AN EXTENDED ARCHITECTURE FOR ADAPTATION OF SOCIAL NAVIGATION

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Abstract: Social navigation is a way for users to navigate through social information such as resources and social annotation (tags). However, due to the growth of social networks, the user could be lost. To avoid this problem of disorientation, we try to adapt the social information through a recommendation technique by providing useful information according to the user's needs. In this paper, we present an extended architecture of social recommender system. The originality of this architecture rely on the way to combine the collective intelligence of the social network with the user's behaviour especially his tagging behaviour.

1 INTRODUCTION

In general, social navigation is a way for users to navigate through social information such as resources and social annotation (tags). Social navigation is classified as direct or indirect (Farzan, 2009). The direct interaction of users with each other in the form of recommendation or guiding is defined as *direct social navigation*. Tracing activities of users to guide new users in the system is defined as *indirect social navigation*. Indirect social navigation can be classified as: *collaborative filtering* and *history-enriched information spaces* (Brusilovsky, *et al.*, 2010). Collaborative filtering aims to help users to navigate according to information of all users. History-enriched information spaces provide support for navigating by making individual action of others visible.

Even if, indirect social navigation explores different techniques (collaborative filtering and history-enriched information spaces) and due to the growth of social networks, the user could be lost. To avoid this problem of disorientation, some researchers have been done to adapt the social information through a recommendation technique by providing useful information according to the user's needs. Some researchers study either how to recommend pertinent resources based on user profile (Zheng, *et al.*, 2011) (De Meo. *et al.*, 2010), or how to recommend relevant tags based on user tagging behaviour (Musto, *et al.*, 2009), or how to recommend both resources and tags (Carmagnola, *et al.*, 2011) (Nauerz, *et al.*, 2008).

There are several architectures which adapt social information based on recommendation technique. In general, these architectures use the same modules that exist in the classic architecture of adaptation systems like AHA! (De Bra, *et al.*, 2003): the user modelling module and the adaptation module which could be devised in three sub modules (Brusilovsky, 1996): adaptation of presentation, adaptation of contents and adaptation of navigation. In social context, adaptation architectures add social modules such as: social networking module (Carmagnola, *et al.*, 2011) which define social objects (i.e.: users, resources, etc.) and social interactions (i.e.: assigning an annotation, rating a resource, etc). From this social networking module, some architectures define a sub module that specify the tagging behaviour of user (which resource is been tagged by which user) (Nauerz, *et al.*, 2008) (Kim, *et al.*, 2010).

Architectures which adapt social information based on recommendation technique and using these modules like (Nauerz, *et al.*, 2008) (Carmagnola, *et al.*, 2008), don't take into consideration the ambiguity associated to tags and so the quality of recommendation could decrease. However, (Carmagnola, *et al.*, 2011) architecture takes into consideration the semantic of tags. But, tag ambiguity is not treated efficiently which affect the recommendation quality. Another limit is that the architecture depends on the TV partner and uses the log file to build a user profile.

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In order to overcome limits related to these architectures and to avoid the disorientation of the user, we introduce an extended architecture of social adaptation systems. The extended architecture recommends information suitable to users, based on analyzing tags, tagging behaviour and user profiles. The originality of this architecture rely on the way to combine the collective intelligence of the social network with the user's behaviour especially his tagging behaviour.

We try through this architecture to adapt indirect social navigation. Although the majority of projects, dealing with social navigation are exploring collaborative filtering, we try to employ both collaborative filtering and history-enriched information spaces. From this latter, individual action of other users would be extracted from social annotation (tags) assigned by users.

This paper is organized as follow: Section 2 presents an overview of the related works. Section 3 is dedicated to the presentation of our extended architecture. Section 4 presents the detailed modules used in our extended architecture. In Section 5 we will conclude the paper by presenting some future works.

2 RELATED WORKS

In social networks, the adaptation of social information (resources and tags) could be based on a recommendation technique. The latter, is classified in (De Meo, *et al.*, 2010): i) *Content Based* approach (CB), which aim to recommend objects that are relevant to the user; ii) *Collaborative Filtering* approach (CF), which aim to use the collective intelligence of the social network to recommend social information. As the CF becomes widely used, tag-based CF becomes more present in literature (Kim, *et al.*, 2011).

There are many techniques using Tag-based CF: (Wang, *et al.*, 2010) employ tag-based CF for integrating the individual user's tagging history in the recommendation of tags and content of resources, in order to adapt social navigation. (Wang, *et al.*, 2010) don't update for the user profile through time. (Zheng, *et al.*, 2011) use the importance and usefulness of tag and time information in a CF context, when predicting user's preferences. From this prediction, they examine how to exploit such information to build an effective resource-recommendation model, but tags used are not filtered and ambiguous. Researches of (Wang, *et al.*, 2010) and (Zheng, *et al.*, 2011) and don't consider the semantic ambiguity associated to tags. Contrary to (Zhao, *et al.*, 2008), who suggest a tag-based collaborative filtering, based on the semantic distance among tags (from WorldNet dictionary) for calculating user similarity. However, the similarity measure is not very accurate since it doesn't treat tag ambiguity.

In this work, we are interested in architectures which use the tag-based CF for recommendation. In portals, (Nauerz, *et al.*, 2008) analysis user's tagging behaviour to learn interests and preferences of users, groups or communities, for better adaptation and recommendation of tags and resources. (Carmagnola, *et al.*, 2008) presented "iCITY" as an adaptive, social, multi-device recommender guide which deals with cultural events taking place in Torino city. These cultural events considered as resources, are recommended based on the tagging behaviour of users.

All these works don't take into consideration the ambiguity associated to tags and so the quality of recommendation could decrease. However, (Carmagnola, *et al.*, 2011) suggest an architecture derived from the "iCITY" architecture named "iDynamicTv", to recommend TV content (video) and navigate through resources, tags and users. The "iDynamicTv" architecture is a good way to discover and organize TV content; it takes into consideration the semantic of tags. However, tag ambiguity is treated with a semantic similarity using WordNet dictionary only and doesn't consider spam and personal tags which affect the recommendation quality. This architecture depends on the TV partner for TV content. Another limit is the use the log file to build a user profile especially the no tracking event in a log file.

We try to overcome the limitations in the existent tag-based CF architecture, by extending the "iDynamic" architecture.

From techniques listed above, we try to overcome their limits. We try to integrate tagging history in our architecture system in a different way by analyzing tagging behaviour from the whole users and update each user's profile to adapt social navigation. Analyzed tags are filtered to guaranty accuracy. User's similarity is calculated from their similar behaviour, similar annotations (extracted from WordNet dictionary) and from similar users sharing common interests.

In table 1, we compare these architectures according to specific criteria. Criteria are devised into two main categories. The *user* category, which compare how a user is represented through: a *static* way (by gathering information that rarely changes like name, age, etc.,) or *dynamic* way (by gathering information that frequently changes like the tagging behaviour), user's interest *update* as they change over time and user *similarity*. The tag category specifies if the architecture takes into consideration the *semantic* aspect of the folksonomy (tags), *filters* inappropriate tags and if it considers tags' *weight* (the weight reflect the degree of importance of the tag).

Table 1: Comparison of architectures which use the tag-based CF for recommendation.

Reference \ Characteristic	User				Tag		
	Static	Dynamic	Update	Similarity	Semantic	Filtering	Weight
Nauerz *et al.*, 2008	✓	✓					
Carmagnola *et al.*, 08		✓	✓		✓		
Carmagonla *et al.*, 11		✓	✓	✓	✓	✓	
Our architecture	✓	✓	✓	✓	✓	✓	✓

3 ARCHITECTURE

From architectures discussed above and from the comparison between these architectures and our architecture (in table 1), we try to explain deeply our approach of adaptation. We present first a motivating scenario which explains the purpose of our architecture. Then, we present an overview of the architecture across its different components and interactions.

3.1 Motivating Scenario

Let's take an example of a user who uses his social network to navigate through its different resources and tags.

In social networks, the number of resources is regularly growing. The user has a limited view of what exist in his social network. In consequence, pertinent information may exist but the user doesn't see it. In spite of the fact that the user is connected to other users (friends) and is a member of groups (users sharing common interests), he could not have pertinent information and could be lost or influenced by other bad users (i.e.: spammers) while navigating.

In order to avoid these limits, we try to adapt the indirect social navigation. This adaptation ensures that the user will have the pertinent information he needs by recommending relevant resources and tags.

To adapt indirect social navigation, we need to analyse different social elements especially the user through his profile and his social behaviour. We need also to analyse resources and tags and how these elements are relevant to the user and could affect his social navigation.

3.2 Architecture Overview

In this paper, we present an extended architecture to adapt social navigation by recommending tags and resources. The architecture is inspired by (Carmagnola, *et al.*, 2011), which combines web2.0, social networking and user-model personalization. Architecture of (Carmagnola, *et al.*, 2011), is proposed to get a powerful tool for discovering organizing of content in interactive television. We try to overcome some limitations in this system, which cause the dependence of the content of the TV partners, no filtering of inappropriate tags and limits of using log file to build a user profile.

In figure 1, we present the main components of our system and relationships between different modules of the architecture. This work aims to prevent the disorientation of user in social networks. It offers the possibility to navigate through resources and tags. The system can detect similar users according to their similar behaviour, similar annotations (extracted from WordNet dictionary) and from similar users sharing common interests. It analyzes the tagging behaviour and filters no appropriate tags to improve tag-based recommendation.

The databases (DB) presented in this architecture are:

DB social network:

The data exploited in this approach are extracted from a specific social network (delicious, *movieLens*, etc). Social information recommended is depending on the social network (i.e.: bookmarks in *Delicious*, scientific articles in *CiteUlike*, music in *Last.fm*).

DB user model:

From the *DB social network*, this module specifies information about users and networks of users (interest, preferences, friends, professional relationships, etc.).

DB Contents:

From the *DB social network*, this module stores information about the resources of the social network (type of resource, tags associated by each users, metadata, etc.)

We present a simplified scenario for the communication between modules. Architecture's modules will be detailed in section 4. After

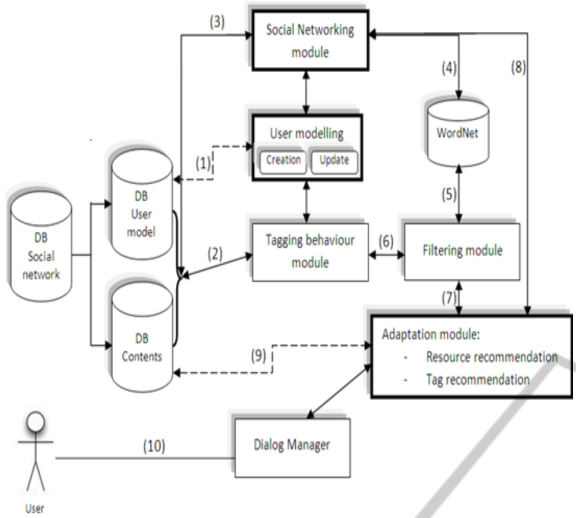

Figure 1: Extended architecture.

defining databases, interactions will be as follow: (1) The module *user modelling* gets information from the *BD user model* to create a user profile and update it as his information change through time. (2) From *DB user model* and *BD contents*, the tagging behaviour module defines the relation between user and resource through a common annotation (tag). (3) The *social networking module* takes information from both *DB user model* and *BD content* to construct a social network. The social network is defined by social elements (i.e.: users, resources) and social interactions (i.e.: friends, annotations). (4) The *social networking module* tries to define similarity between users by calculating it through the WordNet dictionary. (5) The *filtering module* detects tag's synonyms and homonyms, etc., from functionality present in the WordNet dictionary. (6) The *tagging behaviour module* contains inappropriate tags which are detected due to the filtering module. (7) In order to increase the quality of adaptation, the *filtering module* provides appropriate tag already filtered. (8) The *adaptation module* needs social connections as friends, active users, etc., from the *social networking module*, to recommend social information. (9) The *adaptation module* needs social elements such as resources to recommend them. (10) Interaction between users and the system. This interaction is the only input-output in the architecture. The input is the user's information (especially static information) and user's request. The output is the result of the adaptation process (the recommended resources and tags).

4 MAIN AND SECONDARY MODULES

Modules are divided in two categories: i) The main modules which are presented in the most social adaptation architecture and already presented in section 1 (*the user modelling module*, *social networking module* and *adaptation module)* ii) the secondary modules (the *tagging behaviour module*, the *filtering module* and the *dialog manager* module).

4.1 Main Modules

User modelling module:

The user is an important entity in the adaptation process. This module aims to represent each single user in the social network. It defines information needed to represent a user profile, extracted from the *DB user model*.

In the literature, a user profile is constructed either in a *static* way, by gathering information that rarely changes like name, age, etc., or in a *dynamic* way, by gathering information that frequently changes. In this module, we consider both *static* and *dynamic* information.

In the most classic adaptation system, a user profile contains personal information like name, age, etc. In a social context, a user has social connections or relationships and interests which are represented in his profile through a FAOF (Friend-Of-A-Friend) vocabulary. FOAF is based on the RDF/XML vocabulary. Usually, interest in FOAF file, specifies a resource. An extension has been made with "e-FOAF:interest" vocabulary which provide more detailed vocabularies related to user interests.

In a social environment, many approaches suggest to define a tag-based user profile. It can be constructed in an *explicit* way, by analyzing the tag defined by the user (Firan, *et al.*, 2007); or in an *implicit* way, by observing his tagging behaviour (Carmagnola, *et al.*, 2011) (Carmagnola, *et al.*, 2008) (Nauerz, *et al.*, 2008) and enrich user profile by neighbour tags (Kim, *et al.*, 2011). But tags are ambiguous and need to be filtered (by the filtering module) for a better profile construction.

Although tags are important elements reflecting user's interests on a resource, they are not represented in his FOAF profile. Associating tags in a FOAF file is not existent in the literature as far as we are considered. So we try to extend the FOAF file, by adding a new attribute which specifies the tag assigned by the user, in order to extract from the FOAF file information especially tags so we will analyze user profile once in order to decrease the execution time.

Social networking module:

This module exploits the user modelling by analyzing the similarity between users to build networks of similar users using same tags (similarity between tags is deduced from WordNet) and access the user's profiles to build networks of friends (Carmagnola *et al.*, 2011). This module is able to identify similar users with a similar tagging behaviour (Nauerz, *et al.*, 2008). Based on social relation, it is able to send information such as most popular users, friends, etc. for the adaptation module.

Adaptation module:

This module usually treats three dimensions of adaptation: content, presentation and/or navigation. We are interested in the adaptation of navigation because it's a way to avoid the disorientation of user (Farzan, *R.*, 2009).

In a social recommendation context, adaptation layer performs various recommendations and adaptations such as navigation adaptation model, content adaptation model, etc. (Nauerz, *et al.*, 2008). Adaptation module may just adapt the content to the user and personalizes the presentation (Carmagnola, *et al.*, 2008).

This module takes in entry the filtered folksonomy, the social network elements and the content to achieve the task of adaptation by recommending social information which include: i) Resource recommendation: a recommending technique which recommends resources according to data present in the DB contents, tag and users needs; and ii) Tag recommendation: a recommending technique which recommends tags according to the user's tagging behaviour and needs.

Adapting more than an information leads to offer the user more than a possibility to navigate through social information.

4.2 Secondary Modules

Tagging behaviour module:

Contains information about users who annotate, by means of plain keywords known as tags, resources of various types (i.e.: photos, videos, scientific papers, etc). The result of the collaborative tagging practice is also known as folksonomy (De Meo, *et al.*, 2010). This tagging behaviour is usually presented as a 3D matrix (Wang, *et al.*, 2010) (Kim, *et al.*, 2010) which link tags (t), users (u) and resources (r). This matrix is usually very hard to analyze, due to the fact that tagging data are generally sparse. To deal with this problem, we create three matrixes, analogously to (Wang, *et al.*, 2010), each one represent a simplified view:

- User–Tag (UT): Element (u, t) equals the number of resources that user u tagged with tag t.
- Resource–Tag (RT): Element (r, t) equals the number of users that tagged resources r with tag t.
- User–resource (UR): Element (u, r) equals the number of tags that user u assigned to resources r.

Tagging behaviour module is able to extract the user's preference and interest (based on the assumption that tagging expresses interest in a resource), update then the user profile according to the evolution of his behaviour.

Filtering module:

The Filtering module aims to decrease tag ambiguity present in the tagging behaviour module in order to provide a correct tag to the adaptation module.

From the tagging behaviour module, analyzing the folksonomy presents a challenge. In (Carmagnola *et al.*, 2008) tags are analyzed with the support of WordNet to classify them in various categories (i.e.: *subjective tags*, which reflect the user's point of view, or *free tags*, which are not derived from the textual description of the cultural event). (De Meo, et al., 2010) introduce the "authoritative" tag (i.e. tags having a high PageRank) to enhance recommendation. "Authoritative" tags are exploited to refine user's query and so improve recommendation. These works, do not consider the semantic ambiguity in folksonomy.

In our architecture, this module tries to filter noisy tags by means of different techniques. From folksonomy, this filtering module firstly detects personal tags which don't reflect the content of the resource tagged but a personal opinion (i.e.: like, awesome, etc.) (Gupta, *et al.*, 2010). Then, it detects spam (fake tags that are generated in order to enhance the visibility of some resources or to confuse users) (Liu, *et al.*, 2009) by means of specific algorithms. Finally, this module performs a semantic analyze from WordNet dictionary to detect synonyms, tags which belong to the same topic, etc. The purpose of this last step is to generate tags (already filtered) which are similar, so in a recommendation context, we can recommend resources to the user who is interested in a topic described by means of different tags.

Dialog Manager:

This module manages interactions between users and the system.

5 CONCLUSIONS

The history-enriched information spaces considered as tags assigned by a user are combined with the collaborative filtering to adapt social navigation. The originality of our architecture relies on analyzing information like the tagging behaviour, social environment (i.e. relationships, friends) and the merging of different techniques and methods to recommend useful information according to the user's behaviour and the user's environment. We use the social information and user's needs to overcome the problem of disorientation. This architecture tries to overcome limits such no updating for the user profile, as his preference changes; the semantic analysis of tags and the detection of the inappropriate ones.

Our work is in its first step. In perspectives we try to develop the resource and tag recommendation techniques and extend the FOAF profile. We try to combine the wisdom of the administrator (metadata) and the user expression (tags) to recommend resources and evaluate our method in large databases. For the user profile, we try to figure out pertinent user's interests by analysing his *<foaf:interest>* and his tags which reflect an interest.

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