Mobile Social Network and Its Open Research Problems

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Abstract—**Mobile social networking is social networking where one or more individuals of similar interests or commonalities, conversing and connecting with one another using the mobile phone. With the development and proliferation of smart phone devices and social network systems such as Facebook and MySpace, research on mobile social network gains huge attention from the academic community. The migration of social networks from web-based applications onto mobile platforms not only increases the connectivity of people, but also promotes the convenience of people's life. We will review in this article the current most active research topics on mobile social network, along with their challenges. The finding in this study shows that current researches are in an immature period as researchers are trying to "study" the network more than actually derive new research artifacts.**

I. INTRODUCTION

Prehistoric studies on social networks can date back to the day Milgram *et al.* investigates the "Small World Problem" [1]. In Milgram's study, relational information was based on the forwarding of letters of acquaintances. In other words, two nodes A and B of the social network were connected if A either sent to or received a letter from B. The result of the study tells us that we live on a small world with "six degrees of separation." Study on complex networks contributed additional knowledge on the structural properties and dynamics of the networks. In another notable study, Watts and Strogratz [2] investigated the structure of the social world of Hollywood by defining two actors as connected if they acted in the same film. Analyzing the information present in the Internet Movie Database, they concluded that the 225.000 actors were separated from each other by only four steps.

The definition of social network sites based on [3] firstly is a web-based service that allows individuals to construct a public or semi-public profile within the system, secondly it manages a list of other users with whom they share a connection, and thirdly is possible to view and traverse their list of connections. A social network provides a variety of mechanisms for users to share data with other users. Also, it has the ability to search for users with similar interests and to establish and maintain communication between them [4]. Online social networks have become very popular during in these last few years. For example, Facebook hits 650 million users as reported in February 2011 [5].

The origins of social networks lie in the early 1990's when they were simple means of communication between
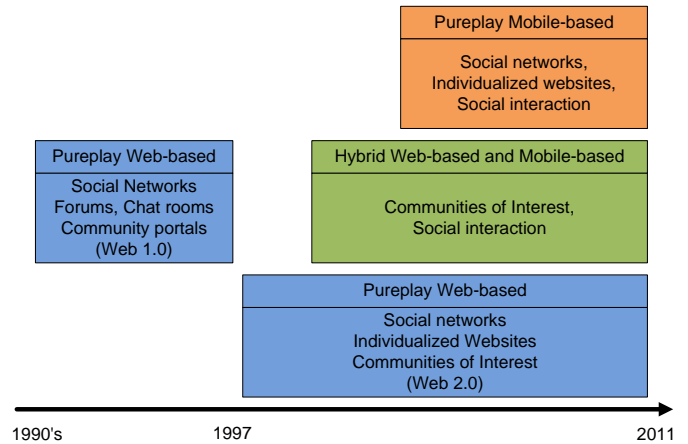

Fig. 1: Evolution of social networks.

people over the Internet, such as forums, discussion groups, professional associations or other places where people could exchange ideas. Internet technologies evolved together with social software. In this evolution, the social networks as we know them were created; people started to have a profile, and in turn started sharing content in a more active way in Internet communities. According to the definition that was provided at the beginning, the first social network site was launched in 1997, namely SixDegrees.com.

Social network as a part of the Web 2.0 was born in a conference brainstorming session between O'Reilly and MediaLive International. They noted that the web was more important than ever and there were a lot of new applications and sites appearing every day. The central concept behind Web 2.0 was the power of collective intelligence: sharing data [6]. One of the main reasons for this evolution into Web 2.0 was that people start participating more active in the Internet. This occurred because the technology started to allow the Internet users to add content to it. Before Web 2.0, few users shared content in the Internet and most of the Internet users where typically receivers of the information.

The technology continued to evolving and with it the social software. Nowadays cell phones or other mobile devices are something that most of the people have. And mostly all new cell phones have the ability to navigate through the Internet.

Mobile 2.0 is the name given to the transfer of all the current trends of Web 2.0 to mobile devices. And *mobile social networking* refers to transferring the current trends in social networking to these mobile devices, adding new features that the mobility and the context awareness provide.

Nowadays, there are more cell phone users than Internet users. Also, the cell phone is a personal device that goes wherever the owner goes. As a result, it can provide a lot of information about the environment of the user. For example, where he is, what music he is listening to, which photos he is taking ...

The aim of this article is to study the mobile social network systems (MSNS), analyzing features that they share with ordinary desktop based social networking and their difference. We also survey a few active research topics on MSNS, along with their challenges and research methodologies.

II. Mobile social network features

Before going into the analysis of current research topics in MSNS, we would like to do a quick note on how different a MSNS is from a traditional Web-based social network system (SNS). This will provide us with more background and insight for better understanding the current research issues.

A. Architecture

The common architecture for MSNS systems is client-server architecture. The serve consists of a number of components including http server, databases, profile repository and application logic. The client are the web interface and (or) the applications running on users' mobile phones. [7] has proposed a general architecture for building MSNSs, which is illustrated in Figure 2. It consists of four main components: 1) the Client device, 2) the wireless access network, 3) the Internet and (4) the Server side. There are five modules at the Server side: Web server, location database, profile repository, matching logic, and privacy control.

Hybrid or purely mobile: There two possibilities for MSNSs. One is a purely mobile social network with be these that were specifically designed from the first moment to be used in mobile devices. The other is a hybrid one containing social networks that was first designed to work in web-based platform and then later being migrated to the mobile platform. While social networking were initially only accessible through websites, the development of mobile platform motivates the users to participate both through a website and by using their mobile devices. To name a few MSNS representing the first group (i.e. purely mobile), we have Dodgeball, Smallplanet, Rabble and Playtxt; while we have Facebook, MySpace, Twitter ... represents the second group (i.e. hybrid systems).

Client software or mobile web browser: Another important characteristic of a mobile social network is the way it was designed. There are two different approaches, namely web-based and software in the client, and the result obtained can be very different. If there is some software installed on the mobile device, mobile social network will be able to obtain
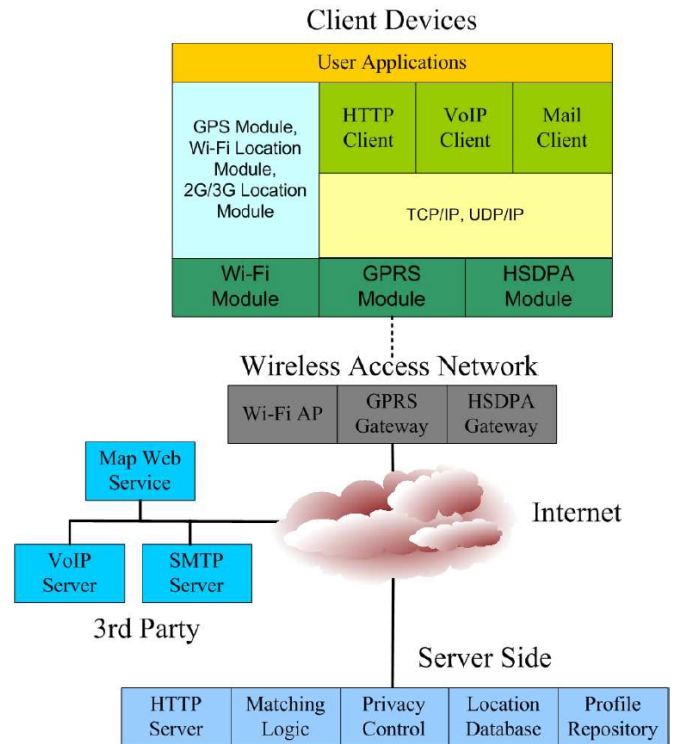

Fig. 2: System architecture for the mobile social network systems in the context of social services. Image from [7]

more contextual information from the mobile device than will the social networks that just rely on a mobile web browser. However, this approach also consumes more resources and the client has to be developed for a lot of different mobile planforms. For example, Facebook users nowadays have two different ways to connect to Facebook from their mobile phones: through Facebook application or through the handset device's web browser. Different Facebook clients have to be developed for different phone OSs (iOS on iPhone, Android on Android phones and Windows Mobile on Windows phones).

B. Context information

In general, mobile social networks are different from the desktop based social networks because they have some additional features like, contextual information. As depicted in Figure3, the mobile context can be generated by means of information such as the location of the mobile device, the time, tags that describe the environment information from other devices that surround it, some capabilities that the handset has and some preferences provided by the user.

Positioning: Positioning means knowing the user exact location. The positioning feature is one of the main differences between a desktop device and a mobile device. In contrast to the former, mobile phones can inform where the user is and this information can be used for enriching the information of the user.
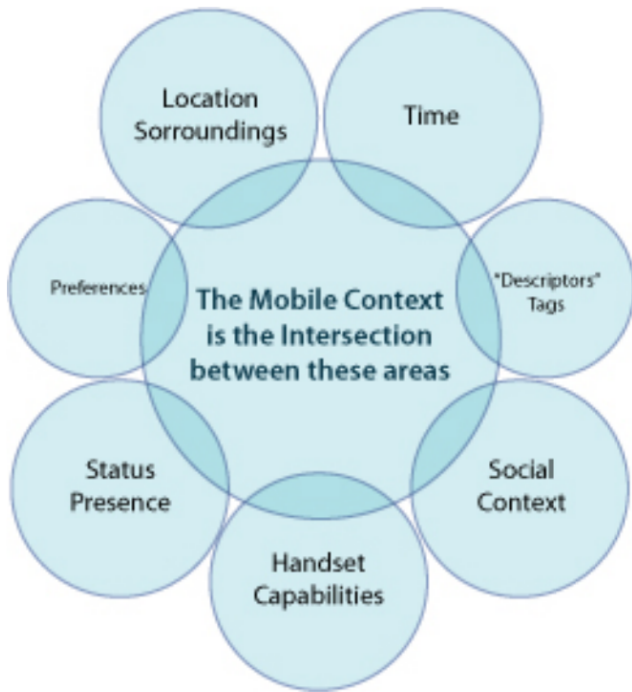
Fig. 3: Mobile context. Image from [8]

The most popular application that make use of the positioning feature of mobile phones is the Virtual Sticky Notes. This application have different names on different platform, but they all share the same idea. Users will add "virtual" nodes at different geographic locations. The note and the location will be uploaded to a server and is shared among the user with a specific group of his friends. Next time one of the friends visit that location, the note will be visible to that friend. Another interesting example is the automatic localization of photos. When a user takes a photo using his handheld device, the system will automatically places the photo on the map where it was taken. By knowing the location of users, more interesting services and applications could be provided like meeting arrangement, offline dating, friend locating ...

Information tagging: The idea behind this feature is to "sense" and use contextual information to provide pre-defined/commonly used tags based on location and proximity to other users or places. An sample application would be two colleagues taking pictures of each other at their office. The mobile phone is smart enough to infer the location and automatically tag the picture with the tag "office".

Automatic personal status update: This is another example where the phone can "sense" the current environment and automatically update the user's status accordingly on the social network profile. Information on the status could be the user's location, user's favorite music, user's current action, location ... However, this also exposes user privacy and is undesirable in many situations. In the end, user should have an option on weather or not he wants to share his personal data to all or some specific groups of friends.

Advertising: Mobile devices have an enormous advertisement potential. Besides being extremely popular, most people carry them all the time, enabling personalized advertising [9]. There are some reasons why mobile advertisement is an important branch in the mobile business. Firstly, the high penetration rate of mobile terminals. Secondly, mobile terminals are personal communication devices and are individually addressable. Lastly they have multimedia capabilities and provide interactivity. Again, despite many advantages of mobile devices, there are some serious challenges regarding mobile advertising such as: spam, limited user interface, privacy concerns and the cost of mobile communication.

III. OPEN RESEARCH PROBLEMS

In this section, we will survey some of the current active research topics as well as their challenges on MSNS. Typical researches on each topic will also be briefly mentioned.

A. Network structure studying

Studying the network structure is probably the most popular topic in both MSNS and SNS. Approaches vary from using simple statistical techniques on graph to complicated algorithms like community detection or diffusion and spreading algorithms. In [10], Kumar *et al.* study the structure and evolution of two of the social networks from Yahoo: Flickr and Yahoo! 360 (currently only Flickr is operating, Yahoo! decided to close Yahoo! 360 due to the lack of features and the massive growth of adversary social networks). They simply use node degrees to separate the network into three regions: 1) *Singletons*: degree-zero nodes who have joined the service, but have never connected to another user in the network 2) *Giant component*: densely connected core users, each connected to each other through paths in the social network and 3) *Middle region*: remainder - isolated communities that connect to each other, but not the network at large. Findings from the study reveal that surprisingly, isolated communities account for a significant portion of the population: 1/3 of Flickr, 1/10 of Yahoo! 360 despite the massive growth and dramatic changes in particular users. Besides, most of the components form a "star" formation with one or two high-degree center nodes connected to many low-degree twinkles.

Onnela *et al.* [11] examine the communication patterns of millions of mobile phone users to simultaneously study the local and the global structure of a society-wide communication network. The authors observe a coupling between interaction strengths and the networks local structure, with the counter-intuitive consequence that social networks are robust to the removal of the strong ties but fall apart after a phase transition if the weak ties are removed. The authors also show that this coupling significantly slows the diffusion process, resulting in dynamic trapping of information in communities and hen it comes to information diffusion, weak and strong ties are both simultaneously ineffective.
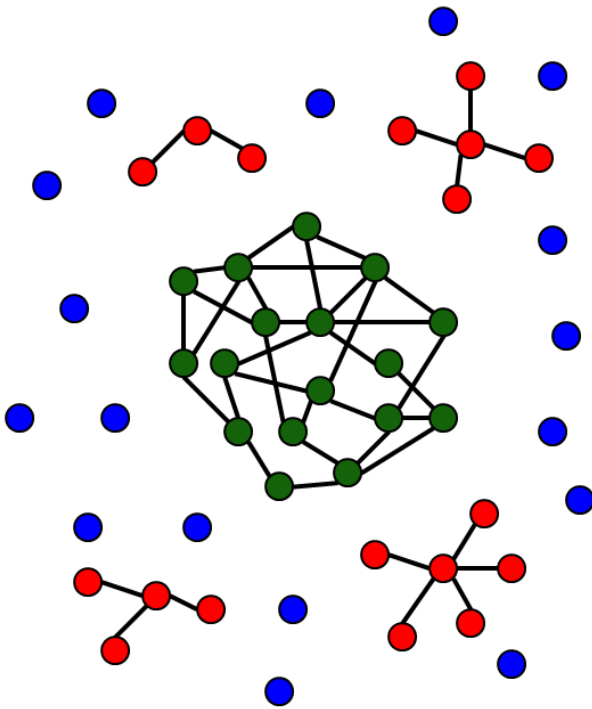
Fig. 4: Yahoo! network separated into three distinct regions. Blue nodes are Singletons. Red nodes from the middle region. Green nodes are giant components. Image from [10]

In another the effort to deal with community detection in social network, Xiong *et al.* [12] suggested an improvement over the infamous Girvan - Newman algorithm [13]. The author pointed out that Girvan - Newman algorithm is computational expensive and is inappropriate to be used in massive-scale networks like social networks. They suggested an improvement of Girvan - Newman algorithm in which at each step, more than one edge can be removed when all betweenness scores have been computed. The method is shown to be fast and effective through theoretical analysis and experiments with several real data sets.

B. Case studying the mobile social network

This category tries to tackle researchers' curiosity on the mobile social network. Most frequent research questions that motivate researchers are: How are the mobile social networks formed? How do they evolve? What kind of encounter model the users exhibit in the network? Mobile user behavior analysis? ... As previously mentioned, Kumar *et al.* [10] case studied Yahoo! 360 and Flickr networks to find out the network structure and characteristics. In [14], Dong *et al.* build and mobile social network in China and extract call logs for data analysis. Findings from the study is interesting. It shows that the social network is a typical scale-free network and has small-world phenomenon. Interesting enough, the analysis shows middle-age people are more active than the young and old people, and the female is unusual more active than the male while in the old age.

In another well known series of publications [15] [16], Humphreys *et al.* explores how Dodgeball network was used to facilitate social congregation in public spaces, especially urban crowded areas; and how ideas of mobile communication and public space are negotiated in the everyday practice and use of mobile social networks. Facebook, the current biggest social network is also investigated by Boyd *et al.* in [17]. The author examines the attitudes and practices of a cohort of 18– and 19–year-old surveyed in 2009 and again in 2010 about Facebooks privacy settings. Result concludes that both frequency and type of Facebook use as well as Internet skill are correlated with making modifications to privacy settings; and there is just a few gender differences in how young adults approach their Facebook privacy settings, which is interesting given that gender differences exist in so many other domains online.

Baker *et al.* in [18] studied MSNS user behavior by conducting a survey on 134 MySpace users about their intent to blog and several psychosocial variables. Participants have to complete a questionnaire and will be graded. Intending bloggers scored higher on psychological distress, self-blame, and venting and score lower on social integration and satisfaction with number of online and face–to–face friends. Intending bloggers may view this activity as a potential mechanism for coping with distress in situations in which they feel inadequately linked with social supports.

C. Influence maximization

Influence maximization is the problem of finding a small subset of nodes (seed nodes) in a social network that could maximize the spread of influence. Models for the processes by which ideas and influence propagate through a social network have been studied in a number of domains, including the diffusion of medical and technological innovations, the sudden and widespread adoption of various strategies in game-theoretic settings, and the effects of "word of mouth" in the promotion of new products. This research topic is particularly useful to business marketing people since they want to determine pivotal users in the network who they can focus to "persuade". This user, with their influence, will perform a cascading effects that influent other users in the network. It will be the most cost–effective advertising approach.

In [19], Kempe *et al.* prove that the optimization problem of selecting the most influential nodes in the network is NP-hard, and provide the first provable approximation guarantees for efficient algorithms. Using an analysis framework based on submodular functions, the authors show that a natural greedy strategy obtains a solution that is provably within 63% of optimal for several classes of models. Also, the proposed approximation algorithms significantly outperform node selection heuristics based on the well-studied notions of degree centrality and distance centrality from the field of social networks. Later in [20], Chen *et al.* study the efficient influence maximization from two complementary directions. One is to improve the ordinal greedy algorithm in [19] and second is to propose a new degree discount heuristics that

improves influence spread. The studied result shows that fine-tuned heuristics may provide scalable solutions to the influence maximization problem with satisfying influence spread and fast running time.

D. Trusting and privacy

The term "trust" can be used to indicate different types of social relationships between two users, such as friendship, appreciation, and interest. "Privacy" on the other hand, represents the concept of protecting user personal information. Trusting and privacy are two important concepts in social networking. Everything must be done with the consensus of the users, which information should be public and which private. In mobile social networking privacy and security are key components of the application. Because contextual information can uncover real time data of the user, this can create data that the users might think that is intrusive of incorrect. For example, user location is something that should be displayed with a lot of privacy consideration.

In [21], Dwyer et al. conducted an online survey between two social networking sites: Facebook and MySpace, to compare perceptions of trust and privacy concern, along with the willingness to share information and develop new relationships. Members of both sites reported similar levels of privacy concern. Facebook members express significant trust in both Facebook and its member, and are more willing to share identifying information. This finding matches a previous study in [17] where the concern of Facebook users over–trusting the network is raised. This work also shows that in an online site, the existence of trust and the willingness to share information do not automatically translate into new social interaction. Similarly, Fogel et al. [22] conducted another survey between Facebook and MySpace and confirm the fact that Facebook users has a greater sense of trust than MySpace. The authors also finds that people with profiles on social networking websites have greater risk taking attitudes than those who don't, and women disclosure greater privacy concerns than men.

Li et al. in [23] point out that although many trust management systems have been proposed, few of them can be applied to mobile social networks because of the unique network and communication characteristics. The paper presents a new trust management system, termed MobileTrust, to establish secure, reliable, and accurate trust relationships between network participants. Specifically, the construction of trust models encompasses three key factors associated with the similarity of user profile, reputation, and history of friendship. This approach is reasonable given that the correlation between reputation and trust in mobile social networks was confirmed in [24]. Also on the same topic, Trifunovic et al. suggest that a more fundamental trust, social trust (assessing a user is genuine with honest intentions) must be established beforehand as many identities can be created easily. By leveraging the social network structure and its dynamics, the authors propose two complementary approaches for social trust establishment: explicit social trust and implicit social trust. Explicit social trust is based on consciously established friend ties by building a robust tree-like graph of paired users. Implicit social trust, on the other hand, leverages mobility properties using complex network tools, since one might not pair with every encountered user (e.g., some friends or familiar strangers). The proposed approach is shown to be more robust against manipulation attacks compared to state-of-the-art approaches such as PGP-like certification chains and distributed community detection algorithms.

IV. Conclusion

With the rapid development of mobile devices and wireless technologies, a large number of mobile social network systems have emerged in the last few years. This article analyzes advantages and differences of the mobile social network over the traditional social network. From that understanding, we survey open search topics and their challenges. Also for each topics, we present the most representative examples and summarize their findings. By the end of the way, we see that current researches on MSNS focus too much on "studying" the network rather than really deriving something new on it. This is understandable since the topic is new and currently immature. It is expected that in future, more research topics would be better studied by the academia like: mobile context detection, advance privacy and security, business aspect of MSNS...

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