Bridging Different Generation of Web via Exploiting Semantic Social Web Blog Portal

Yuh-Jong Hu and Cheng-Yuan Yu

Emerging Network Technology (ENT) Lab. Dept. of Computer Science
National Chengchi University, Taipei, Taiwan, 11605, (hu, g9302)@cs.nccu.edu.tw

Summary. The goal of this research is to analyze one of the Web 2.0 platforms, e.g., weblog (or blog) and to justify whether it is possible to bridge Web 2.0 ↔ Web 3.0 (or the semantic web) via exploiting semantic social web blog portal. Compared with semantic annotation system using web mining techniques to extract keywords from the WWW, our semantic social web annotation system is based on ontologies derived from folksonomy tagging system to truly reflect the intentions of people on the classification of resources. The blogsphere will be our first experimental example to validate the ontology+folksonomy mashup model. We hope this idea can be applied to the other Web 2.0 platforms, such as wiki, web services. We have built a semantic social web blog portal from the Taiwan's biggest blog service provider (BSP). From this semantic social web blog portal, users are allowed to execute a variety of online semantic social web queries that can not be achieved from other Web 2.0 blog search engines, such as Blogpulse or Technorati. The incentives of having semantic social web annotation for blogsphere were justified and this might shed some light on bridging Web 2.0 ↔ Web 3.0.

1 Introduction

The principles on how to identify one application as "Web 1.0" and another as "Web 2.0" were previously clarified by Tim O'Reilly [21]. The Web x.0 indicates how the x.0 Web generation platform copes with their contents writer and reader's experiences. The bridging of Web generation is defined as the contents created in previous generation of Web can be extracted or accessed in next generation (or vice versa). The bridging of Web 1.0 ↔ Web 2.0 is an ongoing process while the bridging of Web 2.0 ↔ Web 3.0 is not well understood yet. To bridge different Web generation does not necessarily mean the old generation Web will be completely phased out. On the contrary, different Web generation still might be happily live together. Ever since the New York Times reporter John Markoff coined the semantic web as Web 3.0 [16], we were curious whether there existed a feasible bridging mechanism for Web 2.0 ↔ Web 3.0 via integrating respective folksonomy and ontology technologies.

The folksonomy of tagging system for blogs is an example to enable social web services in the Web 2.0. On the other hand, ontologies with their machine understandable metadata aim at achieving Web 3.0 vision. If we can (semi-)automatically mash up the ontology data and query model with the folksonomy tagging system services, then we are in a very good shape toward this paradigm shift. Eventually, this might realize Tim Berners-Lee's semantic web vision for an extension of the current web (Web 1.0 or 2.0) in which information is given well-defined meaning and better enabling computers and people to work in cooperation [2].

In Web 2.0, people interact with each other and address their opinions voluntarily. The challenge of this social web services depends on whether we can collect these huge amount of unstructured public opinions and discover the patterns among them. For the past few years, research issues for the development of annotation system on bridging Web 1.0 $\leftrightarrow$ Web 3.0 were intensively investigated. People were trying to figure it out whether it is possibly to bridge existing Web 1.0 with the future semantic web (or Web 3.0) [7][8][14]. Unfortunately, the progress of this study seems to be very slow because it is a grand challenge to have (semi)-automatic semantic annotation system to create ontology-based semantic annotations from huge amount of unstructured WWW contents.

The social web annotation of bridging Web 2.0 $\leftrightarrow$ Web 3.0 seems to provide another window to deal with this problem. In social web annotation system, people use free tags (or vocabularies) to address their opinions or preferences on the Internet resources, such as bookmarks, videos, blogs, and web pages, without relying on controlled vocabularies. This resolves a hard design problem for the construction of agreeable monolithic heavyweight ontologies. Because it is more explicit and direct on the categorization of resources via free tags from folksonomy than keywords mining from the Web's contents [4]. Tagging systems are still not well studied and have the research potential for further improvement [17]. Are there any other incentives to use free tags social web annotation rather than to use conventional keywords-based annotation? This will be the issue we are interested to investigate further.

Ontologies are top-down approach with hierarchical classification of information sharing and manipulation mechanism while folksonomy is a bottom-up approach using flat indexing to organize and search information through user feedback. When we regard users' free tags as social web annotations, we still might need ontologies to classify these free tags into different taxonomy. Furthermore, ontologies can provide well-defined structure schema to bind entity semantic association together and that was impossible to be realized by the tagging system alone. These entity relationship semantics might exist among tagger, tags, and resources declared implicitly by entity themselves. We propose a blog ontology and a topic ontology to harbor all of these free tags to describe the semantics of entity relationships in the blogspace. We allow users to explicitly enable semantic social web query for tags with their entity semantic relationships to get what they are really interested.

In order to exploit the incentives of bridging different Web generation, we have built a semantic social web blog portal from the biggest blog service provider (BSP) *WRETCH* in Taiwan [1]. We have implemented blog crawlers to collect all of necessary context and content information from this BSP. Three kinds of information sources were collected for this study: semi-structured HTML blog pages, structured XML-based RSS, and users' annotation free tags. The content and context information from these sources were extracted, analyzed, and stored to satisfy user's later semantic query services. Furthermore, we also analyzed the blog information diffusion flow using social network analysis (SNA) to examine the possible patterns in the *WRTECH* BSP [24]. Therefore users are allowed to enable semantic social web query services using a variety of SNA measures in our semantic social web blog portal.

2 Related Work

Several important elements are required to exploit the bridging problem of Web 2.0 $\leftrightarrow$ Web 3.0 to have semantic social web search services. They are annotation, ontology, blog, folksonomy, and SNA. Unfortunately, most of the related studies shown as the followings did not have these comprehensive considerations so they can not have the service capabilities as ours:

- Semantic annotation for ontology+web: The semantic annotation (or bridging) of Web 1.0 $\leftrightarrow$ Web 3.0 were extensively investigated before to support the indexing and retrieval of well-defined semantic information for agents [14][19][22]. The goals of these studies were too ambitious to have any significant progress.
- Semantic tag for ontology+folksonomy: Gruber proposed the mashup of ontology and folksonomy to enable social web ecology on the Internet [10]. The tagOntology was a very primitive study for identifying and formalizing a conceptualization of the activity of tagging.
- Semantic blog for ontology+blog: Semantic blog systems were built to leverage the power of ontology data model so that people can extract all of the implicit semantics from blogs [3][5][13]. But they did not really work for lacking enough amount of real dataset to experiment the system's feasibility.
- Tagging blog for tags+blog: Brooks et al. analyzed the top 350 tags from the Technorati blog search engine and they demonstrated that tags are useful for grouping articles into broad categories but less effective in indicating the particular content of an article [4]. This study did not aim at solving the bridging problem of Web 2.0 $\leftrightarrow$ Web 3.0 either.
- Semantic Web (or Web) as social network: In a semantic social network, a number of electronic information sources including web pages, emails,

[1] http://www.wretch.cc/

FOAF profiles, are extracted and analyzed to acquire their semantic relationships [9][19]. The purposes of these studies were to apply SNA techniques to analyze the ontology-based context information for the semantic web research community.

- Blog as social network: Gruhl et al. studied the dynamics of information propagation through blogspace [11]. Furthermore, the blogspace can be shown as community using SNA model to express its entity social relationships through links, comments, and trackbacks, etc [1][6][15]. But they only addressed pure blog ecosystems.

3 Research Goal

The goal of this research is to construct a semantic social web portal and to exploit the incentives of bridging Web 2.0 $\leftrightarrow$ Web 3.0. The incentives will be justified when we can search information through this semantic social web portal compared with other systems that only provide simple tags (or keywords) search on Web 2.0 or ontology query on Web 3.0. Unless we can extend tags to have corresponding semantic context, the expressive power of tags is limited. In this study, we found that coherent taxonomies of blog articles can emerge from users tagging so relevant customized ontologies can be constructed.

3.1 Social Network Analysis

Social network analysis (SNA) is the quantity study of the relationships between individuals or organization. By quantifying social network structures, we can determine where are the most important nodes in the network [24]. The implications of SNA usage are quite different when we apply SNA to different generation of Web.

- SNA for Web 1.0: The information on Web 1.0 is rather static so people only apply SNA on paper citation network or person relationship network to discover their stable relationships [18].
- SNA for Web 2.0: The nature of information flow on Web 2.0 is dynamic and user oriented. All of the tags, resources, and tagger's profiles on Web 2.0 are dynamically created so the challenge to apply SNA for this platform is how can we timely extract the relationships between taggers with annotated tags and their respective resources to enable effective information search [12].
- SNA for Web 3.0: We are aiming at bridging of Web 2.0 $\leftrightarrow$ Web 3.0. The issues we consider including Web 2.0, Web 3.0, and SNA, are different from pure semantic social network approach shown in [19].

3.2 Blogs as Social Network

Applying SNA model to the blogsphere has revealed interesting findings about how individuals share information and interact socially online. Social relationships can be expressed online as different forms of blogs ties: blogroll links, citation links, and comment links [1]. We observed the *WRETCH* blog communities in terms of important SNA measures, such as indegree/outdegree, closeness/betweenness, and k-cores, to interpret their social implications. The basic idea is that blog article written by important blogger also becomes important itself so we can reinforce the semantic search service capabilities for users to satisfy their interested from this perspective idea.

- Indegree and Outdegree: The higher indegree measure indicates the higher spread of blogger (or article) influence in the blogsphere. The indegree measures of the top 300 bloggers in the *WRETCH* BSP were shown as power law distribution. Contrarily, outdegree measure did not indicate any importance of a blogger in the community and its pattern did not appear as power law distribution either.
- Closeness and Betweenness: The higher closeness (or betweenness) of a blogger means it is in the social network center (or pivoting bridge) so the spread of influences of this blogger is significant in the community. We found that closeness (or betweenness) is similar to indegree but it incurs high computation overhead so we avoid computing this measure in our online information access.
- K-Cores: A k-core is a maximal subgroup in which each blogger (or article) has at least degree k within the subgroup. Thus k-cores measure is effectively to demonstrate a particular subgroup cohesive relationship. The common interests of a community derived from k-cores are important for topic-specific semantic social web query services to discover similar resources from this high cohesion level subgroup.

3.3 Semantic Social Web Query Services

We provide different level of semantic query services in our semantic social web portal: basic semantic query services, advanced semantic query services, and semantic social web query services:

- Basic semantic query services: The initial contribution of this article is to combine the tagging system's folksonomy with ontology to achieve basic semantic query services. This service provides people or agents to effectively access clustering of blog information through tags and related tags.
- Advanced semantic query services via ontology+tags: In this service, user enables conceptual semantic query services with relevant tags. The conceptual semantics can be defined as a channel declared from ontology with relevant tags in the tags cloud. In other words, the search space for this

service is classified and focused so the search time is reduced and accuracy is also improved.

- Semantic social web query services via SNA+ontology+tags: In a blog ontology, we define properties to describe the relationships between bloggers, tags, and articles. Additionally, the important SNA measurement attributes are also declared in a blog ontology. Therefore, we can leverage the power of SNA measures from dynamically generated relations through blogger's daily activity events to enhance this service. We propose two possible scenarios for this service that could justify our hypothesis [2]:
  1. Scenario One: I would like to search authors and their blog articles with "cuisine" tag paired with "restaurant" keyword in the associated title or content of the article collected from the entire blog community. Furthermore, please present these authors' names and their associated titles of article in a decreasing order of authors' indegree measures:

```
prefix blog: <http://blog.nccucs.org/blog.owl#>
prefix rdf: <http://www.w3.org/19999/02/22-rdf-syntax-ns#>

SELECT DISTINCT ?Author ?Article
WHERE
{?Article rdf:type blog:Article
 ?Article blog:has_articleTag blog:cuisine
 ?Article blog:has_author ?Person
 ?Person blog:person_ID ?Author
 ?Person blog:person_indegree ?Popularity
 FILTER {regex(?TitleOfArticle, "restaurant") ||
 regex(?ContentOfArticle, "restaurant"))}
  }
ORDER BY DESC (?Popularity)
```

  2. Scenario Two: I would like to search blogger names and their articles from the cuisine channel for those of whom are known by authors presented in scenario one. Furthermore, please present these blogger names and their associated titles of article in a decreasing order of authors' indegree measures:

```
prefix blog: <http://blog.nccucs.org/blog.owl#>
prefix rdf: <http://www.w3.org/19999/02/22-rdf-syntax-ns#>

SELECT DISTINCT ?Author ?Friend ?TitleOfFriendArticle
WHERE
{........
 Codes Same As Scenario One
 ........
?Person blog:has_knows ?friend
?friend blog:person_ID ?Friend
```

[2] The embedded codes are shown as SPARQL query language but users do not require to have knowledge of SPARQL syntax in order to execute semantic social web query services.

```
?FriendArticle blog:has_author ?friend
?FriendArticle blog:has_channel blog:CuisineChannel
?FriendArticle blog:article_title ?TitleOfFriendArticle
?FriendArticle blog:article_description ?ContentOfFriendArticle
FILTER {regex(?TitleOfFriendArticle, "restaurant") ||
regex(?ContentOfFriendArticle, "restaurant"))}
  }
ORDER BY DESC (?Popularity)
```

Compared with Technorati [3], it only provides limited independent search services for user from his input blog posts, tags or directory where user can not have semantic (social web) query services for any possible relevant outputs using his previous search results. So user can not search the most influential blogger friend's articles or he can not search high similarity articles from those bloggers with certain higher level of SNA indegree measures.

4 Semantic Social Web Blog Portal

In this research, a semantic social web blog portal was constructed to exploit the incentives of bridging Web 2.0 ↔ Web 3.0 where users could enjoy semantic social web query services on this portal. This portal structure is a layer schema shown as Fig. 1. In the bottom layer, crawler collects semi-structured HTML blog pages, structured RSS or FOAF context information, and free tags. Both RSS 1.0 and FOAF ontology schema are based on RDF(S) so their semantics are explicitly specified. Then, we extract and store the crawler's collected information in our local repository. In the ontology and tags annotation layer, we mash up the blog ontology and the topic ontology with collected free tags from social web annotation by folksonomy. The blog information diffusion patterns will be analyzed by using SNA software Pajek to derive important SNA measures, such as indegree, outdegree, closeness, betweenness, and k-cores, etc[20]. Finally, we provide semantic social web query services for users to satisfy his best interested.

4.1 Data Collection

WRETCH is the biggest BSP platform in Taiwan with more than 2 million registered bloggers so huge amount of living and recreation information were available for our experiment on the research issues of bridging of Web 2.0 ↔ Web 3.0. After filtering out insignificant noise data, the number of useful bloggers information samples in our analysis is around 108,518 bloggers. The period of time for our data collection was one month spanned from Sep. 09 2006 to Oct. 09 2006.

[3] http://technorati.com/

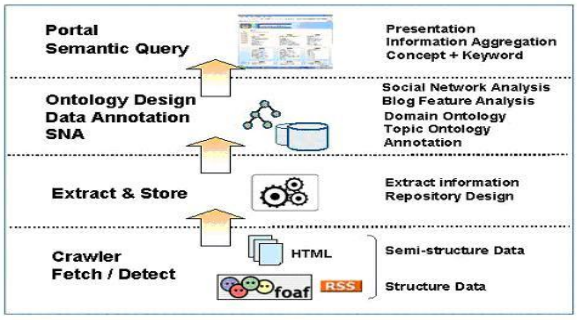

Fig. 1. A layer conceptual schema for construction a semantic social web blog portal

4.2 Data Analysis

In our mashup model, the free tags collected from users are usually 2-word or 3-word Chinese words (or characters) to annotate their daily real life's living activities. The scan and parsing processes of Chinese characters are different from the English free tags. There are no spaces between Chinese characters so we use regular expression to extract the meaningful high frequency 2-word or 3-word tags as our folksonomy final consensus social web annotations. With no surprise, the distribution for the top 300 tags is shown as power law that is similar to lots of other studies [12].

Initially the tags addressed by blogger in the *WRETCH* only imply that the taxonomy of blog articles can be classified as one of 16 broad channel categories, such as living, cuisine, music, drama, travel, etc. When we carefully examined the tags, we surprisingly found that those of significant 54,824 bloggers (approximate to 50% of 108518 bloggers) with their addressed 1046 tags were converging to some of high frequent 521 2-word and 197 3-word tags. And these tags were evenly distributed to our 16 broad channel categories. This demonstrates that the social consensus opinions are possibly formulated in terms of folksonomy tagging. We are expecting a more powerful folksonomy annotation scheme can be realized in a near future as long as we have more versatile ontology+tag structure.

4.3 Blog Ontology

The blog ontology describes the profile of a blogger with his blog articles (see Fig. 2). The profile of a blogger is very similar to FOAF that defines a blogger's personal ID, friend relationship, and mbox, etc. The attributes of each blog article include article title, date, feedback comment, and trackback, etc. In addition, the SNA index measure is defined as one of a blogger's profile attributes. Therefore, SNA analysis capabilities were embedded into blog ontology to serve our SNA+ontology+tag semantic social web query services.

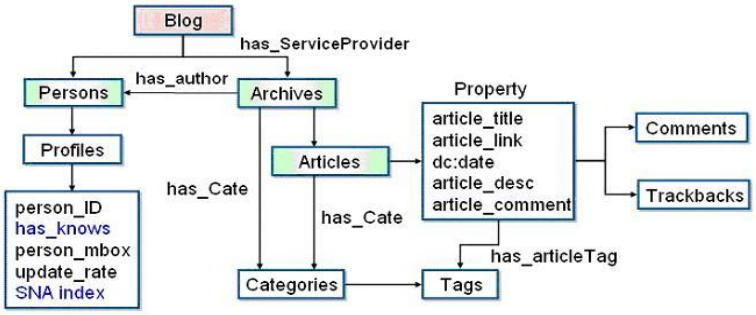

Fig. 2. The blog ontology describes the profile of a blogger with his blog articles

The blog ontology is declared as OWL ontology language, where property can be classified as two types: object property and datatype property. For example, the domain and range of the *has_author* object property are declared respectively as *Archives* class and *Persons* class, where *Archives* is the superclass of both *Articles* and *Categories* classes. Based on this object property, we describe the abstract relationships between a blogger and his blog articles. The datatype property allows us to define a concrete XML-Schema attributes, such as SNA index, for $Profiles$ subclass for further arithmetic operations.

4.4 Topic Ontology

The blog articles in the *WRETCH* were classified into one of the 16 broad topic channels based on their attachment tags. The design processes of broad classification of blog article channel will be shown as three steps (see Fig. 3): First, we subjectively declare 16 broad topic channel as instances under their superclass *Channel*. The 16 broad topic channels are life, cuisine, music, etc, where *Channel* and *Tag* are subclasses of *Category* superclass in the topic ontology. Second, a set of possible tags we consider for each channel are those with higher frequent 2-word or 3-word tags presented by users. Third, if a new blog article has attachment tags that match at least one of higher frequent tags in the set declared for one of a broad topic channels, then this new blog article will be automatically classified to that channel.

4.5 Social Web Annotation

The goal of Web 1.0 annotation is to create a well-defined and computer understandable structure knowledge base e.g., ontologies, whose content mirrors that of the WWW. The biggest challenge for bridging of Web 1.0 $\leftrightarrow$ Web 3.0 is the terms mining from the Web can not be automatically and exactly fitted into the ontology that defines the vocabularies for the target knowledge base

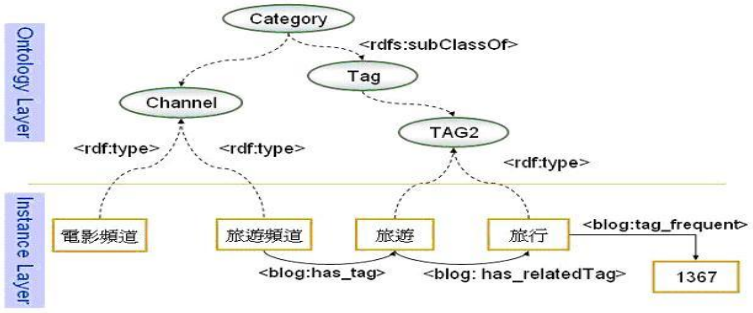

Fig. 3. Topic ontology - Channel and Tag are subclasses of Category so we can automatically mash up ontology data and search model with the folksonomy tagging system services

[7]. Therefore, most of the semi-automatic annotation systems usually apply machine learning techniques to recognize new class instances and relation instances mining from the Web. In the folksonomy annotation for bridging of Web 2.0 ↔ Web 3.0, the granularity of class instances and relation instances are restricted to the resource targets that can be clearly tagged by folksonomy. The folksonomy of social web annotations are explicitly collected from tags or implicitly initiated by users from their activity events. These explicit tags and implicit events are precise terms that describe the instances and relations corresponding to our ontology schema.

The objective and granularity of tags for describing instances and relations that corresponding to the target resources can be further refined if we have more elaborate social web annotation system in the future. As semantic wikipedia in [23], we might allow users to enable semantic tags similar to *typed links* and *attributes* two kinds of property for describing corresponding abstract relationship and concrete attributes within/between entity. Then various levels of reasoning for discovery of semantic relationship among taggers, tags, and resources can be achieved.

Our semantic social web annotation system takes three inputs either collected by web crawler or computed by local software agent. The first is HTML blog pages with hyperlinks , comments, and trackbacks context. The second is RSS context with permalink, publication data, author, and description attributes. The third is tags, channel, and SNA indices computed via agents. They are all stored in a local database and to be mashed up for afterward semantic social web query services (see Fig. 4).

4.6 Semantic Social Web Blog Portal Testbed

An online semantic social web blog portal testbed (see Fig. 5) was constructed based on previous layer conceptual schema (see Fig. 1) to experiment our

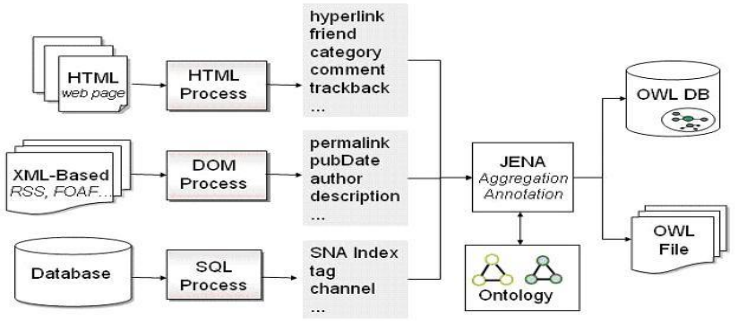

Fig. 4. Semantic social web annotation from three inputs of data sources for mashup purpose to enable semantic social web services

mashup model. The crawler collects all of the necessary context information from the *WRETCH BSP*. The context information shown in Figure 4 were processed to create relevant class and relation instances defined in the blog ontology and the topic ontology (see section 4.3 and section 4.4). This semantic social web annotations for folksonomy were automatically generated except in the bootstrapping stage where we have to analyze the blog site dependent context to specify our initial lightweight ontology schema. A variety of important SNA measures, such as indegree, closeness, betweenness, and k-core, were computed via Pajek SNA software. [4] to provide semantic social web query services shown in section 3.3.

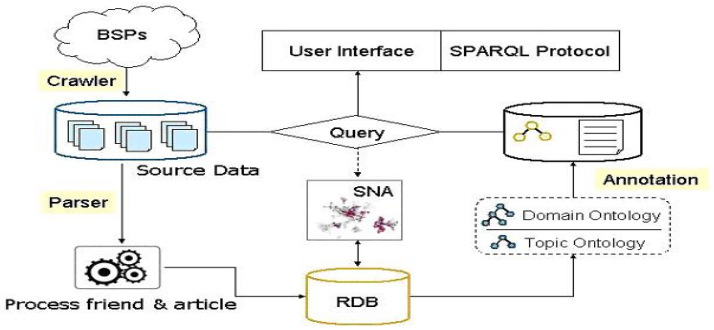

Fig. 5. The semantic social web blog portal to experiment our Web 2.0 ↔ Web 3.0 bridging model

[4] http://valado.fmf.uni-lj.si/pub/networks/pajek/

5 Conclusions

The goal of this research is to exploit the incentives of bridging Web 2.0 ↔ Web 3.0 via building a semantic social web blog portal. On the Web 2.0, we usually use tagging system to label all kinds of Internet resources. Web 2.0 is a folksonomy social web, where we effectively search what we are desirous of information through tags. The tagging system enables the wisdom of crowds and surprisingly social consensus can be derived from these voluminous and unregular tags. Contrarily, Web 3.0 (semantic web) is aiming at using ontology for effectively information search under taxonomy classification. We have justified that the concepts of folksonomy and taxonomy can be mashed up together to achieve semantic social web query services via bridging of Web 2.0 ↔ Web 3.0. That allows us to leverage search capabilities from both bottom-up folksonomy indexing and top-down taxonomy ontology two techniques.

Conceptually, tags in the tagging system are equivalent to terms mining from the WWW in the conventional annotation system. The terms mining from the Web are usually defined as instances that are related to a particular class or property in ontology. But tags from the folksonomy are usually instances related to a particular class. Therefore, all of the relation instances have to be created dynamically following the ontology schema. The relation instances that describe the relationships between bloggers, tags, and blogs, are generated from blogger's daily activity events based on our blog ontology. Although users can effectively search information by folksonomy tagging system in Web 2.0, we still have the capacity to improve search capability via social network analysis (SNA). A real SNA-based semantic social web query services could possibly encourage users to find out what they are really interested in because well-organized topic-specific ranking contents are ready for user to enjoy.

Acknowledgements

This research was partially supported by Taiwan National Science Council (NSC), Under Grant No. NSC 95-2221-E-004-001-MY3.

References

1. Ali-Hasan, N. and Adamic, L. A., Expressing Social Relationships on the Blog through Links and Comments. `http://www-personal.umich.edu/~ladamic`.
2. Berners-Lee, Tim, et al. (2001). The Semantic Web. Scientific American, May.
3. Bojars, U. , Breslin, J. G., and Moller, K. (2006). Using Semantics to Enhance the Blogging Experience. Proceedings of 3rd European Semantic Web Conference (ESWC 2006), 679-696.

4. Brooks, C. H. and Montanez, V. (2006). Improve Annotation of the Blogosphere via Autotagging and Hierarchical Clustering. WWW 2006, May 23-26, Edinburgh, Scotland.
5. Cayzer, S. (2004). Semantic Blogging: Spreading the Semantic Web Meme. XML Europe, Apr. 18-21, Amsterdam.
6. Chin, A. and Chignell, M. (2006). A Social Hypertext Model for Finding Community in Blogs. HyperText (HT'06), Aug. 22-25, Odense, Denmark.
7. Craven, M., et al. (2000). Learning to construct knowledge bases from the World Wide Web. Artificial Intelligence, 11, Elsevier, 69-113.
8. Dill, S., et al. (2003). A case for automated large-scale semantic annotation. Journal of Web Semantics, 1(1), 115V132.
9. Ding, L., et al. (2005). How the Semantic Web is Being Used: An Analysis of FOAF Documents. Proceedings of the 38th Hawaii International Conference on System Sciences.
10. Gruber, T. Ontology of Folksonomy: A Mash-Up of Apples and Oranges. `http://tombruber.org`.
11. Gruhl, D. et al. (2004). Information Diffusion Through Blogspace. WWW 2004, May 17-22, New York, USA.
12. Hotho, A. et al. (2006). Information Retrieval in Folksonomies: Search and Ranking. Proceedings of 3rd European Semantic Web Conference (ESWC 2006).
13. Karger, D. R. and Quan, D. (2004). What Would It Mean to Blog on the Semantic Web?. The Third International Semantic Web Conference(ISWC 2004), Springer-Verlag.
14. Kiryakov, A., Popov, B., and Terziev, I. (2004). Semantic Annotation, Indexing, and Retrieval. Journal of Web Semantics, 2(1), 49-79.
15. Kumar, R., Novak, J., Raghavan, P., and A. Tomkin. (2004). Structure and evolution of blogspace. Comm. of the ACM, 47(12).
16. Markoff, J. (2006). Entrepreneurs See a Web Guided by Common Sense. New York Times, Nov. 12, `http://www.nytimes.com`.
17. Marlow, C. et al. (2006). HT06, Tagging Paper, Taxonomy, Flickr, Academic Article, ToRead, HyperText (HT'06), Aug. 22-25, Odense, Denmark.
18. Matsuo, Y., Mori, J., and Hamasaki, M. (2006). POLYPHONET: An Advanced Social Network Extraction System from the Web. WWW 2006, May 23-26, Edinburgh, Scotland.
19. Mika, P. (2005). Flink: Semantic Web Technology for the Extraction and Analysis of Social Networks. Journal of Web Semantics, 3(2-3), 211-223.
20. Nooy, de W., Mrvar, A. and Batagelj, V. (2006). Exploratory Social Network Analysis with Pajek. Cambridge University Press.
21. O'Reilly, Tim. (2005). What is Web 2.0: Design Patterns and Business Models for the Next Generation of Software. `http://www.oreillynet.com/lpt/a/6228`.
22. Uren, V., et al. (2006). Semantic annotation for knowledge management: Requirements and a survey of the state of the art. Journal of Web Semantics, 4(1), 14-28.
23. Völkel, M., et al. (2006). Semantic Wikipedia. WWW 2006, May 23-26, Edinburgh, Scotland.
24. Wasserman, S. and Faust, K. (1994). Social Network Analysis: Methods and Applications. Cambridge University Press.