The Interaction Effects between Synchronous CMC Technology and Task Networks: A Perspective of Media Synchronicity Theory

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Abstract

A "task network" is a type of social network that consists of experts who exchange professional help and advice regarding executing tasks. In this study, we investigate the task network used within the IS department of a national bank in Korea. We identify how this network moderates the influence of computer-mediated communication (CMC) technology on an individual's task performance. Size, density, and centrality were measured as the characteristics of a personal task networks. Size equates to the total number of colleagues who work with a specific member for a certain project. Density is the ratio of the number of actual relationships to the total number of available relationships. Centrality defines whether an individual's position is in the exact center of whole network, and is measured by betweenness centrality, meaning the position one member holds between others in a network. Our findings conclude that the conditions - the larger the size of the task network, the smaller its density and the higher its level of centrality - lead to more benefits of using CMC media. Further, this positive effect of CMC is more noticeable when it provides synchronicity.

Keywords:

Media synchronicity theory; Social network; Task network; CMC; Synchronicity

Introduction: Synchronicity and Information Technology

An organization's members try to solve task problems with help and advice from others in their social network when they cannot figure out an issue on their own. This task network is derived from diverse social activities such as projects, educational alumni, and friendships. Information technology (IT), particularly computer-mediated communication (CMC), is an efficient instrument that facilitates task networks because it facilitates communication. Communication within a task network, however, does not have the same impact on each user's task performance because individuals have different roles and positions. Differences in status within the task network means differentiated access to and processing of information in the network. Previous studies have focused on task characteristics, facilitating conditions, and individual demographics in relation to an individual's adoption of IT. These have been examined from the standpoints of social cognitive theory, technology acceptance models, and innovation diffusion. A point missed by these studies is that an individual's performance, particularly in the context of project tasks such as those found in information systems (IS) development, are also subject to the value of the personal task network in conducting activities. Such a task network is a useful and nascent type of social network due in part to the prosperity of Internet-based communities.

The finding that individuals, teams, and organizations have demonstrated different ways to use the same kind of IS [8] adds momentum to this study's assumption that a user's status in his/her personal task network could moderate the impact of CMC technology. This study focuses in particular on the task network of an IS department, where IT experts share and exchange knowledge and experiences to conduct tasks or help colleagues. Information content and flow in a group and an organization are influenced by various relational aspects in a task network (such as power). For example, information flows from the strong and powerful position to the weak one [8]. Anyone in a group or organization may need to communicate in real time with the individual in a powerful position (e.g., highest position in a hierarchy). In this way, the individual in the powerful position in a task network benefits more from synchronous CMC technology than those in the less powerful positions.

IT generates more benefits with the support of polychronicity (i.e., simultaneous communication with many people) rather than with monochronicity (i.e., communication with one person) [34]. In line with this argument, this study further investigates who in a task network benefits more with the support of polychronicity enacted and promoted by IT. In other words, this study's research question is "Does an individual's status in a task network moderate the influence of CMC media on the individual's task performance?"

In accordance with our approach, Berger [9] proposes investigating the communication routes when examining the benefits of personal communication. This approach, which emphasizes the network context in analyzing the role of CMC media, is distinguished from traditional approaches such as structuration (or social interaction theories) and social cognitive theory.

MIS studies related to CMC can be categorized into two perspectives: 1) rational technology choice that focuses on the choice of media and 2) social interaction theories that focus on usage of CMC [53]. The first perspective, rational technology choice, proposes that communication technology is chosen when it fits well with tasks to be completed. This perspective is a kind of trait theory because it places priority on the media traits and is represented by media richness theory [19]. Social interaction theory, on the other hand, places more weight on interactivity with other users rather than on media traits when choosing and using communication media. This perspective, represented by the social influence model [28], proposes that the perception of communication media is subjectively forged and affected by close and/or significant others. These two seemingly contradictory theories each have relevant contexts. Rational technology choice focuses on the fit between task and IT and thus focuses on the characteristics of the communication media for the sake of task performance. Social interaction theory, meanwhile, focuses more on group dynamics regarding the use and choice of CMC media rather than influences on task performance.

In this typology of CMC theories, the present study is close to rational technology choice and shed lights on synchronicity. This subject has attracted little attention in IS studies. Synchronicity is important in communication behavior, however, because demand for synchronous and agile communication is subject to personal status on a social network that is being used for communication. Our subsequent curiosity thus becomes which characteristics of task networking are positively related to the value of synchronous CMC.

This study's theoretical foothold is in media synchronicity theory, which focuses on the capacity of communication media to embrace synchronicity during communication [22]. This theory starts with the fact that each media has a different capacity to support real-time communication. Capacity to support synchronous communication consists of five components: 1) immediacy of feedback; 2) symbol variety; 3) parallelism; 4) rehearsability; and 5) reprocessability. Similar to media richness theory, media synchronicity theory adopts the contingency approach and proposes that the synchronicity fit between task and CMC media generates desirable communication results. The present study seeks to address the critique of media synchronicity theory that it lacks empirical evidence and testing (e.g., [41]).

Our study consists of six parts. After the introduction, section two provides this study's theoretical foundations. With focus on media synchronicity theory, the second section compares synchronous technology (i.e., MSN Messenger) with asynchronous technology (i.e., an e-mail system). This section also discusses the important moderator variable; that is, the task network. Theories about the relationship between time and IT are also discussed. Section three introduces the research model and describes the hypotheses. Section four presents the research methodology, which is followed by analysis results in the section five. The last section discusses this investigation's findings and conclusions.

Methods Literature Review

Time and Information Systems

Time in MIS studies has been conceptualized from two opposite perspectives: physical time and social time [35]. The social dimension of time refers to the phenomena where time norms have emerged from social, cultural, and political considerations rather than the scientific basis of physical time [36]. For example, the meaning of an individual's history is susceptible to age in his/her life time and the seasons and traditional holidays are the products of cultural time [38].

MIS studies related to physical time can be further divided into the two types. First, the influence of physical time (as an independent or moderate variable) has been investigated on dependent variables such as individual and organizational behaviors. For example, Dennis, Aronson, Heninger, and Walker [21] empirically tested differences in decision quality when the same length of time allowed to make a decision included an intermission or was spent uninterrupted. Uninterrupted time facilitates collecting and coordinating diverse opinions, whereas an intermission amidst the same overall length helps generate diverse opinions. Second, MIS studies have considered time as the dependent variable of changes in organizational operations. Studies related to improvements in time durations due to Six Sigma and quality improvement efforts fall into this category.

MIS studies related to social time can also be subdivided into several realms. First, several studies have investigated how diverse social times that individuals, groups, and organizations maintain influence human behaviors. In these studies, social time is an independent variable. For example, there are functional differences between future-oriented IS and past-oriented IS [17]. Past-oriented IS measures current performance on the basis of past assumptions, whereas future-oriented IS supports efficiently manipulating past assumptions when users must make changes in these assumptions. Massey, Montoya-Weiss, and Hung [42]

empirically found that a virtual team's performance was influenced by the composition of certain behaviors during interactions using asynchronous IT. They found that high performing teams assigned more time to coordinating opinions among team members rather than delivering opinions or maintaining social interactions.

Second, in models where social time is a dependent variable, studies have investigated the influence of organizational and technology changes on individuals' and the organization's behaviors in terms of time dimension. For example, Barley [8] found that introducing an ICT scanner in a hospital unified the time perceptions of medical equipment technicians and radiologists into the monocronicity mode and helped overcome discrepancies in chronological perceptions and behaviors. Technicians were accustomed to being monochronical, whereas radiologists were accustomed to being polychronical in conducting their tasks. Failla and Bagnara [25] insist that IT changes perceptions about time during decision making and improves flexibility in decision making away from a strict process orientation. For example, in the mainframe environment, the organization runs under strict centralized schedules and policies, whereas the PC environment has liberated organizational members from such shackles due to its distributed processing capacity. In the future of virtual computing, users will be able to engage in decision-making about non-existent future phenomena and experience a differentiated computing environment, while only past experiences were previously handled. Lee [34] reported the case of a Korean export company that demonstrated the increase of polychronicity by introducing an IS named KTNET.

Among these diverse approaches to time, the present study investigates social time with special emphasis on the influence of CMC on individual performance when users have different demands for synchronicity in communication, which, in turn, is influenced by his/her status on the task network.

In carrying out this study's investigation, the authors needed to make some issues clear. First, monochronicity and polychronicity need to be distinguished in event occurrence (execution). The former means that only one event occurs (or is executed) at a single point of time, and the latter denotes that multiple events can occur (or are executed) at once. Polychronicity, however, is not identical to random temporality, where event occurrence cannot be estimated or forecasted. Random temporality means that events occur at random without timely regularity or constraints. This concept is distinct from polychronicity, where multiple events can occur simultaneously. For example, the new ICT scanner in the hospital noted above requires close collaboration and communication among equipment technicians and radiologists [7]. Random temporality, however, does not embrace the concept of collaboration because it is not a bilateral event. It merely describes the irregular occurrences of events within a time horizon. Synchronicity means two partners simultaneously start communicating, continue the session with similar concentration, and finish communicating at the same time. This cycle of bilateral interaction can repeat for subsequent events in many different occasions.

Second, timely coordination embraces the concept of synchronicity. Barley [8] interpreted that the conflict between the equipment technician and radiologist resulted from their different perceptions and expectations of time in task execution. Radiologists preferred to conduct tasks at their discretion, a phenomenon Barley [8] interpreted as polychnonicity. Meanwhile, technicians waited for orders from radiologists to start to work, an attitude interpreted as synchronicity. This particular conflict in task execution was not actually between polychronicity and monochronicity. Instead, it was the conflict between random temporality and monochronicity. Timely coordination, therefore, presupposes the intent to collaborate not simply ad hoc or random activity conducted at one's discretion or convenience. Timely coordination, meanwhile, can take the mode of monochronicity or polyschronicity between two communication partners. In some cases, one side of the communication could be monochronous, whereas the partner is polychronous.

Comparing E-Mail and MSN Messenger from the Perspective of Media Synchronicity Theory

Media Synchronicity Theory (MST) explains synchronicity through the following five characteristics of media capability [22], which should be matched between task and media:

1. Immediacy of feedback. This is the core feature of media synchronicity. With this feature, media can allow one counterpart to respond immediately to another counterpart's message.
2. Symbol variety. Symbol variety provides extra information other than plain text during communication. It supports acquiring contextual information and linguistic semantics.
3. Parallelism. This feature allows simultaneous communication such that users can send and/or receive messages with multiple counterparts.
4. Rehearsability: This capability allows individuals to rehearse or edit messages before sending. This feature is impossible with face-to-face communication, but a major attraction of an e-mail system.
5. Reprocessability: This feature supports recording and retrieving past data and information. This, too, is not available with face-to-face communication, but is major attraction of an e-mail system.

MST takes the contingency approach by arguing that these five sychronicity characteristics should be matched between the task and the IT used for the sake of task performance. This theory, however, lacks empirical support and evidence of positive performance [41].

The present study is a rare empirical study of media synchronicity theory as we compare the influences of two opposing CMC media in terms of synchronicity; that is, MSN Messenger (synchronous CMC) and an e-mail system

(asynchronous CMC). These two technologies are chosen for this investigation because they are very popular in organizations [33]. For example, MSN Messenger is used in about 85% of organizations around the world [54]. Further, 46% of youngsters age 18 to 27 prefer to communicate through Messenger than e-mail [40]. Both MSN Messenger and e-mail are popular not only for social communication, but also for task-oriented communication [40]. The common features of these two CMC media include text-based communication and features inherent to both monochronous and polychronous communications. The polychronicity characteristics of these two CMC include: 1) users can continue other tasks during communication and 2) users can communicate with multiple partners at the same time [54].

Messenger is a synchronous CMC, whereas e-mail is asynchronous [40, 41]. Messenger supports rich functions (e.g., real-time chatting, video talk, counterpart's on-line availability, emoticons, etc.) that run on proprietary technologies, while e-mail systems typically run on standard protocol [16]. Li, Chau, and Lou [40] summarize the features of Messenger in the following five aspects: 1) identification of counterpart's availability on-line; 2) delivery of messages by pop-up mode; 3) simultaneous communication with numerous people; 4) quiet interaction; and 5) unrecorded interaction histories.

Kreijins, et al. [33] empirically showed that both synchronous and asynchronous CMC media have the capacity to accommodate social interaction and thus engender social forums where participants feel social presence. Social presence [52] is the illusion that causes communication participants to "feel" the counterpart's physical presence in cyberspace and is a strong cause for active social interaction. Messenger has promoted both group awareness (which is related to social aspect of communication) and task awareness (which supports task execution) [33]. Group awareness is promoted by identifying the availability of communication counterparts. Task awareness is enhanced by transferring and exchanging control of the cursor on the computer. Both features have increased so-called tele-proximity [33]. Accordingly, such technical capabilities are more useful and appreciated for synchronous communication than for asynchronous communication [33].

Two of communication's major objectives are information delivery and opinion convergence. Many studies have reported that CMC is appropriate for information delivery, but is limited in opinion convergence compared to face-to-face meetings (see [23, 41, 46]). This contingency of CMC results from the fact that information delivery and opinion convergence are opposite in terms of immediate feedback and parallelism. Information delivery is low in immediate feedback, but high in parallelism; whereas opinion convergence is high in immediate feedback and low in parallelism [41]. It is tempting, therefore, to conclude that e-mail is appropriate for information delivery, whereas Messenger is good for opinion convergence. E-mail also features the ability to store records, simultaneously deliver the message, and easy-to-use functions (e.g., forwarding and file attachments) that are useful for delivering information. Messenger, on the other hand, is appropriate for developing informal relationships because it supports feedback in the form of exchanging trivial messages [53].

These systems also elicit different responses in users. For example, a message sender likely prefers immediate feedback, whereas the message receiver may value the ability to delay his/her response. Therefore, e-mail is a receiver-centric media, whereas Messenger is sender-centric [50]. This conclusion is too simplistic, however, because Messenger allows the receiver to declare his/her on-line availability as waiting, off-line, or absent, which dilutes the benefit of immediacy. The receiver can also refuse to receive messages through Messenger. These functions of Messenger allow the receiver to maintain control of the communication. We cannot, therefore, simply conclude on the basis of media traits that the sender and receiver maintain stable preferences for CMC media. This discussion indicates in part that media traits are the less important factor in understanding media choice and use than communication routes, such as social networking [9].

Two Perspectives on the Effects of Social Network

Two perspectives have existed in examining the benefits of social capital found in media such as mentoring networks (cf. [24, 57]): 1) the embeddedness perspective, also called the bonding view, and 2) the diversity perspective, also called the linking view [1].

The embeddedness perspective explains the benefits of social capital by focusing on communal networks with strong and multiplex personal ties (e.g., [29]). In the diversity perspective, the benefits of social capital result from diverse networks that link otherwise disconnected people, and thus provide more unique and timely access to information, greater bargaining power, and control over resources and outcomes (see [15]). As indices of network effectiveness, network density and strong ties epitomize the embeddedness perspective [29], while network size and structural holes are the major concerns of the diversity perspective [15].

In conducting social network studies, researchers have tended to adopt either an embeddedness or a diversity viewpoint, treating them as mutually exclusive (see [15, 29, 48]). The possibility that dense and strong ties can also be diverse in interpersonal networks is ruled out by the theory of cognitive balance [31]. This theory assumes that people with strong ties are naturally affiliated [10], and insists that those who develop strong ties rarely pursue network diversity and vice versa. The idea that individuals can benefit from simultaneously having strong and diverse ties, however, is reflected in more recent social network research (see [5, 6, 11, 27, 49]). For example, a hybrid interface that combines embedded and diverse ties achieves the benefits of both perspectives, such as reduced opportunism and access to multiple information networks [6].

Research Model and Hypotheses

The use of computer-mediated communication (CMC) tools does not always produce desired results. Only by providing adequate education, promotion, restriction, support, and guidance do organizations experience favorable outcomes [23]. Thus, user performance with the CMC that does not always produce consistent results may indicate a situation within the organization must be a significant factor rather than the use of CMC itself.

To achieve effective communication, a networked team needs high levels of both clustering and heterogeneity. When a team clusters high (or physical proximity is close), the rate of communication among team members is smooth and the likelihood of communication gaps is low. When team diversity or heterogeneity is high, a wider range of opinions is introduced and thereby the likelihood of more creative and diverse output increases. In this case, the team proximity is in adverse relationship to the structural hole, and team diversity is highly related to the size of the team (i.e., directly proportional to size).

Within an individual's task network, a phenomenon called the "Ringelmann effect" exists, which means the performance of the entire group will be lower than the aggregation of individual performance [18]. As both group size and physical distance between members increases and they fall outside of visible range, individuals tend to exhibit greater tendencies toward a "free rider" mentality [18]. Here, because the concept of distance covers both physical distance (that is, physically separate locations) and behavioral distance (that is, ease of personnel recognition), the concept is also related to the immediacy of interactivity. In other words, if the group size is too big or they cannot visibly see each other, individual efforts are not easily recognized and group members tend to go with the "mainstream flow," rely on the efforts of others, and hold back their very best effort.

Given that "collaboration" requires simultaneous interactivity, a larger structural hole (i.e., low team proximity/density) or team size (i.e., high team diversity) can result in more difficult simultaneous interactivity and lead to reduced collaboration. In such situations, the use of CMC is expected to bring about greater value to the system. Specifically, "structural hole" can be expressed in terms of "betweenness centrality" or "density." The greater the "betweeness centrality" and the lower the "density," the expected user satisfaction and output from using CMC for collaboration is greater. Taking the network attributes of size, density, and the "betweenness centrality," we can organize Hypothesis 1 into the following sub-hypotheses.

Hypothesis 1: *The attributes of the task network will lead to differences in the effect of CMC use on work performance.*

Hypothesis 1-1: *The use of CMC will have a greater positive effect on the performance of members in a larger task network than for members in a smaller network.*

Hypothesis 1-2: *The use of CMC will have a greater positive effect on the performance of members in a low-density task network than for members in a high-density network.*

Hypothesis 1-3: *The use of CMC will have a greater positive effect on the performance of members in a high "betweenness centrality" task network than for members in a low "betweenness centrality" network.*

Social Entrainment Theory (SET) is based upon the premise that objects or processes within a group possess high levels of mutual synchronicity and tend to stay aligned with associated external "pacers" [30]. The circadian rhythm in human beings is a good example of entrainment. The circadian rhythm is a biological phenomenon in which a "day" (approximately 24 hours) serves as the period around which biological entities operate in a state of constancy by factoring out external changes or cues. Humans' internal metabolic systems such as body temperature and blood pressure are highly responsive to external physical changes such as sunlight or darkness, while maintaining their changes in a rhythmic manner [45]. When external cues such as brightness suddenly change, the internal rhythms in place are maintained, but synchronization with the external environment is broken. Meanwhile, a new synchronization is gradually achieved with the factors of the new environment. Such dis-synchronization and re-synchronization of internal rhythms can help explain cognitive and physical obstacles inherent to difficulties such as "jet lag," "shift work" and "seasonal factors" [3, 39, 56].

McGrath and Kelly [43] began to apply these concepts to behavioral rhythms or interpersonal pacers to the genesis of social entrainment theory, which is used to describe underlying phenomena in organizations [30]. Aronson et al. [4] used social entrainment theory to study that time pressure has a measurable impact on generating ideas (quantity) and creativity (quality). Social entrainment refers to the processes of forming, structuring, maintaining, and declining temporal (time-related) patterns within social objects. Within various departments of an organization, different task cycles exist. When considered in total, individual departments tend to adhere to the rhythms of other departments, especially of a more influential department. Such a phenomenon describes the process of social entrainment [47] in an organizational setting.

McGrath and Kelly's [43] social entrainment model consists of three internal constructs: 1) rhythm, 2) meshing, and 3) tempo and one external construct: pacer. Rhythm refers to a repetitive or regular biological, psychological, or behavioral set of processes similar to sleep patterns. The popular terms "morning person" and "night owl" are examples. Meshing relates to the synchronization of various rhythms contained in activities such as work, social interaction, and entertainment. For example, if a person who typically awakes at six o'clock each morning will have his/her activities impacted by waking up either earlier or later than his/her regular time. Tempo refers to the pattern of meshing rhythms, such as the speed of a task, communication patterns, and psychological change patterns. For example, while some people awake at the same time each day according to habits formed by biological rhythms,

others find it necessary to depend on the alarm clock. The latter case indicates the behavior depends on external "pacers." External pacers can either initiate temporal patterns or help discover and modify them. Thus, individually or in total, external pacers refer to external incidents or circulating phenomena that affect the elements of rhythm, meshing, and tempo.

It can be questioned whether or not entrainment always results in a positive impact on teamwork. Generally, communication inefficiency is measured by two indicators: delay and interference. The problem is that these two cannot be reduced simultaneously [50]. In other words, while one may communicate through synchronous technology (e.g., instant messages) to reduce delays, frequent requests for conversation result in greater interference. On the other hand, asynchronous technology, such as e-mail, exhibits a delay effect due to the time difference between sending and receiving the message. From the recipient's perspective, however, the level of e-mail interference is comparatively small compared to messaging. Ultimately, SET argues that a major issue is how team members behave with a shared rhythm and thus raise the entire team's performance; that is, reducing delays for the team as a whole, while minimizing privacy interference at the individual level.

Elements that help raise a team's entrainment are "polychronicity" and "synchronicity." According to Turner et al. [54], both e-mail and instant messages commonly support polychronicity. From a synchronicity standpoint, differences between these two technologies exist. E-mail is asynchronous by nature, but instant messaging is synchronous. Turner et al. [54] contend that when individuals or the entire organization prefer polychronicity; do not resist communicating with simultaneous broadcast communication; and do not balk at transitions between tasks; they are also less sensitive to the negative interference effect of synchronous technologies. Furthermore, according to SET, continuously uninterrupted focus on the task is not necessary in order for tasks to get accomplished [43]. That is, depending on the characteristics of the organization, the intervention phenomenon that arises from synchronous technology does not always have a negative influence on organizational performance. More specifically, organizations that tend to favor "polychronicity" have been found to be not particularly sensitive to the potentially negative influences of synchronous technologies. It can be said, therefore, that as the need for polychronicity rises with greater network size, the positive effect of synchronicity can increase proportionally to network size. Further, in a group with a large network, using synchronous technology that provides immediate feedback can help to reduce the "free-rider" effect that arises due to the network's size.

The positive effects of high synchronicity can be understood in terms of SET and from the perspective of sociability. That is, because there is no guarantee that the use of instant messages is limited to close colleagues for personal messages as they become used more often for work [16, 40], the immediate delivery of messages not only increases work efficiency, but also increases social awareness and promotes other interactions as well [14].

Synchronicity is also related to media-richness. While it remains possible to improve relationships through dry media with less synchronicity, media coupled with synchronicity helps relationships develop more quickly. Inasmuch as CMC is related to the opposing intentions of "work" and "social relationships," using media with synchronicity will more likely raise user satisfaction in every aspect of organizational life.

Many studies have reported that focusing on IT to improve work performance to the exclusion of personal relationships leads to a negative end result. In other words, when the main focus is work-related communication, behaviors are formed through objectivized methods such as documents, procedures, roles, codes, standard terminologies, and departments. Once these are systemized using IT, relational aspects are weakened and can ultimately lead to unfavorable results [51]. For example, when an insurance company implemented an IT system that enabled customers to express questions or problems through formal documents, estrangement occurred between the company and its customers. The interests of both parties were confined to the formal document itself [51]. On the other hand, when IT is employed as a system to promote community-like collaboration, relational aspects are strengthened, and the results are more satisfactory [37]. Behaviors that tend to resolve problems through "official methods" rather than through "internalized methods" accompanied by more frequent and natural communication serve to lower the density of relationships. In such a case, using highly synchronous IT will alleviate the aforementioned deterioration.

Kreijins et al. [33] argued that social presence has a stronger influence in synchronous media than in asynchronous media. E-mail is a more advantageous information technology than instant messaging for communicating information because it stores records, broadcasts messages, and offers greater functionality such as mail forwarding and file attachments. Instant messaging, however, is more attuned to immediate feedback and casual conversation, which leads to deeper social relationships [53]. Therefore, the following hypothesis can be established:

Hypothesis 2: *The effect of CMC use on work performance in a task network will be higher for CMC with higher synchronicity than for CMC with lower synchronicity.*

Methods

Project-based Task Network

A project-based task network is defined as an affiliation network in which people are connected to one another based on the projects in which they participate as a team. That is, the affiliation network exists when a set of participants is affiliated with a set of events or activities.

The project examined in this study is such a task network. This study's participants attend to a variety of projects. A binary measurement indicates a participant's attendance to the specific project. The matrix, X, is a two-mode matrix in which rows index participants and columns index projects. 1 is entered in the (i, j) cell if participant i is affiliated with project j, and 0 if participant i is not affiliated with project j. Provided that the transpose of X is denoted as X', the matrix P is given by the matrix product of A and A' (P=XX'). The matrix P records co-membership among participants, indicating the number of projects jointly attended by each pair of participants. The participants are related (i.e., have a tie with) to one another through joint projects.

Network Size. A participant's network size is the total number of other participants with whom he or she has ties (i.e., participates in a project together).

Density. The density is computed by determining the ratio between the sum of all direct ties and the maximum possible number of ties. In an ego-centered network[1], density is defined as the ratio between the numbers of ties among participants with whom the focal person has a project relationship to the maximum possible numbers of ties among these participants. A high density level means that participants in the focal person's network are conducting many projects together.

For example, if focal person A has participated in three projects, and has four persons B, C, D, E who have participated in all three projects, A's network size would be four. The maximum number of possible ties among these five persons is ten. If persons B and C or persons D and E have had no joint project experiences through these three projects, there would be no actual ties between these two possible pairs. In this case, the density would be 8/10 = 0.8.

Centrality. Centrality indicates whether the focal person occupies the central position in the network. In this study, we measure betweenness centrality. This concept measures the extent to which a focal person lies between other persons in the network. The betweenness proportion of a person A for a particular pair of persons B and C is defined as the proportion of geodesics (i.e., the shortest route) connecting this pair, which passes through A. Thus, the betweenness measures the extent to which A plays a brokerage role between B and C. Freeman [26] estimates this property as follows:

$$C_B(p_i) = \frac{\sum_{i}^{N}\sum_{j}^{N}\frac{G_{ikj}}{G_{ij}}}{(N^2-3N+2)/2}$$

Gij is the number of geodesics linking two actors, *i* and *j*. *Gikj* is the number of geodesics linking two actors that contain actor, *k*. Actor n_i's betweenness index is simply the sum of these estimated probabilities over all pairs of actors, not including the *i*th actor. Because the index's values depend on G, Freeman standardizes it by the maximum number of pairs of actors, not including actor ni, which is (N2-3N+2)/2.

Yield ratio. The Korean bank where we collected the data for this study uses yield ratio as the index of individual task performance. The yield ratio is calculated for each project in the following formula: Yield ratio = (expected completion time – actual completion time)*100/expected completion time

The projects in this bank are associated with maintaining current systems or developing new application programs. Each programmer is assigned to projects that include detailed schedules according to the content and challenges of the project. The team manager of each project has full discretion to control how his/her project is implemented. This yield ratio is the critical index indicating whether each project is completed as planned under the leadership of each manager. If the yield ratio is a negative value, this means the project was completed past the established schedule. A positive value means that the project was finished earlier than planned, which this organization deems desirable.

Usage of CMC. The use of e-mail and Messenger indicates the extent to which the programmer actually uses CMC to help accomplish his/her tasks. According to Davis [20], the time, frequency and degree of use are measured in this study.

Data Collection and Analysis

The authors developed the survey items and conducted interviews with IS department employees of a Korean national bank regarding the content validity of our items. After this pilot test, we collected data in June 2005 by surveying employees. All the employees were using a groupware program for project management and communication that contained the functions of schedule management, work flow management, and communication (such as a bulletin board and e-mail). They are working on their own tasks, but also asking each other for help through various communication tools such as Messenger, e-mails, phones calls, etc. These conditions, therefore, qualify this IS department as a task network for employees. We asked employees about their experiences using Messenger and e-mail systems without necessarily being confined to the groupware that connect them to one another.

Before we mailed the survey, the authors called each department employee to explain our research objective and context, and ask for cooperation with our survey. We then sent 363 surveys through various means (including e-mail, face-to-face, etc.) to the employees who promised to reply. If we did not receive a reply within a week, we encouraged their participation in several ways, including meeting in person and making phone calls. Through such efforts, we collected 303 surveys (a response rate of 83.5%). We dropped 17 surveys that marked the same answers along the questionnaire; 22 surveys that left too many blank items; and 29 surveys that reported very rare use of Messenger.

[1] An ego-centered network consists of a focal person, a set of alters who have ties to the ego, and measurements of the ties from the ego to alters and of the ties between alters.

We eventually used 235 surveys for the final analysis. Of these, 231 respondents were standard end-users, while four respondents were involved with IS design and implementation activities for internal purposes.

In our sample, 197 respondents were male (83.8%) and 38 were female (16.2%). Age distribution ranged from 20s to 50s with the majority in their 30s, accounting for 58.5% of the sample (144). Respondents in their 40s amounted to 28% (69) of the sample. In terms of educational background, 57.4% held a bachelor's degree. Job ranks were diverse, ranging from clerk to assistant manager, manager, and deputy executive. Total tenure was 154 months on average (12 years and 10 months), whereas respondents held their current position from one to twenty years.

Results

Means, standard deviations, and correlations for the variables included in this study are reported in Table 1. As in Table 1, the characteristics of networks (i.e., size, density, betweenness centrality) significantly correlate with the number of projects managed. Because the project-based network coincides with the number of project to which the participant attended, the numbers of projects are controlled in the analysis. Among the network variables, betweenness centrality has a significantly negative correlation with density, while size and betweenness centrality show a significantly positive correlation. The directions of these correlations match both of the embeddedness and the diversity perspectives.

Hypothesis 1 proposes that the network characteristics would moderate the effect of CMC use, and hypothesis 2 proposes that this moderating effect would be present only in Messenger, which shows high synchronicity. To test these hypotheses, we adopted hierarchical regression procedures. Before modeling the hierarchical regression, the problem of multicollinearity was checked using VIF and tolerance limit. The maximum VIF for yield ratio is 2.337 with network size and the minimum is 1.016 for the use of e-mail. The maximum tolerance limit for yield ratio is 0.984 for the use of e-mail and the minimum is 0.428 with the network size. Because the VIF is less than 10 and the tolerance limit is larger than 0.2, it can be conclude that there is no multicollinearity problem in this analysis [13].

Table 1 - Descriptive statistics and correlations of variables

Variables	M	SD	1	2	3	4	5	6	7	8
1. Age	34.12	3.986	-							
2. Gender	1.21	.407	-.478**	-						
3. Project numbers	5.66	3.96	.048	-.091	-					
4. E-mail frequency	2.01	.87	-.127	-.028	-.055	-				
5. Messenger frequency	1.74	1.009	-.172	.071	-.071	.173	-			
6. Size	14.74	10.11	.029	-.101	.500**	-.054	-.079	-		
7. Density	0.74	.19	-.043	.033	-.488**	.029	.008	-.674**	-	
8. Betwenness Centrality	0.01	.014	.081	-.080	.326**	-.040	-.101	.638**	-.679**	
9. Yield ratio	1.31	1.33	-.065	-.118	-.041	.056	.069	.187*	-.061	.031

* p <.05, ** p <.01

Note: As for the gender variable, males are numbered 1, and females are zero.

Table 2 - Hierarchical regression analysis about the messenger use frequency and network characteristics

	M1	M2	M3	M4	M5	M6	M7	M8
Age	-.160	-.148	-.132	-.175	-.147	-.139	-.149	-.145
Gender	-.209	-.207	-.182	-.227*	-.209	-.218*	-.205	-.236*
Project	-.039	-.032	-.179	-.173	-.093	-.079	-.052	-.070
Use		.054	.059	.102	.050	.083	.056	.172
Size			.275*	-.160				
Density					-.122	.254		
Betwenness Centrality (BC)							.058	-.419*
UseXSize				.496**				
UseXDensity						-.417*		
UseXBC								.560**
R2	.038	.041	.043	.101	.052	.088	.043	.101
ΔR2		.003	.006*	.058**	.014	.036*	.006	.058**

* p <.05, ** p <.01

Note: The numbers in the table are the standardized regression coefficients. As for the gender variable, males are numbered 1, and females are zero.

Table 3 - Hierarchical regression analysis about the e-mail use frequency and network characteristics

	M1	M2	M3	M4	M5	M6	M7	M8
Age	-.165	-.157	-.142	-.146	-.154	-.158	-.158	-.169
Gender	-.212	-.208	-.182	-.193	-.209	-.209	-.206	-.210
Project	-.043	-.041	-.182	-.187	-.099	-.097	-.062	-.097
Use		.045	.052	.038	.050	.049	.049	.050
Size			.268*	.062				
Density					-.120	.087		
Betwenness Centrality (BC)							.059	-.301
UseXSize				.229				
UseXDensity						-.224		
UseXBC								.409
R2	.039	.041	.092	.101	.052	.060	.044	.071
ΔR2		.002	.053*	.009	.013	.008	.005	.027

* $p < .05$, ** $p < .01$

Note: The numbers in the table are the standardized regression coefficients. As for the gender variable, males are numbered 1, and females are zero.

Two separate hierarchical regression procedures were conducted for different degrees of synchronicity: high synchronicity (use of messenger) and low synchronicity (use of e-mail). The use of messenger and e-mail and the characteristics of the project-based network (size, density, and betweenness centrality) are mean-centered, according to the suggestions of Aiken and West [2]. Age, gender, and the number of projects were entered first as control variables in model 1; subsequently the use of each CMC is entered in model 2. The interaction terms of CMC use and network characteristics are added in model 3.

As shown in Table 2 and 3, the significant moderating effects of the network are apparent only with the use of messenger (network size, $\Delta R2 = .058$, $p < .01$; network density, $\Delta R2 = .036$, $p < .05$; betweenness centrality, $\Delta R2 = .058$, $p < .01$), while the moderating effects are not significant with the use of e-mail (network size, $\Delta R2 = .009$, n.s.; network density, $\Delta R2 = .008$, n.s.; betweenness centrality, $\Delta R2 = .027$, n.s.). This pattern of interaction supports Hypothesis 2. Specifically, the use of messenger shows a significantly positive interaction with network size and also betweenness centrality (network size, $\beta = .496$, $p < .01$; betweenness centrality, $\beta = .560$, $p < .01$), and demonstrates a significantly negative interaction with network density ($\beta = -.417$, $p < .05$).

To further verify that this pattern of interaction matches our hypothesis, we conducted a follow-up analysis adopting the procedure suggested by Aiken and West [2]. We conducted separate regression analyses for two subgroups with strong (one SD above the mean) and weak (one SD below the mean) internal attribution. Figures 1, 2, and 3 visually depict the results of this analysis. In Figure 1, participants with a large network size demonstrate a stronger positive relationship between messenger use and yield ratio than participants with a small network size. Figure 2 depicts a positive effect of network density on yield ratio for a participant with low density. Figure 3 addresses that a stronger positive relationship exists between messenger use and yield ratio for participants with high centrality than for those with low centrality. All directions of the interaction effects in Figure 1, 2, and 3 match the expected patterns of Hypothesis 1.

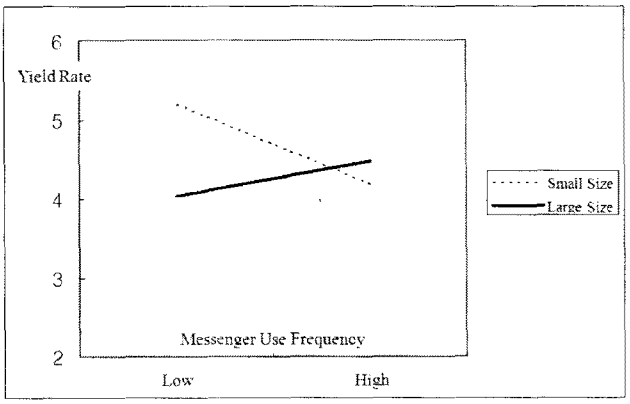

Figure 1 - The Moderation Effect of Network Size on the Relationship between Messenger Use Frequency and Yield Rate

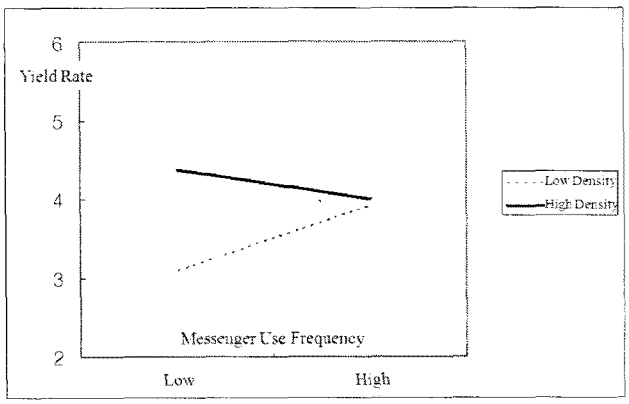

Figure 2 – The Moderation Effect of Network Density on the Relationship between Messenger Use Frequency and Yield Rate

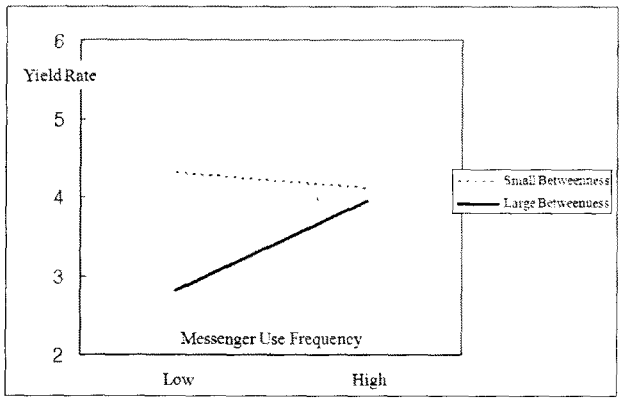

Figure 3 – The Moderation Effect of Betweenness Centrality on the Relationship between Messenger Use Frequency and Yield Rate

Discussion and Conclusion

Diverse CMC media are being used to improve productivity of tasks. This study focuses on the possibility that the positive influence of CMC media is moderated by the user's status in his/her task network, which was originally created and maintained for social purposes. This study investigates this hypothesis using a project team in a Korean national bank whose members resolve personal task problems with help from other professionals within the IS department by using e-mail and MSN Messenger. To be clear, the department studied is the task network where professional inquiries and administrative work has been conducted by helping one another. This study's findings conclude that the influences of CMC are susceptible to the task network characteristics and an individual's status in this network. The positive influences of CMC on task performance are noticeable when the task network is large yet sparse in density and when the user is close to the center of the network. Positive benefits under such conditions are more tangible for synchronous technologies.

It is no longer the case that only the official information systems that automate and integrate the enterprise's formal processes (e.g., ERP) substantially influence organizational member's task performance. Since the introduction of web 2.0, IS researchers need to be aware of the new IS environment, where users create and destroy both culture and processes of socialization as well as task execution within the community and network. This study should "sound an alarm" that organizations' formal and CMC media may not be working as formally designed. Individuals clearly have different roles and status in task networks, which are beyond the scope of the IS designer's knowledge.

This study also finds that the value of information systems depends on the social value of time. Even the same amount of time has different values according to the social status of each person. For example, synchronicity is more important to people who have a larger task network, high centrality in the network, and sparse network density. Task performance of employees using such a network is expected to benefit more for when these employees have access to synchronous CMC media for task-related communication. This study also empirically conclude that synchronous technology, such as MSN Messenger, has a positive influence on task performances and on the traditionally-cherished value of social network maintenance. Social network technologies have been criticized for the possible negative impacts they have on task performance due to its social nature. This study, however, confirms that such a concern is not serious.

As do other social science studies, the present study has numerous limitations. First, we conducted an empirical test using one case of a national bank. Our sample included IS experts who had proficient experiences with IT. They were asked about their experiences using e-mail and Messenger for the purpose of task execution within their task network (i.e., the IS department). This study's findings, however, may have resulted from task characteristics, proficiency with IT, and the bank's unique idiosyncrasies. For the sake of external validity, future studies should expand the data sample so that diverse tasks and organizational characteristics can also be including in the analysis.

The present study takes the posture of structuralism [12] and tests the influence of social network on task performances. This perspective places a higher priority on network typology and an individual's status on the network rather than on the individual's demographic characteristics. Because this study examined the interaction between network characteristics and use of CMC media, the authors did not include the influence of individual differences in the research model. Researchers are curious about the relative strength between network effect and individual demographics (e.g., [32, 44]). This topic, therefore, is a candidate for future research.

This study calls attention to the possibility that the benefits of CMC are not absolutely guaranteed. Communication participants need to identify the fit of various circumstances with CMC media. This study has identified that a task network, which is a social network designed for executing tasks, is an important moderator that can either fortify or diminish the potential of CMC media.

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Appendix

1. The following questions are about your satisfaction with project tasks.
(Please indicate your satisfaction with the project tasks of the last January and April)

1-1 I spend my working hours only for tasks during project
1-2 I feel sense of enjoyment and achievement while I work for project
1-3 I work for project with passion
1-4 I appropriately use my knowledge and capability for project tasks
1-5 Overall, I am satisfied with my tasks for project

* The next questions are about your use of communication tools (dependency, duration, and frequency) for task execution.

2. Use of E-mail for Task Execution

2-1 I heavily depend on e-mail for task execution.
2-2 How many times per day do you use e-mail for task execution?
2-3 What is the average duration of e-mail use for task execution?

3. Use of Instant Messenger for Task Execution

3-1 I heavily depend on messenger for task execution.

3-2 How many times per day do you use messenger for task execution?
3-3 What is the average duration of messenger use for task execution?