ICIC Express Letters
Volume **10**, Number **3**, March **2016**

 ISSN 1881-803X
pp. 547–553

RECOMMENDATION USING ANALYSIS OF SEMANTIC SOCIAL NETWORK IN SOCIAL NETWORK SERVICES

Sangun Park[1] and Juyoung Kang[2,*]

[1]Department of Management Information System
Kyonggi University
Yeongtong-gu, Suwon 442-760, Korea
supark@kgu.ac.kr

[2]Department of e-Business
Ajou University
206 Worldcup-ro Yeongtong-gu, Suwon 443-749, Korea
*Corresponding author: jykang@ajou.ac.kr

Received August 2015; accepted October 2015

Abstract. *As Social Network Services became one of the most successful Web-based businesses, recommendation using the social network also became actively utilized to attract and retain customers. One of the current research trends of recommendation is the use of various relationships amongst customers in order to increase the possibility of enhanced recommendation. This paper suggests a semantic social network that represents the various relationships between customers and products through a semantic graph, and a method that generates recommendation rules through semantic social network mining over the semantic graph.*
Keywords: SNS, Recommendation, Semantic graph

1. **Introduction.** Social network services (SNSs) are one of the most successful Web-based businesses where a lot of service is provided, through which many companies utilize as a marketing channel [1]. Recommendation can be used as one of the tools to attract new customers and retain them in SNSs. As it is more likely to provide enhanced recommendation by using the relationships among customers compared to traditional collaborative filtering (CF), there are increasing research works for using the relationships in SNSs [2-4].

CF, one of the popular recommendation methods, recommends unpurchased items from neighbors' purchased items based on the assumption that the customers having similar buying patterns (called neighbors) are likely to have similar taste on choosing items [5-7]. Meanwhile, social filtering (SF) tends to use social networks among customers in order to make neighbors for recommendation in addition to traditional CF. One of SF's major issues is whether this brings better results than CF by using friend relationships of social network [8-10]. Previous research on SF shows that customers tend to prefer the products that friends like or introduce. Moreover, methods using SF or SF mixed with CF show better performance than those only using CF [11-13].

However, current works tend to use simple limited relationships between customers because it is not easy to represent and consider all the relationships at the same time. We expect that our research can significantly enhance recommendation by representing and using various explicit and implicit relationships in SNSs. Therefore, we suggest a new recommendation framework, generating neighbor identification rules by using the relationships, consisting of recommendation and neighbor identification processes. Moreover, we utilize Semantic Web technologies and network mining algorithms in the recommendation process by representing the relationships with a semantic social network.

This paper is organized as follows. In Section 2, we review the previous studies about recommendation methods such as CF and SF. Section 3 presents the issues of our research and resolutions for them, and Section 4 describes our recommendation framework. Conclusions including contributions and limitations are presented in Section 5.

2. **Literature Review.** SNSs are defined as "web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system" by Ellison and Boyd [1]. To state a few, Cyworld, Skyblog, LinkedIn, MySpace, Last.fm, Flickr, Facebook, YouTube, and Twitter are very popular SNSs, on which a user can build a social network by adding friends. This social network can be represented with a graph. Therefore, it is possible to apply various graph theories for recommendation. Moreover, implicit information from social networks, as well as explicit social information from friendships, can also be obtained and represented with graphs. For example, Cantador & Castells [14] spread user preferences on multi-layered semantic social networks, in which the components were represented with Semantic Web standards such as RDF and OWL to analyze the semantic social network.

Recent studies defined social filtering (SF) as the recommendation technique that uses explicit or implicit social network information from community networks or affinity networks [8]. Most of the studies on SF aimed to improve recommendation tools by using social information [11,12], and showed that SF outperforms traditional CF in the used scenarios. As aforementioned, a social network naturally has the characteristics of a graph, which makes graph analysis methods in SF more powerful than CF. For example, some studies use centrality, cliques and k-cores of network theories instead of traditional similarity measures between customers of CF to identify neighbors. These studies paid attention to the fact that customer relationships in social networks make graphs, again differing from CF methods [14-17]. Konstas et al. [16] recommended music tracks by using the framework of Random Walk with Restarts (RWR) in Last.fm, an existing special-purpose SNS. Further, Huang et al. [15] suggested recommendation that uses spreading-activation. The algorithm suggested in the paper traverses consumer-product graph from the target consumer, and calculates whether to recommend each product by using the activation levels of the node.

Even though some studies have already used graph theories for recommendation in SNSs, there are still many possibilities to improve them. Firstly, we can represent various explicit and implicit relationships with semantic social network. Secondly, we can apply semantic technologies for a more in-depth analysis. Lastly, we can develop a new recommendation method based on them.

3. **Issues of Recommendation on Social Network Services.** This chapter shows the issues that should be considered in the development of recommendation system on SNSs. Moreover, it shows the required tasks capable of solving the suggested issues. The tasks will be considered in the design of our framework shown in Chapter 4. That is, the purpose of this chapter is to explain which issues we will consider and how they would be handled in the design of the proposed framework.

3.1. **The necessity of a novel approach.** As shown in recent studies discussed in Section 1, the use of data inherent in SNSs is necessary to make recommendations in SNSs. However, most of the studies use just simple relationships such as friendship. There are various explicit and implicit relationships among members in SNSs. It is expected to enhance recommendation methods if we can fully use the relationships. Furthermore, we can exploit the relationships between the customers, services and objects in SNSs. We expect that the recommendation using those various types of relationships could be

an important service in SNSs [17-19]. Therefore, we established the need for a novel approach using formal and systematic methods of the Semantic Web, which can represent and interpret these various relationships.

3.2. **The representation and use of the inherent characteristics of SNSs.** Social networks can be represented with graphs by expressing the relationships among customers and objects including services with different links [15,16]. However, we need a formal standard representation of the graphs in order to process them. Indeed, the objective of Semantic Web is to represent Web resources with semantic graphs and make software understand and automatically process them [20]. One of its most important elements is ontology, which is defined as an explicit specification of a conceptualization [21]. Ontology is inherently a semantic graph that represents shared resources with explicit and formal standards such as RDF and OWL, and it can support automatic understanding and processing by software. Therefore, Semantic Web technologies such as formal representation and inference can represent the various relationships with sematic graphs. Thus, we would need to investigate how to represent the social network information based on description logic, a logical formalism of Semantic Web. Therefore, we expect that it is essential to develop a semantic social network that represents all the various links and supports processing them in one linked graph [14].

3.3. **The use of Semantic Web technologies in recommendation.** The next issue is about using semantic technologies in recommendation algorithm. This issue is closely related to the previous one; sine representation of the relationships of SNSs with a semantic graph requires every consecutive step to apply Semantic Web technologies. Meanwhile, our approach generates neighbor identification rules by using network mining on the semantic social network. In this step, we will develop a decision tree learning algorithm that produces the rules. The algorithm will be applied to the semantic social network in the form of a semantic graph that links connecting resources based on description logic. Thus, we need to customize classification criteria for the algorithm based on Semantic Web technologies.

Once the neighbor identification rules are generated, we can apply them to identify neighbors of a specific customer. In this step, we suggest conducting logical inference, one of the Semantic Web technologies.

3.4. **Proposed solutions to the issues.** The following section proposes solutions to the suggested issues. Firstly, we will suggest a recommendation framework using the semantic social network, which identifies the required components and the recommendation process in SNSs. The framework comprises building a semantic social network, generating neighbor identification rules through network mining, and executing recommendations according to the established rules. Secondly, we will develop an ontology for the social semantic network in order to provide approaches that effectively represent the relationships between customers and products. Thirdly, we will construct a semantic social network mining method by using the knowledge represented with the ontology. The objective of the mining algorithm is to discover rules for neighbors who previously bought the same products. We will develop a description logic based decision-tree learning algorithm that works on our social semantic network. Lastly, we will apply the generated rules to recommend products. The first step is to extract neighbors with the rules and the next step is to recommend products with the neighbors that is very similar to CF.

4. **Recommendation Framework on Social Network.** This chapter describes our suggested recommendation process using semantic social network and the procedure of generating neighbor identification rules by using semantic social network mining. Our framework is designed to apply the solutions proposed in Section 3.4. For example, it

builds semantic social network ontology of the first solution to represent various relationships. Moreover, it includes a network mining algorithm which exploits Semantic Web technologies. Detailed elements of the framework will be explained in the following sections.

4.1. **Overall recommendation process.** Figure 1 shows our overall process of recommendation using the social semantic network. There are five steps in our approach.

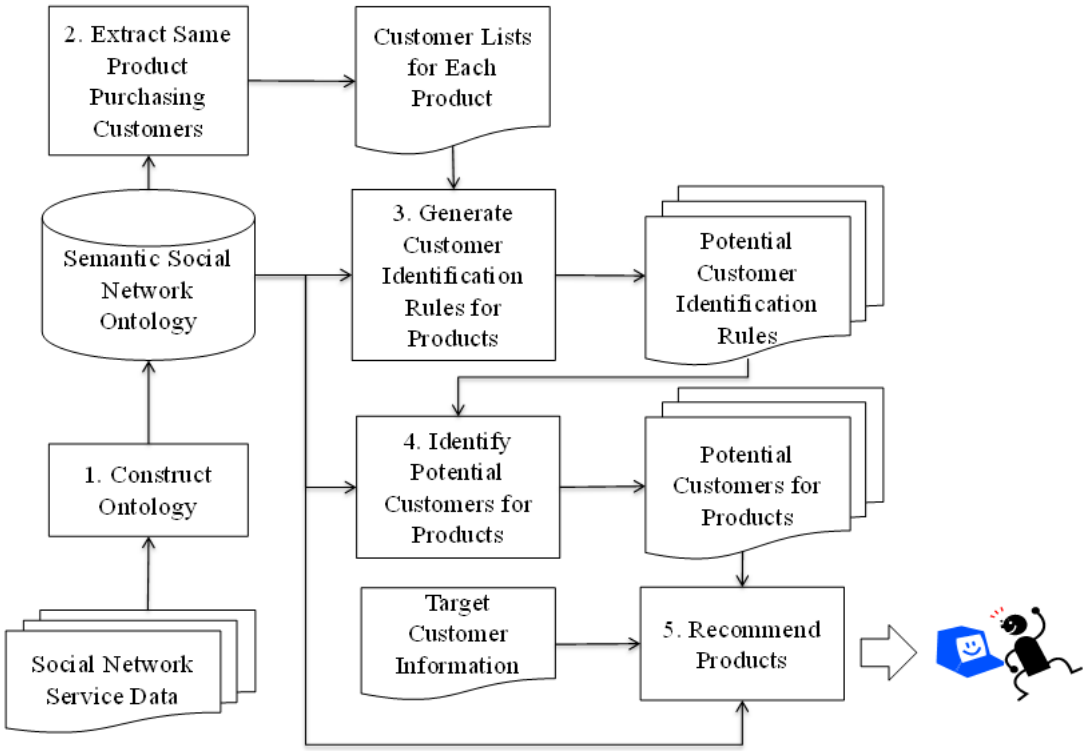

FIGURE 1. Framework of recommendation using semantic social network

In the first step, semantic social network ontology is built by acquiring data from SNSs and analyzing various relationships between customers and products from the data. In this step, we develop a description logic based method of knowledge representation for the information. The knowledge based on the ontology includes all data from the customers' purchase. One of the assumptions of our framework is that SNSs such as Last.FM provide our suggested recommendation, so they need a conversion program that extracts triples of the semantic social network from the SNS data. In case of developing a system outside SNSs, we can use public data set or API provided by SNSs such as Last.fm dataset and Last.fm API [19].

In the second step, we extract customers who purchased the same product or product group from the semantic social ontology to get customer list for each product or product group. Determining the analysis unit, which could be either a specific product or a product group of similar products, will be an issue in this step.

The third step is generating potential customer identification rules from the semantic social network from the customer lists with same purchases. This step is the core of our approach, and the more detailed procedure will be described at the next section. Decision tree learning algorithm based on description logic will be used in the procedure. This method differs from the traditional decision tree learning algorithm since it operates on a semantic graph instead of a database. Moreover, the graph has various logical links of description logic. The objective of the algorithm is to discover the implicit rules for the customers purchasing the same product or product group from a semantic social network.

Those can explain or give hints why they purchase the same products. Therefore, we categorize the algorithm as network mining. The result of the step is decision tree for each customer group of a product or product category. The trees show the rules for customers with same purchases through various relationships among customers and products.

The fourth step identifies potential customers who satisfy the identification rules by using the rules generated from the previous step. In this step, we use ontology inference in order to decide potential customers of each product or product category because the identification rules of the decision trees are based on description logic. Customers who satisfy the rules of each decision tree will be retrieved and we can get potential customer lists of all products.

Lastly, we recommend products to a target customer. By using the customer lists retrieved in the previous step, we can find out products not yet purchased by the target customer from the potential customer lists of each product.

4.2. **Identifying potential customers through network mining.** Figure 2 shows the steps of generating the common relationships of customers who have a tendency of buying the same product or product group. A list of customers who bought a same product is acquired from semantic social network ontology, and we set a target class and a target property from the list. In our setting, the target class includes all customers and the target property is whether each customer bought the product or not.

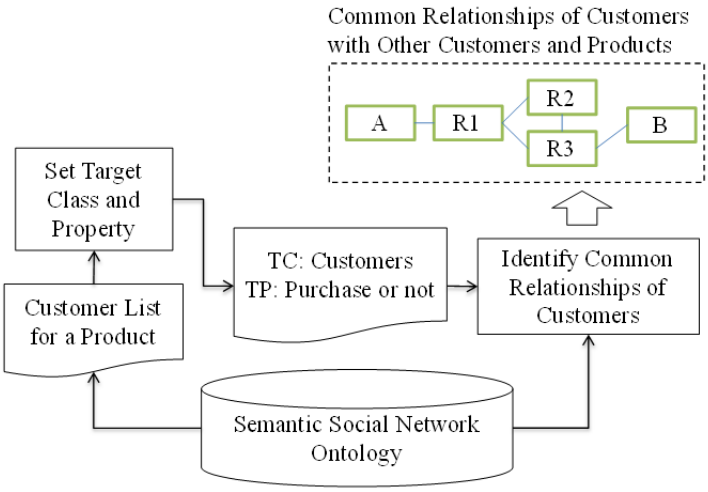

FIGURE 2. Identification of relations between customers buying the same products from semantic social network ontology

Afterward, the algorithm traverses all the relationships of semantic social network. There could be various relationships among customers and products, so our network mining algorithm finds the common relationships of the customers who bought the same product that best explains the customers. The common relationships are used for rules to identify potential customers for the product, and those have a form of a decision tree. The resources of the semantic social network are connected with various relationships between resources such as customer-to-customer, customer-to-product, and product-to-product in addition to relationships of classes of each resource and upper structures of the classes. In order to extract the rules, we will develop a decision tree learning algorithm that generates decision trees over a semantic social network that is a semantic graph.

The first step of the development is designing representation of a semantic graph based on description logic. In order to apply decision tree learning algorithm to the semantic graph, the classification criteria (called refinement) of a decision tree should be formally defined based on description logic.

The general decision tree learning algorithm uses both variable and value type data and represents classification criteria with simple signs such as an equality sign and an inequality sign. However, resources and properties between resources are much more complex than the simple variable-value types. Moreover, the relationships between resources can be overlapped such as existential and universal quantifiers. Therefore, we essentially need to define new refinements of decision tree based on description logic.

The refinements of decision trees are defined based on the structure of instance related graph data. The information of graph data varies from the type of the instance to object property that shows the relations between instances. The following shows the representative types of possible refinements:

- Instance type information: refinements are defined based on the class to which instances belong to.
- Instance property information: refinements are defined based on the relation that connects instances.
- Instance literal information: refinements are defined based on the literal value of instances that are similar to variable-value type refinements.

In addition to the refinements above, more refinements based on description logic should be defined, which can be exploited in a new description logic based decision tree learning algorithm that can analyze semantic social networks.

The next step is to develop an algorithm to discover the rules for customers who bought the same products with decision tree learning. Once the new refinements are defined, the algorithm itself is similar to the traditional one. It traverses the semantic social network to find next candidate relationships and resources to explore until it succeeds in classifying the customers who bought the product and the others with a predefined threshold. The resulting decision tree can be easily converted to a set of rules.

5. **Conclusions.**

Recommendation is recently becoming an effective marketing tool of SNSs. New approaches using graph-based analysis are getting attention because social network is a kind of graph which shows the relationships between customers with friendship. However, most works are just using simple limited relationships between customers even though there are a lot of various explicit and implicit relationships.

Thus, we propose a new recommendation framework, using an approach that represents the diverse relationships of the semantic social network, and consisting of potential customer identification processes and recommendation that utilize Semantic Web technologies as well as network mining algorithms. The network mining algorithm is suggested based on a decision tree learning algorithm that is newly developed by defining new refinements based on description logic.

Further, there are issues about proving our framework in a practical way to resolve in future work. Firstly, we need to fully implement the decision tree learning algorithm customized for recommendation in SNSs. Theoretically, the algorithm can be applied to SNSs, but it further needs to be tested and verified. Secondly, the ontology should be implemented by collecting real data from SNSs. Once we choose a domain, we can collect a public data set by using API or from public sources such as Last.fm. It is possible to show that the algorithm works with sample data, but a larger data pool is required to effectively verify the functionality of the algorithm. Lastly, the algorithm needs to be compared with the traditional CF methods to demonstrate that it indeed enhances the recommendation performance.

We expect the suggested framework to be faster than CF because it uses pre-generated rules for recommendation, meaning that it is more easily applied to SNSs. Moreover, the rules can explain the customer groups that buy similar products. Secondly, we expect that our framework shows a new recommendation approach that uses various relationships

with the Semantic Web. The framework is expected to be applied in various domains, not necessarily restricted to SNSs.

Acknowledgment. This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2014S1A2A1A01024915).

REFERENCES

[1] N. B. Ellison and D. M. Boyd, Social network sites: Definition, history, and scholarship, *Journal of Computer-Mediated Communication*, vol.13, no.1, pp.210-230, 2007.
[2] P. Domingos, Mining social networks for viral marketing, *IEEE Intelligent Systems*, vol.20, no.1, pp.80-82, 2005.
[3] J. H. Park, Y. H. Cho and J. K. Kim, Social network: A novel approach to new customer recommendations, *Journal of Intelligent Information Systems*, vol.15, no.1, pp.123-140, 2009.
[4] X. Su and T. M. Khoshgoftaar, A survey of collaborative filtering techniques, *Advances in Artificial Intelligence*, vol.2009, no.1, pp.1-19, 2009.
[5] Z. Huang, X. Li and H. Chen, Link prediction approach to collaborative filtering, *Proc. of the 5th ACM/IEEE-CS Joint Conference on Digital Libraries*, Denver, CO, USA, 2005.
[6] H. Kautz, B. Selman and M. Shah, Referral web: Combining social networks and collaborative filtering, *Communications of the ACM*, vol.40, no.3, pp.63-65, 1997.
[7] F. Liu and H. J. Lee, Use of social network information to enhance collaborative filtering performance, *Expert Systems with Applications*, vol.37, no.7, pp.4772-4778, 2010.
[8] J. Bobadilla, F. Ortega, A. Hernando and A. Gutiérrez, Recommender systems survey, *Knowledge-Based Systems*, vol.46, pp.109-132, 2013.
[9] S. Thay, I. Ha and G.-S. Jo, Collaborative filtering method based on user's behavior in social network, *Proc. of Korea Intelligent Information System Society*, 2012.
[10] T. You, A. N. Rosli, I. Ha and G.-S. Jo, Collaborative filtering based on clustering method using genre and interest in SNS, *Proc. of Korea Intelligent Information System Society*, 2012.
[11] J. Golbeck and J. Hendler, Filmtrust: Movie recommendations using trust in web-based social networks, *Proc. of the IEEE Consumer Communications and Networking Conference*, 2006.
[12] C. S. Mesnage, A. Rafiq, S. Dixon and R. P. Brixtel, Music discovery with social networks, *Workshop on Music Recommendation and Discovery*, Chicago, USA, 2011.
[13] U. Shardanand and P. Maes, Social information filtering: Algorithms for automating "Word of Mouth", *Proc. of the SIGCHI Conference on Human Factors in Computing Systems*, Denver, CO, USA, 1995.
[14] I. Cantador and P. Castells, Multilayered semantic social network modeling by ontology-based user profiles clustering: Application to collaborative filtering, *Managing Knowledge in a World of Networks*, Springer, 2006.
[15] Z. Huang, D. Zeng and H. Chen, A comparison of collaborative-filtering recommendation algorithms for e-commerce, *IEEE Intelligent Systems*, vol.22, no.5, pp.68-78, 2007.
[16] I. Konstas, V. Stathopoulos and J. M. Jose, On social networks and collaborative recommendation, *Proc. of the 32nd International ACM SIGIR Conference on Research and Development in Information Retrieval*, Boston, MA, USA, 2009.
[17] Y. Xu, J. Ma, Y.-H. Sun, J. Hao, Y. Sun and Y. Zhao, Using social network analysis as a strategy for e-commerce recommendation, *Pacific Asia Conference on Information Systems*, Hyderabad, India, 2009.
[18] M. K. Devi and P. Venkatesh, Kernel based collaborative recommender system for e-purchasing, *Sadhana*, vol.35, no.5, pp.513-524, 2010.
[19] B. Sarwar, G. Karypis, J. Konstan and J. Riedl, Application of dimensionality reduction in recommender system – A case study, *ACM WebKDD Workshop*, 2000.
[20] T. Berners-Lee, J. Hendler and O. Lassila, The semantic web, *Scientific American*, vol.284, no.5, pp.28-37, 2001.
[21] T. R. Gruber, A translation approach to portable ontology specifications, *Knowledge Acquisition*, vol.5, no.2, pp.199-220, 1993.