Managing Workplace Resources in Office Environments through Ephemeral Social Networks

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Abstract. With the ubiquity of mobile devices, GPS and WiFi, location-based social networking services are developing rapidly. The rise of services such as Foursquare and Google Buzz, enable users to instantaneously in real-time report their activity to online social networks around the places they visit. The people that we encounter and connect with around physical resources such as meetings, provide opportunities for extending our social networks which are rarely captured. In this paper, we designed and deployed an indoor location-based resource management and social networking system called Nokia Find & Connect for managing workplace resources and enabling social networking in office environments. Central to our system is the concept of an ephemeral social network, temporary networks that are created for a specific time and event like a meeting. We carried out a trial to study the impact of our system on managing office resources and creating ephemeral social networks. Results show that Nokia Find & Connect inspired people to make new friends and provided great convenience when people book or are about to have a meeting.

Keywords: Mobile social network, workplace management, ephemeral social network, location-based services, opportunistic networking

1 Introduction

With the ubiquity of mobile devices and network technology, online social networking sites (OSNs) have blossomed during the past few years, however they are not integrated with real life. For example, in the office, people often cannot find the meeting and do not remember if they have met the person nearby. In current OSNs, it is tedious and error prone for people to manually update their personal

status when changing location or activity. Adding positioning technologies such as GPS to mobile devices that are combined with the OSN can be a feasible solution to the above problems, as have been implemented by Foursquare and Google Buzz.

According to Jyri Engestrom, "social networks consist of people who are connected by a shared object" which he calls object-centred sociality [1]. For example, in Flickr, the social objects are the photos which users tag, comment and share with others. Therefore, the problem yet to be solved is how to use the resources in the physical environment (like the office) to help facilitate social networking and vice versa. Physical resources are social objects where people connect to each other. In the office, the meeting room is the shared social object because people meet there. In addition, physical resource management is difficult because current systems assume that users will notify the system if they are not using that resource. In the office, there is commonly a shortage of meeting rooms when in actuality, many of these rooms are not used.

Our research questions are the following. First, how can positioning and social networking technologies be used to efficiently manage office resources. Second, how can ephemeral social networks be used to improve current social networking protocols, where ephemeral social networks are created based on opportunistic encounters that occur for a short time period during a specific activity. Inspired by the demands of managing office resources and the concept of object-centred sociality, we designed and developed a location-based social networking solution for workplace and office management called Nokia Find & Connect(NF&C) that uses the workplace resources such as meeting rooms and desks as social objects. Our major contributions are two-fold, first, we present NF&C as a system and user interface for efficiently managing office resources dynamically and locating rooms and people, forming the basis for social networking. Second, we conduct a real-life case study of NF&C by deploying it in our office to demonstrate its viability.

This paper is organized as follows. Section 2 describes background and related work. Section 3 explains the motivation and describes the system, functionality and user interface of NF&C. In Section 4, we analyze the data collected from our office trial to determine its usage, system efficiency and validity. Finally, Section 5 concludes the paper and discusses areas for future work.

2 Background and Related Work

2.1 Location-based services (LBS)

We are seeing an increasing number of commercial LBSes (eg. Foursquare and Google Buzz) as well as research LBSes (Intel's PlaceLab [2] and MIT's iFind [3]). However, most of these efforts have focused on accuracy improvement and ignored their impact on the social network. Barkhuus et al [4] discussed how the awareness of location people experienced of each other affected their self-presentation, but did not mention about the affection on the social network.

Tsai et al [5] also described their location-sharing application, but focused more on the impact of feedback. WhozThat [6] builds a system that ties together online social networks with mobile phones, but does not utilize the advantage of location awareness to bring convenience. However, many of the previous systems fail to exploit how mobile social interactions can be recorded and used to create and maintain social networks.

2.2 Indoor positioning

Indoor positioning technology uses either sensors or wireless LAN (WLAN) for location tracking and navigation. There are many sensor-based indoor positioning systems such as infrared sensing [7, 8], ultrasonic sensing [9, 10], and radio frequency identification (RFID) [11, 12]. However, these systems are dependent on specific device and network, are limited in sensing range (usually less than 1 meter), and are complex to deploy. On the other hand, WLAN-based positioning [13, 14] has wide coverage and does not require additional hardware. WLAN-based positioning can be based on propagation model [13, 15] or machine learning [13, 16]. Considering existing techniques and our actual demand, we decided to choose the machine learning WLAN-based positioning technique to build our positioning system.

2.3 Proximity-based systems and opportunistic networking

Many applications of social proximity-sensing software are based on ephemeral social networks and proximity encounters. Eagle and Pentland [17] review some of this work which include LoveGetty, SocialNet and Jabberwocky. The proximity encounters, which can be detected by RF or Bluetooth, can be used for introducing people directly and making inferences about a user's social network like Serendipity [17] or for finding people nearby and suggesting people to add based on frequency of encounters like Aka-Aki [18]. This relates to the concept of the "familiar stranger" [19] where people often pass by or encounter others but do not know them, otherwise known as opportunistic networking [20]. Mobile social networks can use opportunistic contacts for friend recommendations [21] and for collaborative internet access [22], yet there still does not exist a killer application [23]. Ephemeral groups, related to proximity encounters and opportunistic networking, are ad-hoc and used for collaboration [24] and informal communication [25].

Considering the above systems, none take into account the social interactions that occur in the ephemeral social networks and the social context of the environment. We developed Nokia Find & Connect for combining the location of encounters and social objects and the content of social events based on meetings, for managing workplace resources and enabling social networking in the office environment.

3 Nokia Find & Connect

NF&C is a location-based mobile social networking solution for workplace management based on the problem that the inefficient use of workplace resources results in unnecessary loss of valuable work time. For example, many meeting rooms are often reserved but not actually occupied. NF&C provides a solution for updating the status of meeting rooms and reservations in real-time that reflect the room's actual occupancy and use, based on WiFi indoor positioning and allows users to create social networks from opportunistic encounters and meetings. In this section, we describe the system structure of NF&C, and then introduce the user interface and functions of the system.

3.1 System Architecture

Figure 1 shows the overall system structure of NF&C where the positioning subsystem provides the user's location and the NF&C subsystem provides location-based services, resource management, and social networking to users.

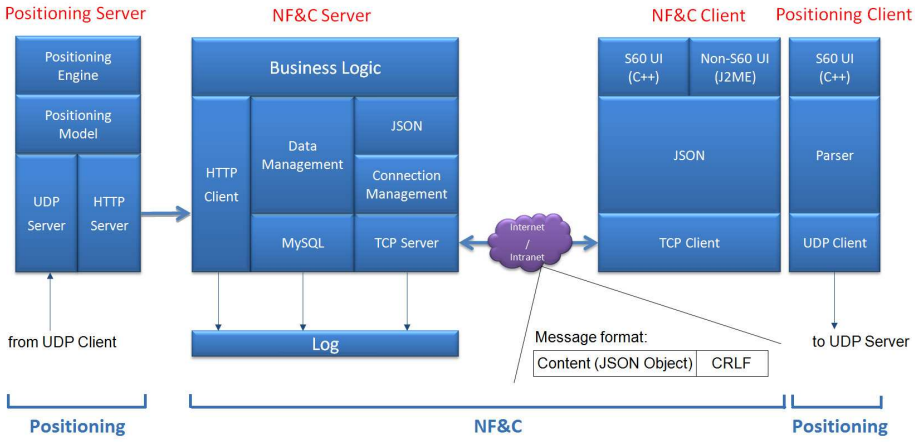

Fig. 1. System Architecture of NF&C

The positioning subsystem consists of the Positioning Client and the Positioning Server. The Positioning Client collects WiFi signal strengths from nearby WLAN access points at a user-specified interval, and sends them to the Positioning Server through UDP (User Datagram Protocol). After the Positioning Server receives the WiFi signal data, the Positioning Engine uses the Positioning Model and machine learning algorithms to approximate the positioning of the user on a floor map. The Positioning Model is created by performing a site survey that involves recording the WiFi signal strengths and access points of all floors in the building on the floor map. For our implementation, we used an off-the-shelf commercial WiFi positioning server.

The NF&C subsystem consists of the NF&C Client and NF&C Server. The NF&C Client sends requests to and receives responses from the NF&C server in JSON format through TCP. The business logic layer provides the functionality of resource management and social networking as explained in Section 3.2. The JSON message format includes two parts, the content label and the content value. The NF&C server reparses the JSON message, and sends the result back to the NF&C Client using TCP, while storing all data in a MySQL database.

3.2 Functions and User Interface

The user interface for NF&C has a main home screen and 3 functional modules: Maps, Reservations, and Contacts. All of these functions have been implemented on the Symbian C++ platform for Nokia S60 3rd and 5th edition phones. Figure 2 shows the screenshots of the functions in the NF&C user interface.

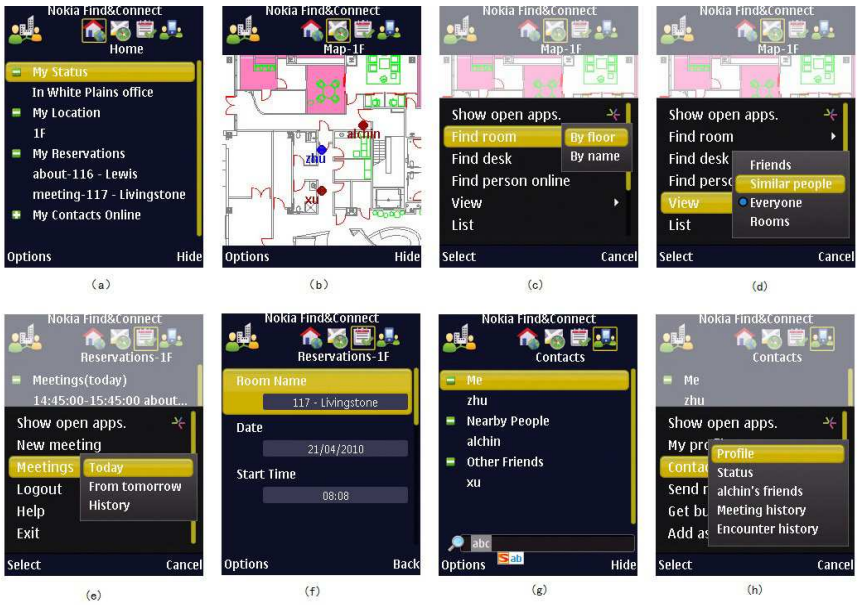

Fig. 2. Client user interface of NF&C: (a)Home screen; (b)Maps screen; (c)Maps function list; (d)View options of Maps; (e)Meetings function list; (f)New meeting reservation; (g)Contacts screen; and (h)Contact details

Home screen : The Home screen (Figure 2 (a)) provides a personalized summary of the features consisting of 4 parts: My Status, My Location, My Reservations and My Contacts Online. My Status is an automatic status message that dynamically changes according to the user's location and the user's activity or event. Currently, My Status is divided into "In Office", "In a meeting", "Online"

(if logged in but not in the office) and "Offline". My Location shows the floor where the user is at or "Not in office" if outside of the office. My Reservations has a list of today's meetings where you are an organizer or participant. My Contacts Online shows all of your online friends.

Maps : The Maps module contains 5 parts: My Location, Find Room, Find Desk, Find Person Online, and View. In My Location, the user's location is shown on the floor map as in Figure 2 (b). For privacy, users can set their location sharing to private to not share their location with others. Users can search for meeting rooms and desks by floor and by name, show the resource details on the map, and reserve rooms as in Figure 2 (c). Find Person Online finds out if someone you know is online. View provides a filter as to what you want to see on the map, and is broken down into People Nearby, Similar People, Everyone, and Rooms as shown in Figure 2 (d).

Reservations : In Figure 2 (e), the reservation services include reserving a new meeting (Figure 2 (f)), editing, or deleting a meeting. Users can find today's meetings, future meetings and past meetings in this module. If the meeting is reserved but not occupied, the NF&C server will delete the meeting reservation 10 minutes after the meeting start time if no one is in the room, allowing others to use the room. If the room is reserved and there are people in the room, then the status of the room is occupied and all the participants' status is changed to "In a meeting".

Contacts : From Figure 2 (g), users can manage their profile similar to other social networking sites. Users can manage their friends by adding and removing friends, group friends together, and obtain the friend's details. When the user selects a friend or a contact that is nearby, the user can look at the contact details. These include downloading the contact's business card to the phone, finding out when the user met that contact using the meeting history, finding out the last encounter time and location, and sending questions or messages to that contact. The meeting history is an ephemeral social network (defined in the next section) because it records all the people you encountered in meetings. We use friend-of-a-friend mechanism to determine how A can know B through C where A and C are friends and B and C are friends and have met. Last encounter is useful to help in friend recommendations by finding those people you have physically encountered recently and often.

Therefore, by tracking a user's location with WiFi in meeting rooms and combining that with the meeting management system in the Reservations module, we can infer whether a user is in a meeting. Then we can use notifications, status updates, messaging, and friend management to communicate this activity to others. This addresses the first research question of how positioning and social networking technologies can be used to efficiently manage office resources.

3.3 Ephemeral Social Network in Nokia Find & Connect

Current online social networks (OSNs) are inconsistent with physical real social networks because users can randomly send and accept friend requests, therefore prompting the question: How many friends in your online social network are your

true friends? [26] Also, it is popular that when you come across a person, you have a recollection but cannot remember who that person is or where you have met. There is no system to record this temporary event to remind you. The question then becomes how to capture social networks as they happen occasionally in the real world. Our solution to this is the concept of an ephemeral social network, which is related to that of ephemeral groups [24].

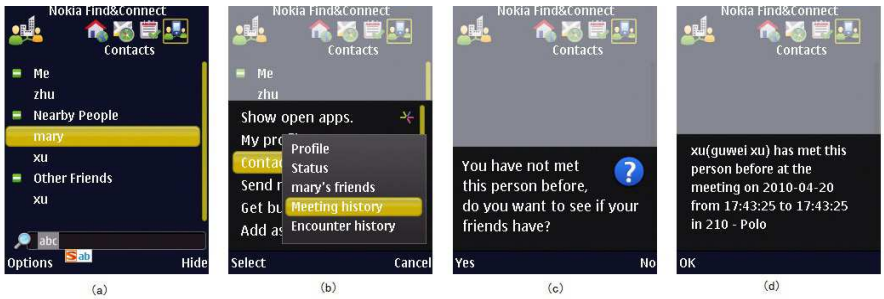

Fig. 3. Client User Interface of NF&C: (a)Nearby people with Mary selected; (b)Contact details for Mary; (c)Meeting history between you and Mary; (d)Finding out your friend Xu has met Mary before

The ephemeral social network is defined as a social network created spontaneously in an ad-hoc manner at a specific point in time for a specific purpose and lasting a short time. For example, employees have opportunities to attend a meeting for cooperation of a project. It is possible for some of them to know each other, while others may not. However, the ephemeral social network is created by the interaction among the participants during the meeting marked by meeting topic, meeting time and participants. Thus, it is probable to find out some interesting information, such as who just passed by, who are friends during the meeting and what are their common interests. Ephemeral social networks occur frequently in our daily lives where people opportunistically encounter each other or get together for a special purpose like having lunch in the canteen, attending a lecture, or attending other organized activities.

The ephemeral social networks in NF&C are based on encounters and meetings. We incorporate encounters into the NF&C framework so that users can find other people nearby using our user interface. If one user is interested in a certain person that just passed by, the user can find out who that person is by using the View People Nearby function and then view the contact details. Then, the user could get some information about that person and send an instant message to start a meaningful conversation, and add that person as a friend. Users can also find out if they or their friends have met a certain person from the meeting. Users can also download business cards from the participants of the meeting and record their contacts on the phone. Therefore, users can set up the relationships among the nearby people to provide services to help users build and strengthen

the relationships, because NF&C has recorded the ephemeral social networks. This addresses the second research question of how ephemeral social networks can be used to improve current social networking protocols.

4 Analysis of Nokia Find & Connect

Nokia Find & Connect was developed and piloted in Beijing for four weeks during August 2009. We received 247 registrations, of which 234 were enrolled and 151 actually used our software. Due to time constraints, we did not implement all the features of the Contacts screen but just the Profile feature. At the end of the four week trial, participants completed an online survey about the usage, helpfulness and their evaluation of NF&C.

4.1 Data Collection

The collected data from the trial include the functions that users used, their position, friend lists, meetings, meeting history, encounter history and evaluation of NF&C using the server database, server logs and survey (with their names being anonymized). The server logs recorded every request from the clients including time, username and specific function name and parameters for further data analysis. The survey was used to evaluate the helpfulness and ease of use of NF&C.

We now analyze NF&C according to the following categories: Usage, meeting management analysis, ephemeral social network analysis and evaluation of NF&C.

4.2 Usage

During the trial, a total of 151 users used NF&C, with 125553 NF&C requests sent. This gave an average of 24 requests for each person every day.

Figure 4 shows the request distribution for all the features over the four week period. As shown in Figure 4 (a), meetings have the highest utilization which validates our hypothesis of NF&C motivation. We discover that the "Find Office" and "Find Room" features are in great demand when the user does not know the office or room location. In Figure 4(d), the number of requests for "Others Near Me" and "Find Someone" are much greater than for "Friends Near Me". This is because it is easy for users to find their friends directly but they turn to NF&C to find information of unknown people nearby or encountered people. An anomaly for meetings is that users can start and end the same meeting for several times, because due to time limitations, we did not track if users were in the meeting room at the time of the meeting. Therefore, the number of requests for "Start Meeting" are greater than for "Book a Meeting" in Figure 4 (e). Also, we find that people forget to end meetings as the number of "Start Meeting" requests are more than the number of "End Meeting" requests. This will be fixed in our next version.

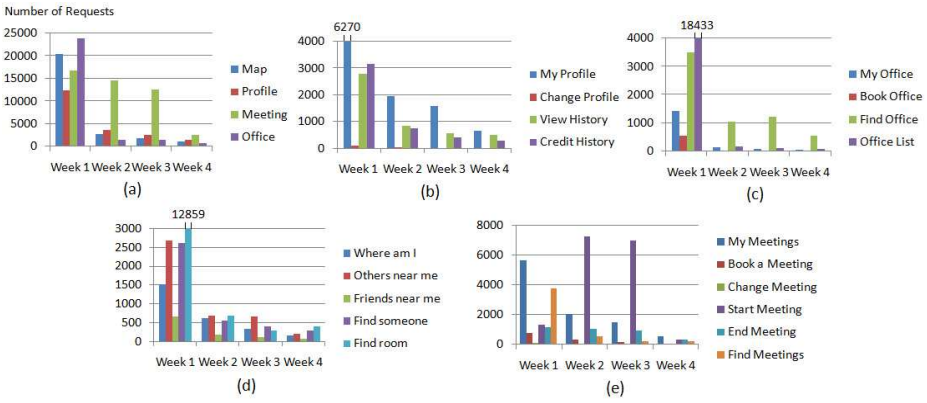

Fig. 4. Distribution of requests by week in:(a) all the features ;(b)Profile;(c)Office;(d)Map;(e)Meetings

4.3 Meeting Management Analysis

According to the usage, the meeting features are the most widely used. Therefore, we analyze this module to study how our system affects users' behaviors and how it enables social networking around meetings. We implemented a credit system to encourage users to start and end meetings on time. We add 5 credits if the user starts or ends a meeting more than 10 minutes earlier than the reserved time, and deduct 5 credits if the user starts or ends a meeting more than 10 minutes later than the reserved time.

At the end of the trial, there are a total of 3536 meeting reservations with more than one person, of which 88.94% are started on time and 88.21% are ended on time, and an average of 2.07 participants per meeting. There are a total of 6130 credit records stored in our database, of which 92.68% are add credits and 3.96% are deduct credits. This high percentage of add credits is a result of the side effect of the credit system because users can repeatedly start and end meetings at any time.

For social networking around meetings, of all 512 one-to-one relationships, 182 pairs participated in at least one same meeting and 211 meetings were among friends. It is important to note that many of the meetings did not actually occur. Nonetheless, these results preliminary show that relationships around meetings are an important component of a user's social network in office environments, helped users form a good meeting habit, and helped make better use of workplace resources. The effect on the maintenance and extension of such relationships will be discussed in the next section on ephemeral social network analysis.

4.4 Ephemeral Social Network Analysis

In this section, we analyze the different types of ephemeral social networks that arise from the encounters and the meetings.

Encounters: As mentioned above, our analysis of the ephemeral social network is based on the encounters. The locations of users are updated every 1 minute while the encounters are calculated every 5 minutes. The algorithm of the encounters is as follows. STEP 1: Calculate the distance of two persons on the same floor. STEP 2: If the distance is within 5 meters, find out the last 2 distances of these two persons, else go to STEP 1. STEP 3: If there is at least 1 record of the last 2 distances that is within 5 meters, this is assumed to be the same encounter, else this is a new encounter.

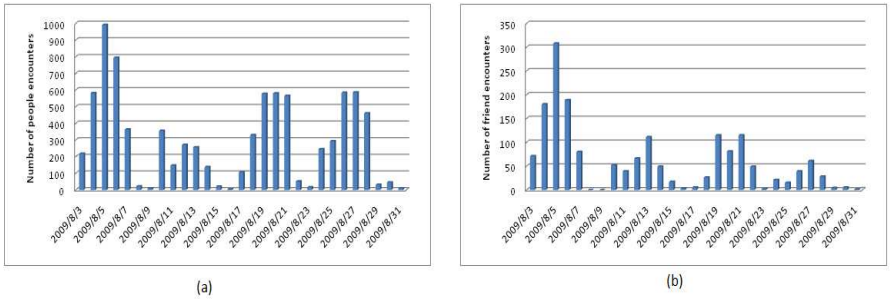

Fig. 5. Encounters:(a)Distribution of people encounters;(b)Distribution of friend encounters

The observation of Figure 5 is that the first week involved the most number of people encounters as well as friend encounters. The spikes in the graph include the games that we arranged on those days to encourage people to use NF&C. Comparing all the people in the trial with those that had meetings, we discover that a user encountered an average of 107.45 people, had an average of 21.52 friend encounters, and an average of 4.94 friends. The users who attended meetings had higher statistics, that is, they had an average of 140.75 encounters, an average of 28.29 friend encounters, and an average of 5.39 friends. This shows how ephemeral social networks formed from meetings have contributed to greater social networking.

Social Networks: In NF&C, we have three types of independent social interactions (friends, encounters and meetings), which define and construct the different types of social networks. Suppose we have two users A and B. A and B are considered as friends if A adds B as a friend and B confirms this friend request. A and B are considered as encounters if the location of both users satisfies the definition of an encounter as described in the encounter algorithm in the previous subsection. Finally, A and B are considered as having met if both have attended at least one meeting together. This results in a total of 5 types of social networks that are undirected and unweighted, and considered valid, which we describe below.

Friend network(FN): An edge between two users means that the two people are friends, regardless if they have encountered each other or not. People encounter network(PEN): An edge between two users means that both have encountered before. Friend encounter network(FEN): An edge between two users means that both are friends and have encountered before. Meeting participants network(MPN): An edge between two users means that both have attended the same meeting at least once regardless if they are friends. Meeting friend participants network(MFPN): An edge means that the two people are friends and have attended the same meeting at least once.

As is shown in Figure 6(a), 47.2% of nodes in MPN have friends while 87.1% of nodes in PEN do. From Figure 6 (b), about 24.3% of unique edges in MPN and only about 9.3% of unique edges in PEN become friends in our system. Therefore, it seems more helpful and efficient to get more friends from meetings than from encounters. Another observation is that the number of nodes and edges of FEN are similar to that of MFPN. From Figure 6, there are 59 nodes and 91 unique edges in MFPN while there are 70 nodes and 129 unique edges in FEN. Therefore, ephemeral social networks from meetings have greatly contributed to building the friend network.

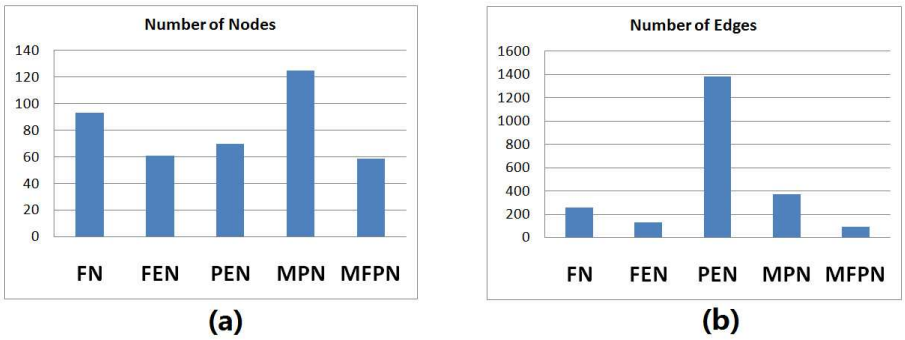

Fig. 6. The attributes of the 5 networks:(a)Number of nodes;(b)Number of unique edges

Properties of Social Networks: We examine the properties for each of the 5 social networks (that are fully connected) in NF&C using the following common social network properties [27]. Density is the proportion of ties in a network relative to the total number possible (sparse versus dense networks). Average shortest path(ASP) is defined as the average number of steps along the shortest paths for all possible pairs of network nodes. Diameter is the maximum length of all shortest paths between any two connected nodes. Average clustering coefficient(ACC) is a measure of degree to which nodes in a graph tend to cluster together, which relate to a subgroup's group betweenness centralization(GBC

range: $0 < GBC < 1$) where $GBC = 0$, when all the nodes have exactly the same betweeness index and $GBC = 1$, when one node falls on all other geodesics between all the remaining (N-1) nodes. This is exactly the situation realized by a star graph.

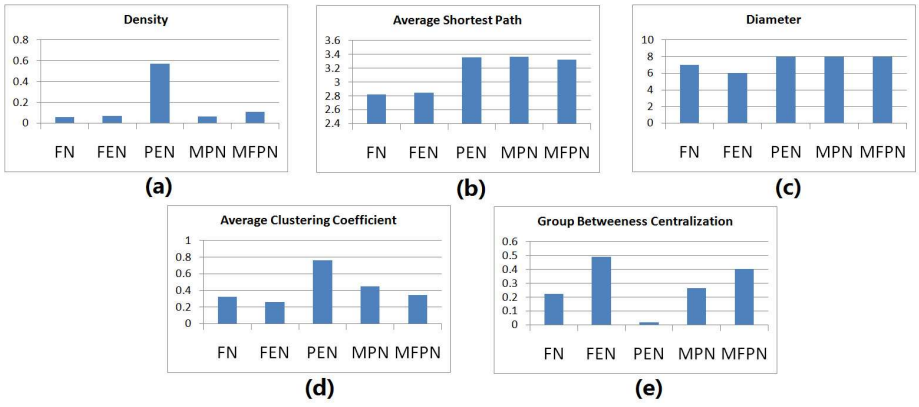

Fig. 7. The attributes of the 5 Networks:(a)Density; (b)Average shortest path; (c)Diameter; (d)Average clustering coefficient; (e)Group betweenness centralization

Figure 7(b) obviously shows that the average shortest path of PEN and MPN are 17.9% higher than that of FN, FEN and MFPN, which implies that becoming a friend of each other helps a lot in terms of communication efficiency, especially in the office environment when we try to connect and communicate with others. This is also supported in Figure 7(c), where the diameter of PEN and MPN is higher than other networks. Average clustering coefficient of PEN and MPN is higher than that of FN, FEN and MFPN, as shown in Figure 7(d). Higher average clustering coefficient of PEN can be explained in that encounters in PEN mainly happened within several well-connected subgroups, which is true for example in that people encounter each other a lot during lunch and at the office building entrance. The spike in density in Figure 7(a) supports this explanation. In MPN, people attending meetings together are mainly on the same team and connect a lot whenever a meeting starts, while the possibility of people from different teams attending a meeting together is relatively small. These two reasons result in a high average clustering coefficient in MPN. However, average clustering coefficient of FN, FEN and MFPN is small, showing that people in these networks are connected more uniformly.

Therefore these results show that social networks that involve friends (FN, FEN, and MFPN) have small and uniform subgroups compared to those that do not involve friends (PEN and MPN) where they are large, dense, and have well-connected subgroups.

4.5 Evaluation of Nokia Find & Connect

In this section, we evaluate the usability of our system. We conducted a survey to collect users' evaluations on NF&C by rating the helpfulness and convenience levels of each feature using a Likert scale from 1 (low) to 5 (high). We received 76 valid feedbacks, 29 from females and 45 from males with 2 hiding their gender. Table 1 shows the usage and usability statistics for each of the NF&C features. The Meeting feature overall was the most helpful as it received the highest evaluation (3.85) followed by the Map, which is in line with our statistical results above. The Map feature was the most easy to use (3.80) followed by the Profile (3.70) and Meeting (3.68). When asked whether they thought NF&C was useful, 81.6% of the responders said yes while only 14.5% of the responders said no. The features that users were willing to use if NF&C was provided again in the future, were Map (90.4%) and Meeting (92.6%) as expected.

Therefore, the results from the data analysis prove that NF&C appears to be useful and is generally well accepted by users.

Table 1. Usage and Usability Evaluation of NF&C

Feature	Helpful	Easy to use	Willingness to use
Profile	3.10	3.70	75.3%
Map	3.73	3.80	90.4%
Meeting	3.85	3.68	92.6%
Office	3.13	3.56	66.1%

5 Conclusion and Future Work

In this paper, we designed and developed an indoor location and proximity-based social networking solution for workplace and office management on mobile devices called NF&C. We described NF&C as a system and user interface to efficiently manage office resources dynamically and locate rooms and people, forming the basis for social networking. To address the gap between physical and online social networks, we proposed the concept of ephemeral social network and implemented some applications of encounters and meetings, how it affected meeting behaviors, and how it utilized ephemeral social network relationships to extend the social network in the workplace. We conducted a user study of NF&C by deploying it in our office environment to demonstrate its viability as described in the user evaluation of the system.

Our conclusions are as follows. First, meeting features have the highest utilization ratio in the office-based environment which validates our hypothesis of NF&C motivation. Second, NF&C helped users form a good meeting habit to start and end meetings on time and make better use of workplace resources.

Third, ephemeral social networks based on meetings and encounters contributed to an increase in friend social networking.

Our future work involves the following. First, we have started to improve the NF&C UI and build a better robust system to give users a better user experience and secure their privacy. Second, we would like to perform user studies in other office locations to determine if culture and location has an affect on the use of NF&C and ephemeral social networks, as well as gather more data for our research. Third, we would like to explore the efficiency of meeting management using ephemeral social networks and location, by using actual location to determine the status of the meeting rooms and synchronizing with our office meeting room reservation system. Fourth, we would like to investigate how encounters and ephemeral social networks can be used to improve friend recommendations. Finally, we would like to deploy NF&C to other indoor environments like a conference and analyze the results in order to prove the viability of ephemeral social networking.

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