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Combining Social Networks and Collaborative Learning in Distributed Organizations

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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.

Keywords: Collaborative learning, personal connections, on-line social networks, collaborative help networks, mediation, and software agents.

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 on 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.

W propose PeCo-Mediator-II (Ogata et al., 1996a; Ogata et al., 1997) 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 paper first describes overview of PeCo-Mediator-II. Section 3 proposes how this system can support exploration of social networks. Based on this model, implementation of PeCo-Mediator-II is summarized in section 4. Moreover, we describe the experimental results of our system in section 5 and we present the related works about our approach in section 6. Finally, the concluding remarks are given in section 7.

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.

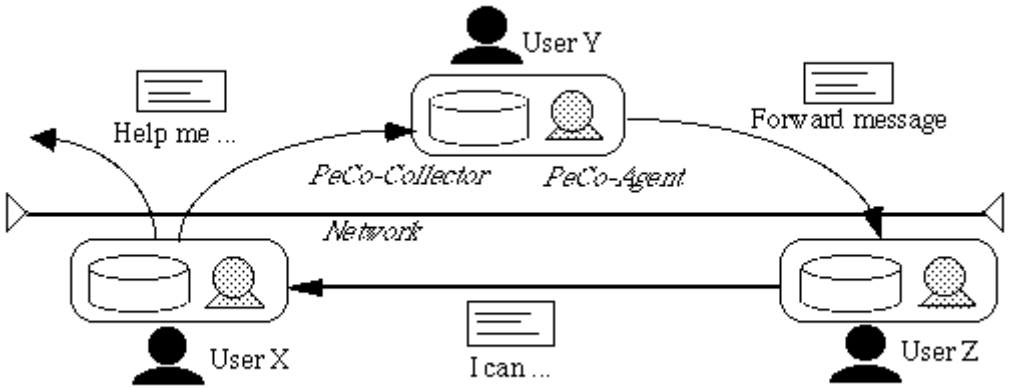

Figure 1. Overview of PeCo-Mediator-II.

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.

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 (Ogata et al., 1996a). 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 (Ogata et al., 1996a).
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 collaborators' 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.

3. Exploration Model of Social Networks

This section proposes a data diagram of PeCo exploration and the way to support the exploration based on it.

3.1. PeCo Exploration Diagram

Figure 2 shows the data diagram of exploring social networks. User A is a sender of e-mail and user B is its receiver. Each node denotes the state during the exploration, and it moves to the next state if the user acts on the activity of the arc. The starting point is the state one and the ending point is the state four, five and six. The state 2' shows the exploration is continued from the state 2 after changing the receiver.

The sender has three options: request, cancel and remind. The receiver has five options: read, not-read, accept, forward, and reject. For example, if user A sends a request to user B, the receiver either reads it or does not read it. If user B does not read it, user A may

remind user B to read it. If user B reads it, s/he either accepts the request, rejects it, or forwards it to his/her friends. Until someone accepts the request or user A cancels it, the exploration of social networks is continued. Finally, user A acknowledges to user B.

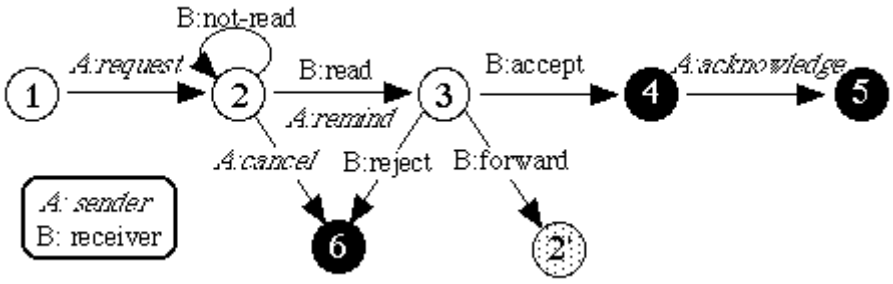

Figure 2. Data diagram of exploring social networks with e-mail.

3.2. History of PeCo Exploration

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 PeCo exploration diagrams, 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.

Table 1. Taxonomy of users with the exploration history.

User type	Condition
Collaborator	*accept*> α and *accept*> *reject* and *accept*> *forward* and *accept*> *request*
Mediator	*forward*> α and *forward*> *reject* and *forward*> *accept*
Requestor	*request*> α and *request*> *accept* and *request*> *forward*
Non-collaborator	*reject*> α and *reject*> *accept* and *reject*> *forward*
Semi-collaborator	*receive_accept*> α and *receive_accept*> *accept*

(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 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.

3.4. Supporting PeCo Exploration with History

PeCo-Agent helps a user in the following situation:

1) Request support: When the user decides a receiver of the request, this system shows the user the following information about the receiver:
   a) User's type (a collaborator, semi-collaborator, mediator, requetor, non-collaborator, or unknown user): If the receiver is a collaborator, the user may find the answer easily.
   b) Strength of relationship: If the connection between the user and the receiver is strong, it is easy to ask for cooperation.
   c) The number of requests left unattended: If the receiver has many requests, his/her answer may be late.
   d) System usage: If the receiver uses this system at that time, the user can obtain the response as soon as possible.
2) Acceptance support: If the user accepts a request, the system provides the reply of the request to the user. The user edits the past results to answer it.
3) Forward support: PeCo-Agent shows the user the possible acquaintances that can help the user with the results of the past exploration. If the user has a friend who is

a collaborator, semi-collaborator or mediator, PeCo-Agent recommends them as the receiver.

4) Reject support: PeCo-Agent automatically rejects the request, if the relationship strength between the user and the request sender is lower than the given value by the user.

3.5. Reducing the overload of collaborators

Collaborators are often burdened with the requests from others. To mitigate that, we propose the following support in this system.

1) Educating semi-collaborators: If semi-collaborators are educated and reach a level of collaborators, the number of collaborators increases. Therefore, PeCo-Agent recommends a collaborator to send the request to semi-collaborators and reduces the overload of collaborators. The collaborator sends the answer to the requester after checking and correcting the answer from the semi-collaborators. Next time, PeCo-Agent recommends that the requester sends the request directly to the semi-collaborator. After that, the semi-collaborator becomes a new collaborator and the requester becomes a new semi-collaborator. Moreover, the free rider issue (Salomon, 1992), which is a user who obtains information without giving any, might be settled also.
2) Sharing answers with a database: 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.
3) Spreading answers: 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

This section describes the development of PeCo-Mediator-II.

4.1 System Configuration

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

(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.

PeCo-Agent consists of the following components:

1) Monitoring e-mail: PeCo-Agent watches the e-mail exchange of users and it distinguishes between normal e-mail and PeCo e-mail. If an e-mail is normal, it gathers the user's ties into PeCo-Collector. Otherwise, PeCo-Agent interprets tag fields of the messages and sends the results to the message management module.
2) Managing messages: This module stores PeCo e-mail into a message files database and it manages system's messages based on PeCo exploration diagram in Figure 2.
3) Monitoring user: PeCo-agent monitors user's actions in the exploration process and stores them into his/her PeCo exploration history database.
4) Network visualization: This component graphically shows the exploration process of social network at real time.
5) Supporting PeCo exploration: Using the local databases, PeCo-Agent helps the user to find suitable collaborators and connections.
6) Storing PeCo & measuring strength: This module stores the user's PeCo and the frequency of the e-mail exchange into his/her PeCo database.
7) Storing & seeking the shared knowledge repository: The result of the collaboration is provided into the repository. The user can seek for the needed knowledge in the repository.

4.2. Interface

(1) PeCo-Collector

Figure 3 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.

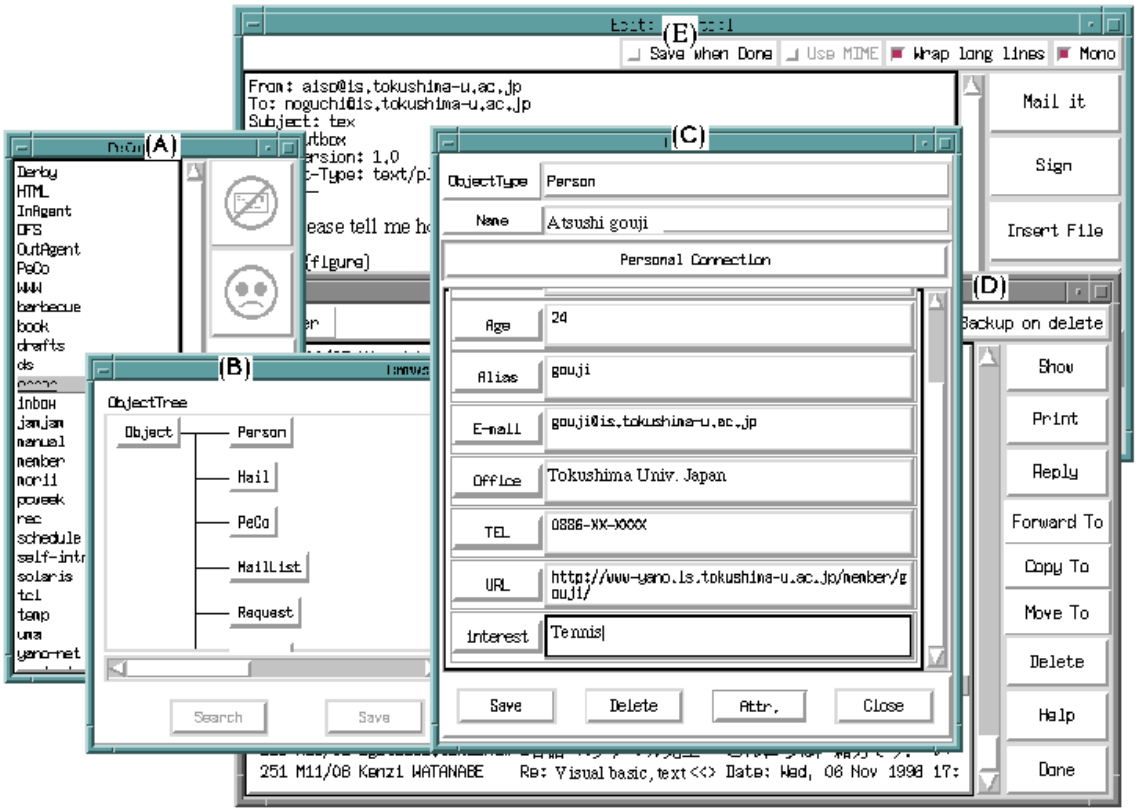

Figure 3: Screen shot of PeCo-Collector.

(2) Exploration of social network

Figure 4 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.

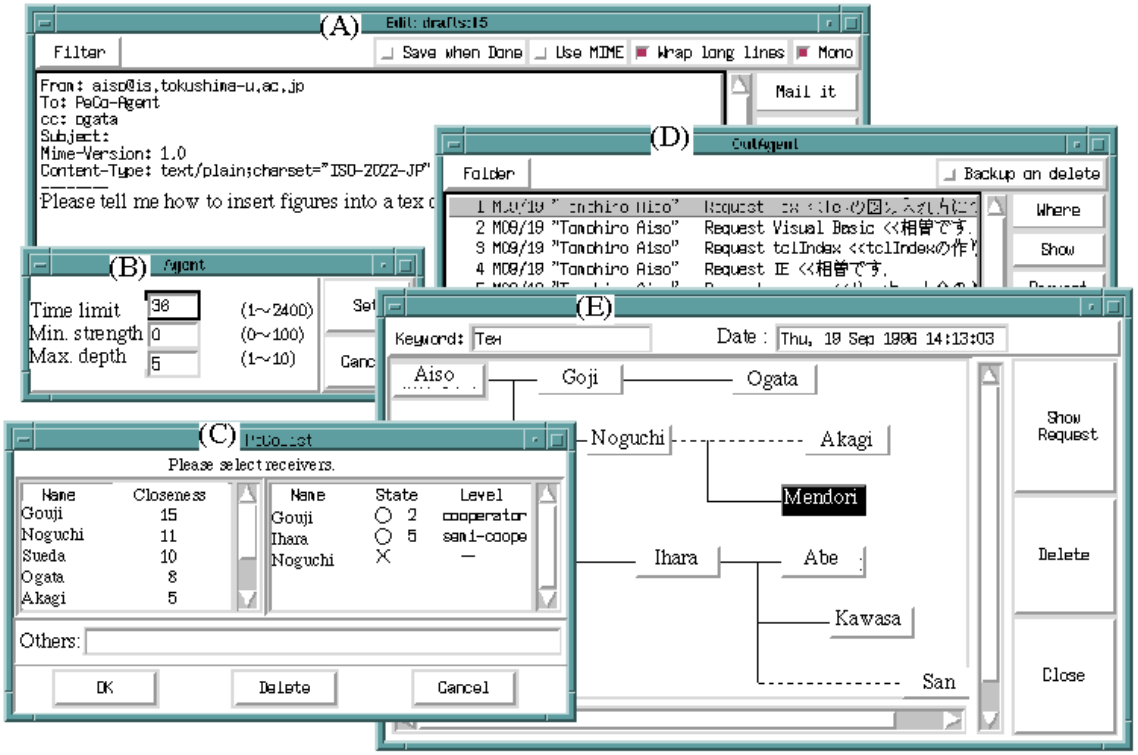

Figure 4: Screen shot of PeCo exploration with PeCo-Mediator-II.

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

We experimentally tested and evaluated PeCo-Mediator-II in small 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. 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 6 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.

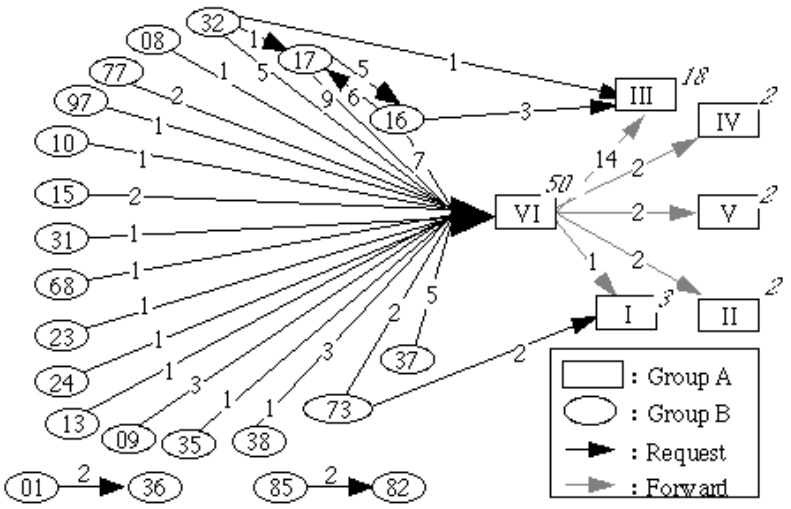

Figure 5. Network forming in the term 2.

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.

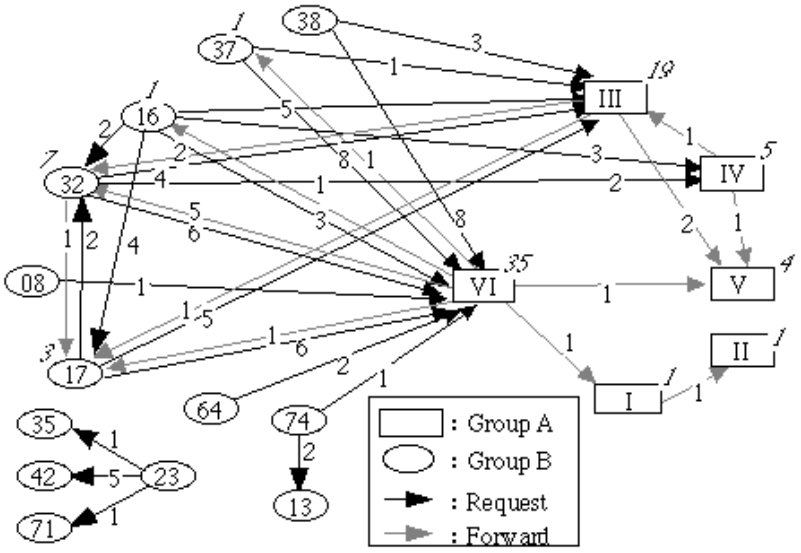

Figure 6. Network forming in the term 3.

Figure 6 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.

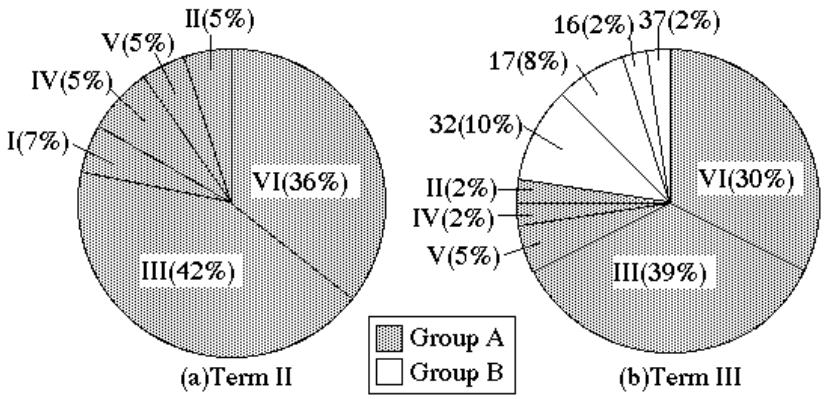

Figure 7. Rate of collaborators in the term 3.

Figure 7 shows the comparison of the collaborators in the term 2 and 3. In term 2, the user VI and II accounted for 78% of all collaborators, and there was no collaborator in group B. In term 3, the cooperation rate of the user VI and III decreased 69% and some of group B became collaborators. This experimental result seems to show that the facility of this system is available to prevent the collaborators from being fixed and to facilitate mutual cooperation.

In the term 3, the users provide their knowledge into the shared repository. Figure 8 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.

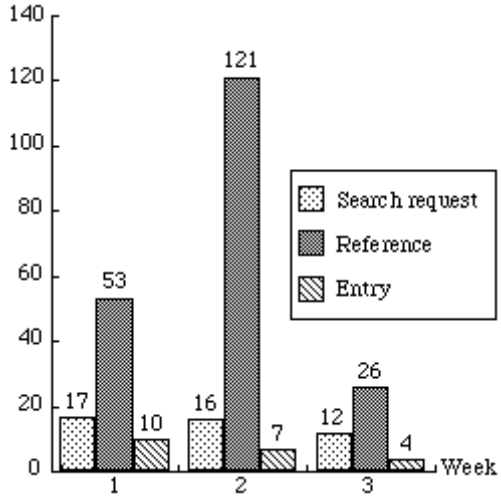

Figure 8: The usage of the shared knowledge repository in term 3.

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.

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., 1996) 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.

To increase communication opportunities, awareness is one of the most interesting topics. Awareness is an understanding of the activities of others, which provides a

context for personal activity (Dourish and Bellotti, 1992). For example, VideoWindow (Fish et al., 1990), and Portholes (Dourish and Bly, 1992) were developed to support informal communication. However, through only such awareness, it is hard to realize collaboration on the specific task with other users or accomplish tasks and common goals. Therefore, social aspects are very important to get other's cooperation and valuable information.

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.

Acknowledgment

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