Augmenting Collaboration beyond Classrooms through Online Social Networks

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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 an agent based social networking system called PeCo-Mediator-II for seeking for a collaborator with the chain of personal connections (PeCo) in distributed organizations. This system helps gathering, exploring, and visualizing social networks. This paper proposes a social-networks based matchmaker (SNBM) agent for bridging heterogeneous classrooms. The experimental results show that the system facilitates that learners encounter collaborators and develop a new helpful relationship beyond the classroom and that SNBM on behalf of a teacher played an important role of a mediator between heterogeneous groups.
Keywords: **collaboration, social and cultural issue, on-line social networks, personal connections, collaborative help networks, matchmaker, and software agents.**

1. Introduction

Recently, opportunities for communication and collaboration via computer networks have immensely been increased in networked organizations[19]. 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[6].

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[1]. 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 on an organization is its informal networks of collaborators, colleagues and friends. The networks of helping relationships are called "***Help Network***"[2]. 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[19], where people who share learning goals within an authentic learning environment can develop ties that reinforce learning outcomes. From this viewpoint, Greer et al.[5] 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. Therefore, our approach focuses on how a system can support both storing and exploring "***Personal Connection***" (***PeCo***) in a collaborative learning environment.

PeCo-Mediator-II[11][13] has been developed 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. This system was evaluated in heterogeneous classrooms, and its experimental results showed this system was very useful to increase collaboration across classrooms[15]. In the experiment, the teacher played a very important role of a mediator between the classrooms and the teacher was burdened with the role. Then, the problem arises: how to support mediators with this software system.

Foner[3] has been developed Yenta that is a matchmaker agent to bring people together. In this approach, a broker agent automatically introduces other agents and people. In this paper, we propose a social-network based matchmaker (SNBM) agent on behalf of mediators between heterogeneous classrooms.

2. Computer Supported Social Networking

There are many possible sources for determining direct relationships. The initial version of our system imposed the entry of relationship lists upon organizational members[10]. The provision of individual ties makes the burden heavy for the users. Schwartz and Wood[18] 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[6] 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.

Our initial system called PeCo-Mediator[10] 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[4]. Computer Mediated Communication (CMC) systems also reduce the transaction costs of initiating and maintaining interpersonal ties[16]. Weak ties created by CMC expand the channels of information sources for the individual and have potential for strong ties.

PeCo-Mediator-II is combined PeCo-Mediator and on-line social networks. It consists of the two systems; PeCo-Collector and PeCo-Agent. 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.

The characteristics of this system are:

1) Accumulation of on-line and off-line social networks: Mainly, our system deals with

PeCo based on the exchange of e-mail. PeCo-Mediator-II automatically stores relationships based on e-mail tags[11]. In addition, the user can provide on-line relationships; e.g., based on the exchange of name-cards.

2) Measurement of PeCo strength: The strength of PeCo is estimated with the frequency of e-mail exchange. This degree is very useful for deciding the receivers of the request .
3) Privacy protection: PeCo-Mediator-II manages individual ties with a distributed personal database in the user's own site. Personal data is safer in a personal database than in a common database. Therefore, it is easy for this system to protect user's privacy and to be accepted in a large-scale organization.
4) Compatibility: The architecture of PeCo-Mediator-II is compatible with existing e-mail mechanisms. Compatibility reduces user overhead in taking advantage of the e-mail tools.
5) Scalability: Even if the number of users increase, this system can work robustly because of an agent based distributed system architecture.
6) Parallel exploration assisted by agents: PeCo-Agent supports the user to search for a collaborator through social networks while negotiating with other users and PeCo-Agents. Moreover, the user can visually understand the current status of the exploration and easily control that process.
7) Mitigation of experts' overload: The questions are possibly concentrated on a part of users (experts). This system provides a common database of answers and navigates the questions with strategies on educating the secondary collaborators and on spreading the answers [15].

This paper appends a matchmaker agent into the agent-based architecture of PeCo-Mediator-II.

3. Social-Networks Based Matchmaking

SNBM mediates learners a kind of their questions, their capabilities and social networks.

3.1 Registration of Social-networks and capability

SNBM has two approaches to acquire user's capability and their social networks:

(1) Self-registration: User registrars his/her own capability, interests and social networks into the matchmaker.

(2) Automatically registration: SNBM automatically gathers learners by watching e-mail exchange. If a user answers other learner's question, the keywords of the question are registered into SNBM as capabilities of the user.

SNBM finds suitable peer helpers with personal information.

3.2 *Taxonomy of learners*

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. We represent the history with the following attributes:

1) Who: Who did the user send the request to, or receive it from?
2) When: When did the user do it?
3) What: What did the user send or receive the request about?
4) Which: Which action did the user do?
5) How: How strong was the relationship between the user and the requester?
6) Path: Which path was the message sent through?

Based on the user's history log of e-mail exchange, the attribute "which" 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.

With the above history, users can be classified into the five types:

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 stating 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.

3.3 *Matchmaking*

The matchmaking agent finds collaborators and semi-collaborators who have the capabilities about requested keywords. If one of the candidate accepted similar requests to the request, the facilitator takes the candidate high priority. Moreover, the agent seeks for the social networks between the requestor and all the candidates. If a candidate has relationship to the requestor, e.g., a friend of the requestor's friends, the facilitator takes the candidate high precedence. Finally, the agent recommends the ordered candidates to the requestor.

4. Implementation

4.1 System Configuration

We developed a prototype system on a workstation with Tcl/Tk.

(1) PeCo-Collector

This system has two components: data management and E-mail handler. All the data is managed by TRIAS and the e-mail tool is TkMH based on MH (Mail Handler). 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.

(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[8]. Keywords are extracted with Chasen[9] 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.

(3) Matchmaker

SNBM was developed with KQML (Knowledge Query and Manipulation Language) that is a language and a protocol for exchanging information and knowledge[7]. The message

routing method of agents is based on brokering routing that consists of advertise, ask, tell and broker performative. For example, user registers his/her capabilities and interests into the database of the matchmaker using advertise performative. Likewise, PeCo-Agent sends the capabilities of its user with an advertise message.

4.2. Interface

(1) PeCo-Collector

Figure 1 shows a screen of PeCo-Collector of user "aiso". The user manages e-mail in the window (A), e.g., moving a message into folders. The window (B) shows the class hierarchy of the database. The user can search for the data of a person, relationship or e-mail from this window. For example, personal data of user "Gouji" is shown in the window (C). The user can easily update these data and add attributes. The window (D) is a list of e-mails of a folder. When the user sends the e-mail in the window (E), PeCo-Collector stores PeCo data. Only the connections that the user has permitted are registered into SNBM.

(2) Exploration of social network

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.

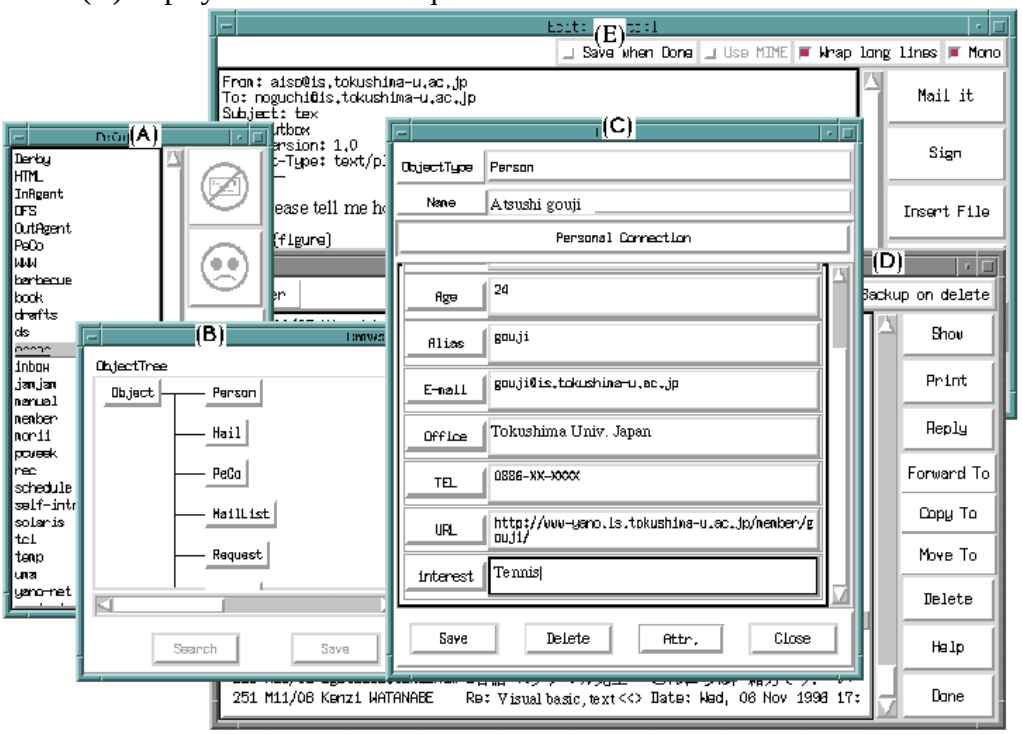

Figure 1: Screen shot of PeCo-Collector.

The window (E) shows the flow of the exploration from the user "aiso" graphically. This tree is the result of traveling with PeCo-Mediator-II and SNBM. 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.

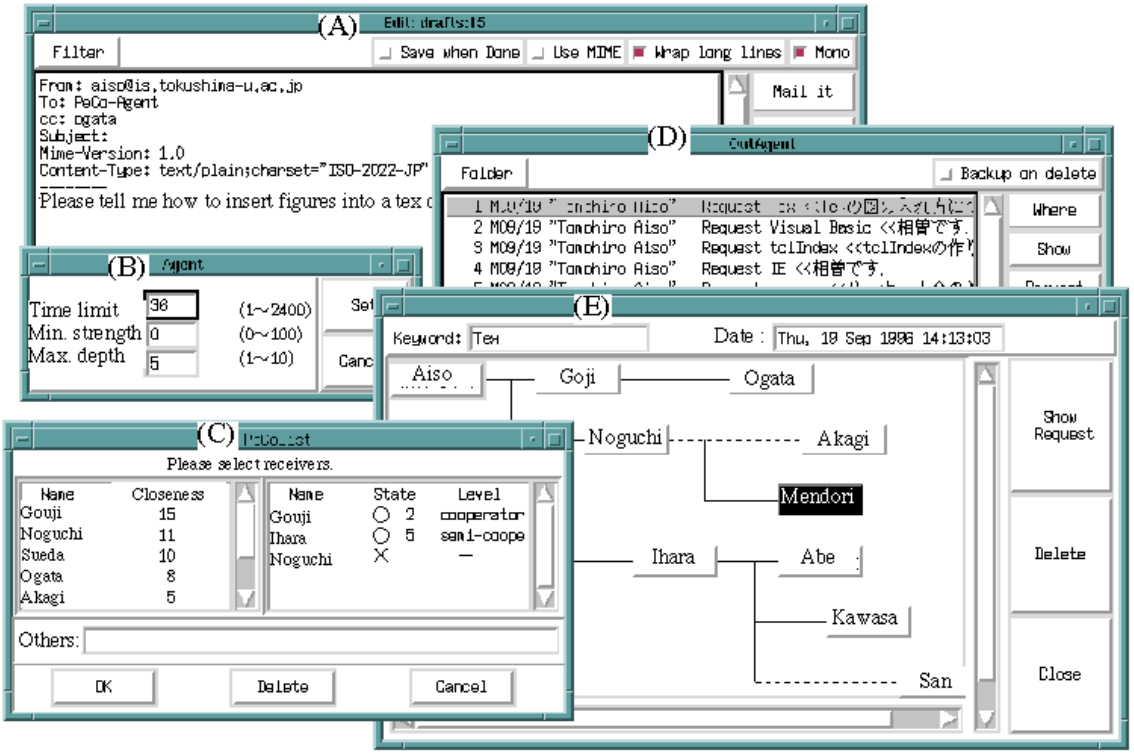

Figure 2: Screen shot of PeCo exploration with PeCo-Mediator-II.

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

We experimentally tested and evaluated PeCo-Mediator-II in small heterogeneous communities.

5.1. Users and Tasks

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 and capabilities. Each group member communicated among the internal group members without the contact of the other group.

Term 2: In the second three weeks, 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 SNBM.

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; for example, 16, 32 and 73. In this way, some user could encounter a collaborator and developed the new relationship with the collaborator. However, 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. Teacher VI received 50 messages from learners in group B and he the work. In the next term, a matchmaker agent took the burden of his work instead of the teacher.

In the previous experiment [14], 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, [21] describes the interaction patterns of e-mail and bulletin board are stable from the long-term usage observation.

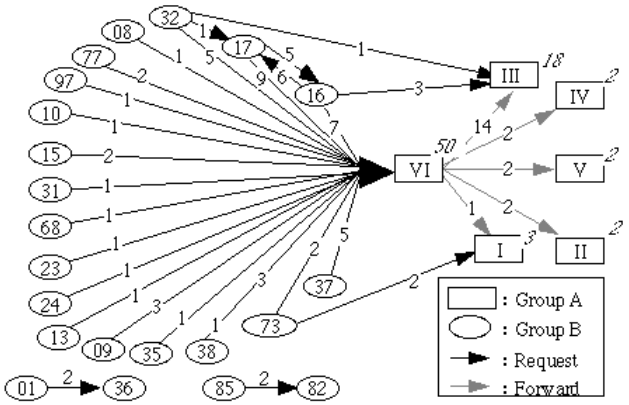

Figure 3. Network forming without SNBM in the term 1.

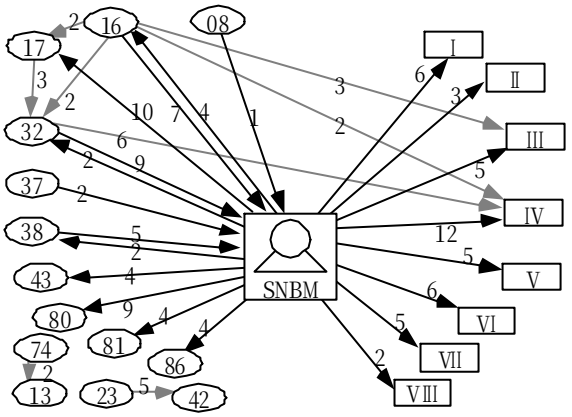

Figure 4. Network forming with SNBM in the term 2.

In term 2, all of the learners sent questions to SNBM and SNBM recommended appropriate collaborators who can assist problem-solving. Figure 4 depicts the message flow in the term 2. SNBM received 49 questions from group B, and it recommended at least three collaborators for each question. 91.67% of the requestors received answer from the recommended collaborators. Inversely, only 8.33% of the receivers rejected the requests. These results show that SNBM could introduce suitable collaborators. Moreover, Teacher received 50 requests from users in term 1, but he received only six requests in term 2. In this way, SNBM could reduce the overload of teacher VI as a mediator.

6. 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. Moreover, we also proposed a SNBM (social-networks based matchmaker) for PeCo-Mediator-II and SNBM were experimentally used and evaluated in a C programming language course. The results showed PeCo-Mediator-II could help the user to encounter a collaborator and developed the new relationship with the collaborator and SNBM played an important role of a mediator between heterogeneous groups in stead of a teacher.

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