Dynamic Media Distribution in Ad-Hoc Social Networks

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Abstract—This paper proposes a social distribution mechanism for finding, connecting and propagating contents in social networks using context and communication history of users together with meta information about the content. The proposed mechanism operates by propagating invitation messages to a prioritized group of users to build up an ad-hoc social network from the original social network while at the same time preventing spamming the users with unwanted invitation messages. The proposed mechanism makes it possible to implement and deploy a wide variety of services targeting the specific needs of a user. As a proof-of-concept, the paper shows how the proposed social distribution mechanism can be used to invite users to a shared space, which can contain various kinds of collaboration tools allowing a group of users to communicate and solve problems together. In order to investigate the efficiency of the proposed mechanism, the paper also presents result from a simulation study. The result shows that the social distribution mechanism should consider both social strength and context for propagating social media contents as some of the recipients may have equal interest of the social media but different level of trust about the originator.

Index Terms—Aggregated Social Graph, Social Media Distribution, Dynamic Group Formation, Social Networks and Communication Services Mining.

I. INTRODUCTION

Online social networks services such as Facebook and Twitter have become a huge success and are now an integrated part of most peoples daily life. One of the main reasons of the popularity of these services is that they improve communication among colleagues, friends, family, and communities. For example, they help sharing information such as contacts profile, posting blog entries, allowing the users to produce and consume digital media contents wherever they are.

Although social networking services such as Facebook and Twitter make it possible to easily share information among individuals, an open issue is still how a user can be able to share contents dynamically when the targeted individuals are not predefined by having email address, phone-numbers and may not be accessible on communication services like Facebook or Twitter. For example, Facebook only provides limited support to share information with users outside the users own social network. Typically, when a user posts messages on someone's wall, only users having access to that wall can read it, which makes it impossible to reach users outside the users own social graph.

Additionally, it is often time consuming to manually set up groups in todays social networking services, which makes it hard to create ad-hoc groups for lighter instant collaboration or establish groups targeting specific user needs. For example, the average number of contacts in Facebook is more than 130 [1], which makes it time consuming to make a selection. Therefore, if the intention is to implement effortless sharing among a large population, manual selection may not be an appropriate way of inviting users.

This paper proposes a solution that makes it possible to automatically generate new social networks from existing ones. This makes it possible to effortlessly share information with users beyond the users’ own egocentric social graphs, ultimately being able to easily connect to a wider audience on a specific subject. One example where dynamically forming social networks could be useful is to form groups to coordinate planning efforts in case of a disaster such as an earthquake or tsunami. A related area where dynamic social distribution could be useful is online collaboration. In many of today’s collaborative services such as Google+ or Ericsson Labs Distributed Shared Memory service, a user cannot easily invite contacts in an automatic manner [2], [3] to enhance group communication activities. For example, in order to allow a group of users to share photos from an event, the users have either to share all photos publicly or manually invite the users to the photo service, which can be very difficult if the identities of the users are unknown.

To implement a social distribution mechanism for dynamically generating social networks several problems need to be addressed. One problem is to find relevant contacts for distributing social media contents without spamming the users with invitations messages. In order to form an ad-hoc social network, distribution constraints need to be defined with trust of the receivers so that it is possible to control the viral distribution of invitation messages and delivers the content to the most appropriate receivers. Otherwise, the distribution of contents or invitation may be considered as spam and may negatively impact the user experience of the service.

This paper investigates the following research questions:

• Can social strength be used to form ad-hoc social net-
works for media distribution?

- How can social strength be used as a trust metric to control viral distribution of media while also considering a users context (such as interest)?

The rest of the paper is structured as follows: Section 2 gives a short background to ad-hoc social network and related works. It also describes some motivating scenarios. Section 3 proposes an algorithm for social distribution. Section 4 provides proof-of-concept prototype and evaluation results. It discusses a proof-of-concept prototype where social distribution algorithm is applied for automatic invitation of participants to collaborative-shared spaces. Section 5 contains discussion and finally, Section 6 concludes the paper.

II. BACKGROUND

Emerging services and applications in the area of online social networks have the potential to significantly improve group communication services. For example, by organizing peoples in contact lists or in circles as in Google+, it becomes easier to share social media such as blogs, wall-posts, video-clips. This paper envisions a new kind of social network, which is referred to as ad-hoc social networks in the rest of this paper. Typically, an ad-hoc social network is generated automatically by taking input tags (e.g., place, topic etc.) from the users. Input tags are referred as context keys or interest keys to the rest of paper. In contrast to todays social networking services, an ad-hoc social network may have limited lifetime and is typically not used after it has served its purpose. By deploying web applications on the newly formed ad-hoc social networks, it becomes possible to create personalized group communication services targeting the need of the users.

An ad-hoc social networking service may utilize both local contacts stored in the mobile devices or contacts residing in others social networking services such as Facebook to form an aggregated social graph. An aggregated social graph merge knowledge from multiple social networks and can thus give an aggregated view of a users relation to other users. Aggregated social graphs have been elaborately discussed in [4], where an Aggregates Social Graph (ASG) framework has been proposed. The ASG framework can also be used to rank the contacts in the graph based on their social relationship or tie strength.

A. Related Work

Finding appropriate social media contents is challenging due to the fact of abusive contents [5]. Eugene et. al., introduces a general classification framework that qualifies social media contents based on the information of the different sources [5]. In our solution, aggregated social graph service [4] is utilized to identify appropriate contacts for sharing contents or initiating an activity. Social spam is becoming a more effective distribution mechanism than traditional email spam [6]. This indicates that some of the friends in social network for example in Facebook, sent spam messages or abusive contents in the networks. Hongyaet. al., proposes a method on detecting and characterizing social spam campaign by analyzing Facebook wall messages [6]. They provide classifier for social spam filtering. However, such classifier, if badly trained may degrade the usability of the social networks. Alternatively, effectively understanding users’ interest and propagating the invitation messages among the interested users may be another option to control social spam. In this paper, our proposed social distribution mechanism partially covers that problem.

Mircoet. al., provides an ad-hoc mobility model based on the social networking theory [7]. The paper is written before the densely used social networking data for mobile services and apps creation. To measure social relationship the authors considered co-location relation (i.e., working in same location, living in the same city). Social networking theories are considered for social and communication data ranking [4]. This forms an aggregated social graph service. Our proposed solution is benefited by that service, as the service provides ranked user list based on particular contexts.

Jun et. al proposes a framework for ad-hoc social networking [8]. They applied a semantic web based approach for profile matching. However in their approach, they considered only Bluetooth connectivity to search for users and unable to form a network considering large scale user-base physically residing all over the world. Though the authors proposed a framework for ad-hoc social networks, they only addressed the issue of setting up a network utilizing near field communication enabled devices, i.e., proposed solution is lack of tools to perform social interactions among the participants in the network. In our solution, the ad-hoc social network is capable to sustain for a longer period of time to achieve a particular goal and pluggable to Web-based sharing tools.

Jun et. al proposes a mechanism for building ad-hoc social networking by fetching users interest from Web contents [9]. However, the paper does not address any particular method of profiling users interest from the content. The peer or node selection process in their solution is also resource consuming, as it broadcasts the discovery message to the whole network. Moreover, in the discovery message, users profile is added, which requires additional processing of message content to the clients side before accepting or rejecting invitation. As well as, due to flooding over the network, the approach could be in risk of spamming. In our approach, the propagation of invitation message is done based on trust metrics and interest keys, therefore unknown and unwanted nodes are easily prohibited from the distribution, which makes the distribution controlled within the interested contacts.

A community detection algorithm is proposed by Guillaume-Jeant. al., which considers link density and link-stability for generating dynamic ad-hoc social networks [10]. Kusakeet. al., considers social human relation-ship for large-scale ad-hoc networking [11]. In that approach, social relationship is used for deciding routes of each message. The work shows that social strength could be a reliability factor in terms of forming ad-hoc social networks.

Social media source such as Facebook can be used for predicting social strength or tie strength [12]. However, single source of social media is not enough to predict more accurate
strength. In our solution, aggregated social media interaction is utilized for predicting social strength.

B. Motivating Scenarios

Ebba is planning a party together with her closest friends and is meeting two of them to organize the party. They discuss some ideas and decide to create an ad-hoc social network for the party. She brings up her mobile creates ad-hoc social network, where her two friends are automatically added by using matching locality and tags as indication of interest, workplace, profile match. Ebba is then presented with a list of recommended persons based on her and her two friends aggregated social graph information. They decide to filter out persons in their age and that lives close to them, then limits the network size to 20 persons. They decide to remove one person on the list as she is indicated to be traveling in her Facebook wall-post and then they activate this social network before watching the movie.

When Ebba arrives home she opens ad-hoc social network service and composes a new ad-hoc social network for another purpose by placing a poll component, some media components and a chat component, which she then configures with adding a name, a picture of the movie, a song from her current play-list and a welcome message. She then selects the new party group and sends the app. Some of her friends immediately respond by answering the poll, chatting suggestions and adding a few photos of their own. At the party, people use the app to continue chat and share photos, and new members are invited that joined the party after hearing about it. At the party time, Ebba is dynamically added a new component for real-time video sharing.

III. MODELING SOCIAL DISTRIBUTION MECHANISM

Figure 1 illustrates the distribution of invitation message using the proposed social distribution mechanism. The figure shows how invitations are sent to the yellow-headed contacts, which has similar interest with respect to the tag or interest keys. It also shows that invitations are propagated beyond 1st degree of contacts and eventually forms an ad-hoc social network. The proposed mechanism is designed around a Find/Discover, Review/Analysis and Invite/Distribute schema.

Figure 2 illustrate the main building block of the mechanism. As an input from the user, the mechanism processes tags and generates an ad-hoc social network for the user. The Find/Discover block finds appropriate contacts from different communication services. The Review/Analyze block generates distribution key that are send along with the invitation to the contacts. The Invite/Propagate block receives invitations and publishes itself in the network. It also verifies the distribution key to decide how to further distribute the invitation. If the contact has sufficient strength to distribute the invitation, it follows the same Find/Discover, Review/Analysis and Invite/Distribute schema to further propagate the invitation.

Each of the blocks performs some activities, which are mentioned in below:

Find/Discover

Figure 3 describes the Find/Discover activity of the social distribution mechanism. User tags can be input such as the user current location or other kind of sensor data as well as contents such as keywords indicating the purpose of the communication. Based on the resources and content, the Aggregated Social Graph component mentioned in Section 2 recommends a list of contacts [4]. Some tasks of the Aggregated Social Graph component are done in the client device and some other tasks of may be done in the network considering the deployment of the Aggregated Social Graph service. Thus, main tasks of the blocks consist of the following objective.

- Assign input tags
- Tag characterization (contact, content, resources)
- Search in the Aggregated Social Graph component
- Identify a list of contact for inviting to join in this ad-hoc social network

Review/Analyze

Figure 4 shows the main tasks of Review/Analysis block of the social distribution mechanism. After receiving a list of contacts, it reviews the social strength of each of the contact, as well as associates the distribution key based on the social strength. It then sends the invitation to the contact to be part of the ad-hoc social network. The Social Distribution
Key Manager uses the social strength as key metrics for the social distribution. Invitation key contains a universal address of collaboration tools, where the participants in the ad-hoc social network are being able to collaborate. In a way, the invitation key refers a Web link of collaboration or shared space, which is equipped with several collaboration tools. Similarly, the distribution key contains an alphanumeric value to decide if the invited contact has access to re-distribute the invitation. The distribution key is dynamically re-calculated before propagating to other contacts. Thus the main tasks of the blocks in Figure 4 is a following:

- Review each of the contacts in relationship with social strength and location
- Identify social strength of the contact comparing with the invitation owner for the purpose of generation of appropriate distribution key
- Invite the contact by sending invitation with distribution key

In case of re-distribution, it performs the step 1 to 3 and always checks distribution key to verify if the contacts have credential to re-distribute invitation.

Finally, the ad-hoc social network is formed with group of contacts based on the tags. In this network, all contacts hold first-degree relationship, which means that the contacts may communicate with each other without any limitations of privacy perspective.

A. Social Distribution and Key Management

As shown in Figure 4, the Social Distribution Key Manager generates and re-calculates the distribution key during runtime. It first checks if the originator of the invitation provides distribution key in the Find/Discover phase. If it contains distribution key, the key generator modify the key, otherwise it generates a new distribution key to initiate the distribution process. As an input, the social strengths of the participants are required, which is collected through the Aggregated Social Graph component.

The format of distribution key is a Boolean expression with four numeric values such as N0000, orY0410. The first token in the format indicates if the receiving node is allowed to further propagate the invitation. If the token is set to Y, the mechanism re-distribute the invitation messages. If it is set to N, the mechanism stops the distribution of the invitation message. The next two digits contain degree of propagation followed by two digits provide which defines the percentage of contacts from the participants list to have distribution power based on their social strength. For example, if the key is set up Y0410, the mechanism interprets Y as it has distribution credential. 04 is considers four degree of distributions, 10 provides 10% of recipients will get distribution credential on the basis of having higher social strength with the distributor.

In each of the iterations, the distribution key is recalculated. Algorithm 1 provides details approach of calculating distribution key and inviting the nodes of the system. In the proposed algorithm, there are two input parameters, which are dKey, and tags. dKey is distribution key and tags are the context of distribution which are the key words given to the systems for identifying potential nodes for social distribution. For example, location, activities can be considered as tags. Algorithm 1 illustrated in the Figure 6 contains different variables such as token, distribution credential, degree of propagation, pertg_of propagation, my_social_graph, num_allowed_disth, matched_contacts and i. The variable token contains parsed properties of the distribution key. For example, token[0] value for distribution credential. The variable distribution credential provides distribution credential for the receiver node, which has two values such as “Y” or “N” as previously discussed. For “Y” value, the content will be considered for redistributed inside the receiver node’s social graph. For “N”, there will be no redistribution. The variable degree_of propagation contains the degree of propagation. At each receiving node the value of the degree of propagation is decremented by 1. The propagation is continued until the degree_of propagation or distribution credential contains ”N”. The my_graph_strength contains...
Algorithm 1: Social Distribution

Function DistributedKeyGeneration (dKey, tags)

var list token
var string distribution_credential
var integer degree_of_pognition
var integer part_of_pognition
var list my_social_graph
var list num_allowed_invites
var list matched_contacts
var integer i

if(dKey == null)
    token = parse(dKey);
    distribution_credential = token[0];
    degree_of_pognition = token[1].toInt;
    part_of_pognition = token[2].toInt;
    my_graph_strength = getGraphStrengthInPrioritizedOrder(
        matched_contacts = keywordMatch(my_graph_strength, tags)
    )
    distb_quota = (matched_contacts * part_of_pignon)/100;

if(distribution_credential == "Y")
    degree_of_pignon = degree_of_pignon - 1;
    part_of_pignon = part_of_pignon * 0.10;

if(degree_of_pignon > 0)
    dKey = "Y" + degree_of_pignon.toString + part_of_pignon.toString
else if(degree_of_pignon == 0)
    dKey = "N0000"

While matched_contacts[i] != null
    if(distb_quota > 0)
        invite(matched_contacts[i], dKey, tags)
        i = i + 1
        distb_quota = distb_quota - 1;
else
    default dKey = "Y0440"

Reset(dKey)

Fig. 6. Social Distribution Algorithm

list of the global contacts (i.e., nodes) in a prioritized manner.

The matched_contacts contains a filtered list of nodes form the receiving nodes graph that match with the tags. By fixing distb_quota, the number of the nodes that may have distribution capability can be controlled. In the default settings, 40% from the filtered list of contacts with social strength will be considered for associating in re-distribution process. Rest of the nodes in the list will only get invitation message due to their interest about the tags. The algorithm also contains functionality for re-calcultating of distribution key before sending the invitation. Therefore, each of the receiving nodes gets an updated distribution key to control distribution and keeps the distribution targeted and task specific.

IV. EVALUATION

The proposed mechanism has been evaluated using both a proof-of-concept prototype and simulator to verify that it can be utilized for forming ad-hoc social networks and to distribute media content. Particularly, the formation of the ad-hoc social network is evaluated by using the proof-of-concept prototype. The proof-of-concept prototype is also used to explore the end-user benefits of collaboration tools running on an ad-hoc social network.

The simulation study is specifically conducted to test if the distribution of the invitations is controlled to limit spamming yet spanning over the whole networks only to the interested and trusted contacts. To measure the distribution capability, the simulation study is based on the LiveJournal social networking dataset [13].

A. Proof-of-concept prototype

The proof-of-concept prototype illustrated in Figure 7 consists of several components. It utilizes the previously mentioned Aggregated Social Graph component and the proposed social distribution mechanism to generate ad-hoc social networks. It also uses the Ericsson Labs Distributed Shared Memory (DSM) service to provide a collaborative shared space runtime environment running different kinds of collaboration widgets such as shared notes, real-time chatting, shared maps etc. Each of the ad-hoc social networks utilizes a unique DSM address space for collaboration management. The social distribution mechanism is primarily used to distribute this address space among participants so that every user in the ad-hoc social network can collaborate. The run-time is implemented for Android OS based smart phones.

Referring back to motivating scenarios section, here in the Figure 7, Eblie found a task to form a consortium for Group Media project proposal. She would not make an announcement for the participation in the project in Facebook, as most of the contacts in Facebook may not be interested for that project. Therefore, Eblie creates an ad-hoc social network for the purpose of Group Media project using shared space app illustrated in Figure 7b and Figure 7c. The app recommends and propagates invitation to the contacts that might be interested in this project. To reduce manual operation, the app utilizes social strength of the potential contacts for automatic re-distribution of invitation message. Upon receiving invitations, Eblie and Alex are able to perform collaborative tasks using the collaboration tools illustrated in Figures 7c and 7g. In this way, Eblie is able to form a new ad-hoc social network and share Group Media activities among the interested and trusted contacts through different collaboration tools, for instance being able to chat with Alex through the real-time chatting tool as illustrated in the Figure 7d and Figure 7h.

B. Simulation study

To evaluate the distribution mechanism, it is important to have access to real social networking data, not only on a particular users egocentric graph, but also on the 2nd degree or 3rd degree nodes of the network and so forth. Initially, Facebook app, LinkedIn app was developed to capture graph data (users profile and friends profile data). Also, an application for fetching location data from through GPS from Android OS based mobile devices was developed. Finally, a web application was developed where the user may form new groups on the basis of the context key.

The proposed distribution mechanism is applied to form ad-hoc social networks and sending invitations to among to participants of the network to share media contents. However, in most of cases the invitation process is strict among the 1st degree friends or 2nd degree fiends due to lack of large number
of users in the systems. We have identified the following facts from the above-mentioned experiments:

1. Egocentric graph is insufficient to evaluate the social distribution mechanism.
2. Incomplete graph is insufficient to evaluate the social distribution mechanism.
3. Relationship-tier is insufficient to evaluate the social distribution mechanism.

This experience could be concluded in a way that huge number of users involvement are required to evaluate the distribution mechanism. Therefore, to run the experiment LiveJournal social networks data were utilized. LiveJournal dataset provides the social graph without profile information. For that reason, the context data and social strength of the users are randomly generated to the dataset. A subset of 100 nodes or users are utilized to run the experiment.

The LiveJournal Experiment
As social strength and users interest are considered two important constraints of social distribution in the proposed solution, therefore the experiments are run to measure the effects of such constraint in controlled viral distribution. More specifically, the following four criteria were considered to run initial experiment.

1. Neutral social strength and neutral interest keys: In this scenario, users or nodes in the networks do not have social strength and interest keys. Thus the graph is not weighted and the nodes do not provide any interest keys for accepting or rejecting invitation messages.
2. Neutral social strength with interest keys: The graph is not weighted but the nodes contain interest keys to specify their interests.
3. Social strength with neutral interest keys: In this case the graph is weighted, thus the nodes are ranked in terms of social strength. However, it lack of interest keys.
4. With social strength and interest keys: In this case the
graph data is weighed and the nodes contain interest keys.

Figure 8 shows that in the cases neutral social strength and neutral interest, the invitation messages is distributed to all the contacts of the users. X-axis shows the index the users in the data source and provides the number of invitations distributed to the contacts. The black line illustrates the distribution of invitations to all the contacts of the users that can be considered as social spam as the invitations are propagated over the whole networks without considering contacts preference. The dashed line illustrates controlled distribution of invitations. Randomly selecting 40% of distribution, the dashed line shows reduction of invitations distribution. However, specific filtering parameter is not applied to identify appropriate nodes for invitation from the data set. For that reason, the reduced distribution could be considered as spam.

In the Figure 9, which shows (dash-line) that the distribution can be controlled by identifying the appropriate nodes that are interested to the given context keys. However, some of the nodes may still consider the invitation as spam due to the fact that the originator of invitation message does not have a strong relationship-tier with the recipients. The same issue may rise if the distribution mechanism considers only the relationship-tier controlling as parameter for propagating invitation.

In Figure 10, invitation is distributed among the top 60% of the edges of the receiving node. Among the invited nodes, it is unknown that the receiving nodes are considering the invitation as spam or not as the interest keys is not taken into consideration. Figure 11 show the best case among the samples where the distribution is controlled by both the relationship-tier and interest keys constraints. Here the distribution and propagation is done on the basis of the relationship-tier, interest keys and configuration of distribution keys.

V. DISCUSSION

Can social strength be used to form ad-hoc social networks for media distribution?

This paper has discussed a social distribution mechanism for inviting desired participants to ad-hoc social networks, based
on the social relation to the participants (utilizing a find-analyze-distribute methodology based on social strength). The ad-hoc social network can then be supported by a collaborative workspace, such as a dynamic shared space, that can enhance communication among the desired participants by inclusion of apps for specific needs.

The proposed distribution mechanism discovers contacts based on the contacts’ interests as well as the strength of the relationships between the contacts. Therefore, an ad-hoc social network can be formed of trusted entities that fulfil a shared interest or goal. Also, another benefit of ad-hoc social networks is the capability of providing users the freedom of creating networks in a decentralized manner (where the user is the owner of the network).

How can social strength be used as a trust metric to control viral distribution of media while also considering a users context (such as interest)?

This approach considers two factors for distributing invitation. The first factor is the meaningfulness of the content that the user is interested in. This will invite the users only when the mechanism gets possible clues that the user is interested in that content. In some cases, users feel lack of confidence to accept invitation if the sender of invitation is unknown or have weak relationship [6]. Therefore, it might be perceived that the user is more likely to accept an invitation, if strong relationship-tier exists between them. The second factor is therefore related to trust and is based on the social strength between distributors and receptors. The evaluation shows that the two factors both needs to be considered for successful distribution of media content (such as combining social strength between users with the interest of the users).

VI. CONCLUSIONS

To conclude, this paper has proposed a new mechanism for social distribution of media, which addresses the problems of identifying potential users for performing social collaborative activities and sharing social media content. It simplifies the process of propagating invitations to different levels of contacts by exploiting aggregated social graphs. It shows that viral distribution is effective and useful if the distribution parameters take recipients interest and trust into account.

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