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A tie strength based model to socially-enhance applications and its enabling implementation: *mySocialSphere*

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ABSTRACT

The growing omnipresence of the Social Web and the increasingly number of services in the Cloud have created a favourable atmosphere to develop socially-enhanced services, that is, services which are aware of the social dimension of the users to improve their experience in the Cloud. This paper introduces a model and an architecture for socially-enhanced services by mining interaction information across different Social Web sites. Most of the existing social applications require knowing who are the users socially-linked to each individual by exploring topological connections in social networks or, even, calculating the interactions network that underlies social sites. However these approaches are, on the one hand, hardly scalable when the number of users grows in the interaction network and, on the other hand, tightly coupled to the social application and so hardly reusable. The key contribution of this paper is a user-centred model whose goal is not to infer the aforementioned interaction network, but to build users' social spheres. That is, assessing the strength and the context of the user's ties by using signs of interaction available from social sites APIs (private messages, retweets, mentions,...) with user's permission. To this aim, contrary to previous approaches, we take into account (i) different interaction types and contexts, (ii) the time in which interactions occur, (iii) the people involved in them and (iv) the interactions rhythms with the rest of user's contacts. A prototype of this service has been implemented in order to, not only validate the tie strength model, but also to deploy some pilot experiences.

1. Introduction

The outburst of the Social Web technologies is provoking a socialisation of the network through the active participation and involvement of the users, since they actually act not only as typical consumers, but also as producers of information. In Social Web technologies or systems, people communicate online with others through social networks, upload and share multimedia contents, maintain personal bookmarks and blogs, post comments and reviews, rate and tag resources available on the Web, and contribute to wiki-style knowledge bases. There is not a single motivation to develop such online relationships, but the increasingly acceptance of online social networks can hardly be ignored (see Li (2011) for and empirical research). Social networks are widely accepted as the electronic counterpart of the word of mouth, and so a key application in the attention economy (Jansen, Zhang, Sobel, & Chowdury, 2009).

Nearly at the same pace than the above social trend, other revolutionary phenomenon has rushed into the technological landscape (Zhang, Cheng, & Boutaba, 2010). The so-called Everything as a Service (EaaS or XaaS) enables a Cloud (a metaphor of the Internet) which hosts resources that will be delivered as services of a high level of granularity and which may be composed in a flexible manner in response to complex necessities. A user living in the Cloud can access their documents and applications from anywhere and using whichever capable device as a lightweight client. Unfortunately, the massive availability of services in the Cloud poses challenges and opportunities comparable to those of the massive availability of information on the Internet. In fact, the full realisation of the Cloud vision could worsen the well-known digital divide born with the advent of the Information Society: a citizen with no access to the Cloud, or without the ability to take advantage of it to cater for his/her needs, could have lessened opportunities in society.

To mitigate this new digital divide, we propose to assist users in their access to the services in the Cloud by taking advantage of the popularity of social networks and the increasing number of virtual ties among people. With this aim, we exploit the information of interaction among users in social networks and other Social Web

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technologies to improve the effectiveness and usability of existing services in the Cloud. That is, making services aware of the social dimension of the user (socially-enhanced services) by mining interaction information across social networks. The great acceptance of the Social Web technologies, their penetration in all social sectors and the freedom with which the users participate suggest that the use of such information will be greatly beneficial (Beer & Burrows, 2007; Birdsall, 2007).

Interaction networks, i.e. networks of users who often interact through Social Web technologies, have previously been used to socially-enhance existing applications in the web (Wilson, Boe, Sala, Puttaswamy, & Zhao, 2009). However, to the best of our knowledge, applications developed to date, apart from implementing their own functionality, have had to build their users' interaction network, which entails a great deal of work. For this reason, most of the times these applications only use data from one Social Web site and do not consider all users' available data in the site. Our research objective is to define a model for a user-oriented conception (as opposed to product-oriented) of services in the Cloud, what also comes to the aid of growing concern in the privacy of data, since user' opinions and habits are maintained in structures local to the user, but possibly located in the Cloud. We are not longer interested in calculating the interaction network that overlies users' interactions in Social Web, but in extracting the social sphere of every single user: his topics of interest and his contacts when using social networks.

A key contribution of our work is a model to build up these social spheres only from interaction data retrieved from public APIs (with users' permission). Although in this paper we only detail Facebook and Twitter evidences of relationships, the model is easily extensible to other social sites with open access to their users' data. To this aim, for a specific user u, we mine data from Social Web sites and identify: (i) which subjects u is interested in (social contexts) and (ii) the strength of the relationship between u and each user with who he interacts (social contacts or contacts) in each specific context. From this mined information, we define u's *social sphere* to refer to a contextualised view of the u's contacts together with a measure of the strength of their relationship. Our previous work in Servia-Rodríguez, Fernández-Vilas, Díaz-Redondo, and Pazos-Arias (2013) has explored the problem of extracting user's interest (contexts) by applying Natural Language Processing (NLP) and clustering techniques to the data and metadata linked to the user's interactions in social networks. Now, in this paper, apart from detailing the global model to build the spheres, we propose a measure to assess the strength of the user's ties by using signs of interaction available from social sites APIs (private messages, retweets, mentions,...). To this aim, contrary to previous approaches, we take into account (i) different interaction types and contexts, (ii) the time in which interactions occur, (iii) the people involved in them and (iv) the interactions rhythms with the rest of user's contacts. Furthermore, to the best of our knowledge, our measure is the first which fine-tunes tie strength indexes taking into account the specific time of the interaction and the people involved in it. The evaluation of the tie strength measure against human judgement reported encouraging results.

Apart from the social spheres model and the tie strength measure, the last contribution in this paper is a service-based approach to socially-enhance applications. Specifically, we offer a crawler service in charge of monitoring and processing evidences of relationship among users (interactions with others) in Social Web sites (social networks, blogs or other social media sites) to build up social spheres by the implementation of the proposed model. This service, called *mySocialSphere*, makes the social spheres available through a public API. So that, it can be integrated into any social service, avoiding it to gather the social information needed to work properly.

This paper is organised as follows. Next section shows, briefly, some previous works related with our current proposal. Later, in Section 3, we give an overview of our model to build up social spheres from interaction evidences of relationship in the Social Web. In Section 4 this model is particularised to Facebook and Twitter. Moreover, as the purpose of *mySocialSphere* is socially-enhancing existing services in the Cloud and promoting the emergence of new ones, in Section 5 we describe some scenarios for this socially-enhanced Cloud. After introducing the validation of our measure of tie strength (Section 6), the technical aspects of *mySocialSphere* and some pilot experiences are sketched (Section 7). Finally, in Section 8 we provide the conclusions of our proposal and our ongoing work in this area.

2. Background

Our approach to Social Computing tries to provide socially-enhanced software which, in the form of SaaS, is always aware of the social environment of the users. To this aim, it is essential to know the users with whom they are related and the strength of their ties. The concept of *tie strength* was defined by the anthropologist Granovetter (1973) as a function of duration, emotional intensity, intimacy and exchange of services. He distinguished two kinds of ties in social networks: strong and weak ties, highlighting the importance of weak ties as responsible for individuals' integration into communities since they act as bridges between otherwise unrelated social clusters. Later, Granovetter revisited his theory (Granovetter, 1983) with a round-up of studies that adopted tie strength. Other outstanding work in this field is White (2008), in which White postulates that a social network is composed of different subnetworks depending on domains (*Netdoms*). Dunbar, in his well-known social brain hypothesis (Dunbar, 1998), postulated something similar: the cognitive constraints of human brain limit the number of social relationships maintained by a person at different levels of emotional closeness. Specifically, Dunbar postulated the existence of four "circles of acquaintanceship" (Dunbar's circles), which are, from the closest to the weakest: *support clique*, *sympathy group*, *affinity group* and *active network*.

In the case of computer science, online social networks already provide users' social structures, which are made of links between users and their contacts on these networks. However, initial studies on interaction networks have brought great insights into how an interaction network is structurally different from the social network. For instance, Wilson et al. (2009), Viswanath, Mislove, Cha, and Gummadi (2009), Backstrom, Bakshy, Kleinberg, Lento, and Rosenn (2011) and Xiang, Neville, and Rogati (2010) process users' activity to get the interaction network which underlies Facebook (also LinkedIn in the work of Xiang). Also in the Facebook case, Gilbert and Karahalios (2009) and Kahanda and Neville (2009) measure tie strength using interaction data, users' profiles (age, political ideals,...), users' links in social networks and interactions between common friends. On Twitter, Huberman, Romero, and Wu (2009) infer which Twitter followees (followers) are related to the user by taking into account directed tweets (mentions in tweets). Grabowicz, Ramasco, Moro, Pujol, and Eguiluz (2011), meanwhile, validate Granovetter's hypothesis (Granovetter, 1973) in online social networks, so that links with retweets should more likely appear as bridges between different groups, whereas links with mentions should connect users in the same groups.

Meanwhile all these previous works provide models to develop an interaction network, our aim is to develop a service to be used by other applications in the Cloud. To this aim, unlike other proposals, we only use interaction data available through public APIs and within users' permission. Furthermore, to make the tie strength calculation more accuracy, we take into account (1) the