Encouraging Cooperation Through Community Dynamics

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***Abstract*—Cooperation among users only takes place if they are willing to share data among themselves. As users tend to easily exchange information with others they have some sort of social relationship (i.e., belong to the same community, share similar interests), we discuss on this paper how information about users' relationships and communities they belong to can be used to increase social capital and, consequently, improve cooperation within the sensing context.**

***Index Terms*—community formation; user cooperation**

I. Introduction

Cooperative sensing requires users to exchange some sort of information (e.g., related to noise levels, temperature, emotional status, contact with other devices) and that they are willing to do it so. In the context of opportunistic networks, sensing is done through the wireless cards present in the users' devices and can be used to infer social relationships among them by observing the length (i.e., duration) of contacts they have. It has been proven that social information can be used to improve even more the exchange of data among users as they tend to become more cooperative (i.e., have higher willingness) with one another if they belong to the same community [3], share similar interests [1], and interact with popular nodes [6]. Thus, it is imperative to consider the social relationships users have among themselves to improve routing in opportunistic networks.

With the popularization of portable devices, users present a very dynamic behavior. That is, they not only want to be able to send/retrieve information at anytime, but also in different places and on the go. This sort of behavior affects connectivity performance as communication is disruptive and intermittent. And, the dynamicity of nodes' social interactions (be it based on the notion of communities, shared interests, or popularity) should be very well defined in order to facilitate the exchange of information among users.

Thus, in this paper we present the role of community formation when it comes to encourage cooperation among users. For that, we will briefly present the aspects encompassed in the community notion followed by our ideas on how users' behavior should be dynamically captured to form more reliable communities, which will increase social capital and encourage users in engaging in cooperation.

II. Community for Cooperation

People have different levels of relationship (e.g., family, friends, acquaintances) among themselves and present different tastes (i.e., interests). Both relationships and interests can group people together (i.e., forming communities). Since devices are carried by people, user communication can take advantage of this feature. This means that users can relay information to other users belonging to the same community of the destination and/or sharing the same interest with the destination. It is important to mention that information here can be understood as sensory data, news, public interest broadcast, etc., and that can be delivered to a single destination as well as to a group.

Different proposals take advantage, explicitly or implicitly, of the notion of community. By explicitly, we mean those proposals which are concerned in forming communities as users interact, so later such information can be used for information exchange. One of the most current work within this context is Bubble Rap [3] in which users form communities according to their interaction (i.e., number and length of contact) with one another. Yet, the implicitly use of community notion relates to proposals where communities are not formed as in Bubble Rap, but users exchange information with others that share the same interests or are more popular than themselves. That is, implicit consideration of group formation based on interests or popularity. Examples of such proposals are SocialCast [1] and PeopleRank [6], respectively.

Since 2007 [5], there has been a great effort to consider the notion of community based on different social metrics such as contact among nodes, their relationships, common interests, and popularity within society to improve information forwarding. One may have no doubt on the forwarding performance improvements brought by considering social information based on the aforementioned proposals. That is, because users can easily engage in cooperation with others they are familiar or share interests [4].

However, these proposals can consider either the static formation of communities or strong assumptions such as users spending longer time co-located with others who have the same interest, which do not reflect the dynamicity of user behavior. Hossmann et al. (2010) [2] have shown that,

independently of how elaborate the social metric may be, if the solution fails in capturing the dynamism of user behavior, it will end up having an epidemic-like behavior [8], which is not cost effective.

Thus, we believe that by considering the community dynamics through clearly identifying the social interactions among users, social capital can be improved, and, consequently users are encouraged in engaging in cooperation. For that, communities should consider users' contacts to be built as well as to be updated in order to reflect their dynamic behavior. That is, users will form communities according to the contact length among them and will leave communities as their interaction decreases. Consequently, only strong relationships will stand out, where information is expected to be reliably exchanged (also considering the different interests and user popularity) increasing social capital of individuals and of the different communities they belong to, and certainly encouraging cooperation.

Furthermore, the knowledge domain built by community dynamics could be an enabler for realizing novel information-centric networking paradigms [7]. Social networking is purely information-centric that can be expressed in multi-hierarchical scopes. Scopes build information networks where data/content/services can be accessed/disseminated/retrieved in the context of the captured interactions within the scopes of social communities. Such means of information scoping can be used to build the required mechanisms that allow for limiting reachability of information to parties.

III. Conclusions

Opportunistic networks can take advantage of cooperative sensing to improve information exchange. Given the power of today's portable devices, users' devices can sense the presence of one another and from this infer the existing social relationships to aid routing. By knowing about such social relationships, social capital of individuals and communities they belong to can be measured to build reliable communities, which consequently will encourage cooperation among users as they tend to be more cooperative to others they know and/or share interests.

The main issue is capturing community dynamics and suitably incorporating into routing. By community dynamics, we mean being able to capture how community structure changes over time. Be it based on contacts nodes have or interests they share, communities must reflect the changes happening in the social life of users (e.g., physical distance between strong related users, change of interest).

As already previously discussed [4], what is missing is the suitable use of community dynamics. So far solutions consider statically defined communities and interests, which do not reflect the reality of users' interactions. Thus, it is our belief that managing communities by building and updating them according to real user social behavior will provide a better view of the social capital of individuals and their communities and surely increase cooperation.

However, there is still a lot of work to be done regarding the usage of social metrics (e.g., contact duration, common interests, popularity). It can be seen that all of them somehow improve information exchange when applied solely, but what about a combination of them? So far little is known about combining such metrics. We believe that the combination of different metrics can result in the formation of more reliable communities as the users belonging to them will be more strongly related. If the combination of social metrics is a good start point, how should this combination happen? The simplest way is to make a user be part of my community if I spend a certain time period with him/her and that we have same interests. But still, what is this certain time? We are all unique individuals and this time will certainly be different for each individual. And what about interests? There are different levels of interests for each activity, literature reading, music genre, so this different level should also be taken into account.

There is a great potential when combining social metrics, but more detailed studies about their joint functionalities should be carried out to help answering these open questions.

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