

Collecting Organizational Memory Based on Social Networks in Collaborative Learning

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Abstract: The exploration of social networks is essential to find capable collaborators who can help problem-solving and to augment cooperation between users. This paper describes PeCo-Mediator-II for seeking for a collaborator with the chain of personal connections (PeCo) in distributed organizations. Moreover, this system helps gathering, exploring, and visualizing social networks. The experimental results show that the system facilitates that learners encounter collaborators and develop a new helpful relationship beyond the classroom.

1. Introduction

Recently, opportunities for communication and collaboration via computer networks have immensely been increased in networked organizations (Sproull and Kiesler, 1991). A fundamental problem is how to encounter people who can help problem-solving. We are focusing on the problem of discovering such people through social networks. Social networks are at least as important as the official organizational structures for tasks ranging from immediate, local problem solving (e.g., fixing a piece of equipment), to primary work functions, such as creating collaborative groups (Kautz et al., 1997).

In CSCW (Computer Supported Cooperative Work), researchers are interested in the role of social networks between organizational members. Clement stated that users developed informal collaborative networks to know how to use a new software (Clement, 1990). Then, private networks are important for workers to solve problems by providing helpful information. A number of studies have shown that one of the most effective channels for gathering information and expertise within an organization is its informal networks of collaborators, colleagues and friends. The networks of helping relationships are called "Help Network" (Eveland et al., 1994). However, the networks are not collected and generally follow work group alignments rather than technical specialization. Therefore, it is significant to use members' interpersonal connections effectively in their activities.

In CSCL (Computer Supported Collaborative Learning), one common component of collaborative learning is the "informal peer-help networks". This notion is compatible with Wenger's communities of learners (Wenger, 1996), where people who share learning goals within an authentic learning environment can develop ties that reinforce learning outcomes. From this viewpoint, Greer et al. (1998) proposed PHelpS (Peer Help System) that supports workers as they perform their tasks, offers assistance in finding peer helpers when required, and mediates communication on task-related topics. On the other hand, our approach focuses on how a system can support both storing and exploring "Personal Connection" (PeCo) in a collaborative learning environment.

A concept of organizational memory is proposed as organizational knowledge with persistence (Conclin, 1992). Answer Garden (Ackerman and McDonald, 1996), and COMES (Ogata et al., 1996b) have been proposed to record and use organizational memory. In an organization, however, information seeking is not straightforward information transfer. Colleagues chose not to go to the channel of the highest quality for information, but rather to go to the channel of heights accessibility (Allen, 1977). Accessibility is concerned with psychological cost that is in the potential lack of reciprocity between giving and obtaining information and so on. PeCo makes it easy to agree to the cooperation and to access information.

We propose PeCo-Mediator-II (Ogata et al., 1996a) for gathering, seeking, and visualizing social networks in a networked organization. PeCo-Mediator-II is a distributed system with a personal database (PeCo-Collector) and a software agent (PeCo-Agent). Every user has the two softwares on the respective site. PeCo-Collector incrementally gathers information on its user's acquaintances and the relationships through watching the exchanges of e-mail. PeCo-Agent moves to colleagues' sites and negotiates with other agents and users to find collaborators. Although the users of both NetNews and e-mail lists are passive to find answers, our system can actively discover collaborators with the chain of personal connection from the user and the collaborators.

2. Overview of PeCo-Mediator-II

Our initial system called PeCo-Mediator (Ogata et al., 1995) is a groupware that allows sharing of PeCo in a group and to search for connections between the user and targets. The users need to share PeCo with the common database of PeCo-Mediator. Although the system was very available in some small groups, it was reluctant in terms of users offering their private information like PeCo into the common database. Also, it is hard for the users to entry personal data of their friends.

When a computer network connects people or organizations, it is a social network. Just as a computer network is a set of machines connected by a set of cables, a social network is a set of people connected by a set of social relationships, such as friendship, co-working, or information exchange (Garton et al., 1997). Computer Mediated Communication (CMC) systems also reduce the transaction costs of initiating and maintaining interpersonal ties (Pickering and King, 1992). Weak ties created by CMC expand the channels of information sources for the individual and have potential for strong ties.

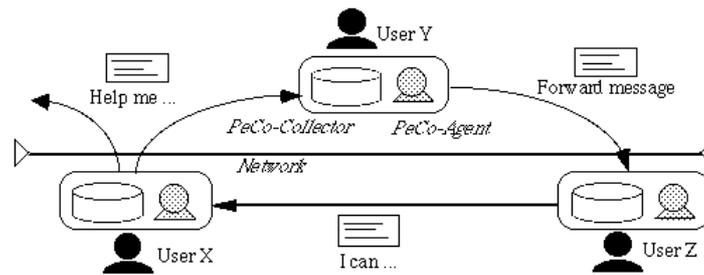


Figure 1. Overview of PeCo-Mediator-II.

PeCo-Mediator-II is combined PeCo-Mediator and on-line social networks. It consists of the two systems; PeCo-Collector and PeCo-Agent (see Figure 1). Every organizational member has the two softwares on the respective site. PeCo-Collector gathers information on its user's acquaintances and the relationships through watching the exchanges of e-mail. PeCo-Agent moves between members' sites to find a partner in the community. The user's PeCo is a starting point for the exploration. The user's acquaintance acts as a liaison between the user and the partner in this situation. In this figure, user X requests user Y to help the problem solving, and user Y introduces user Z. After that, user Z can help user X by request.

3. Gathering Organizational Memory Based on Social Networks

We have proposed a data diagram of PeCo exploration (Ogata et al, 1998). To support the exploration of social networks, it is very important to store the history of PeCo exploration when the user has sent or receive messages. Based on PeCo exploration diagrams, the attribute includes the following user's actions: request, accept, reject, forward, receive-request, receive-forward, receive-accept, receive-reject. The topic of the request is represented with keywords that are extracted from e-mail.

Table 1. Taxonomy of users with the exploration history.

| User type | Condition |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Collaborator | <i>accept</i> > α and <i>accept</i> > <i>reject</i> and <i>accept</i> > <i>forward</i> and <i>accept</i> > <i>request</i> |
| Mediator | <i>forward</i> > α and <i>forward</i> > <i>reject</i> and <i>forward</i> > <i>accept</i> |
| Requestor | <i>request</i> > α and <i>request</i> > <i>accept</i> and <i>request</i> > <i>forward</i> |
| Non-collaborator | <i>reject</i> > α and <i>reject</i> > <i>accept</i> and <i>reject</i> > <i>forward</i> |
| Semi-collaborator | <i>receive_accept</i> > α and <i>receive_accept</i> > <i>accept</i> |

(Italic word shows the number of the action. α is a constant given by the user.)

3.3. Taxonomy of Users

Based on the above history, we divide users into the five types (see table 1):

- 1) Collaborator: The collaborator is a user who usually accepts the request during this system use. The collaborator is often an expert about the request.
- 2) Semi-collaborator: The semi-collaborator is a user who potentially has the capability for cooperation about the request. We assume that a semi-collaborator receives the answer from others rather than accepting requests.

- 3) Mediator: The Mediator is the user who usually forwards the request to his/her friends.
- 4) Requestor: The requestor is a user who asks a question and s/he becomes a starting point of exploration of social networks.
- 5) Non-collaborator: The non-collaborator is a user who almost rejects the request.
- 6) Unknown user: If a user has never received or sent a request, the user is unknown for the system.

PeCo-Agent understands the users' capability through watching the exchanges of questions and answers. We represent the capability of the user and his/her acquaintances with the keywords in the e-mail. For example, a friend is a collaborator about C programming language although the friend is a non-collaborator about Tcl/Tk.

3.5. Collecting Organizational Memory

Organizational memory has been proposed as a concept for sharing organizational members' knowledge (Conclin, 1992). We also apply that concept into our situation. If a collaborator permits sharing of an answer, it is entered into a shared repository. Because the requesters can refer to the answers in the database before sending the requests, collaborators need not write down the same answer repeatedly. Moreover, when a collaborator permits propagation of the answer, the system sends the answer to the mediators between the collaborator and the requester as well as the requester. By this facility, mediators can also know the answer.

4. Implementation

4.1 System Configuration

We developed a prototype system on a workstation with Tcl/Tk (Ousterhout, 1994). The system consists of PeCo-Collector and PeCo-Agent. Every group user has the two systems on the respective site.

(1) PeCo-Collector: This system has two components: data management and E-mail handler. All the data is managed by TRIAS (Yamamoto et al., 1989) and the e-mail tool is TkMH based on MH (Mail Handler) (Peek, 1994). PeCo-Collector links an e-mail object and its sender's or receiver's object automatically and the user can make hypertext links among e-mails.

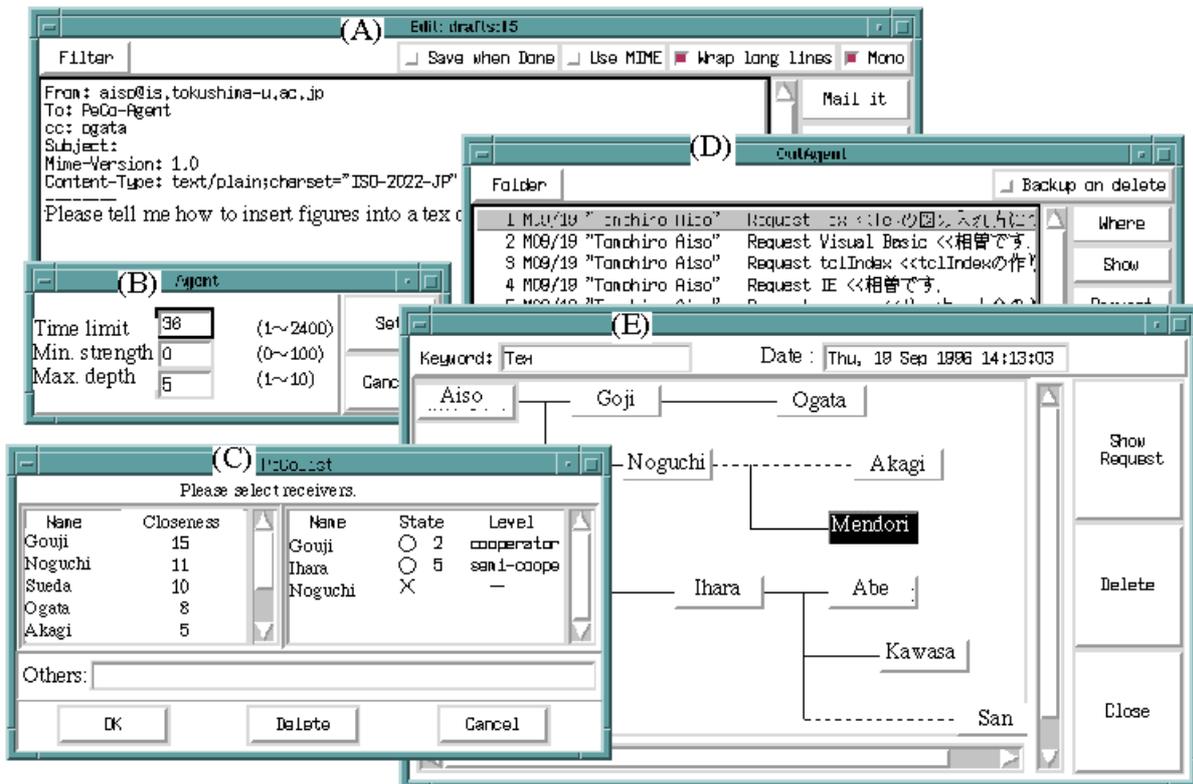


Figure 2: Screen shot of PeCo exploration with PeCo-Mediator-II.

(2) PeCo-Agent: The characteristics of PeCo-Agent are:

- 1) To represent capability of users with keywords about e-mails;
- 2) To obtain the capability of users from the user and other agent;
- 3) To move around the Internet and communicate with other users and agents;
- 4) To find the candidates of partners concurrently.

In PeCo-Mediator-II, a user communicates and negotiates with others through e-mail. In the same way, PeCo-Agent communicates with other agents with structured e-mail (Malone, 1986). Keywords are extracted with Chasen (Matsumoto, 1997) that is a Japanese morphological analysis tool. PeCo-Agent calculates the similarity between the given question and the stored questions by matching nouns elicited from Chasen filter.

4.2. Interface

Figure 2 shows the interaction after user "aiso" ask a question to his PeCo-Agent. In the window (A) "aiso" writes the request message. In the window (B), the user sets time out for seeking social networks, the minimum strength of PeCo and the maximum steps between "aiso" and the receiver. PeCo-Agent finishes the exploration according to this setting. In the window (C), PeCo-Agent assists "aiso" to decide who is the better receiver of his acquaintances and the user agent provides information about the candidates of the receivers. The window (D) displays the list of the requests that the user has sent.

The window (E) shows the flow of the exploration from he user graphically. This tree is the result of traveling with the connections of "aiso". The icons except "aiso" denote the candidates of partners. The shorter the distance between two icons, the stronger the relationship they have. While the dotted line denotes the receiver has not read the message yet, the solid line shows the receiver has already read it. The black icon means the user has rejected the request. The node icon shows the user has forwarded the message to his/her friends. The leaf and white icon means the user has accepted the cooperation. In this figure, "mendori" refused aiso's request, and "ogata", "abe", and "kawasaki" agreed to his request. "akagi" has not read the message yet. If the user reminds the reply to the request from this window, PeCo-Agent of "akagi" tells him to read the message. From this result, "aiso" is the most familiar to "goji" and can easily access the collaborator "ogata" through the mediation of "goji".

5. Experimental Use

5.1. Users and Tasks

We experimentally tested and evaluated PeCo-Mediator-II in small communities. In this experiment, we arranged 13 master course students (group A) and 94 undergraduate students (group B) who had no relationship with the members of group A at the first stage of the experiment. Only one person, teacher VI, knows all the members of group A and B. They used the prototype system during nine weeks in a class of programming language C. We divided nine weeks into three terms. Teacher VI gave group B some homework every week, for example, making a program of data sorting.

Term 1: In the first three weeks, the system gathered their usual ties. Each group member communicated among the internal group members without the contact of the other group.

Term 2: We allowed group A and B to communicate and collaborate with each other to solve problems. The users solved the given problems through this system without supporting PeCo exploration with history.

Term 3: In this period, we evaluated the function for supporting PeCo exploration with the history that was stored in the term 2.

5.2. Experimental Results

Figure 3 shows the social networks between the users after six weeks from the beginning of this experiment. While the user of group A is indicated by a circle, the user of group B is shown by a square. The thick arrows denote the requested messages from the sender to the receiver. The thin arrows represent the forwarded messages over one time. The weight of the arrow shows how many times e-mail was exchanged from the sender to the receiver. The user VI was a central person and acted as a liaison between group A and B. As shown in this figure, group A and B learned to communicate with each other through the introduction of user VI, although they did not have connections beyond the group. Moreover, most of the requests from group B concentrated on user VI and III, and the collaborators were almost fixed at six persons of group A. In this case, there was no collaborator in group B.

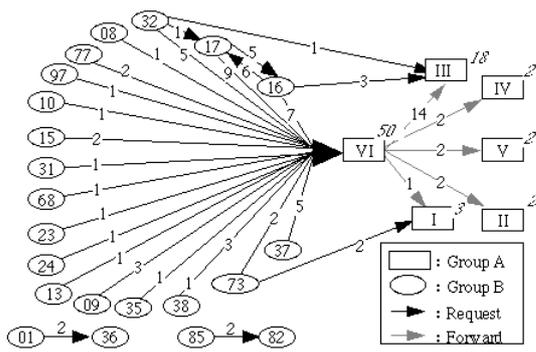


Figure 3. Network forming in the term 2.

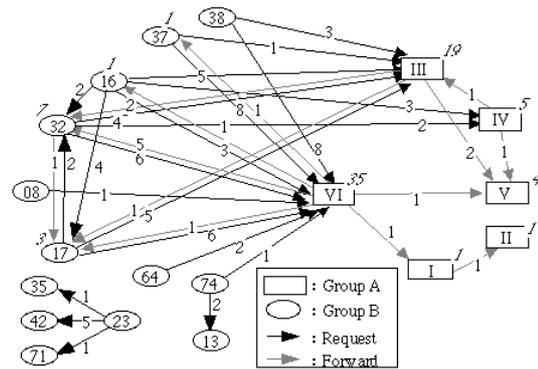


Figure 4. Network forming in the term 3.

In the previous experiment (Ogata et al., 1998), we compared this system with e-mail, mailing list and NetNews during four weeks. This experiment was executed in the same class. Both mailing list and NetNews were not often used for getting answer, because the student hesitated to ask a question. On the other hand, both this system and e-mail were frequently used. In this case, social networks were stable because direct and explicit relationships were used to get collaborative help. Likewise, (Yamakami, 1995) describes the interaction patterns of e-mail and bulletin board are stable from the long-term usage observation.

Figure 4 depicts the message flow in the term 3. Some of group B became collaborators because our system lead the users to reduce the incipient collaborators' load. For example, the system recommended user VI to forward the request from user 32 to user 17 who was a semi-collaborator. After that, user 32 directly requested user 17 to cooperate with problem solving.

In the term 3, the users provide their knowledge into the shared repository. Figure 5 shows the bar chart of its usage every week. The times of reference were 200, and the times of entry were 21. The number of knowledge in the repository was small, but the knowledge was basic. Therefore, the users often made use of it. As a result, the overload of collaborators was reduced.

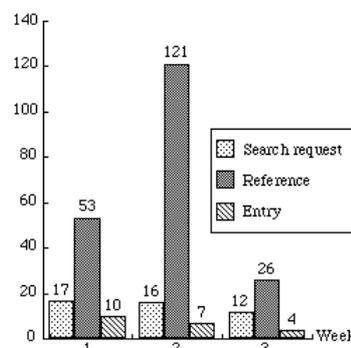


Figure 5: The usage of the shared knowledge repository in term 3.

6. Related Works

There are many possible sources for determining direct relationships. The initial version of our system imposed the entry of relationship lists upon organizational members (Ogata et al., 1995). The provision of individual ties makes the burden heavy for the users. Schwartz and Wood (Schwartz and Wood, 1993) proposed a way to obtain relationships by analyzing e-mail logs. However, the use of such information raises concerns of privacy and security that are hard to allay. ReferralWeb (Kautz et al., 1997) system uses the co-occurrence of names in close proximity in any documents publicly available on the Web as evidence of a direct relationship. Although this system is readily available to discover public relationships, it may be difficult to find real private networks. Our system focuses on current and personal ties based on the exchange of e-mail.

Foner (Foner, 1995) proposes Yenta that is a matchmaker agent to bring people together. In this approach, a broker agent automatically introduces other agents and people. On the other hand, our work pays much attention to human-centered approach for enhancing cooperation between organizational members. Therefore, the agency of PeCo-Agent is weak.

7. Conclusion

This paper proposed PeCo-Mediator-II as a support to find capable collaborators with the chain of personal connections (PeCo) in a collaborative learning environment. This system helps gathering, seeking, and visualizing social networks of organizational members. PeCo-Mediator-II is an agent-based system to deal with e-mail. This system consists of PeCo-Collector as a personal database and PeCo-Agent as a user's assistant. PeCo-Mediator-II was experimentally tested and evaluated in a C programming language course. The results showed the system could help the user to encounter a collaborator and developed the new relationship with the collaborator.

References

- Ackerman, M. S. & McDonald, D. W. (1996). Merging Organizational Memory with Collaborative Help, *Proc. of CSCW 96*, ACM Press, pp.97-105.
- Allen, T. (1977). *Managing the Flow of Technology*, MIT Press.
- Clement, A. (1990). Cooperative Support for Computer Work: A Social Perspective on the Empowering of End Users, *Proc. of CSCW 90*, ACM Press, pp.223-236.
- Conclin, E. J. (1992). Capturing Organizational Memory, *Groupware 92*, pp.133-137.
- Eveland, D. J., Brown, W. & Mattocks, J. (1994). The Role of "Help Networks" in Facilitating Use of CSCW Tools, *Proc. of CSCW 94*, ACM Press, pp.265-274.
- Foner, N. L. (1995). Clustering and Information Sharing in an Ecology of Cooperating Agents, *Proc. of AAAI Spring Symposium on Information Gathering from Distributed, Heterogeneous Environments*, AAAI Press/
- Garton, L., Haythornthwaite, C., & Wellman, B. (1997). Studying On line Social Networks, *Journal of Computer Mediated Communication*, vol.3, no.1. (<http://www.usc.edu/dept/annenber/vol3/issue1/garton.html>)
- Greer, J., McCalla, G., Collins, J., Kumar, V., Meagher, P. & Vassileva, J., (1998). Supporting Peer Help and Collaboration in Distributed Workspace Environments, *International Journal of Artificial Intelligence in Education*, 9, (to appear)
- Kautz, H., Selman, B. & Shah, M. (1997). The Hidden Web, *AI Magazine*, vol. 18, no. 2, pp.27-36.
- Malone, T. W. (1986). Semi-Structured Messages are Surprisingly Useful for Computer Supported Coordination, *Proc. of CSCW 86*, ACM Press, pp.102-114.
- Matsumoto, Y, Kitauchi, A., Yamashita, T., Hirano, Y., Imaichi, O. & Imamura, T. (1997). Japanese Morphological Analysis System ChaSen Manual, *Nara Institute of Science and Technology Technical Report NAIST-IS-TR 97007*. (in Japanese)
- Ogata, H., Yano, Y., Furugori, N., & Jin, Q. (1995). PeCo-Mediator: Development and Modeling of a Supporting System for Sharing and Handling Personal Connections, *Transactions on Information Processing Society of Japan*, vol. 36, no. 6, pp.1299-1309. (in Japanese)
- Ogata, H., Goji, A., Jin, Q., Yano, Y. & Furugori, N. (1996a). Distributed PeCo-Mediator: Finding Partners via Personal Connections, *Proc. of 1996 IEEE Systems, Man and Cybernetics (SMC)*, vol. 1, Beijing, China, pp.802 - 807.
- Ogata, H., Tsutsumi, K., Jin, Q., Yano, Y. & Furugori, N. (1996b). COMES: Collaborative Organizational Memory System, *Proc. of IEEE Systems, Man and Cybernetics (SMC)*, vol. 2, Beijing, China, pp.983-987.
- Ogata, H., Aiso, T., Furugori, N., Yano, Y. & Jin, Q. (1998). Computer Supported Social Networking in Virtual Communities, *Proc. of IEEE International Conference on Intelligent Processing Systems*, pp.47-51.
- Ousterhout, J. (1994). *Tcl and the Tk Toolkit*, Addison-Wesley.
- Pickering, M. J. & King, L. J. (1992). Hardwiring Weak Ties: Individual and Institutional Issues in Computer Mediated Communication, *Proc. of CSCW 92*, ACM Press, pp.356-361.
- Peek, D. J. (1994). *MH and XMH: E-mail for users and programmers*, O'Reilly and Associates, Inc.
- Salomon, G. (1992). What Does the Design of Effective CSCL Require and How Do We Study Its Effects?, *ACM SIGCUE Outlook*. (http://www.cica.indiana.edu/cscl95/outlook/62_Salomon.html)
- Schwartz, F. M. & Wood, M. C. (1993). Discovering Shared Interests Using Graph Analysis, *Communications of ACM*, no.36, vol.8, pp.78-89.
- Sproull, L. & Kiesler, S. (1991) *Connections: New ways of working in the networked organization*, MIT Press.
- Wenger, E. (1996). Communities of Practice: The Social Nature of Learning, *HealthCare Forum Journal*, pp.20-26.
- Yamakami, T. (1995). Information Flow Analysis: An approach to evaluate groupware adoption patterns, *Transactions of Information Processing Society of Japan*, vol.36, no.10, pp.2511-2519.
- Yamamoto, Y., Kashihara, A., Kawagishi, K., & Tsukamoto, S. (1989). A tool for construction of personal database: TRIAS, *Transactions of Information Processing Society of Japan*, vol.30, no. 6, pp.733-742 (in Japanese).

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