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An In-House Communication Support System Based on an Information Propagation Model Utilizing Social Networks

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SUMMARY

Almost all companies are now utilizing computer networks to support speedier and more effective in-house information-sharing and communication. However, existing systems are designed to support communications only within the same department. Therefore, in our research, we propose an in-house communication support system which is based on the "Information Propagation Model" (IPM). The IPM is proposed to realize word-of-mouth communication in a social network, and to support information-sharing on the network. By applying the system in a real company, we found that information could be exchanged between different and unrelated departments, and such exchanges of information could help to build new relationships between the users who are apart on the social network.
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Key words: in-house communication; social network; information propagation model.

1. Introduction

With the recent spread of information devices, many enterprises maintain in-house communications via computer networks. According to Ref. 1, personal computers are used as means of communication by about 97% of enterprises in various industries. This includes e-mail, corporate Web, groupware, and so on. In addition, these communication tools have become indispensable to business activities for about 87% of companies, which is reported to contribute to faster and more efficient propagation of information. At the same time, however, about 58% of companies feel an insufficiency of communication between different divisions and departments [1]. Thus, we may assume that although the use of computer networks has resulted in faster and more efficient in-house communications, the currently used applications do not provide sufficient support for horizontal connections within corporate structures. We may also assume that maintaining daily communications not directly related to professional activities is important in the long run for general vitalization of in-house communications.

A number of tools have been proposed [2, 3] and implemented [4] as solutions to the above problem. These tools involve a sort of corporate SNS (Social Networking Service) to build up smooth in-house connections using existing social relations. Corporate SNSs are, basically, public SNS platforms such as *mixi* [5] tailored to corporate needs, and the use of blogs, communities, and other tools to support various exchanges between employees, not restricted to professional activities. As a result, we may expect better communication between company departments. However, such existing applications provide support to users with established social connections, or to users that share hobbies and interests. Therefore, such tools are hardly helpful in improving communications between loosely related departments or socially passive users, which is important to the vitalization of in-house communications.

In this context, we aim at improvement of in-house communications by the expansion of information exchange between socially active users to include other users, thus providing socially passive users with communication op-

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portunities. Thus, in this paper, we propose an *interpersonal communication support system* for in-house communications using the *information propagation model* that we proposed previously as a communication model to propagate information via social networks, while reflecting real-world social connections. In addition, we report verification experiments performed to evaluate the effectiveness of the proposed system for the promotion of interdepartmental communications, information exchange, and new social connections.

2. In-House Communication Support System Based on Information Propagation Model

2.1 Interpersonal communication support system

A system to support sustained vitalization of in-house communications must deal not only with users who have established connections but also with users belonging to different departments or socially passive users not involved in daily communications. The system proposed in this study supports users of the latter group by providing an *interpersonal communication support system*, which is a corporate-oriented extension of the *information propagation model* [7] developed for propagation and sharing of information via social networks.

2.1.1 Information propagation model

This model underlying the proposed interpersonal communication support system is a human communication model of the word-of-mouth type meeting the following conditions.

(1) A network based on strong social relations

All users voluntarily contact only known partners, thus developing a highly reliable social network. This network is assumed to comprise real-world social relations.

(2) Free and reliable propagation and sharing of information

All users can send any messages at their own discretion, and messages are forwarded only to known partners. Eventually, a message reaches users not involved in direct communications.

(3) Traceability of information propagation patterns

The sender and forwarder (retransmitter) can be identified for any message, and hence the recipient ascertains the route by which a message has arrived.

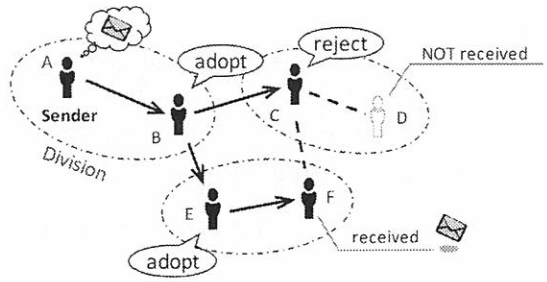

Fig. 1. Information propagation model.

For example, as shown in Fig. 1, information sent by a user propagates only to directly connected users (neighboring users). If the recipient finds the information interesting, it is then propagated to other neighboring users. Otherwise, the information does not propagate any further.

2.1.2 Application to in-house communications

In order to apply the information propagation model to in-house communications, we developed an interpersonal communication support system by modifying the model as follows.

- Directory service

The information propagation model assumes that a user specifies known users as neighbors; however, in in-house communications, efficient user search is required. Thus, we provide a directory service (DS) that lists all registered employees.

- Selection of destinations

The information propagation model assumes that messages are forwarded to all neighboring users; however, in in-house communications, information should be protected from viewing by outsiders. Thus, we provide for selection of retransmission destinations using DS.

- Traceability

We use DS to retrieve the particulars of senders and forwarders in order to trace users involved in the propagation of information.

- Monitoring by administrators

Administrators need to understand the current situation for improvement of in-house communications, and hence we use DS to analyze the distribution of information in the current network environment in terms of company departments, user age, etc.

2.1.3 Features and effects of support system

In the proposed system, information is first shared by known users. Therefore, we may expect better mutual understanding between socially connected users, just as in conventional communication support systems. However, according to the information propagation model, part of the information propagates to other users via neighboring users. In the case of in-house communications, this means that it is shared by users with loose social and professional connections. Thus, the proposed system offers socialization opportunities not only for active users but also for passive or new users. We may expect that in this way, new social links will be established and developed regardless of users' awareness.

On the other hand, users reproduce their real-world interpersonal relations in a virtual space, and managers or HR executives can trace the development of real-world connections and information propagation routes. Usually, it is very difficult to simultaneously gain a knowledge of users' social connections and daily communication flow (not necessarily related to work). However, in the proposed system, the strength of interdepartmental connections can be evaluated from users' activities, which may give valuable hints about organizational improvement.

2.2 Related research

Communication support using computer networks is considered to activate real-world communications [8, 9]. However, conventional tools such as e-mail, the Web, and groupware have proved insufficient in everyday life, which has created a demand for SNS (Social Networking Service) platforms such as *Orkut* [6] and *mixi* [5]. These services assure reliability of communications by utilizing social connections.

In corporations, too, the maintenance of everyday communications, not necessarily related to work, is important in the long run, and corporate SNSs are considered helpful in supporting such communications [4]. The existing SNS platforms, however, require that users take a proactive approach to maintaining diverse communications. As a result, it is difficult to support sustained communications between socially passive users, even though they are registered with the service.

On the other hand, social network analysis is helpful in obtaining clues to the improvement of in-house human relations. In particular, social networks reflecting real-world social connections can be extracted from mail exchange or by polling [11], and in-house experts can be found [12]. In addition, relationships between employees and departments can be derived by social network analysis using graph theory [13]. In any event, the improvement of in-house communications requires an insight into the present situation and the proposal of improvement strategies. This places an additional burden on employees, a fact which demands strong motivation on the part of both the corporation and the individual employees. However, the situation of "busy with work, few chances for communication" applies to nearly every other enterprise, and the improvement of in-house communications that we are considering looks difficult in many cases.

3. Verification Experiments to Evaluate Effectiveness of Support System

3.1 Experimental environment

We carried out verification experiments to examine the effectiveness of the interpersonal communication support system proposed in this study in terms of improvement of in-house communications. In the experiments, the test system described below in Section 3.2 was operated for about 2 months in a company specializing in IT solutions. During the experiments, the company had eight functional departments and a total workforce of about 400 employees. In addition, the company had three remote branches. We recruited 83 users under the theme of *Vitalization of In-House Communication*, aiming at promotion of exchange of opinions among employees, and detection of hidden problems.

When the experiments started, we conducted an attitude survey among employees regarding the current situation with in-house communications. Many respondents complained about insufficient interdepartmental communications, which agrees with Ref. 1. Therefore, in this case, interdepartmental social connections and everyday communications were weak, as stated in Section 2.1, thus offering an appropriate environment to evaluate support for socially passive users.

3.2 Experimental support system

In order to implement interpersonal communications support based on the information propagation model, human connections and information flow must be comprehensible not only to users but also to administrators. This is difficult to achieve by means of conventional blogs and message boards, and we therefore developed a client/server Web application system for use in this study.

3.2.1 System configuration

All system functions were implemented as a Web application server using Java servlets and databases. The server performs management of neighboring users, which is the keystone in developing social networks, as well as logging of message senders and forwarders. In addition, when a user logs in, the server notifies him/her about new messages and other updates.

However, since the server itself cannot assure prompt notification, a notification client application (optional) was provided for enabling the users to obtain the immediate notification. The notification content was restricted to the number of unread messages, and access to the server was necessary to view the messages. Thus, all users' actions could be recorded on the server.

3.2.2 Implementation of interpersonal communications

The interpersonal communication support system described in Section 2.1 was implemented as follows. The functions of administrative monitoring mentioned in Section 2.1.2 were not implemented in the experiments because they are intended for the next phase of system development.

First, every user must specify neighboring users for communications via the proposed support system. In the proposed system, information is propagated by sending and forwarding information among the neighboring users; therefore, users should be connected on the basis of mutual recognition. Hence, the DS mentioned in Section 2.1.2 was utilized to seek communication partners, to send them registration requests, and to register them as neighboring users if they agreed. However, the number of registered neighboring users was restricted to 10 to prevent indiscriminate registration.

When information is sent to a user, its title, content, and destination are sent automatically to selected neighboring users (1 in Fig. 2); the recipients are notified via the special notification client (2 in Fig. 2). Thus, a user can view a message as well as its routing data (sender, forwarder, etc.) as shown in Fig. 3. In addition, a message can be forwarded to other neighboring users by selection of destinations on the same screen (3 in Fig. 2). The selected users are then notified automatically (4 in Fig. 2). The same message may arrive several times via different routes, but only the earliest-arriving message is displayed to the user. However, the user can confirm how many times the same message has arrived in order to assess its importance.

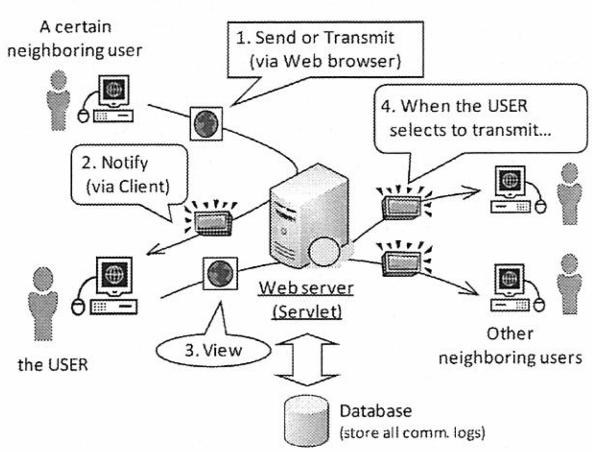

Fig. 2. Implementation of information propagation model.

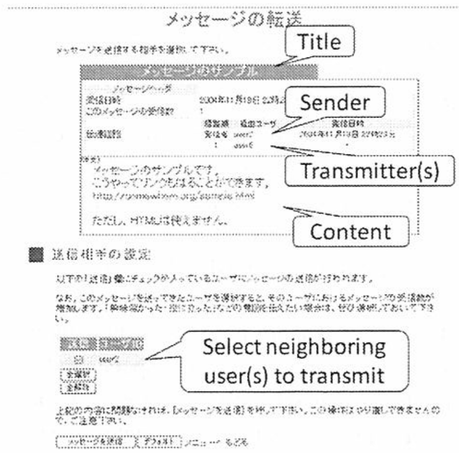

Fig. 3. Screenshot of received message.

3.3 Experimental procedure

3.3.1 Configuring a social network between employees

Aiming at configuration of a social network required for interpersonal communications, we suggested at the beginning of the experiments that every user register his or her colleagues with common interests (not only professional) as neighboring users utilizing the mechanism described in Section 3.2.2. By the end of the experimental period, the network shown in Fig. 4 had been built. The average number of neighboring users was 3.91, with a relatively uniform network density of about 0.05 involving

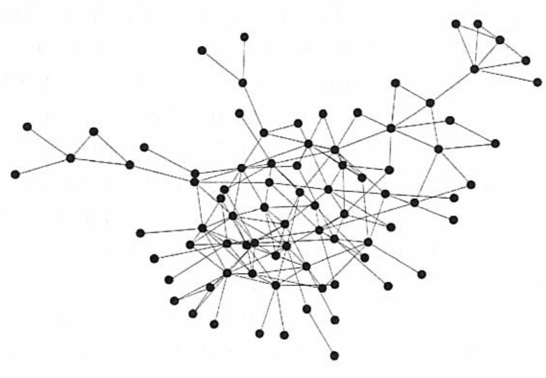

Fig. 4. Social network constructed in experiments.

all users. In the graph, nodes represent users, and edges (paths) denote connections between neighboring users.

It took about a month to establish links that were assumed to reflect real-world social connections, and after that few neighboring users were added. Therefore, the final network configuration in our experiments seems quite representative for evaluation. In addition, as stated in Section 3.2.2, the number of registered neighboring users was limited to 10, but only 2 of 83 participants reached this limit. Therefore, the restriction seems reasonable, and is unlikely to have had any significant effect on the experimental results.

3.3.2 Message exchange

No particular restrictions were imposed on the information propagated among neighboring users in the framework of interpersonal communications; as a result, 94 issues were discussed, mainly related to corporate projects, current affairs, or comments posted at general news sites.

4. Evaluation of Effectiveness and Discussion

4.1 Evaluation

The following criteria were used to evaluate the effect of the interpersonal communication support system on the vitalization of in-house communication.

4.1.1 Support for users with weak social connections

As explained in Section 2.1.3, exchange between users with loose social connections (e.g., those belonging to different divisions and departments) is expected to improve the interpersonal environment, thus contributing to better in-house communication. Hence, we examine the propagation of information between weakly connected departments to evaluate support for efficient information exchange in the framework of interpersonal communications.

Here "loosely connected departments" means that the respective users are not directly connected as neighboring users (below referred to as *direct connections*), but are connected only via other users (*indirect connections*). That is, we consider connection strength in terms of the social network configured by the users themselves, rather than in terms of professional duties or interdepartmental links.

4.1.2 Effect on social relations

In order to confirm the effect of interpersonal communications on the development of new social connections, we used a questionnaire and quantitative evaluation survey to evaluate how activities in the framework of interpersonal communications influenced the registration of neighboring users that expresses social connections within the proposed support system.

4.2 Propagation of information among users with low connectivity

In order to determine direct connections between the eight departments, we found the block density (used in block modeling for social network analysis [14]). The block density is expressed by the actual connections among users belonging to different departments with respect to the ideal case of totally connected users: the higher the density, the stronger the direct connections between departments. In addition, in order to evaluate indirect connections, we found the average number of users existing on the shortest path from a user belonging to one department to a user from some other department (the "geodesic distance" [13]). The shorter the distance, the denser the indirect connections between departments. However, the geodesic distance expressing indirect connections is not necessarily symmetric when the departments differ in the number of employees.

For simplicity of comparison, we calculated the Z-score for every department normalized to a mean value of 0 and a standard deviation of 1, as shown in Fig. 5. The horizontal axis represents the block density: a higher value indicates denser direct connections. The vertical axis represents the sign-inverted Z-score of the average geodesic distance: a higher value indicates denser indirect connections. Division pairs for which both have negative values (that is, in which direct and indirect connections are below average) were considered as loosely connected; those in

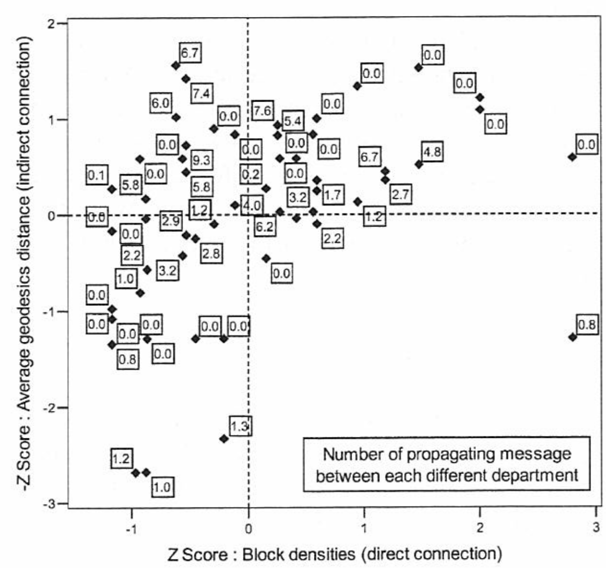

Fig. 5. Distribution of connections and propagated messages among departments.

which both values were positive were considered as tightly connected.

We examined the extent to which messages originating between tightly connected departments propagate to loosely connected departments. Thus, we found that during the experiments, the average number of received messages was 2.17 per user in tightly connected departments and 0.93 in departments with loose connectivity. However, among 19 loosely connected pairs, information propagation occurred in 10 pairs. This demonstrates the effectiveness of the proposed system in promoting exchange even between weakly coupled departments.

4.3 Effect on registration of neighboring users

When a user received a message via a neighboring user, then established connection with the message sender, we considered that the neighboring user registration was influenced by interpersonal communications; thus, we extracted the combinations of such connected users. Since neighboring users can be interpreted as a part of a real-world social relationship, one can evaluate the contribution of the interpersonal communication support system to the development of social relations. Among 163 user combinations in the social network, 6 combinations could be attributed to the effect of interpersonal communications. All of these 6 combinations pertained to departments showing direct connections below the average level and indirect connections above the average level (the second quadrant in Fig. 5). Therefore, the proposed system promoted social relations between departments where everyday contacts were scarce, and social connections were not likely to take place.

In addition, 10 of 45 respondents to our questionnaire answered in the affirmative to the question "When receiving some information, have you ever registered not only the sender but also the forwarder as a neighboring user?"

Hence, we may infer that information propagation in the proposed assist system provides users with opportunities to become acquainted with other people beyond the usual circle of contacts.

4.4 Discussion

The above results indicate that the interpersonal communication support system promoted information propagation between weakly related departments. In such cases, real-world interdepartmental connections are loose, if they exist at all. Therefore, the establishment of new communications is very difficult, and existing communications can hardly be maintained by means of conventional support tools. However, the proposed system based on the information propagation model offered efficient support for exchange between users with weak social connections.

In addition, the proposed system contributed to building social relations, even if few in number, between users belonging to departments with weak direct connections. Since such departments included persons who were physically separated, we may expect that the proposed system would facilitate social relations between users who are not likely to socialize in the real world because of physical constraints, thus improving in-house communications.

On the other hand, as is evident from Fig. 5, messages did not propagate at all between some department pairs, even strongly connected ones. This can be interpreted as "knowing each other well but not feeling the need for communications." It is usually difficult to evaluate connectivity and communication intensity between users, but the proposed system offers statistical metrics of human connections and information flow. Therefore, the metrics explained in Section 4.2 can be analyzed in terms of personnel position, affiliation, age, etc.; as a result, managers and HR executives can obtain valuable hints about organizational improvement.

5. Conclusions

We have proposed an interpersonal communication support system to facilitate in-house communications by information propagation via a social network. In addition, we applied the system to actual in-house communications, and evaluated its vitalization effect. We demonstrated that information exchange occurs between departments that usually have loose connections to each other. In addition, certain social connections were established between departments not directly related to each other. Thus, we may expect that the proposed system will contribute to the vitalization of in-house communications.

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