wiki, conflict resolution, consensus theory, ontology
Category: H.1.1, H.3.5, I.2.11

1 Introduction

Collective intelligence in online information space needs to consider various knowledge processes (e.g., knowledge creation, merging, integration, and so on) in a collaborative manner. Recently, many studies have been focusing on Web 2.0 applications such as blogs and wikis to make the collective intelligence implemented [Souzis 2005;Schaffert et al. 2008;Cayzer 2010]. These social information spaces based on such Web 2.0 applications can provide an efficient platform to publish many types of knowledge and take various social activities with other users to generate "better" knowledge [Jung 2007;Goodfellow and Graham 2007;Jung 2009a].

However, as knowledge in diverse domains has been "collaboratively and simultaneously" published on the social information space [Jung 2008;Jung 2010], it may be *inconsistent* and *conflicted* with each other. This problem can be caused by various factors, e.g., simple mistakes and misunderstandings as well as different background knowledge and opinions. Moreover, the problem makes it more difficult to conduct various knowledge processes, e.g., generating knowledge, integrating knowledge, and so on.

In this paper, we want to investigate a novel framework to detect inconsistencies and conflicts between knowledge. Particularly, we are focusing on semantic wiki systems, which is a wiki that has an underlying model of the knowledge described in its wiki pages. Semantic wiki platforms have been proposed as an extension of wiki systems by using semantic technologies. Essentially, as shown in Fig. 1, a centralized ontology[3] has been employed to the wiki system for allowing users from various organizations (e.g., universities and companies) to efficiently work together on knowledge-enhanced tasks. While conventional hyperlinks on the web are indicating physical links between web pages or resources, the relationships between the resources on semantic wikis are described by a specific vocabulary which means the corresponding semantics. This process is referred to as *semantic annotation* for describing the wiki resources. For example, in Fig. 1,

[3] In this paper, we call this ontology as a global wiki ontology (GWO).

given two wiki pages of a city Seoul and a country Korea, a wiki user can define a semantic relationship isCapitalOf between them.

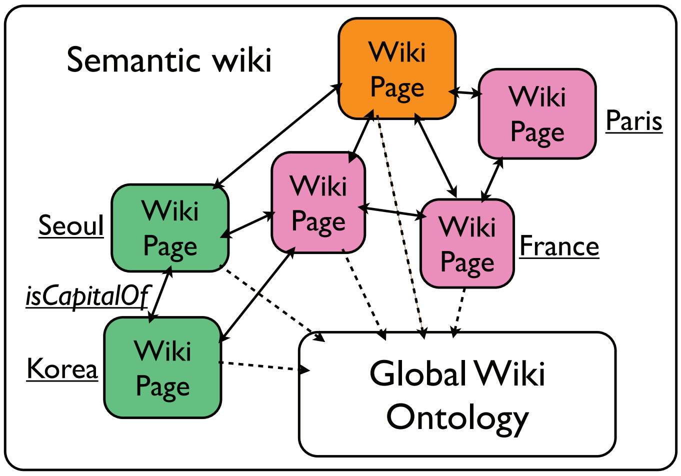

Figure 1: A simple architecture of semantic wikis

While regular wikis have simply structured texts and untyped hyperlinks (such as the links in the hypertext documents), the semantic wikis allow the ability to capture or identify further information (e.g., metadata) about resources, webpages and their relations [Noy et al. 2008]. Thereby, we classify knowledge-based activities within a semantic wiki into four types of knowledge dynamics, as follows;

– Knowledge abstraction (conflicts between generalization and specialization),

– Knowledge refinement (conflicts between accuracy and inaccuracy),

– Knowledge integration (conflicts between mapping and dividing), and

– Knowledge population (conflicts between instantiation and removal).

As another important issue, by the nature of wikis, the information can be very easily propagated on with any wiki pages. Hence, it is important to employ a certain notification system to inform human experts (or administrators) of the conflicted knowledge as quickly as possible [Jung 2009b]. Instead of asking them to determine which knowledge is better (or more righteous), we expect that consensus can select the "better" knowledge to the wiki users.

The outline of this paper is as follows. In the following Sect. 2, we explain the background of consensus theory and how consensus can deal with the conflicts. Sect. 3 addresses a set of knowledge conflicts caused by major patterns of knowledge dynamics through the social interactions on semantic wikis. Sect. 4 explains how to build a consensus decision for a given set of conflicted knowledge. Finally, in Sect. 5, we draw a preliminary conclusion and show our plans for the future.

2 The Roles of Consensus in Solving Conflicts

Consensus has usually been understood as a general agreement in situations where some ones could not come to an agreement on some matters. What then functions consensus should fulfill in solving conflicts in distributed environments and collaborative workspaces? Before the analysis we should consider what is represented by the conflicted content which consists of a number of opinions of the conflicted participations. Let's assume that the opinions included in the conflicted content represent unknown solution of some problems. In [Nguyen and Sobecki 2003], the following two cases have been noted to be taken place:

1. This solution is *independent* from the opinions of the conflicted participants.
2. This solution is *dependent* on the opinions of the conflicted participants.

In the first case, the independence means that the proper solution of the problem exists but it is not known to the conflicted participants. The reasons of this phenomenon may occur from many aspects. Among others, the ignorance of the conflicted participations or the random characteristics of the solution which may make the solution impossible to be calculated in a deterministic way. Thus, the content of the solution is independent from the conflicted content and the conflicted participations for some interest have to "guess" it. In this case their solutions have to reflect the proper solution which is not known if in a valid and complete way.

In the second case, the opinions of the conflicted participants decide the solution. As an example, consider votes at an election. The result of the election is determined only on the basis of these votes.

In both cases there is a need to determine a solution of the problem based on the given opinions. This solution should satisfy the following conditions:

– It should best reflect the given opinions, and
– It should be possible to, in the same degree, reflect the opinions given by the conflicted participants.

The first condition is rather more suitable to the first case described above because the versions given by the conflicted participations reflect the "hidden" and independent solution but it is not known to what the degree is.

The second condition refers to the second case in which the proper solution is dependent on the opinions of the conflicted participants. Thus consensus should not only best represent the opinions but also should reflect them in the same degree (with the assumption that each of them is treated in the same way). It should be an "acceptable compromise," which means that all of the opinions should neither be "harmed" nor "favored". It has been proven that these conditions generally may not be satisfied simultaneously. It has been shown that the choice according to the criterion of minimization of the sum of squared distances between consensus and the profile' elements determines a consensus more uniform than the consensus chosen by minimization of the sum of distances. Therefore, the criterion of the minimal sum of squared distances is also very important. However, the squared distances' minimal sum criterion often generates computationally complex problems (NP-hard problems), which requires working out heuristic algorithms [Danilowicz and Nguyen 2003]. Fig. 2 below presents the scheme of using consensus methods in the cases mentioned above.

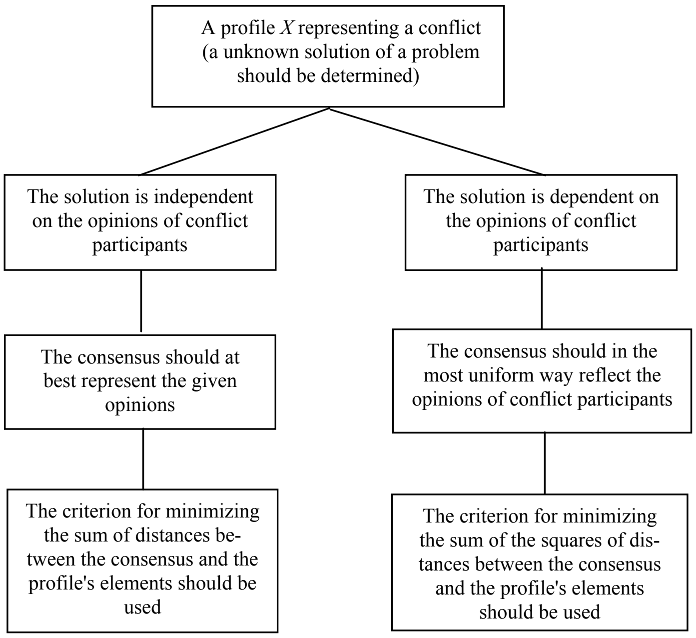

Figure 2: The scheme for using consensus methods

In works [Nguyen 2001;Nguyen 2002;Danilowicz and Nguyen 2003;Nguyen and Sobecki 2003], a methodology for consensus choice and its applications in solving conflicts in distributed systems is presented. It could be partitioned into two parts. In the first part general consensus methods which may effectively serve to solving multi-value conflicts are worked out. For this aim a consensus system, which enables describing multi-value and multi-attribute conflicts, has been defined and analyzed (it is assumed that the attributes of this system are multi-value). Next the structures of tuples representing the contents of conflicts have been defined as distance functions between these tuples. Finally, the consensus and the postulates for its choice have been defined and analyzed. For the defined structures algorithms for consensus determination have been worked out. Besides the problems connected with the susceptibility to consensus and the possibility of consensus modification, have also been investigated.

The second part is concerned with the varied applications of consensus methods in solving of different kinds of conflicts which often occur in distributed systems. The following conflict solutions are presented: reconciling inconsistent temporal data; solving conflicts of the states of agents knowledge about the same real world; determining the representation of expert information; creating a uniform version of a faulty situation in a distributed system; resolving the consistency of replicated data and determining optimal interface for user interaction in universal access systems. An additional element of these works is the description of multiagent systems AGWI aiding information retrieval and reconciling in the Web, for which implementation the platform IBM Aglets is used.

3 Conflict profiling between knowledge on semantic wiki

There are several kinds of social activities, which are collaborative editing, on semantic wikis. During accessing any wiki pages for collaborative editing on semantic wiki, any wiki users can *i*) generate new wiki pages, *ii*) delete the existing wiki pages, and *iii*) modify the existing wiki pages. Through the social activities, we can find out the following knowledge dynamics on semantic wikis, as shown in Table 1.

Thus, we have to think of what kind of conflicts can happen among knowledge published on semantic wikis. Four possible cases (i.e., $\mathcal{A}$, $\mathcal{R}$, $\mathcal{I}$, and $\mathcal{P}$) of knowledge inconsistency by social activities on semantic wikis can be considered.

To do so, we want to formulate the knowledge and personal knowledge space on semantic wiki platform.

Definition 1 (Knowledge). Each knowledge t on semantic wiki is represented as

$$t = \langle k, R, k' \rangle \tag{1}$$

Table 1: Knowledge dynamics on semantic wikis

Semantics	Knowledge dynamics	Description & Example
Knowledge Abstraction $\mathcal{A}$	Generalization	Find a super concept, e.g., "Hominidae is a super concept of Human."
	Specialization	Find a subconcept, e.g., "Chimpanzee is a subconcept of Hominidae."
Knowledge Refinement $\mathcal{R}$	More accurate	Modify a fact more correctly, e.g., "evidence indicates that modern humans originated in Africa about 200,000 years ago"
	More inaccurate	Modify a fact more incorrectly, e.g., "evidence indicates that modern humans originated in Asia about 2,000 years ago"
Knowledge Integration $\mathcal{I}$	Mapping	Find semantic correspondences between knowledge, e.g., "Chimpanzee is same with Human."
	Dividing	Remove semantic correspondences between knowledge, e.g., "Chimpanzee is not same with Human."
Knowledge Population $\mathcal{P}$	Instantiation	Append more instances which are relevant a concept, e.g., "Tiburon is a compact coupe produced by Hyundai."
	Removal	Discard more instances which are irrelevant a concept, e.g., "Tiburon is a compact coupe produced by Honda."

where k and k' are ontological entities in the ontologies, and R is a semantic relationship between k and k'. We can easily understand that it is similar to a RDF triple.

Definition 2 (Personal knowledge space). As i-th user u_i take wiki actions, he can have his own personal knowledge space $\mathcal{T}_i$ with a set of RDF triples.

3.1 Knowledge abstraction

First case is "knowledge abstraction" ($\mathcal{A}$). As a simple example of Fig. 3, while a wiki user A publishes new knowledge $\langle k, Superclass, k' \rangle$, user C asserts another knowledge $\langle k, Subclass, k'' \rangle$. (The knowledge is simply represented as a set of RDF triples. Of cause, knowledge representation depends on the semantic wiki systems. We want to skip to discuss this issue in detail.) If $k' = k''$, two knowledge activities are conflicted with each other. Although this example seems rather simple, as the amount of knowledge is getting increased, it is a very complex problem. Somehow, we need to exploit ontology reasoners (e.g., Pellet[4] and FacT++[5]) to detect them.

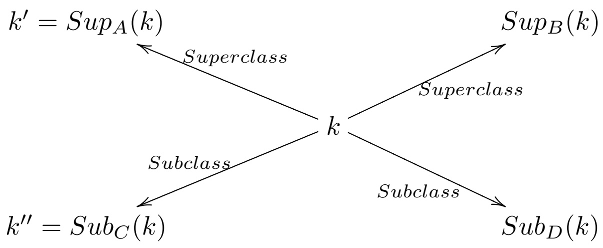

Figure 3: A knowledge conflict on knowledge abstraction

3.2 Knowledge refinement

Second case of knowledge activities that we can be modeled within a semantic wiki is knowledge refinement $\mathcal{R}$. A value v of a certain property P_k of knowledge k can be revised to new value v'.

$$\langle k, P_k, v \rangle \longrightarrow \langle k, P_k, v' \rangle \tag{2}$$

This new value becomes either more precise way or more imprecise way by different users' opinions. For example, assume that k and P_k is "World War II"

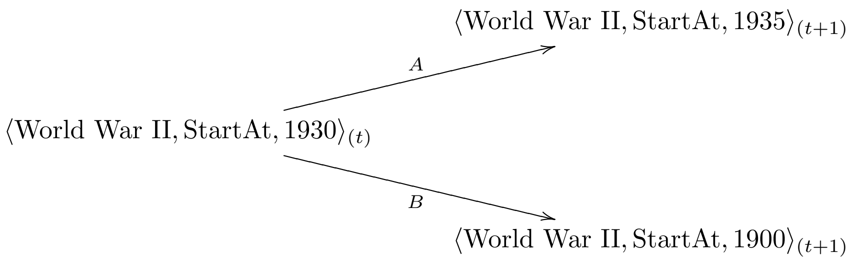

Figure 4: A knowledge conflict on knowledge refinement

and "StartingDate," respectively, as shown in Fig. 4. Two users A and B can

[4] Pellet, http://pellet.owldl.com/
[5] FacT++, http://owl.man.ac.uk/factplusplus/

revise $v = 1900$ at time (t) to $v' = 1935$ and $v'' = 1900$ at $(t+1)$, respectively. In fact, the true value is 1939, so that user A's action is to make the knowledge more precise, but B's action does not.

In the similar context, the rest of knowledge dynamics can be considered, but skipped in this paper.

4 Consensus building on semantic wikis

Knowledge stored and "revised" within a semantic wiki is conflicted with others over time. Here, we want to introduce a novel approach to select a consensus choice as regarding with a global knowledge structure of semantic wiki. The global structure is acquired by two main factors; *i*) majority voting, and *ii*) semantic relevance.

4.1 Majority voting

Basic assumption of majority voting is that a decision selected by more individuals in common should be a consensus decision representing the corresponding group [Schapire et al. 1998;Saaty and Shang 2007]. This is still being employed in democratic decision making, e.g., election.

In this context, the voting action can be replaced with social activities (in Table 1) for a certain knowledge dynamics in a semantic wiki. It means that most common social activities resulting in similar knowledge dynamics should be regarded as major activities for determining the knowledge. For simplicity, we want to mention two main counts of activities, as follows;

1. The number n_W of wiki pages for an identical knowledge dynamics. From the conflicted knowledge (e.g., $\langle k, P, k' \rangle$, $\langle k, P, k'' \rangle$, and $\langle k, P, k''' \rangle$), we can choose $\langle k, P, k' \rangle$ as a consensus choice, when the number of wiki pages for the knowledge is the largest, as shown in Equ. 3.

$$n_W(W_{\langle k,P,k' \rangle}) > n_W(W_{\langle k,P,k'' \rangle}) > n_W(W_{\langle k,P,k''' \rangle}) \tag{3}$$

2. The number of wiki users who take actions on the wiki pages for an identical knowledge dynamics. Because the wiki users can publish more than one wiki page, we want to count the number of wiki users.

There are several problems with this majority voting method. One of the problems is that all activities taken by wiki users can make the same and identical influence. Therefore, we have to consider the weighed voting method by taking into account more additional factors.

4.2 Semantic relevance

To weigh the social activities for knowledge dynamics, we want to measure semantic relevance among the knowledge published on semantic wiki. This issue is important to conduct automated consensus building process. We find out two main information should be exploited to adjust and weigh the number of social activities;

- semantic closeness, and
- expertise of wiki users.

For example, in Equ. 3, assume that knowledge k'' is equivalent to k''' with respect to semantic closeness. We can realize that the $k'' \equiv k'''$ should be selected as a consensus decision.

$$n_W(W_{\langle k,P,k''\rangle}) + n_W(W_{\langle k,P,k'''\rangle}) > n_W(W_{\langle k,P,k'\rangle}) \tag{4}$$

This issue is related to some work on ontology mapping methodologies.

5 Concluding Remarks and Future Work

Semantic Wiki have been regarded as an important Web 2.0 application for implementing distributed knowledge management systems [Jung 2009c]. In conclusion, we have introduced a new issue to deal with knowledge inconsistency on semantic wikis.

One important limitation of this work is that the consensus choice recommended by the proposed method is only based on the knowledge within an isolated semantic wiki. We have to consider an approach to integrate semantic wiki platforms. There are several issues that you have to take into account in near future, as follows;

- Stupidity of crowd
- Subjective opinions
- Knowledge can be changed over time.
- Knowledge entailment

As a testing bed, we want to design an semantic wiki authoring system that automatically annotate terms user enters online by referring to background ontology and consensus choices. We will be able to argue that more informative data can be obtained in the case of an online annotation, by asking users to give more information. By using that information, the system suggests appropriate words the user needs to enter, therefore reducing a change that rubbish knowledge is extracted. Furthermore, with an ontology aligner, semantic inconsistency occurred by collaborative editing is allowed can be more reduced.

We are also planning to implement the system and experiment on it to evaluate whether it operates according to expectation. At the same time, more functionalities are expected to be available on the system as follows. Being equipped with more sophisticated natural language techniques, a user is allowed to enter more complex natural language sentence in convenience.

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