Ubiquitous Social Networking

Concept and Evaluation

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Published in:
Sensor Letters

Publication date:
2012

Document Version
Early version, also known as pre-print

Ubiquitous Social Networking: Concept and Evaluation

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Abstract: Despite the great success of online social networks, there is still no automated way to facilitate communication between people in the physical environment. Ubiquitous social networking services target at transferring online social networking benefits to the physical world, by facilitating advantageous relationships during physical meetings between people who do not know each other, but probably they should. In this paper, we present a potential solution for establishing ubiquitous social networking services by integrating online social networks with opportunistic networks. This solution, called local social networks, focuses on uncovering relevant connections between people nearby, by providing a platform for automatic exchange of user personal information in order to discover interpersonal affinities. Firstly, we define and discuss the concept, advantages, preliminary architecture and potential future applications of local social networks as well as introduce the first prototype, named Spiderweb. Afterwards, we present results of a qualitative investigation that researched whether 16 active online social networks users would accept ubiquitous social networking services. The results revealed that all the participants perceived the usefulness of these services and 14 of them would be willing to accept all the necessary requirements for the establishment of local social networks and consequently be potential users.

Keywords: ubiquitous computing; social networking; privacy; information disclosure; mobile computing.

Reference to this paper should be made as follows: Sapuppo, A. (2012) 'Ubiquitous Social Networking: Concept and Evaluation', *Sensor Letters*, Vol. 10, No. 8, pp.1632–1644, American Scientific Publishers.

1 Introduction

The creation of Internet provided an innovative communication infrastructure that reduced the distance between people living in different parts of the world. Soon on the basis of this technology new services have been developed, which improved the communication between people. Such initiatives as Orkut[1], MySpace[2] and Facebook[3], called online social networks (in the following referred to as OSNs), share a common characteristic: they enable people to create a virtual social network where users can stay in touch with friends from the whole world, share pictures, talk, chat, send messages and look for new acquaintances (Counts and Fisher, 2008; Ziv and Mulloth, 2007).

Despite the wide spread of OSNs, the flexibility and sociability of these networks can be questioned. Firstly, the access to OSNs services is not available upon user's demand, as it occurs exclusively while using a desktop computer (Eagle and Pentland, 2005). Further, the human communication is still highly embedded in the physical contact and closeness, provided by the physical environment. Unfortunately, OSNs do not facilitate social communication in the physical environment. Thus, people with shared interests and backgrounds fail to leverage interpersonal affinities for personal benefits (Eagle and Pentland, 2005; Pietiläinen et al., 2009; Gupta et al., 2009).

Recently, the flexibility restriction of OSNs has been solved by enabling the OSNs services on mobiles. The real advantage of mobile social networks, if compared to classic OSNs, is that mobile terminals elevate the freedom of movement while using the applications (Rana et al., 2009). Moreover, mobiles are not seen only as entry points to existing centralized OSNs, but thanks to their wireless technologies they also enable Opportunistic Networks (in the following referred to as ONs). In ONs, nodes are wirelessly connected and have the possibility to identify each other as well as exchange contents in a short communication range (Heinemann, 2007; Persson and Jung, 2005; Ioannidis and Chaintreau, 2009). When user personal information is incorporated to ONs, these networks can be perceived as an important tool for addressing sociability issues in the physical world, as they enable the establishment of ubiquitous social networking services (Delmastro et al., 2009; Eagle

and Pentland, 2005; Beale, 2005; Persson and Jung, 2005; Tamarit et al., 2009).

Ubiquitous social networking services attempt to address sociability issues by providing a controlled automated communication system, applied in everyday physical world. These services help users to develop possible advantageous relationships such as friendships, partnerships, business relations by uncovering hidden connections that people share with others nearby and thus facilitating initialization of face-to-face interactions. As a result, the value of social networking is significantly enhanced and benefits are available immediately upon demand (Eagle and Pentland, 2005; Gupta et al., 2009; Pietiläinen et al., 2009; Tamarit et al., 2009).

In this paper, we present a potential solution for the establishment of ubiquitous social networking services, called local social networks, which incorporates the users' personal information into ONs by integrating OSNs with ONs. Thanks to this integration, local social networks are capable of combining online and ubiquitous social networking services and provide them to the users through a single platform. In order to analyze the acceptance of local social networks, we ran a qualitative investigation with 16 active online social networks users. Particularly, we researched the perceived usefulness of ubiquitous social networking services as well as participants' acceptance of the crucial requirements for the establishment of these services.

The rest of the paper is structured as follows: in the next section we describes and defines in details the concept of local social networks, presents the preliminary architecture, first prototype as well as suggestions for future potential applications of ubiquitous social networking services. In Section 3, we review the background and design of the qualitative investigation and information about the participants. We present results of the conducted qualitative tests in Section 4. Final conclusions and recommendations for future work are drawn in the last section of the paper.

2 Local social networks

Local Social Networks (in the following referred to as LSNs) focus on promoting ubiquitous social networking services in order to facilitate face-to-face interactions between people during physical meetings. This solution attempts to address sociability issues by providing a platform for automatic exchange of user profiles in order to discover interpersonal affinities and consequently create new beneficial relationships between users, who do not know each other, but probably should.

In the following, firstly, we present an example scenario, illustrating the ubiquitous social networking process, followed by the definition and preliminary architecture of LSNs. Further, we introduce the first prototype and potential application areas of LSNs.

2.1 Example scenario

To better explain the LSN concept, we present an example scenario of ubiquitous social networking services in Figure 1. A user named Bob, who is marked in blue, is located in a public place, such as a canteen of an ordinary work place. Bob is surrounded by people that he knows, marked in green, and people that are strangers to him, marked in white. Even if Bob does not interact with all people in the canteen, his mobile phone does it for him by exchanging personal information with other LSNs peers in his proximity, as shown in Figure 2-A. Due

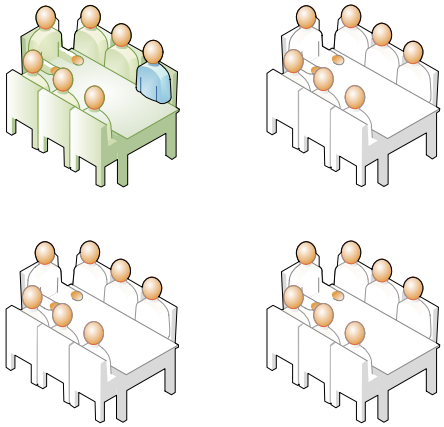

Figure 1 Ubiquitous Social Networking Example Scenario

to the exchange of personal information, LSNs develop an understanding about who are the people nearby as well as their respective preferences. Thus, these services are capable of highlighting relevant social paths between users that would be hidden otherwise, as shown in Figure 2-B. When LSNs find profile similarities between Bob and other LSNs users, highlighted in yellow in Figure 2-B, they are notified about each others' presence and, therefore, have the opportunity to immediately initiate a face-to-face communication. However, in LSNs the exchange of personal information is automatic and it does not interfere with the current Bob's activity. The relevant information, which is useful for networking with other users, can be retrieved and used even at a later time.

As it can be derived from above example scenario, when Bob is taking part in these networks, all the other LSNs peers become aware that he is somewhere around. Moreover, due to the exchange of users' personal information, Bob is able to access others' personal data, as well as his data is revealed to the other peers of the network. Finally, as a result of immediate notifications about relevant profile similarities, Bob can initiate profitable conversations with the users, marked in yellow in Figure 2-B, and vice versa, i.e these users might decide to start a face-to-face interaction with Bob. Consequently, following this example scenario, we can identify three crucial requirements for the establishment of local social networks:

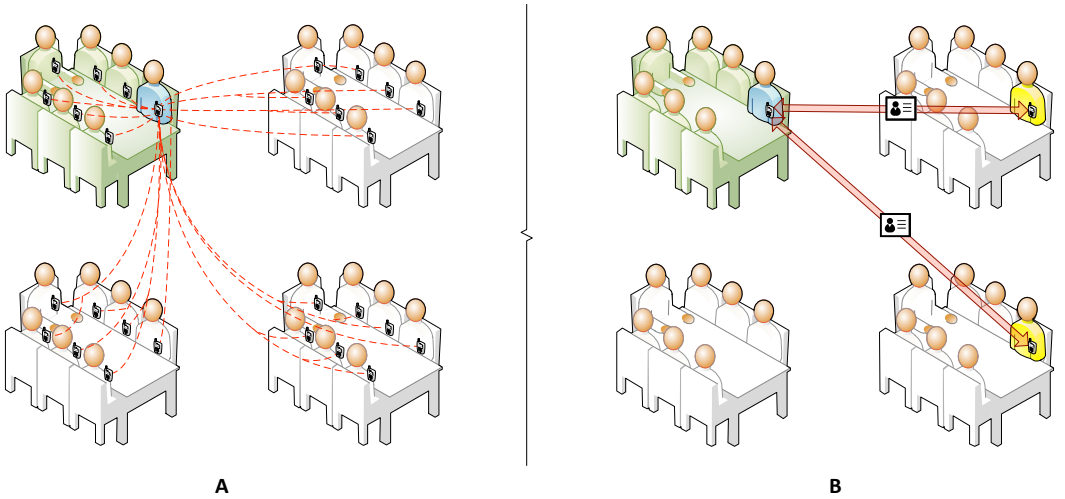

Figure 2 Ubiquitous Social Networking Example Scenario

- Announcement of users' presence: users must accept to inform other nearby LSNs users about their whereabouts;
- Disclosure of personal data: users must accept to share their personal information when encountering other LSNs users;
- Potential initiation of face-to-face interactions: users must accept possible immediate face-to-face interactions with other LSNs users, when notified about potential profile similarities.

2.2 Definition

After introducing the LSNs concept, we concisely define local social networks as follows:

> *A local social network is a wireless network of opportunistically connected sociable nodes*

In other words, LSN is a distributed network architecture in which nodes are linked to online social networks profiles and wirelessly interconnected to exchange personalized contents. The communication range between the sociable nodes is direct and limited to the walking distance.

2.3 Preliminary architecture

Figure 3 shows the preliminary architecture of local social networks, which is based on the integration of OSNs with ONs. The left side of Figure 3 presents the OSN architecture that is following the classical client/server model. The server is connected to a database that contains all the information about the users of the application: user profiles, messages, contact invitations, relationships between the users, etc. All the other elements are an assortment of clients. A client is able to interact with the server by starting a communication through an IP bearer technology. The right side of Figure 3 presents the ON architecture, which is based on the peer-to-peer wireless communication and consequently does not present any central server.

The main difference between OSNs and ONs is evident: the range where social networks are established. Regarding OSNs, the amount of data is usually vast and therefore it may be difficult to find the needed information. In case of ONs the amount of data is restricted to the range of the wireless technology adopted. This range has to be short enough to ensure that users are in the proximity of each other. At the same time it has to be long enough for users to scan without being noticed (Persson and Jung, 2005). Figure 4-A shows the wireless range of the user, however in reality the communication range is not an ideal circle due to communication signal interferences with the surroundings (Heinemann, 2007). Within the wireless range, users are able to instantly discover each other and exchange personal contents (e.g. profiles, messages, etc). When the device at the center of the circle discovers other users in its proximity, a direct connection between these two users is possible, as shown in Figure 4-B. On the contrary, the device outside the wireless range is not discovered and, consequently, these devices do not know about each other's existence and communication

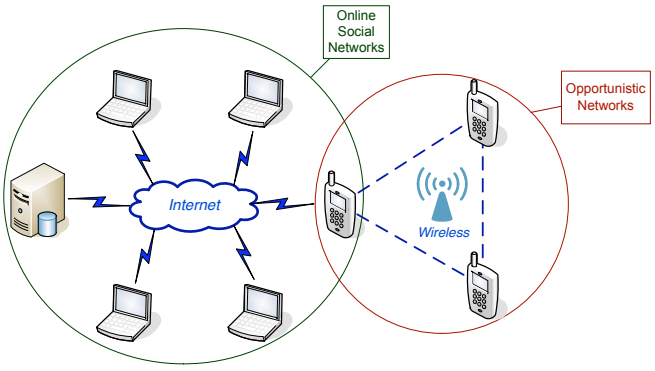

Figure 3 Preliminary architecture of Local Social Networks

between them is not possible unless they move into each others' wireless range.

Importantly, a LSNs node behaves as OSN node and ON node at the same time, as illustrated in Figure 3, where a node is placed in the intersection space between the OSNs and ONs. The LSN node architecture is presented in Figure 5. The bottom layer of the LSN node architecture manages the communication matters. While an IP Bearer technology can be used to access OSN services, the Exchange Data communication is used to enable direct communication in a short range of the selected wireless technology. The Node Discovery and Environment Discovery are adopted to define the current surroundings of the user, respectively information about other nodes in the user's LSN and relevant context data to interpret current users' location, activity, etc.

The second layer of LSN node architecture is composed of collection of services that can be offered by LSNs, which are enabled through the bottom communication layer. They are a collection of OSNs services (e.g. find new acquaintances, search for people on the basis of certain criteria, chat, view profile of other users, etc) and others, which promote sociability during physical meetings. Particularly, the latter services, such as Business Card Management and Exchange services, enable effective control and distribution of personalized user profiles in the users' vicinity. Moreover, the Similarity Evaluation services enable LSNs to compare the user profiles, calculate the similarity scores between the encountering users and consequently trigger the Notification System services when needed. The Notification System alerts users about the exchange of personal information with others, who present relevant profile similarities for networking.

The profile of the user is placed in the third architecture level of Figure 5, which is divided into ambiguous and unambiguous personal data. The Ambiguous User Data represents a set of information that may be subject to continuous changes, such as user preferences (e.g. food taste); the Unambiguous User Data is related to a set of information, which does not change often (e.g. home address) and thus it is considered to be of high sensitivity. Consequently, different strategies for preserving user's privacy can be

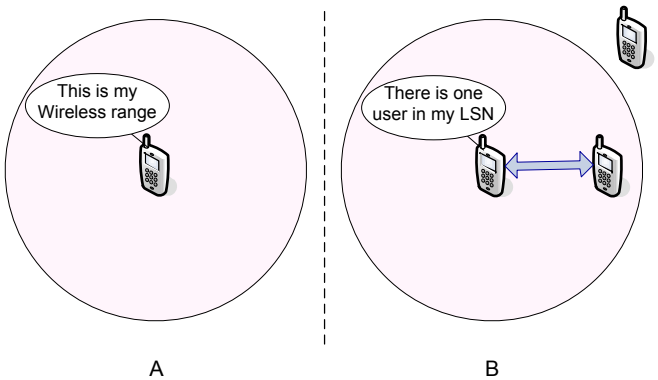

Figure 4 The range of Local Social Networks

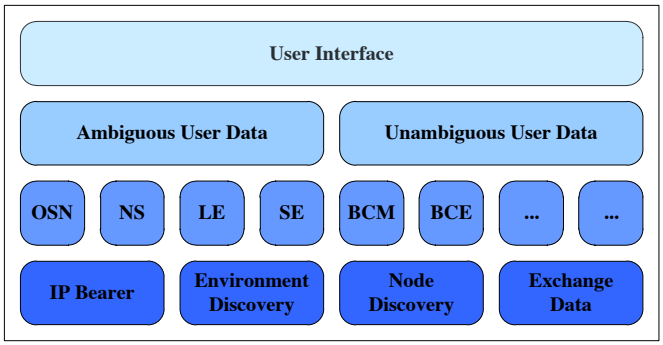

Figure 5 Local Social Networks node architecture

applied based on this data classification. Finally, the interface is placed in the top level of the LSN node architecture. The User Interface has access to all the other layers of the LSN node in order to accomplish its purpose.

2.4 The Spiderweb prototype

The first LSN prototype is the Spiderweb mobile social network application (Sapuppo, 2010), which was selected to be implemented in Java 2 Micro Edition (J2ME) in order to be compatible with all mobile operating systems supporting J2ME (Hammershøj et al., 2010). The application follows the software architecture schema described in Figure 3, thus Spiderweb integrates OSNs with ONs. Spiderweb partly relies on the Internet connectivity and offers several services, already well-known from online social networks sites. In fact, users are able to create their profiles and invite others to their social networks. They are also able to search for people based on certain filtering criteria, exchange messages, let other users know their current position and keep in touch with their friends. Additionally, Spiderweb uses Bluetooth connectivity to allow devices to identify each other and establish direct connections between them by using the short range communication. Within the Bluetooth range, Spiderweb users share a subset of the full user profile, called Business Card (in the following referred to as BC), which is stored in the local memory of the device and is synchronized with the relevant fields of the OSN profile. Due to exchange of BCs, Spiderweb users are capable of uncovering hidden connections that they share with other people nearby.

Two screenshots of the Spiderweb application are shown in Figure 6. On the right side of Figure 6 an example of a BC is presented. The BC is composed of personal information that is accepted by the Spiderweb users to be shared with others in their proximity. On the left side of Figure 6, the notification screen is presented. Notifications regard OSNs and ubiquitous social networking services. In relation to OSN services, users are notified when they change their current status, update their profiles or GPS positions as well as receive text and picture messages from other users or establish

Figure 6 Two screenshots of Spiderweb

new friendships. Moreover, in respect to ubiquitous social networking services, the user is notified if others with specific characteristic that the user is looking for are in the proximity (e.g. likes rock music or is a friend in the OSN). From the notification screen, the user can access both OSN and ubiquitous social networking services, utilizing the icons on the bottom of the screen.

Even if Spiderweb is the first prototype of LSNs, many functionalities of LSNs preliminary architecture, presented in section 2.3, are not fully applied. In fact, some components and services related to the automated creation of users' BCs have not been implemented yet (e.g. Environment discovery, Business Card Management services, etc). Future implementation of these components and application of these services are of crucial importance for improving the Spiderweb application and contributing to the long-term success of ubiquitous social networking services.

2.5 Application areas

In the following we present several application areas, where LSNs services might significantly improve people's social being and connectedness:

- Professional: Ubiquitous social networking services might provide significant improvements to users' professional life. Firstly, they might lead to new personal professional opportunities, such as connecting employers with potential employees and vice versa. Further, LSNs services would help to initiate collaborative teams within organizations. For example, they would assist in connecting people who are working on similar material as well as finding others who have abilities to solve another employee's current problem (Eagle and Pentland, 2005).

- Dating: OSNs that focus on dating services became very common in the recent years. Even Facebook, which is not primarily targeting at promoting dating services, significantly increased its popularity when it enabled users to discover the relation status of others. In comparison to these OSNs, LSNs would definitely provide a new way to facilitate such kind of services between the users. In fact, ubiquitous social networking services would not be limited to desktop applications, but they would help to connect nearby users with similar social interests and thus provide opportunities to immediately initiate potential face-to-face social interactions in their everyday lives (Beale, 2005).

- Events: LSNs might also present significant potential in various events, such as conferences, company events, exhibitions, etc. These situations usually comprise large amounts of participants, who potentially share similar professional or social interests. However, due to time limitations, people do not have enough time to network with all the participants and thus fail to exploit potential networking benefits. As an example, many professional networking connections could be established during large academic conferences with the help of LSNs that would take into account similar research interests (Pietiläinen et al., 2009; Eagle and Pentland, 2005).

3 Investigation methodology and design

In this section we present the methodology and design of a qualitative investigation that aims at analyzing the acceptance of ubiquitous social networking services among active online social networks users. Our investigation aims at answering the following question:

> *Would participants accept ubiquitous social networking services?*

In order to answer this question, we considered to apply the Technology Acceptance Model (TAM) that comprises analysis of perceived ease of use and usefulness of the application (Davis, 1989). The perceived ease of use was already investigated in regard to the Spiderweb local social networks application. The results of the investigation were very satisfactory, as the 70% of the participants found Spiderweb to be "very easy to use". This indicated that Spiderweb users would not require much effort to become skillful in using the application (Sapuppo, 2010). Consequently, in this qualitative investigation, we focus the attention on analyzing the perceived usefulness of ubiquitous social networking services. Moreover, in order to get more insight into the participants' acceptance of ubiquitous social networking services, other factors must be taken into consideration. We refer to investigation of participants' acceptance of all the necessary prerequisites for the establishment of LSNs, presented in the example scenario in Section 2.1.

In the following, we describe the background and design of the qualitative investigation, followed by the information about the participants.

3.1 Background

A qualitative investigation was conducted for evaluating the acceptance of ubiquitous social networking services. Qualitative interviews were preferred alternatively to other investigation methods, such as handing out questionnaires or establishing a focus group interview. This method was chosen because of the following two reasons: (i) participants' unfamiliarity with the ubiquitous social networking subject and (ii) potential misinterpretation of the research questions due to their complexity and ambiguity. Moreover, we decided to run semi-structured interviews to better understand the motivation behind the participants responses and ensure that general areas of information are collected from each participant, however still allowing adaptability of the interview process (McNamara, 1999; Creswell, 2009; Kvale, 2004).

In order to help participants to get more familiar with the ubiquitous social networking concept, firstly, we presented different scenarios from everyday lives, where these services might be applied. Secondly, we introduced all the available Spiderweb services, which are presented in (Sapuppo, 2010) as well as in this video[4], and discussed with participants potential networking benefits and threats. Lastly, participants had an opportunity to utilize a mobile application that simulates the LSNs behavior for 11 days. At least 3 times per day, the mobile application was randomly asking the participants to upload their personal data disclosure decisions for the specific circumstances, encountered at the moment of the request. The selection of data types to be disclosed was provided in accordance to data categorization in popular OSNs sites (e.g. gender, age, favorite music, etc.). This categorization was already used in a previous investigation about disclosure of personal information in ubiquitous social computing environments and the detailed description of the provided data types can be found in (Sapuppo and Seet, 2012). Participants were aware that potential networking benefits would be directly proportional to the amount of shared information, thus their ad hoc data disclosure decisions were representing a compromise between privacy risks and potential networking benefits.

Notably, we preferred to provide a new mobile application, designed specifically for this investigation, rather than utilizing the Spiderweb or other existing ubiquitous social networking applications, such as (Eagle and Pentland, 2005; Persson and Jung, 2005; Beale, 2005; Tamarit et al., 2009), because these applications are still not widely spread yet and participants would encounter difficulties in finding opportunities to disclose their personal information to real users. Afterwards, we interviewed the participants for a duration of 30-45 minutes. The interviews were audio taped and transcribed at later time. Questions were, firstly, related to perceived usefulness of ubiquitous social networking services, which investigated the degree to which participants believe that using a particular technology would enhance their networking performance (Davis, 1989). Further, we analyzed the acceptance of the three crucial prerequisites for the establishment of ubiquitous social networking services, derived from the example scenario in Section 2.1, i.e. announcement of user's presence, disclosure of personal information and potential initiation of face-to-face interactions.

3.2 Participants

The selection of participants was limited to OSNs users. We determined this category to be the most relevant because of their advanced experience in social networking, even if the perception towards the networking services might vary between virtual and physical worlds.

Respondents were asked to provide information about their demographic characteristics and asked to indicate their privacy preferences on visibility of their own personal data (e.g. user profile, pictures, posts) in their main OSN site. Based on these answers, we were able to observe patterns among data disclosure attitudes and divide the participants into three privacy clusters, following the Westin/Harris privacy segmentation model (Westin, 1991):

- Fundamentalists: these respondents were extremely concerned about sharing their personal data with any other online social networks users (friends or strangers);
- Pragmatists: these participants also cared about loss of privacy due to the disclosure of their personal information. However, they often had specific concerns and particular strategies for addressing them. For example, this category of respondents generally preferred sharing personal information only among their friends;
- Unconcerned: these respondents were trusting online social networks sites and believing that the privacy of their data was not jeopardized. Thus, they were willing to share their personal data not only with people who were their friends, but as well with users who were complete strangers to them.

In total we recruited 16 participants with the following privacy and demographic characteristics:

- Gender: 10 of the participants were male, while 6 of them were females;
- Age: 7 of the respondents were younger than 26 years, 7 of them were between 26 and 35 years old and 2 participants were older than 35 years;
- Occupation: 8 of the participants were working and 8 of them were studying at the time of the survey;
- Privacy: 9 of the respondents were pragmatists, 4 of them were fundamentalists and 3 participants were unconcerned.

4 Investigation results

In this section we present results of the qualitative investigation that analyzes participants' acceptance of ubiquitous social networking. As introduced in Section 3, we firstly focus on researching perceived usefulness of LSNs services. Afterwards, we investigated the participants' acceptance of the crucial prerequisites for the establishment of ubiquitous social networking.

4.1 Perceived usefulness

The qualitative interviews were firstly attempting to get insight into perceived usefulness of LSNs by focusing on the following subquestions and motivations supporting corresponding participants' answers:

1. Would respondents perceive that ubiquitous social networking services improve their everyday communication?
2. For what purposes would the participants perceive the ubiquitous social networking services to be useful?

Firstly, as shown in Figure 7, all the participants acknowledged the potential of LSNs services for improving their everyday communication, because they believed that these services would help them to connect with other people nearby, who have similar social and professional interests and goals. Furthermore, the participants considered that LSNs services relevantly support ordinary human interactions and behavior that people usually maintain in their everyday lives. Some of the respondents highlighted that these services would be very useful for people with any distinctive interests, as one of them said:

> *"Many teenagers wear t-shirts representing their favorite music (e.g. metal, rock, etc). The reason why they do so is to attract the attention of other people with the same music preference in their surroundings. Now think about having a complex interest - how can you represent it in a t-shirt? In such cases LSNs would be really helpful"*

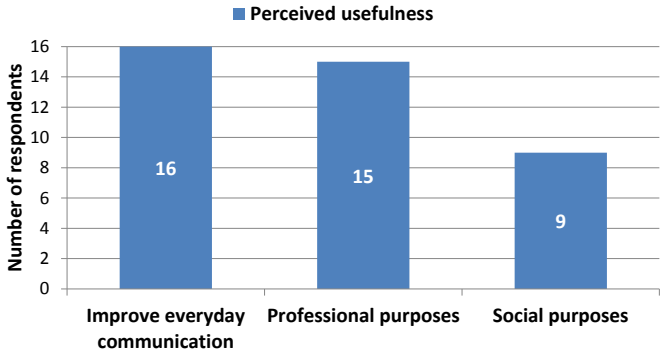

Figure 7 Perceived usefulness of ubiquitous social networking services

Secondly, as illustrated in Figure 7, potential professional networking benefits, received in exchange to disclosure of personal information, were notably considered to be the best motivation for using LSNs services by 15 out of 16 respondents. They indicated that LSNs would improve their professional lives, because such services were considered to be relevant to speed up the process of initiating beneficial professional relationships. For instance, a participant, who was just back from a big exhibition in London, claimed that these services would significantly increase the networking efficiency of that exhibition:

> *"Companies were presenting us what they were working on and invited to submit our curriculum vitae. However, the exhibition was very big and many companies were participating, thus I did not manage to get informed about all the job opportunities and I could not network with the representatives of all the companies. I believe that I lost relevant professional opportunities. In such situations, those services would significantly improve my networking by highlighting which companies are worth to interact with and to present my curriculum vitae"*

While the majority of the respondents found LSNs services to be very useful in regard to professional life, some of them (i.e. 7 out of 16) seemed to be cautious when considering to share their personal information for improving their social relations, as shown in Figure 7. These participants found social interactions to be more sensitive compared to professional ones and they were skeptical about sharing their social life with other people whom they do not know. However, some of them believed that they might start using LSNs also for social purposes after developing an initial familiarity with these services. However, despite their overall carefulness, one of respondents emphasized circumstances where he would be interested in using LSNs also for improving his social interactions:

> *"Last summer, I visited Los Angeles with my friends. I believe that such services would have been very useful in many circumstances during my holiday, as we spent a lot of time in different social environments and we were in the right mood for starting new social interactions with people around us"*

4.2 Acceptance of prerequisites

When inquired about the acceptance of ubiquitous social networking prerequisites, only a few of the participants had serious concerns about accepting all the needed requirements for the establishment of these services. In the following subsections, we present the individual results in relation to acceptance of the three identified prerequisites.

Announcement of users' presence

In order to enable the LSNs users to announce their presence to the others, two main concepts are relevant to be considered: sharing of location information and proximity information. Both of them are related to sharing of the user's current position. However, the location information is generally intended to be shared among acquaintances and in an unlimited range, while proximity information is meant to be disclosed to only all people nearby.

Sharing of the location information is one of the main characteristics of mobile social networks, which enables location based services. Generally, these services help users to connect to friends, be alerted when they are close and discover places around them by sharing users' GPS positions (Ziv and Mulloth, 2007). However, mobile social networks users have presented serious privacy concerns, related to disclosure of location information, even if it is applied only among acquaintances (Chen and Rahman, 2008). Sharing of the proximity information, instead, presents added value for solving privacy issues, related to disclosure of location information, because LSNs users are exclusively discovered within the range of the adopted wireless technology, as shown in Figure 4. In fact, LSN users are notified about the presence of others only when they are in the vicinity. Once the people move away, the information about the users' presence is not available anymore, unless they re-enter into each other's wireless range. As a result, the privacy threats, related to disclosure of current position, are decreased and the application of this concept might lead to positive trade-off between potential benefits and threats.

In relation to ubiquitous social networking, while accepting to share the proximity information is considered to be a mandatory requirement for participation in LSNs, disclosure of location information is an optional feature to access a wider range of services. For example, Spiderweb users can disclose both location and proximity information. However, they can switch the location disclosure feature off at any time, and still be able to exploit ubiquitous social networking services by sharing their proximity information.

In order to gain insight into participants' willingness to share their current position, firstly, we asked them whether they would like to disclose their location information and afterwards we also investigated the willingness to share the proximity information. As shown in Figure 8, the majority of respondents (i.e. 10 out of 16) preferred to maintain their current location private and provided comments, similar to the following:

> *"Location is very sensitive information. I do not think it is important for other people to know where I am. Even in case of people whom I know very well, I still would not disclose the exact address of my position, but I might disclose less detailed information, such as country or city where I am now"*

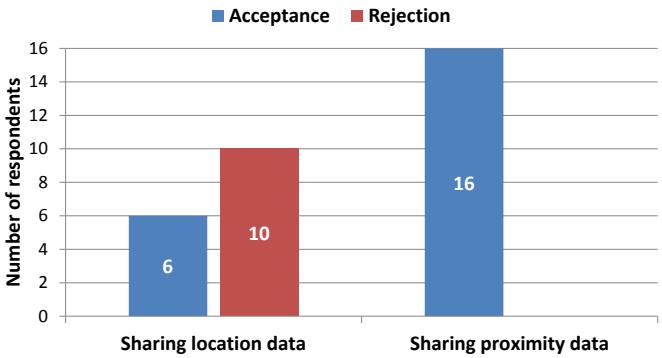

Figure 8 Acceptance of announcement of user's presence

However, the rest of the participants (i.e. 6 out of 16) accepted to share their location information because they could perceived several advantages of this feature. For example, one of them claimed:

> *"Two years ago I would probably tell you that I would never share my current location, but now I have started using location based services, such as Google Latitude[5], and I really enjoy the benefits of these services. My friends can see where I am and join me when they are not far away"*

After discussing the willingness to share the location information, we further inquired respondents whether they would allow the disclosure of proximity information. As shown in Figure 8, all the participants were very positive about this new concept and would permit the disclosure of their proximity information without any concerns. They acknowledged the advantages of announcing their presence only to people nearby over sharing of their location information. It could be assumed that this preference is motivated by the perception that disclosure of proximity information does not lead to invasion of privacy, as many participants provided comments, similar to the following:

> *"I think that disclosure of proximity information is a very good idea. In this case, I would not mind to announce my presence to exclusively people nearby, because if they look around, they can just see me anyway"*

Furthermore, some of the respondents indicated that they would prefer disclosure of proximity information over location information, because the latter comprises unnecessary sharing of user's current position to third parties. These participants claimed that they would not utilize such services, if they had to disclose their current position to third parties, because they were worried about losing control over this *sensitive* personal data.

Disclosure of personal data

Sharing of personal information, such as user's preferences and contact information, is indisputably the crucial foundation of ubiquitous social networking

services. Thus, we asked participants whether they had any concerns about disclosure of their personal information to other nearby users, who would be strangers for them.

As a result, all the participants accepted to disclose their personal information in order to gain potential networking benefits in exchange. Many of them discussed that disclosing their personal information through ubiquitous social networking services would not be much different from having face-to-face interactions with strangers themselves, which as well comprise sharing of personal data. Furthermore, the majority of the participants also emphasized that they would feel more motivated to share personal information, if LSNs ensured that the data sharing occurred only for specific purposes, as one of them noted:

> *"I would definitely disclose very detailed information about my work activities if I perceived potential for getting a better job"*

Furthermore, participants discussed that they would appreciate that LSNs services would empower their users to always keep control over their personal data, even after actual disclosure, as it would increase perceived trust and provide better usability of such services. Many of the participants provided comments, similar to the following:

> *"If I had met a potential employer, I would like to make sure that this person got all the information about my career skills, abilities and expectations. Thus, I would appreciate a possibility to additionally share this information, if it was not disclosed during the initial data disclosure"*

Also, one of the participants, who seemed to be strongly influenced by the public opinion, discussed how keeping control over his shared data would allow him to disclose newly discovered personal preferences, without being worried about future social implications:

> *"If I added to my business card that I am a fan of a famous runner, but at later time it would be discovered that this person was not honest in his sport achievements and thus lose his good public image, I would definitely be very embarrassed to keep him in my profile. The same would apply for other personal preferences, such as new movies or books, which are subjects to public opinion. I would not disclose such preferences, if I did not have the opportunity to modify them at later time"*

Finally, we inquired participants about three different methods for sharing of users' preferences in LSNs and asked them to choose their preferred approach. The three proposed solutions are following described:

1. Static profile: this solution discloses the same profile in all the encountered circumstances. It is a well-known approach, already utilized in the majority of existing ubiquitous social networking applications, such as (Eagle and Pentland, 2005; Persson and Jung, 2005; Beale, 2005; Tamarit et al., 2009);

2. Predefined privacy preferences: this solution attempts to predict all the potential situations and associated data sharing decisions a priori to the actual data disclosure. This approach was already adopted in (Lederer et al., 2003b; Kapadia et al., 2007; Jendricke et al., 2002; Myles et al., 2003; Smailagic and Kogan, 2002);

3. Ad hoc privacy control: this solution provides opportunities to take data sharing decisions *in situ* - at the moment of actual disclosure. This approach automatically manages information disclosure on the users' behalf in order to relieve them from frequent data disclosure decisions (Jendricke et al., 2002; Bünnig, 2009b; Bünnig and Cap, 2009).

After introducing to the participants different scenarios, based on the first two approaches (i.e. sharing of a static profile and predefined privacy preferences), we showed them results of a simulation of ad hoc privacy control mechanism, which takes into account both previous data disclosure decisions and relevant influential factors (e.g. location, activity, mood, mutual friends) that were proven to impact users' data disclosure decisions (Sapuppo, 2012; Consolvo et al., 2005; Sapuppo, 2013; Lederer et al., 2003a). For each participant, we presented his/her corresponding prediction result, obtained by processing his/her data disclosure decisions, collected while using the LSN prototype. Specifically, we applied the binary logistic regression statistical model and achieved an approximate accuracy of 90%, with peaks of 93%, and potential for further increasing performance.

As shown in Figure 9, the majority of the participants (i.e. 14 out of 16) would trust ad hoc privacy control, as they highlighted the advantages of this solution over other techniques, i.e. sharing of a static profile and predefined sharing preferences, to manage their

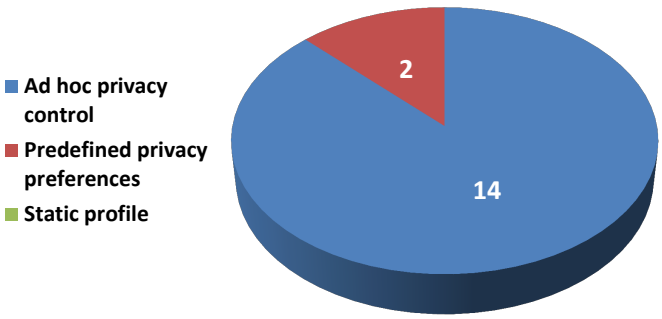

Figure 9 Acceptance of mechanisms for disclosure of user's personal information

data disclosure. Firstly, the participants indicated that they preferred sharing different profiles under different circumstances, e.g. they did not want to share data related to private activities in work environments. Secondly, the participants claimed that it would be difficult for them to define in advance what to disclose per each circumstance and they expected to encounter situations where data disclosure decisions would not be accurately predictable in advance.

Moreover, respondents were confident that by utilizing automated ad hoc privacy control, LSNs would be capable of managing their personal data disclosure decisions in accordance to the real users' data disclosure preferences. In fact, after running the provided mobile application for a few days, participants experienced that they were already using a pattern on what to disclose in similar circumstances. Also, they did not express particular concerns about potential wrong data disclosure decision taken by LSNs. In case of unintended disclosure of not sensitive personal data, they discussed that many times they did not share some of their personal information, because they did not find any reasons for disclosing it, rather than for preserving their privacy. In these cases, the disagreement of data sharing decisions between the participants and ad hoc privacy control would only arise due to different evaluation of relevance, rather than data sensitivity for the current circumstances.

In case of inquiry for highly sensitive data, despite the good prediction results of the binary logistic regression model, some respondents (i.e. 4) would prefer to limit the autonomy of ad hoc privacy control. These participants provided comments similar to the following:

> *"In the majority of the cases I would have no concerns about allowing LSNs to manage my personal information. However there might be either highly sensitive personal data (e.g. religion) or some specific circumstances that are very important to me (e.g. I am attending a job interview) in which I would feel uncomfortable to allow a machine to take decisions on my behalf. In such situations, if possible, I would rather prefer to manage the disclosure of my personal information myself"*

These results confirm the findings of previous studies, which as well investigated prediction of users' information disclosure, based on previous data disclosure decisions, utilizing data mining algorithms (Bünnig, 2009a, 2008; Bünnig and Cap, 2009). Even if presenting significant prediction results, Bünning et al claimed that automated data disclosure should limit its autonomy in case of inquiry for highly sensitive data. In such situations, it was advised to provide only suggested data disclosure choices, while waiting for user's approval before any actual disclosure (Bünnig, 2009a).

Potential initiation of face-to-face interactions

The last prerequisite for the establishment of ubiquitous social networking services that we analyzed in our qualitative investigation is potential initiation of face-to-face interactions. This requirement is directly dependent on another relevant, however not crucial, prerequisite: immediate notifications. In fact, notifying about the presence of other nearby LSNs users with relevant profile similarities provide the possibility to initiate immediate face-to-face interactions. Thus, before investigating participants' acceptance of potential face-to-face interactions, we firstly analyzed whether participants would prefer to receive immediate notifications over the possibility to retrieve the information, relevant for networking, at later time. We believe that participants had enough insight for answering this question, because of the experience gained when running the provided mobile application, simulating the LSN behavior. In fact, the respondents were alerted by the application at least 3 times per day, which can be considered as a realistic replication of LSNs notification system.

As shown in Figure 10, only 4 out of 16 respondents preferred to access the collected information at later time. They emphasized that in many circumstances, when they received the notification from the provided mobile application, they would have preferred to postpone their attention for later time, as they did not want to be frequently interrupted. Following these considerations, relevant challenges for the implementation of the notification system were raised, as very frequent alerts might encourage users to ignore notifications or even disable such feature. Firstly, the design of LSNs should drive users to provide detailed information in their profiles, in order to optimize discovery of profile similarities and thus avoid too frequent notifications. For example, liking *sport* would not be the same as stating to be a fan of *hockey*. Secondly, the participants discussed that the design of LSNs should enable prioritization of users' profile similarities, as one of them claimed:

> *"I would definitely consider to utilize the notification system if I was able to decide what to be alerted about. For instance, If I was unemployed, I would prefer to be alerted only about professional networking possibilities and to retrieve information about other types of profile similarities at later time"*

Moreover, some of the respondents, as well acknowledged additional advantages of accessing the collected information about profile similarities with other users and thus they would like to have this feature as a supplement for the notification system. Firstly, for important matters, participants discussed that they might need time to think and prepare before initiating a face-to-face interaction. In fact, they would prefer to contact the person via email, before having a

conversation. Secondly, in case of lack of time for an immediate face-to-face interaction, such option would still allow to access networking benefits, as one of the respondents noted:

> *"Many times I write down phone numbers of people that I meet at work or social environments, but I rarely contact them, because after few days I forget the reason for having these numbers. LSNs would give me the opportunity to retrieve the relevant personal information, related to the phone numbers. Consequently, I would probably initiate a communication with them, as I would also know the motivation for contacting these people"*

On the other hand, even if acknowledging that storing users' business cards might provide relevant advantages for ubiquitous social networking, the majority of the participants, i.e. 12 out of 16, would prefer to be immediately notified when potential networking benefits arose, as shown in Figure 10. They believed that immediate notifications is a crucial feature for ubiquitous social networking, because if the moment of interacting with other people is delayed, it loses the importance and interest to them. Participants also emphasized that they might not find the time for checking the collected information and contacting those people afterwards. Furthermore, they discussed that the benefits of ubiquitous social networking over online social networks arise due to application of the notification system in LSNs. In fact, many of them provided comments, similar to the following:

> *"Without the notification system, LSNs services would not be so different from classical online social networks in which a barrier is always placed between people who communicate. When notified, I can socially interact without any barrier, because what I need is just there"*

While being notified is an important, but not mandatory prerequisite, potential initiation of face-to-face interactions is a requirement that users must accept when utilizing ubiquitous social networking services. Even if the users prefer to retrieve the collected relevant business cards at later time, they cannot avoid the possibility that another user would prefer to be immediately notified and, consequently, would attempt to initiate a face-to-face interaction. As potential face-to-face interactions are unavoidable in ubiquitous social networking services, during our qualitative interviews, we investigated the willingness of participants to accept this requirement. As shown in Figure 10, the majority of the participants, i.e. 14 out of 16, would accept such prerequisite as long as they had a coarse-grained control over the ubiquitous social networking services:

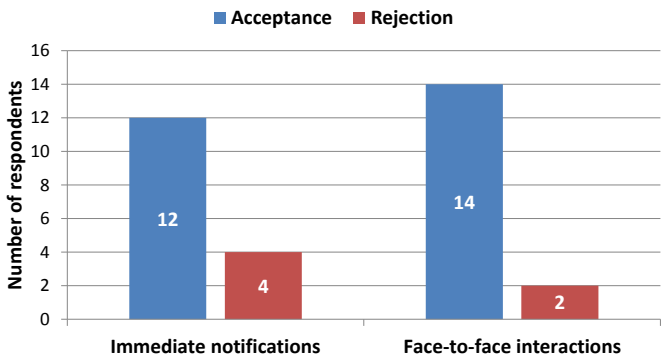

Figure 10 Acceptance of immediate notifications about profile similarities and potential face-to-face interactions

> *"I do not see a reason for not accepting to be approached by other LSNs users, as having potential face-to-face interactions is the motivation for using such services. But, it is crucial for me to have full control over these services and be able to switch them off when desired"*

However, a few respondents, i.e. 2 out of 16, claimed that they would not be potential users of LSNs if they had to accept such prerequisite, because they were too much concerned about potential undesired face-to-face interactions. These participants were worried that someone would unnecessarily disturb them, just because of the information that they had shared. These respondents claimed that they would utilize ubiquitous social networking only if these services enabled an invisible mode option and disclose their information after user's approval, which implied manual evaluations of the trade-offs between potential networking benefits and privacy risks. However, such evaluation of trade-offs in USN would present increased complexity and require too much user's attention and intervention. Application of an invisible mode option should be carefully considered in the development of ubiquitous social networking, as it might not lead to a calm USN technology, where users could effortlessly exploit these services.

5 Conclusions

In this paper we presented a new communication system, called local social networks, as a potential solution for the establishment of ubiquitous social networking services. These services aim at uncovering hidden connections between people in order to leverage interpersonal affinities for networking benefits during physical meetings. We described in details the concept and the preliminary architecture of local social networks, which is based on the integration of online social networks and opportunistic networks. Moreover, we introduced the first prototype, called Spiderweb, and potential future application areas of local social networks, i.e. professional, dating and events. Afterwards, we presented results of a qualitative

investigation that focused on understanding whether active online social networks users would accept ubiquitous social networking services. None of the participants were using ubiquitous social networking services at the time of the survey and 14 out of 16 of them claimed that they would be potential users of local social networks. They appreciated the possibility to be connected with other people and especially with those who share distinctive interests and goals. Participants indicated professional and events as the most relevant potential application areas for ubiquitous social networking services, however they would probably need time to get used to these services before they would also utilize them for facilitating as well their social interactions.

Moreover, we noticed that the participants, who preferred not to utilize ubiquitous social networking services, were younger than 26 years old and studying at the time of the investigation. It could be expected that these participants did not perceive any potential networking benefits in professional life because they had not started one yet. In regard to social life, they were concerned about accepting one of the three prerequisites for the establishment of ubiquitous social networking services, i.e. potential initiation of face-to-face interactions. Specifically, they were worried that their data disclosure would lead to unpleasant and undesired face-to-face interactions. However, all the other respondents acknowledged the usefulness of being immediately notified about discovered profile similarities with other nearby users and accepted the possibility to initiate a beneficial face-to-face interaction with them as long as they had coarse grained control over these services. Finally, we did not observe any crucial concerns about the other two prerequisites for the establishment of ubiquitous social networking services, i.e. announcement of users' presence and disclosure of personal data.

While the majority of respondents had serious concerns about accepting to disclose their location information, all of them accepted to announce their presence to all other nearby users by disclosing their proximity information. Respondents also appreciated the possibility to utilize automated ad hoc privacy control, which would relieve them from frequent data disclosure decisions. However, in case of highly sensitive personal information or specific circumstances (e.g. attending a job interview), a few users preferred to confirm LSNs data disclosure decisions before any actual disclosure. Moreover, they also indicated that ad hoc privacy control should provide possibilities to modify their personal data, even after actual disclosure, in order to increase perceived trust and provide better usability of LSNs.

The results of this qualitative investigation draw the attention to relevant development areas for ensuring the long-term success of ubiquitous social networking services. Firstly, further research is encouraged on variation of human data sensitivity under different circumstances in order to minimize wrong data disclosure decisions that would lead to potential unpleasant face-to-face interactions, as a result of ubiquitous social networking services. Secondly, additional insight into creation of more trustable and functional ubiquitous social networking is needed in order to provide opportunities for the users to effortlessly exploit ubiquitous social networking services, while still remaining in control of data disclosure when desired.

Acknowledgements

This work is supported by Nokia and developed as a part of the Converged Advanced Mobile Media Platforms (CAMMP) project[6], funded by the Danish Advanced Technology Foundation. The author is extremely grateful to the participants of the qualitative investigation who took the time to take part in this study. Without their participation and feedback, this work would not have been possible.

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Note

[1]http://www.orkut.com
[2]http://www.myspace.com
[3]http://www.facebook.com
[4]http://www.youtube.com/watch?v=DgeVNv10CIM
[5]https://www.google.com/latitude
[6]http://www.cammp.dk