

Application and Analysis of Interpersonal Networks for a Community 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 based on an analysis of our scheduling support system employed in an academic conference. Our system supports information exchange among participants and information discovery thereof. It generates participant's interpersonal networks and thereby provides information sharing control. This system was used in an academic conference JSAI2003 involving 276 active users and generating their interpersonal networks. An analysis of these networks reveals that interpersonal networks can promote information exchange among people by indicating existence of people to the others, and that interpersonal networks can support information discovery by its recommendation functionality.

1 Introduction

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

To activate discussion in academic conferences and promote communication among participants, it is important for participants to find interesting presentations, to know what kinds of people participate and which participants share similar concerns. However, it is difficult for a user to learn such information from a large amount of information on presentations and participants.

This system adopted a "person as content" strategy. It means that a person is an information source; We treat a person as an information node that is accessible to other users. Such nodes are connected through an interpersonal network based on their own relationships.

Interpersonal networking can show what kinds of people participate. Furthermore, new routes are created for discovery of papers or other persons because persons are connected with papers or other persons with links. Based on the network found by participants, this system offers recommendation services for papers and participants that are supposed to be interesting for individual users.

2 Community System Using Interpersonal Network

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.

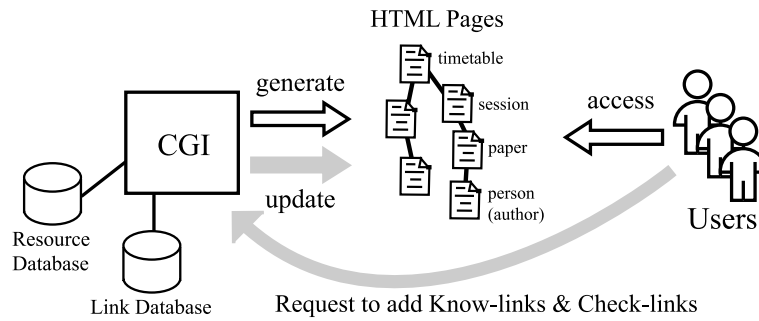


Fig. 1. System Overview

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-know-by" lists) are basic functions. When a user can find an interesting paper in the conference schedule or the paper list, she/he can add it to her/his schedule. 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 user is added to the acquaintance's "I-know-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, her/his presentations and hyperlinks to some services. The rest shows dynamic information i.e., "I-know" and "I-known-by" lists.

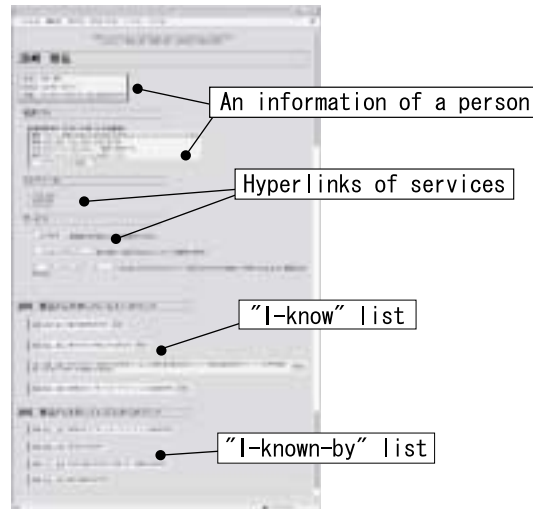


Fig. 2. My Page

Added links are 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 both for papers and for persons. A user can find interesting papers and persons not only by browsing but also by recommendation.

This service has two types of recommendation method. One is a method which similar to collaborative filtering like a GroupLens [1]. This recommendation method refers to data of other persons who have similar concerns of user. In our case, we use check-links as data to guess participants' concern. The other is a method using interpersonal network. This method refers to user's friends. It interpersonal network formed by know-links that users added. 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 that three functions. The first one is *CheckFunction*. It is defined as follows: If person h_0 add check-link to paper p , $Check(h_0, p) = 1$. Otherwise, $Check(h_0, p) = 0$. The second one is *KnowFunction*. Similarly, it is defined as follows: If person h_0 add know-link to person p , $Know(h_0, h_1) = 1$. Otherwise, $Know(h_0, h_1) = 0$. And the last one is *RelateFunction* it is defined as follows: $Relate(h_0, h_1)$ is 1 if $Know(h_0, h_1) = 1$ or $Know(h_1, h_0) = 1$. Otherwise, $Relate(h_0, h_1)$ is 0.

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

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

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

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 picks up five candidates which have highest degrees of recommendation V . And then candidates whose V is more than the thresholds are chosen as recommending items.

3 Experimental Results

We applied this system to the academic conference JSAI2003. In this conference, there are 30 sessions, 259 presentations and 510 authors (including co-authors). About 400 participants joined that conference between Jun 23 and 27, 2003.

3.1 Trace of Users

In this section, we show how users utilize interpersonal networks based on trace of users.

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

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 same in each node (Figure 3).

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

The access log from a paper page to a person page appears more than 1000 times. Furthermore, the access log from person to person appears more than 1300 times.

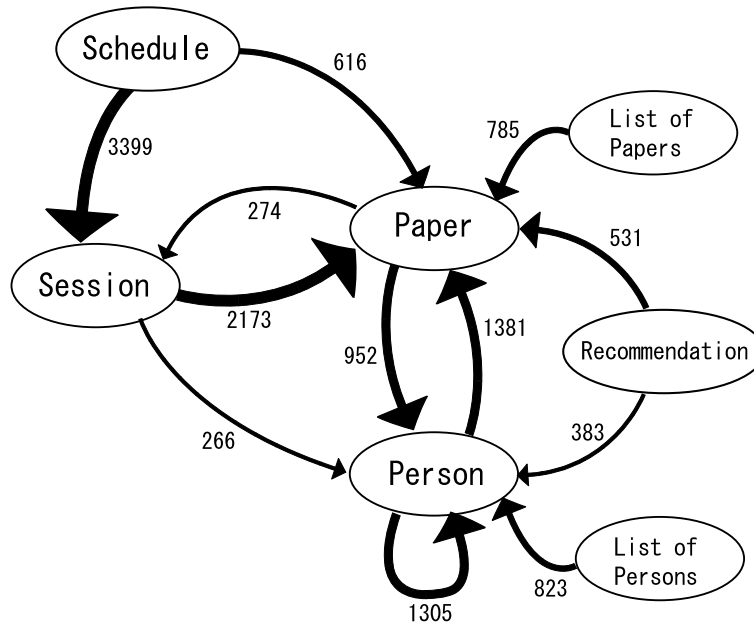


Fig. 3. Access Pattern

Users access to pages through person pages many times. The number is approximately a half of the number of typical access pattern such as from sessions to papers. And an access pattern from persons to persons is also used frequently. The former result indicates many users access to person as content. The latter result indicates user utilize interpersonal networks 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 tail of a check-link and a know-link, and head of a know-link. Similarly, a paper can be head of a check-link. Table 1 shows the number of

persons who have tail of a know-link (she/he added at least a know-link) and the number of persons who have head of a know-link.

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 user 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. User can add link anywhere. As a result, they generated a new widespread network of contents in this system. This network shows users new routes to find information. Interpersonal network is thus utilized in a community system.

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 co-author networks and know-link networks. 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.

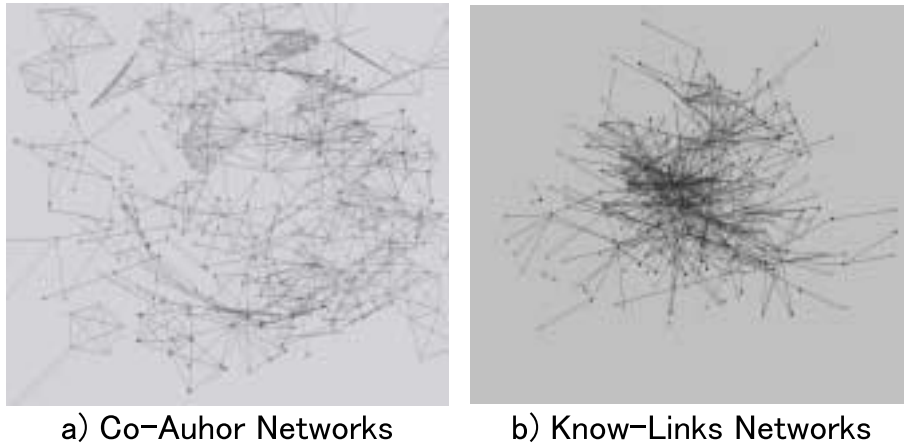


Fig. 4. Co-Author Networks and Know-Link Networks

The co-author networks have 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 networks 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.

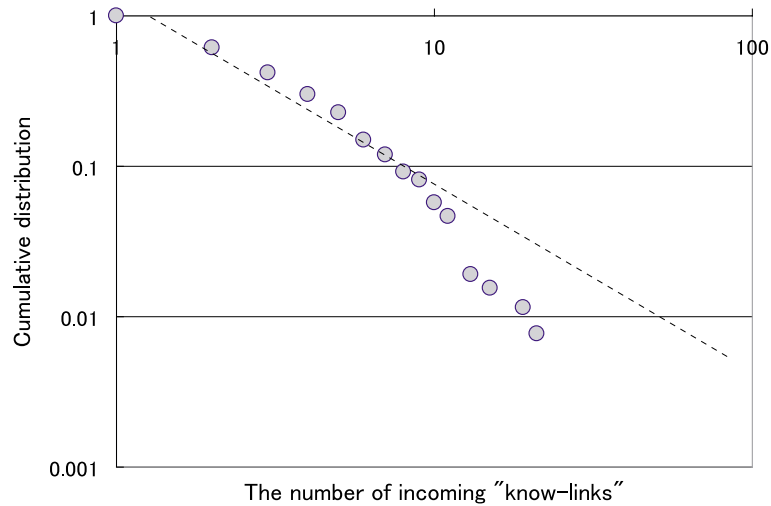


Fig. 5. The Distributions of Incoming Know-Links

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 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 correctly⁴. 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 the user and her/his friends are locally interested in.

Table 3. The Difference of Recommendations between Using Check-Link and Using Know-Link

	Ave. of Checked-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.

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 networks has a difference from a recommendation using check-link like collaborative filtering. So the recommendation method using interpersonal networks (know-link) can be used a one of effective recommendation methods in a community system.

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).

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 end of a check-link added by user h_0 are $P_0 = \{p | Check(h_0, p) = 1\}$, and papers which have end 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 acquaintance H_k checked (Figure 6).

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

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

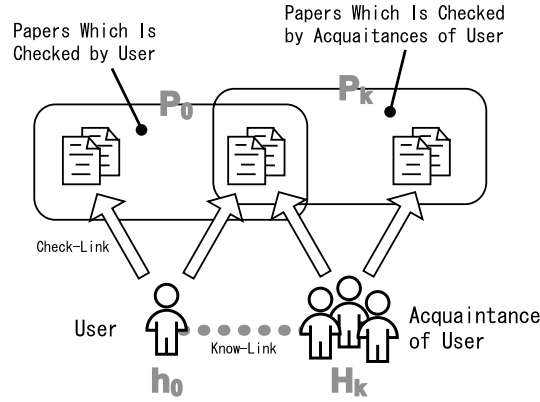


Fig. 6. Relation Among Check-Links of A User and Her/His Acquaintances

The ratio of the number of checked papers of h_0 to the number of papers which H_k also checked is $\frac{|P_0 \cap P_k|}{|P_k|} = \frac{|P_0 \cap P_k|}{|P_0|} \times \frac{|P_0|}{|P_k|} = \frac{12.4 \times 0.67}{52.8} = 0.16$. From this calculation, we can expect that a probability of strong accept of recommendation using know-link (It means that whether a recommended item is checked by user or not). It is about 16%.

Similarly, we expect it in the case of a person recommendation. In this case, P_0 correspond to H_k and P_k correspond 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 $\frac{|H_k \cap H_{kk}|}{|H_{kk}|} = 0.76$. 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 $\frac{|H_k \cap H_{kk}|}{|H_k|} = \frac{|H_k \cap H_{kk}|}{|H_k|} \times \frac{|H_k|}{|H_{kk}|} = \frac{8.5 \times 0.76}{42.5} = 0.15$. 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 provided *ICMAS Mobile Assistant Project* in *ICMAS'96* [4]. They give a mobile computer to a participant and provided 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 developed a conference participants supporting system using a mobile computer and a wireless tag [5]. The system generates personal timetable using positional information of participants.

Sumi provided *Digital Assistant Project* in *JSAI2000*. The purpose of this system is a supporting to meet among participants in a conference. A user can get information about a conference real-time using PDA and information kiosk.

These services using a mobile computing is an applicable way to support users in session. However, it requires a big cost to give users original mobile computers and have users used them yet. We aim a community system which can attract attentions of participants easily using an online program. We think that it is an appropriate way to promote information sharing using asynchronized online community system like our proposed system before a conference, while communication and discussion among participants using synchronized system with mobile computing in session of a conference.

Jameson provided *UM2001* website which is a conference support system based on an online program [6] [7]. This system recommends users papers using access logs in order to have users make personalized timetable. On the other hand, our system uses not only papers but also persons for a recommendation.

Girgensohn applied the special BBS named *CHI Place* in *CHI2002*. A convenient BBS supports discussion among participants. However, it is a burden for users to discuss on BBS. Actually, our system has BBS, but it was not used by users. From the result in chapter ?? shows that it is not too big burden for users to make interpersonal network on the web. We think that to generate a light relationship like that can be a first step to realize to discuss among participants on a web system.

5 Conclusion

This paper reported the community system based on interpersonal networks and analysis. We found that a character of online interpersonal networks differs from

real-world interpersonal networks and using interpersonal network is effective in a recommendation.

Recently, there are some social networking services, e.g. Orkut⁵ and Gree⁶, and interpersonal networking on the web has lost much of its novelty now. However, it is difficult to extend interpersonal network to some degree since these networks are closed in the system. Our proposed system has same problem. In the future we consider interoperability of interpersonal networking on the web using open system technology, e.g., FOAF [8] or XFN[9].

References

1. Konstan, J.A., Miller, B.N., Maltz, D., Herlocker, J.L., Gordon, 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., Barthélemy, 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. Nishimura, Y., Yamaki, H., Komura, T., Itoh, N., Gotoh, T., Nishida, T., H. Takeda, A.S., Maeda, H., Kajihara, 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. 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
7. 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>.
8. Brickley, D., et al.: Friend of a friend (2002) <http://www.foaf-project.org/>.
9. Celik, T., Meyer, E.A., Mullenweg, M.: Xhtml friends network. In: *Demonstration and Poster Proceedings of Hypertext2004*. (2004) 48–49 <http://gmpg.org/xfn/>.

⁵ <http://www.orkut.com/>

⁶ <http://gree.jp>