A Method of Social Network Extraction via Internet and Networked Sensing

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***Abstract*— There are many situations where individuals who belong to large social networks meet in smaller communities on an 'ad hoc' basis. This paper reports on the development and use of a system to support the micro-communities that form in these settings. The system combines the benefits of automatic social network visualization with the ability for members to strengthen the network using real world encounters via internet and networked sensing. Two systems, the web-based *Polyphonet Conference* and real-world based *Tabletop Community* combine to activate and support user's wider social network, by engaging them in multi-media micro-community interactions.**

Networked sensing; internet sensing; social network; web mining; real-world oriented interaction; network visualization; social networking service

I. INTRODUCTION

Interest continues to grow in social networking services (SNS), notably due to the popularity of community web sites, where users can develop their network by adding known individuals to it. Perhaps because of this, research emphasis has focused on the development of communities online, where data mining can be done to analyze the network of memberships and relations. Increasingly, data is being produced that shows the 'small-world' nature of online communities [1] and the effect of online communities in the real world [2].

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Research into human interaction in organizations suggests that awareness of the activities of other members of the community is an important factor in who will receive or give information [3]. More recently in the ubiquitous computing community, the importance of embodied interaction [4] has begun to be recognized in tangible computing [5].

Though many types of communities exist online, we focus on the development of a system utilizing networked sensors to support real-world community, incorporating insights from both studies of online community and real-world community interaction. It is clear that people have multiple memberships of different social networks, yet there are occasions where those networks can be expanded and strengthened significantly by real-world interaction. The system we present uses this real-world environment to help users engage with previously known and newly met individuals in contexts of viewing their (visualized) social networks. This combination of web-based social network analysis, an online interactive SNS with rich contents, and an integrated on-site system of SN modification and representation is a new development in bridging the online-offline divide via internet and networked sensing.

Focusing on real-world community and especially communities that have pre-existent interest in each other's associations and relationships, we have a long-term goal: strengthening the wider social network of the users. This is done by introducing a tangible interface in temporary situations of 'micro-community' interaction, namely, the meeting of users around a table with multimedia sensors. The aspect of the system – the *Tabletop Community* – provides users with the ability to form 'communities of memory' [6] as multimedia

contextual information is 'tagged' to the edges between nodes of their social networks. This information, which is shared only between those who physically interact with each other at the conference, builds a strong sense of community, which subsequently activates the wider social network of users at the conference and after the event.

The next section presents a description of the basic system design of the social network visualization for community support. In section III and section IV, we propose the Polyphonet conference, which obtains social networks automatically from the web and which can improve from user interaction to the system and Tabletop Community, which capture the action of micro-communities. We demonstrate the effectiveness of our system in section V. We conclude this presentation and show future work in section VI.

II. HYBRID SOCIAL NETWORK EXTRACTION

It is important for participants to know what kinds of people participate and which participants share similar concerns to activate discussion at academic conferences and promote communication among participants. A participant list that has participants' names, affiliations, etc. and position papers are good information for showing what kinds of people participate. That information is personally attributive information. On the other hand, relationships among users in the community are numerous and sometimes quite strong. Such social networks should be analyzed and revealed to users. Such user feedback has rarely been attempted in the field of sociology.

There are various methods to analyze and obtain the social network in a community. Conventionally, questionnaires and interviews were main method for such network analyses. Recently, communication by e-mail [12], Multimedia BBS [15] and links among web pages [11] have served similar purposes.

Semantic map [7] has a similar purpose to our system. It shows networks among participants and exhibits, and keywords. Participants register interesting exhibits to the system with a PDA. Then the system makes relationships among participants that registered the same exhibits. Our previous system [8] shows relationships among persons via their Web bookmarks. Referral Web [9] and [10] extract social networks from the web automatically. Our previous system [10] attempts to discover the human relational network using the number of retrieved documents.

Table I shows categories of methods to extract social networks. 'Precision' means the quality of extracted human relationships if each method is used to extract social network. In the column of extraction 'Cost', we compared the cost to extract SN with same numbers of members.

TABLE I. METHODS OF EXTRACTING SOCIAL NETWORKS

	Information Source	**Source Type**	**Precision**	**Cost**
Interview, questionnaire	Person	Description	High	High
Mail, BBS	Mail, BBS	Interaction	High	Middle
Links among home page	Web	Interaction	Middle	Low
Semantic map, kMedia	Favorite List, Bookmark	Profile	Middle	Middle
Referral Web, Matsuo[10]	Web	Profile	Low	Low

TABLE II. METHODS TO EXTRACT SOCIAL NETWORKS OF OUR SYSTEM

	Information Source	**Source Type**	**Precision**	**Cost**
Polyphonet	Web	Profile	Middle	Low
Polyphonet	Person know link	Description	High	Low
Tabletop Community	Person Touch link	Interaction	High with multimedia data	Middle

Notwithstanding, conventional methods cannot retrieve social networks among a community automatically and further improve them using user-system interactions. We propose a combined social network extraction system that includes many web services based on community interests and contents and onsite system that have been deployed in real-world space for supporting mobile users in the site.

We think it is important to create the initial network without demanding any personal information input except name and affiliation from the user to make the whole social network useful. Next, the initial network should be modified according to the user interaction with the system. The web system that has a click button to show that you know this person or you are interested in some content, which might resemble the preferences of other users. Such information from web systems is added to the social network. Thirdly, onsite interaction information is also added. For example, if three users used the same table together and the same demonstration was visited simultaneously by two other users. Such a small group might be called a micro-community or temporary community; we believe that such small and short-lived communities will bolster the usefulness of social networks.

In section 3 and section 4, we realize one example of social network visualization for community support by seamlessly combining two systems, Polyphonet Conference and Tabletop Community, which are applied to a ubiquitous international conference, Ubicomp2005. The Polyphonet Conference (we call this system *Polyphonet* hereafter) creates an initial network from the web and gathers user clicks of the acquaintance button as shown in Table II. Tabletop Community sends the IDs of touched cards which exist simultaneously on the table to the Polyphonet. The Tabletop Community is designed to attract users by providing micro-community scene capturing and browsing services as a personal image network.

III. POLYPHONET CONFERENCE

Polyphonet is a social network browser and a conference scheduling system. Polyphonet obtains attendees' relationships and research topics from web sites. A user can find what research topic a researcher is doing or whom she is working with. In the scheduling part, a user can register interesting presentations (papers, demos and posters) and get recommended presentations and other researchers.

Polyphonet has three methods to extract social networks among participants. The first one is based on web mining techniques. The second one and third one are based on user interaction on the web system and at the conference.

A. Edges Extracted from the Web

We applied the web mining method based on method [10] to extract a social network among participants. In this section, we give a synopsis of the method and modifications for our system.

The simplest approach is to measure the relevance of two nodes based on the number of retrieved results obtained by a search engine query. For example, assume we are to measure the relevance of two names “Mark Weiser” (denoted X) and “Alan Key” (denoted Y). We first address a query “X and Y” to a search engine and get a documents including those words in the text. In addition, we make two queries “X” and “Y”, and get b1 and b2 documents. The relevance of “Mark Weiser” and “Alan Key” is approximated by the Simpson coefficient.

$$rel(x,y) = Simpson(X,Y) = \frac{\#(X \cap Y)}{\min(\#(X),\#(Y))}$$

Say a is divided by b. The rel(x,y) represents the relevance of node x and y.

B. Edges Registered by Users

Creation of personal acquaintance lists ("I-know" and "I'm-known-by" lists) is a basic function. A user can make an addition to the "I-know" list when that user finds an acquaintance on paper or session pages or authors and other users listed in order of calculated weight. At that time, the acquaintance is also added to the acquaintance’s "I'm-known-by" list. These actions are additions of a know-edge.

IV. TABLETOP COMMUNITY

A. System Design

We developed a system based on the idea of a micro-community similar to that created around tables and situations where people are drinking coffee in a casual way.

Using a tabletop/desktop as horizontal interactive human-computer interface has been examined by many researchers [13]. However, the cultural context that a table has is the main concern that the system focuses on. Tables in cafés, kitchen tables, and/or dining tables have been playing an important role to form communities for a long time in human history. The table is used here as community device. Computer technology is used in this system to enhance and extend this cultural context of the table in order to form micro-communities [14].

Therefore, the environment that the system is targeting is such as a corner of conference room and places for coffee breaks. In contrast to environments such as that in the middle of a big conference room, a much closer relationship in a micro-community will occur in this kind of environment and occasion.

We also address the temporary-community that is also being created around a similar situation. The system also aims to maintain a temporary-community to a long term one in case it is needed. We developed the system based on the following three conditions to realize the vision we propose above.

1) The system has a function of sensing the state of the micro-community by using visual sensors, audio sensors, ID sensors, vibration sensors, temperature sensors, etc.

2) The system has a function of reviewing past actions of the micro-community.

3) The system has Monitor displays for displaying social network as well as items of common interest among community members, such as schedules, private information and social networks.

To include the conditions above, Tabletop Community has the following function aside from those of Polyphonet. First, the system can capture information such as visual information of the people around the table and additional information such as audio/voice data and ID data. The capture will occur when the user desires it. A typical instance is when the user applies a user device to the system.

Secondly, to allow community members to share experiences with other members, the system has a function of visualizing the human network inside of the micro-community with rich multimedia data.

We also use user device ID information that the Tabletop Community obtains to improve the precision of the data of social network of the entire community that Polyphonet targets. In the next section, we will describe one example of such Tabletop Communities which we have developed.

B. Implementation

We have developed the system shown as Fig. 1. We chose IC cards as a user device because they are gaining popularity and are becoming widely used in Japan. An omni-directional camera and IC card readers are on the table of the system. Using these camera and card readers, when the user puts an IC card onto a reader, the system detects that individual’s rough location (direction of the user from the camera) and identification of users in the picture, which is taken by an omni-directional camera every time when a user places/withdraws a personal IC card.

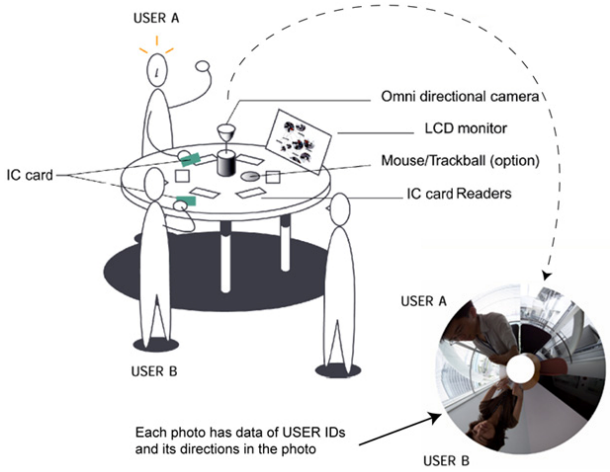

Figure 1. Tabletop community usage.

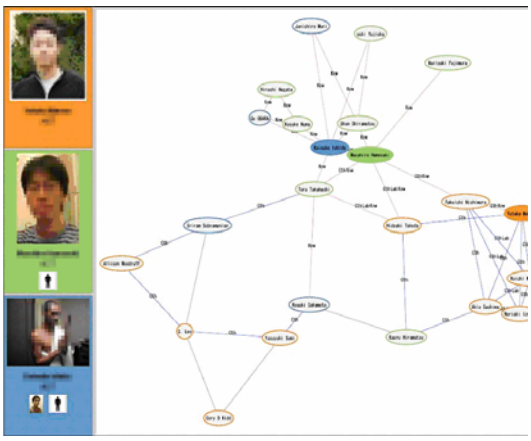

Figure 2. Social networks among three users

Each picture has additional information in addition to graphical data such as the name of the photo, the time and date when the photograph was taken, a unique ID number of the table (if we use more than one table): all the ID information of the IC cards from card readers. These data will be stored in each PC as well as the PC that is connected directly to the camera and card readers via a network. We infer that it is possible to put a database server in the middle of the network of the Tabletop Community system and store all photograph data in it. However, considering the bandwidth and stability of the network we use, we chose to use a decentralized database system instead.

When a single participant puts an IC card on a card reader, that participant can log in directly to the Polyphonet Conference. If two or three participants put IC cards together, they can see social networks among them (Fig. 2). Then the social-tie "We meet and see social networks together" is added automatically to the Polyphonet conference. These actions in the real word mean additions of know-edges.

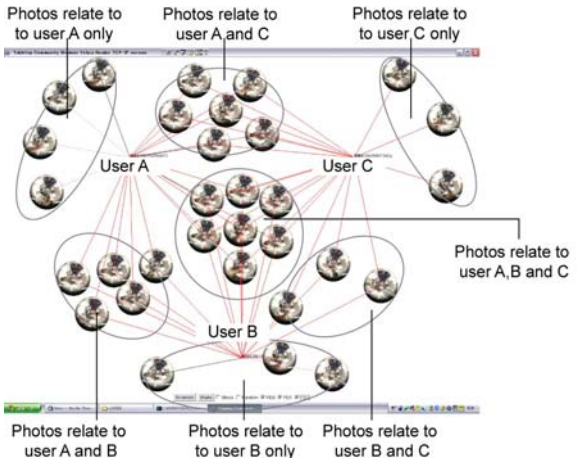

Figure 3. Snapshots are shown as a network from users.

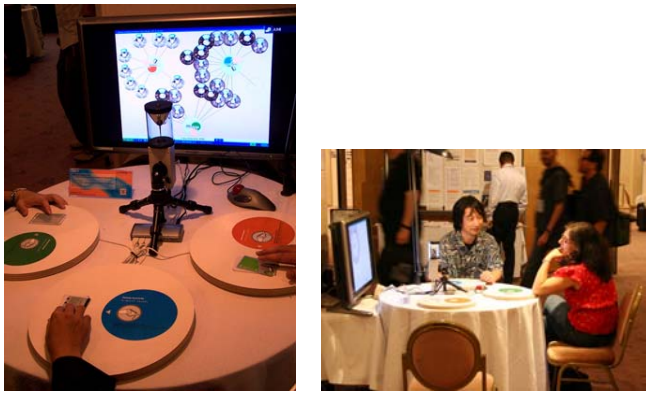

Figure 4. Pictures from the installation of Tabletop Community

Here we show another monitor screen screenshot (Fig. 3). It illustrates three IC card readers on the table for three users. Unlike the static screenshot implies this network of pictures reacts to a change of the network as well as users' interaction through a mouse pointer as if it were living. A picture that has all three users moves to the center of the screen. A picture showing only one of three users moves towards the edges of the screen. This motion is created by calculation based on basic physical simulation. We applied two physical simulation models onto the screen. One is repulsion among each picture. The other one shows that attraction between the user node and the photograph node relates to the user using a spring model. This simple simulated physics in the visualization program automatically lays out the pictures and its network on the screen in an artistic way.

V. Field Testing

We tested our system at a three-day international conference. In this conference, there were 122 presentations and 355 authors (including co-authors). About 500 participants joined the conference. We opened Polyphonet conference a week before the conference and deployed four tabletop

communities on site. Fig. 4 shows the hardware components of the tabletop community in the conference room.

A. Results

The number of the Polyphonet users is 308 and 175 users registered from the web system and 133 users are invited from information kiosks in the conference room.

Polyphonet extracts social networks among participants with three methods. First, the system extracts them using Web-mining technique as initial data (Mining-link). Second, users can register their own social network with our system (Know-link). Third, two or three users can register their meeting through the information kiosk (Touch-link).

The number of Web-Mining link, Know link and Card-touch link is 22,332, 924 and 726, respectively. The number of Mining-links is much larger than the others. This tendency is good because our system use Mining-links as an initial data of social networks. It is desirable that every user should have their own initial data.

Fig. 5 shows the number of Touch-links and Know-links. Users check Know-link on Polyphonet and touch the user device on a card reader of Tabletop Community. The number of Know-link is almost constant and the number of Touch-link is high on the first two days. This results show both link data are important and Touch-link is more convenient during the conference period.

Fig. 6 shows the networks extracted from Know-links, Touch-links and web mining-links, from left to right of the figure, respectively. In this figure, the threshold of the mining-link network is controlled in order to reduce the number of edges for clear visualization.

VI. CONCLUSION

In this paper, we described the system design of a method of hybrid social network extraction. We integrated the Polyphonet conference in order to obtain an initial network and Tabletop Community, which captures the action of micro-communities with vision and IC card sensors. The field test shows the system has potential for gaining social network utilizing both internet and networked sensing. Future work includes improving the network visualization method especially how to clearly visualize various kinds of edges and shows the accuracy of the network.

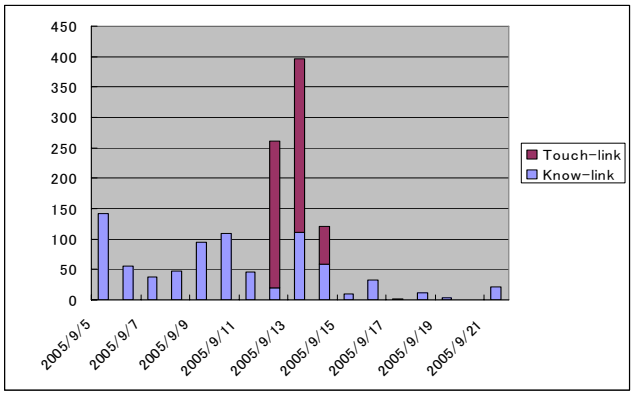

Figure 5. The number of Touch-links and Know-links

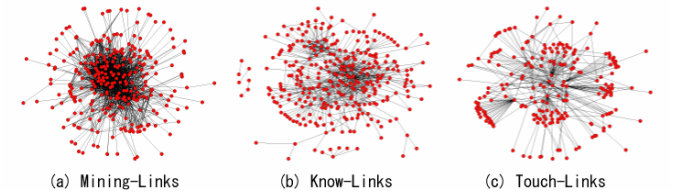

Figure 6. Three Types of Social Networks

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