Information Processing and Management 49 (2013) 773–791

Contents lists available at SciVerse ScienceDirect

Information Processing and Management

journal homepage: www.elsevier.com/locate/infoproman

Mining direct antagonistic communities in signed social networks

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ARTICLE INFO

Article history:
Received 20 April 2012
Received in revised form 21 December 2012
Accepted 31 December 2012
Available online 28 February 2013

Keywords:
Direct antagonistic community
Mining maximal bi-cliques
Signed social network

ABSTRACT

Social networks provide a wealth of data to study relationship dynamics among people. Most social networks such as Epinions and Facebook allow users to declare trusts or friendships with other users. Some of them also allow users to declare distrusts or negative relationships. When both positive and negative links co-exist in a network, some interesting community structures can be studied. In this work, we mine Direct Antagonistic Communities (DACs) within such signed networks. Each DAC consists of two sub-communities with positive relationships among members of each sub-community, and negative relationships among members of the other sub-community. Identifying direct antagonistic communities is an important step to understand the nature of the formation, dissolution, and evolution of such communities. Knowledge about antagonistic communities allows us to better understand and explain behaviors of users in the communities.

Identifying DACs from a large signed network is however challenging as various combinations of user sets, which is very large in number, need to be checked. We propose an efficient data mining solution that leverages the properties of DACs, and combines the identification of strongest connected components and bi-clique mining. We have experimented our approach on synthetic, myGamma, and Epinions datasets to showcase the efficiency and utility of our proposed approach. We show that we can mine DACs in less than 15 min from a signed network of myGamma, which is a mobile social networking site, consisting of 600,000 members and 8 million links. An investigation on the behavior of users participating in DACs shows that antagonism significantly affects the way people behave and interact with one another.

1. Introduction

Each of us forms positive and negative relationships with others. With these relationships, communities are formed. At times, due to the nature of human interactions, some communities exhibit antagonistic behaviors among their members. Examples of such communities are many including social groups that hold differing opinions on topics such as industrialism *vs.* conservation, and formal organizations that are direct competitors in a market.

Several researchers have studied the nature of antagonistic communities (Dasgupta, 2009; Dasgupta & Kanbur, 2007; Denrell, 2005; Giles & Evans, 1986; Labovitz & Hagedorn, 1975; Tolsma, Jochem, Graaf, & Quillian, 2009). It is well known that

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http://dx.doi.org/10.1016/j.ipm.2012.12.009

individual level antagonism exists in any social networks. However, the existences of well ‘‘organized’’ form of antagonism between sub-groups should be detected in an early stage because they are potentially detrimental to the productivity and harmony of the community. Moreover, identification of antagonistic communities in the social networks could potentially open a path to further study the structure of the antagonistic community, the evolution of the antagonistic community, etc.

Antagonistic communities on the other hand are not always bad. In some cases, they are actually welcomed. In massively multiple player on-line games, gamers are expected to form groups to fight with gamers that do not belong to the same group. Here, a game's success depends very much on antagonistic behaviors among different gamer groups. The more antagonistic the groups are, the more fun and challenging the game would be. Also, by expressing common negative relationships with members from another group, users belonging to the same group may form stronger bonds among themselves. This increases loyalty within the group and improves the survivability of the group in the long run.

With the advent of Web 2.0, on-line social networking sites and forums have gained much popularity. In these venues, people declare their network of friends. Some venues also allow members to explicitly declare negative relationships with other members. Abundant information on positive and negative relationships which is unavailable to many past studies in sociology is now available to be analyzed. We therefore leverage these large scale information to shed light on antagonistic communities in Web 2.0 social networks.

In this study, our goal is to discover Direct Antagonistic Communities (DACs) automatically from explicit positive and negative relationships among people in a social network. We define a direct antagonistic community to be a pair of sub-communities with each sub-community having members with positive relationships with one another while having negative relationships with members of the other sub-community. Investigating mined direct antagonistic communities potentially enriches our understanding of antagonistic social interactions. Mined DACs could also be leveraged for various applications, e.g., in the monitoring and prevention of social conflicts, in improving friend recommendation systems, in designing better marketing or product survey strategies, etc. Mined antagonistic communities could be used to identify the existence of two sub-communities that are large and are antagonistic with each other. Friend recommendation could be improved by not recommending two potential friends from opposite sides of an antagonistic community. Also, when views are to be solicited from a network of users, the knowledge of antagonistic communities will help to select a fair subset of users so as to obtain a balanced set of views. An extended discussion of potential applications of DACs is provided in Section 6.

Identifying all direct antagonistic communities from a large signed network however is challenging. Many combinations of two sets of people, which are two sets of nodes in the network, need to be considered and checked for antagonism. In a large signed network, the number of such combinations is very large. To tackle this challenge, we design a graph mining algorithm to mine antagonistic communities by leveraging past work on computing strongest connected components and mining maximal bi-cliques.

We experiment with Epinions trust-distrust dataset and friend-foe information from myGamma, a mobile (i.e., mobile phone based) social network. We observe that antagonistic communities exist in both networks. We also find that members from opposing sub-communities in an antagonistic community tend to behave differently (e.g., give poorer ratings, have different group affiliations, etc.) compared with members within the same sub-community. This confirms that direct antagonistic relationships between two sub-communities affect their behavioral patterns. The contributions of this work are as follows:

1. We propose a new problem of mining antagonistic communities from signed social networks.[2]
2. We build a novel algorithm by using existing building blocks that have been shown to scale to large datasets hence enabling our approach to scale too.
3. We experiment our approach to extract antagonistic communities from real signed social networks.
4. We present more in-depth analysis and explore behaviors between two opposing sub-communities that have negative relationships with each other.

The structure of this paper is as follows. Section 2 describes related work. Section 3 describes some preliminary definitions. Section 4 describes our approach. Experiments are presented in Section 5. Section 6 discusses some interesting points and issues. We conclude and describe future work in Section 7.

2. Related work

Community finding is a key problem in social network analysis and it has been extensively studied (Cai, Shao, He, Yan, & Han, 2005; Girvan & Newman, 2002; Katz, 1953; Leicht & Newman, 2008; Newman, 2004; White, Harary, Sobel, & Becker,

[2] This article is an extended version of our short paper (six pages) appearing in the 20th ACM Conference on Information and Knowledge Management (CIKM 2011) entitled: Mining Direct Antagonistic Communities in Explicit Trust Network (Lo, Surian, Zhang, & Lim, 2011). We extend the conference paper in the following ways: (1) we include additional background materials and related work, (2) we describe our proposed and baseline solutions in more details through the inclusion of more detailed descriptions and examples, (3) we present our new experiments on additional case studies on Epinions and myGamma datasets enriched with additional inferred negative edges (see Section 5), (4) we present the results of a set of new efficacy experiments on the real datasets to investigate the differences between users in the same side and those in the opposing sides of antagonistic communities (see Section 5), and (5) we add a new discussion section.