Application and Analysis of Interpersonal Networks for a Community Support System

Masahiro Hamasaki[1,2], Hideaki Takeda[2,1], Ikki Ohmukai[1,2], and Ryutaro Ichise[2,1]

[1] Soken University, Hayama-cho Miura-gun Kanagawa 240-3630,Japan
hamasaki@grad.nii.ac.jp,
WWW home page: http://www-kasm.nii.ac.jp/~hamasaki/
[2] National Institute of Informatics, 2-1-2 Chiyoda-ku Tokyo 101-8430,Japan

Abstract. In this paper, we discuss importance and usefulness of interpersonal network in a community support system. We built a scheduling support system for an academic conference. Our system supports information exchange among participants and information discovery with generating participants' interpersonal network. This system was used in an academic conference called JSAI2003 involving 276 active users. The analysis of the networks reveals that interpersonal networks can promote information exchange among people by indicating existence of people to the others, and that it can also support information discovery by recommendation.

1 Introduction

In this paper, we discuss importance and usefulness of interpersonal network in a community support system based on an analysis of the scheduling support system employed in an academic conference. The system is designed to support not only personal activities in conferences such as scheduling but also communication among participants.

It is important for participants in academic conferences to know which paper or presentation is interesting for them, what kinds of people participates, and which participants share similar concerns. However, it is difficult for them to find such information among a large amount of information on papers and participants provided as conference program because the number of papers is too large to glance at in a short conference period and information on participants is usually very limited or missing. We built a system to support them to find such information in an academic conference as a cooperative scheduling system. We adopt a "person as content" strategy for system architecture. It means that a person is an information source; We treat a person as an information node that is accessible from other users. Such nodes are connected through an interpersonal network. The interpersonal network is built from acquaintanceship of individual participants, and used as a new route to traverse information on participants and papers in this system. Users can reach their interesting papers and participants by tracing links in the interpersonal network. Furthermore the system

helps them by recommending papers and participants as the result of analysis of the interpersonal network. We then analyzed the interpersonal network itself and performance of recommendation based on it.

We organize this paper as follows: In Section 2, we briefly introduce the system that we built for conference support. In Section 3, we explain the result of analysis based on actual data taken in 2003 JSAI conference. In Section 4, we compare our work with other studies and conclude the paper in Section 5.

2 Community-Support System Using Interpersonal Network

We built a collaborative scheduler called *community navigator* and applied it to an academic conference. The primary function of the system is to provide online scheduler during the conference, i.e., users browse the conference program and put papers in which they are interested in their schedule. In order to facilitate this activity, we use the interpersonal network built from

2.1 System Outline

The proposed system is based on an online program of an academic conference. The system provides users with a personal timetable and a portal of this system. Figure 1 shows overview of the system. It generates HTML pages using database and stores data which users input.

The system dynamically generates the following four types of HTML pages: author, paper, session, and personal timetable. Each HTML page is linked mutually based on the relationship stored in the database; a user can browse the generated HTML pages freely and even add a new relationship. The personal timetable is changed based on the relationships added by users.

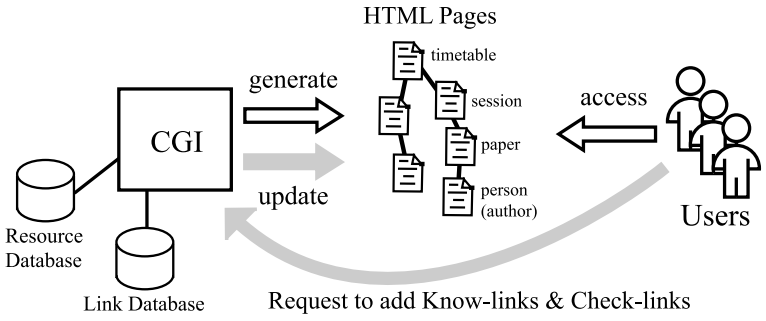

Fig. 1. System Overview

This system roughly addresses two types of data: resources and links. Resources include three categories: session, presented paper, and person (author,

chairperson, and other user). A link shows the relevance from one resource to another. There are five categories on links: *Contain* (session-paper), *Author* (author-paper), *Chair* (chairperson-session), *Check* (user-paper), and *Know* (user-person). *Contains*, *Chairs*, and *Authors* are registered in advance, while *Check* and *Know* can be added by users.

2.2 Adding Links

Creation of personal timetables and the acquaintance lists ("I-know" and "I'm-known-by" lists) are basic functions. When a user finds an interesting paper in the conference schedule or the paper list, she/he can add it to her/his timetable. Then, her/his timetable is updated. Similarly, when a user finds an acquaintance on paper or session pages, she/he can add it to her/his "I-know" list. At the same time, the acquaintance is added to the acquaintance's "I'm-known-by" list. These actions mean additions of a check-link and a know-link, respectively.

Figure 2 is an example of personal page provided for each user. The upper part of the page shows static information like personal information, i.e., her/his presentations and hyperlinks to some services. The rest shows dynamic information i.e., "I-know" and "I'm-known-by" lists.

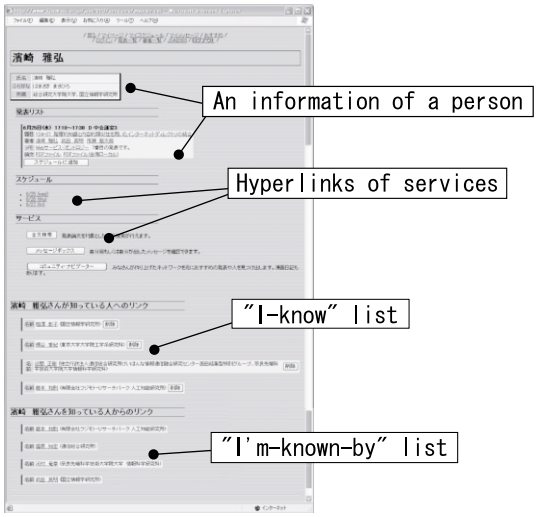

Fig. 2. My Page

An added link is a kind of private information; it is not suitable to the public unconditionally. This system conducts access control using the generated network. The detail information of a person can be accessible for persons who are registered as her/his acquaintance. The similar control is applied for detail information on who "checked" the specific paper.

2.3 Recommendation

We provide information recommendation services using links added by users, i.e., recommendation either for papers or for persons. A user can find interesting papers and persons not only by browsing but also by recommendation.

We adopted two types of recommendation method. One is a method which similar to collaborative filtering like GroupLens [1]. This method finds other persons who have similar concerns of a user and recommends their items, i.e., pap. In our case, we use check-links as information to guess participants' concern. The other is a method using interpersonal network. The method collects acquaintances of the user, and recommends items which are common among them. In this paper, the former is called recommendation using check-link and the latter is called recommendation using know-link.

We explain how to find recommending items. At first, we define three functions i.e., $Check$, $Know$, and $Relate$. If person h_0 adds check-link to paper p_1, $Check(h_0, p_1) = 1$, otherwise $Check(h_0, p_1) = 0$. If person h_0 adds know-link to person h_1, $Know(h_0, h_1) = 1$, otherwise $Know(h_0, h_1) = 0$. $Relate(h_0, h_1) = 1$ if $Know(h_0, h_1) = 1$ or $Know(h_1, h_0) = 1$, otherwise, $Relate(h_0, h_1)$ is 0.

Then we can define $V_{hc}(h_0, h_x)$ and $V_{pc}(h_0, p_x)$ which calculate degrees of recommendation in recommendation using check-link for user h_0 about person h_x and paper p_x, respectively.

$$V_{hc}(h_0, h_x) = \sum_{\{p_x | Check(h_0, p_x)=1\}} Check(h_x, p_x)$$

$$V_{pc}(h_0, p_x) = \sum_{\{h_x | V_{hc}(h_x, h_0)>0\}} Check(h_x, p_x)$$

Similarly, $V_{hk}(h_0, h_x)$ and $V_{pk}(h_0, p_x)$ calculate degrees of recommendation in recommendation using know-link for user h_0 about person h_x and paper p_x, respectively.

$$V_{hk}(h_0, h_x) = \sum_{\{h_k | Relate(h_0, h_k)=1\}} Relate(h_k, h_x)$$

$$V_{pk}(h_0, p_x) = \sum_{\{h_k | Relate(h_0, h_k)=1\}} Check(h_k, p_x)$$

In the recommendation service, each of four recommendation methods shows at most five candidates of which V values are top five and exceed the predefined threshold.

3 Experimental Results

We applied this system to the academic conference called JSAI2003 (The 17th Annual Conference of The Japanese Society for Artificial Intelligence). In this conference, there are 30 sessions, 259 presentations and 510 authors (including co-authors). About 400 participants joined the conference between Jun 23 and 27, 2003.

3.1 Trace of Users

In this section, we show how users utilize the interpersonal network by tracing of users.

We analyzed pattern of users from access logs of HTTP server [3]. Figure 3 shows major routes which users used.

We can see that routes from schedules to sessions and then those from sessions to papers are the main stream. Each route was used by users about 2000-3000 times. It is a typical access pattern of browsing online schedule of a conference.

The route from a paper page to a person page is used more than 1000 times. Furthermore, the route from a person page to a person page is used more than 1300 times.

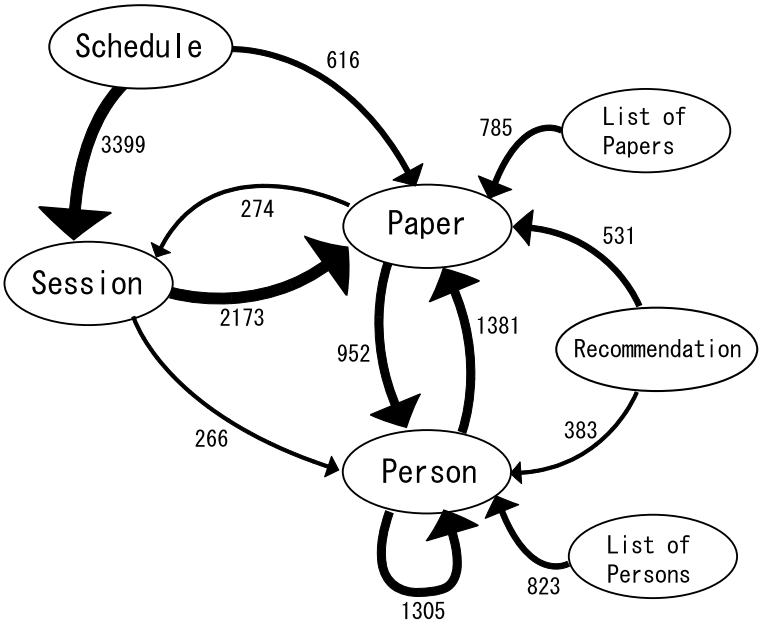

Fig. 3. Access Pattern

Users access to pages through person pages many times. The number is approximately a half of the number of typical access pattern such as routes from a session page to a paper page. And a route from a person page to a person page is also used frequently. The former result indicates that many users access

[3] This method cannot trace users when they use back button of web browser and access to pages directly using www bookmark or typing URL. So the number of in-bound links and the number of out-bound links are not the same in each node (Figure 3).

to person as content. The latter result indicates that user utilizes interpersonal network as an access route among pages. These results indicate a "person as content" strategy supports users to find information in this system.

3.2 Generated Know-Link Networks

In this section, we analyze know-link networks generated by users. In this system, a person can be a tail of a check-link and a know-link, and a head of a know-link. On the other hand, a paper can be head of a check-link. Table 1 shows the number of persons who have tails of know-links (she/he added at least a know-link) and the number of persons who have heads of know-links.

Table 1. Know-Link and Resources

	Person Who Had	Cover Rate
Out-bound Know-link	99 persons	0.18
In-bound Know-link	260 persons	0.47

The number of active users who added links is less than 30 percent of the number of the registered persons. However, 49 percent of persons are included in know-link network. It indicates that interpersonal network can be spread out well even the participants are relatively small.

The system was used by 276 users. 160 users added 1840 check-links add 99 users of them added 840 know-links. Figure 4 shows the co-author network and the know-link network. In these networks, a node is a person and an edge is a relation between persons (co-author or know-link). The two networks shared 135 edges.

The co-author network has 73 clusters, while the network merged with the know-link network has only 5 clusters. It indicates that edges made by know-links connect scattered co-author networks.

Figure 5 shows log-log plot of the cumulative distributions of incoming know-links. It shows a tendency of broad-scale networks that is characterized by a connectivity distribution that has a power law regime followed by a sharp cutoff. This tendency is different from the interpersonal network that Amaral investigated [2]. A possible interpretation of this difference is that cost of adding links. Actions in online systems seem to be less than a real world in cognitive cost.

3.3 Results of Recommendation Using Know-Link

The system provided information recommendation service using two types of recommendation method. One used check-links and the other used know-links. 135 persons used these services.

We investigate whether users accept recommended items or not. In this recommendation service, the system shows all recommended items which are chosen

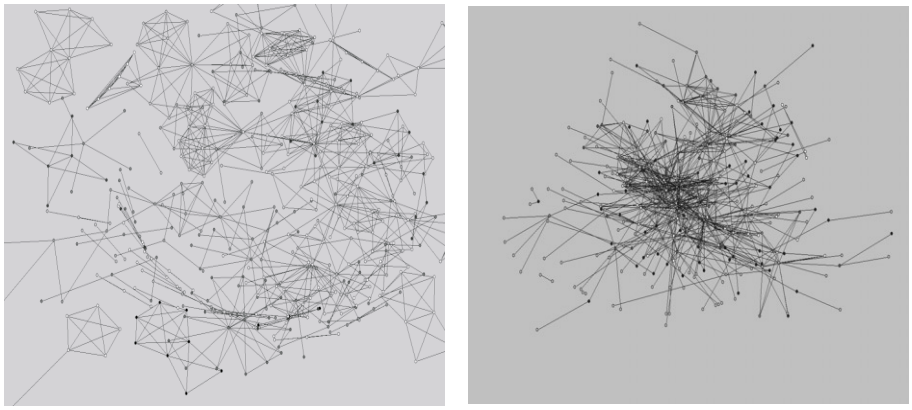

Fig. 4. Co-Author Network and Know-Link Network

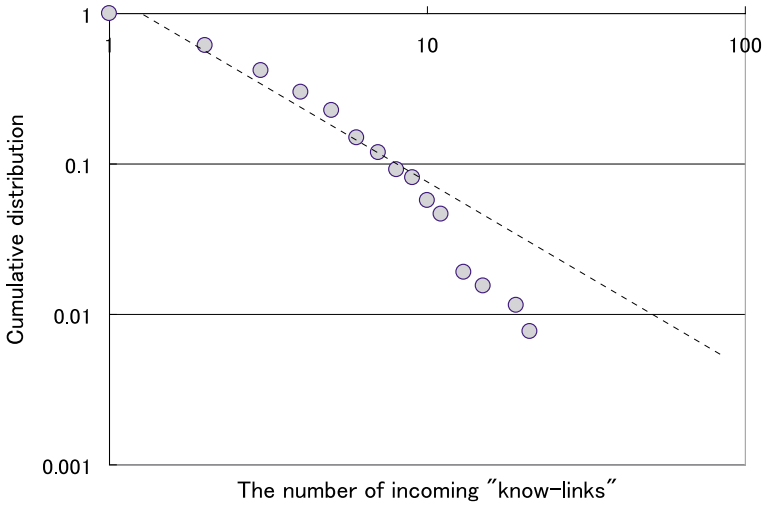

Fig. 5. The Distributions of Incoming Know-Links

by recommendation methods defined in section 2.3. Users can move to a HTML page of a recommended item and add a check-link or a know-link to their list if they click "Add a Link" button on the page. To access to a recommended item indicates that user has an interest on it. It means weak accept of a recommendation. Furthermore, user has a strong interest on it if she/he adds a link to a recommended item. It means strong accept of a recommendation. These measurements correspond to "Click" and "Buy" in a paper written by Cosley [3].

Table 2 shows results of recommendation. We show the number of recommended items approximately since we could not count it precisely [4]. Users added 1800 check-links. Seventy-two of them are added by recommendation using check-link and twenty-three of them are added by recommendation using know-link.

Table 2. Weak Accept and Strong Accept in Paper Recommendation

	a) Weak Accept (Rate)	b) Strong Accept (Rate)	a/b
Using Check-Link	$347(6.6-26.4\%)$	$72(1.4-5.6\%)$	20.7%
Using Know-Link	$210(2.1-16.4\%)$	$23(0.3-1.2\%)$	10.9%

Table 3 shows averages of in-coming check-links for recommended papers. (a) is the highest and (b) is the lowest. This result indicates that the recommendation method using check-link can find items which many people are interested in, while the method using know-link can find items which less people are interested in. They may be the items which the user and her/his friends are locally interested in.

Table 3. The Difference of Recommendations by Using Check-Links

	Ave. of In-Coming Check-Links
(a) Rec. Using Check-Link	25.8
(b) Rec. Using Know-Link	9.9
(c) All	12.3

"Ave. of Checked-Links" is the average of the number of check-links which a paper has. (a) is about checked papers as a result of recommendation using check-link and (b) is about checked papers as a result of recommendation using know-link.

[4] It is difficult to count the number of recommended items since they are generated dynamically in this system. In this case, we estimated this value by multiplying the number of access (maximum is the number of access to the recommendation service and minimum is the number of accessed users) by 5 (It is maximum number of recommended items).

Cosley suggested that a recommender system is one of decision support tools, i.e., it should help users make a decision whether or not to pursue an item [3]. From this point of view, it is a good way to provide a variety of recommendation method since they can present a variety of selections to users. A recommendation using interpersonal network has a difference from a recommendation using check-link like collaborative filtering. So the recommendation method using interpersonal network (know-link) can be used a one of effective recommendation methods in a community support system.

3.4 Capability of Recommendation Using Know-Link

We analyzed capability of recommendation using interpersonal network based on these results.

We define that persons who have edge of a know-link of user h_0 are $H_k = \{h|Relate(h_0, h) = 1\}$, papers which have a tail of a check-link added by user h_0 are $P_0 = \{p|Check(h_0, p) = 1\}$, and papers which have a tail of a check-link added by H_k are $P_k = \{p|Check(h, p) = 1, h \in H_k\}$. In this case $P_0 \cap P_k$ means papers which user h_0 and her/his aquaitance H_k checked (Figure 6).

According to the data in the experimental use, the rate of papers which user checked are checked by friends of each users is $\frac{|P_0 \bigcap P_k|}{|P_0|} = 0.67$.

The average of added check-links per user is $\overline{|P_0|} = 12.4$, and the average of check-links added by H_k is $\overline{|P_k|} = 52.8$. Incidentally, this value is not the same to $\overline{|H_k|} \times \overline{|P_0|}$ since there is overlap.

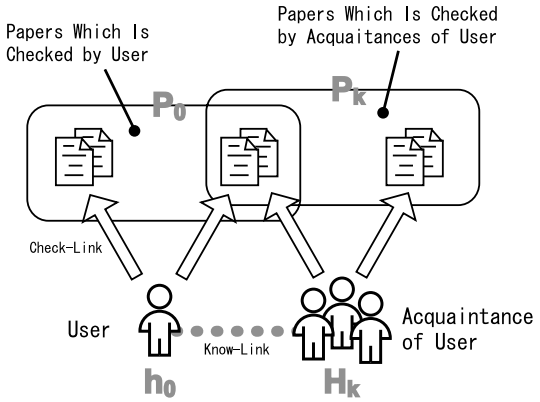

Fig. 6. Relation Among Check-Links of A User and Her/His Acquaintances

The ratio of the number of checked papers of h_0 to the number of papers which H_k also checked is $\frac{|P_0 \bigcap P_k|}{|P_k|} = \frac{|P_0 \bigcap P_k|}{|P_0|} \times \frac{|P_0|}{|P_k|} = 0.67 \times \frac{12.4}{52.8} = 0.16$. From

this calculation, we can expect that a probability of strong accept of recommendation using know-link. It is about 16%.

Similarly, we expect the probability in the case of a person recommendation. In this case, P_0 corresponds to H_k and P_k corresponds to $H_{kk} = \{h | Relate(h', h) = 1, h' \in H_k\}$. The ratio of the number of known persons of h_0 to the number of persons whom H_k also know is $\frac{|H_k \bigcap H_{kk}|}{|H_k|} = 0.76$. The average of the number of know-links which user added is $\overline{|H_0|} = 8.5$ and the average of the number of persons whom H_k known is $\overline{|H_{kk}|} = 42.5$. Therefore the ratio of the number of friends of a friend to the number of friends of them is $\frac{|H_k \bigcap H_{kk}|}{|H_k|} = \frac{|H_k \bigcap H_{kk}|}{|H_k|} \times \frac{|H_k|}{|H_{kk}|} = 0.76 \times \frac{8.5}{42.5} = 0.15$. We can expect the probability of strong accept of a person recommendation using know-link is about 15%.

4 Related Work

There are some systems that support to meet and discuss among participants in an academic conference and some of them was managed in academic conferences in real. Ishida et. al. provided *ICMAS Mobile Assistant Project* in *ICMAS'96* [4]. They give a mobile computer to a participant and provide services that support to activate discussion, e.g. e-mail, bulletin board system (BBS), an announcement system about surrounding areas and a supporting system to meet among participants on that mobile computer network. Dey et. al. developed a conference participants supporting system using mobile computers and wireless tags [5]. The system generates personal timetable using positional information of participants. Sumi provided *Digital Assistant Project* in *JSAI2000* [6]. The purpose of this system is support to meet among participants in a conference. A user can get information about the conference in real-time using PDA and information kiosk.

Services using mobile computing like the above systems are one of feasible ways to support users in session. However, it requires a big cost for service providers to prepare original mobile computers and also a lot of efforts for users to use a new device. We aim a community support system which can attract attentions of participants easily using an online program. It is an appropriate way to promote information sharing using asynchronized online community support system like our proposed system because we can start information sharing before a conference, while synchronized systems with mobile computing are suitable to support communication and discussion among participants during a conference.

Jameson provided *UM2001* website which is a conference support system based on an online program [7] [8]. This system recommends users papers using access logs in order to have users make personalized timetable. His system is similar to our system, but our system uses not only papers but also persons for recommendation.

Girgensohn applied the special BBS named *CHI Place* in *CHI2002*[9]. The system is a convenient BBS supports discussion among participants. BBS alone

is not sufficient to support discussion in conferences because conferences are too short in time to get to know each other and to make close discussion. Use of Interpersonal network can shorten the process to know each other.

5 Conclusion

This paper reported the community support system based on interpersonal network and analysis. The analysis reveals that characteristics of online interpersonal network are different from real-world interpersonal network. Nevertheless it also showed that interpersonal network is effective in a recommendation. We used interpersonal network just for information access and recommendation, but we believe that interpersonal network has huge potential for information and knowledge sharing. Recently, there are some social networking services, e.g. Friendster [5], Orkut[6] nad Mixi[7]. These services maintain independent interpersonal network. In the future we consider interoperability of interpersonal network on the web using open system technology, e.g., FOAF [10] and XFN[11].

References

1. Konstan, J.A., Miller, B.N., Maltz, D., Herlocker, J.L., Gorden, L.R., Riedl, J.: Grouplens: Applying collaborative filtering to usenet news. Communications of the ACM **40** (1997) 76–87
2. Amaral, L.A.N., Scala, A., Barthelemy, M., Stanley, H.E.: Classes of small-world networks. Applied Physical Science **97** (2000) 11149–11152
3. Cosley, D.: Referee: An open framework for practical testing of recommender system using researchindex. In: Proceedings of the 28th Very Large Databases Conference. (2002)
4. Nishibe, Y., Waki, H., Morihara, I., Hattori, F., Ishida, T., Nishimura, T., Yamaki, H., Komura, T., Itoh, N., Gotoh, T., Nishida, T., Takeda, H., Sawada, A., Maeda, H., Kajihara, M., Adachi, H.: Mobile digital assistants for community support. **19** (1998)
5. Dey, A.K., Futakawa, M., Salber, D., Abowd, G.D.: The conference assistant: Combining context-awareness with wearable computing. In: Proceedings of the 3rd International Symposium on Wearable Computers. (1999) 21–28
6. Sumi, Y., Mase, K.: Conference assistant system for supporting knowledge sharing in academic communities. Interacting with Computers **14** (2002) 713–737
7. Schwarzkopf, E.: An adaptive web site for the um2001 conference. In: Proceedings of the UM2001 Workshop on Machine Learning for User Modeling. (2001) 77–86
8. Jameson, A., Schwarzkopf, E.: Pros and cons of controllability: An empirical study. In: Proceedings of Adaptive Hypermedia and Adaptive Web-Based Systems. (2002) Available from http://dfki.de/~jameson/abs/JamesonS02.html.
9. Girgensohn, A., Lee, A.: Making web sites be places for social interaction. In: the 2002 ACM Conference on Computer Supported Cooperative Works. (2002) 136–145 Available from http://www.webcollab.com/alee/papers/cscw02.html.

[5] http://www.friendster.com/
[6] http://www.orkut.com/
[7] http://mixi.jp/

10. Brickley, D., et al.: Friend of a friend (2002) http://www.foaf-project.org/.
11. Celik, T., Meyer, E.A., Mullenweg, M.: Xhtml friends network. In: Demonstration and Poster Proceedings of Hypertext2004. (2004) 48–49 http://gmpg.org/xfn/.