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A Social Network Approach to Activate Collaboration in Enterprise

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Abstract

A Social Network Approach to Activate Collaboration in Enterprise

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In recent years, the economic globalization and the diversification of consumer needs have made it difficult for an enterprise to create a sustained competitive advantage. In such a business environment, there are some concepts to create competitiveness based on some kind of internal interactions between members. One of these concepts is the network organization that arranges the organizational structure for adaptation to the circumstances by using ICT. But this concept does not show enough a concrete management method at a manager level. Therefore, the objective of this dissertation is a development of a management method for the network organization.

A company organization is one of social networks that has two components. One is a node of a member, and the other is a link of an interaction for a co-work. This dissertation used two approaches based on each component to propose a management method. One is a management approach focusing on members, and the other is a management approach focusing on relations between members.

Collaborative activities to occur from communication acts between members create competitiveness in the network organization. Therefore, in a management approach focusing on members, it analyzed correlations between communication acts (log data of voice-mails and e-mails) and collaborative activities (some indexes of the social network analysis) by paying attention to the members of creative core and key persons of information sharing. And it sought some common tendencies from the case of a small company and the case of a large company.

This approach observed two key results to be common to the two cases. By the analysis for the creative cores, the message sent of their communication expanded their own collaboration network. Thus, creative core members can be encouraged via their communication acts from management. And, by the analysis for the key persons, the

message received of their communication changed a collaboration network of a whole organization to a small world. Thus, collaborative activities of a whole organization are easy to occur via communication acts to key persons from management.

On the other hand, in a management approach focusing on relations between members, it confirmed that a relation influences outbreak of collaborative activities around it. It proposed the original index "k-hops closure link incidence rate" by quoting the concept "Triadic closure" of the social network theory for measuring influence on outskirts. And it examined that the members of the case of large company have positive / negative relations for co-works by the survey. The index was inspected the effectiveness for all kinds of relations. As a result of the case analysis, a nature of a relation affected outbreak of collaborative activities in three- and four-way relationships. Therefore, it is necessary for management to assign tasks members on the basis of a nature of a relation.

Some clues to manage the network organization were shown by putting the result of the two approaches together. The innovative point is that the management method is based on an interaction between members, not a work flow. The academic contributions are the empirical analysis of the case companies and the proposal of the original index "k-hops Closure Link Incidence Rate." The empirical analysis showed concrete implications for a manager. The k-hops closure link incidence rate has possibility to implement into a communication support system to harness three- and four-way relationships. This index is effective for business.

Key words: Network organization, Communication, Collaboration, Creative core, Small world, k-hops closure link incidence rate, Positive / negative relation.

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1. Introduction

1.1. Background

In the late of 1980s the Japanese economy entered a boom phase, later known as the bubble economy, accompanying exuberant speculation mainly on real estate. In due course, however, real economic growth and the divergent rise in asset prices slumped. Up until that point, Japan's economy had been consistently supported since the postwar period of rapid economic growth by export industries such as steel, automobiles and electronics. But when the bubble economy burst, many companies connected to these industries, so the banks that supplied companies with funds, became burdened with large numbers of bad loans. During the long recession that followed from the mid-1990s, often called "The lost decade," the ability of companies burdened with bad loans to compete in overseas markets gradually declined[1], making economic recovery[2] increasingly difficult for Japan.

The key to recovery from this long and seemingly perpetual recession seemed to be the economic growth of the BRIC economies (Brazil, Russia, India and China). Particularly in China, which has strong relations with Japan, a massive market was created by the synergy between the world's largest population (1.3 billion) and the establishment of special economic zones and promotion of a reform policy of opening up to the rest of the world. It was a promising market for the export of Japanese products, and the export industry seemed to be revitalized. However this is not necessarily a reason to be pleased for Japanese industry.

China has successfully acquired advanced manufacturing technology through its national policy of attracting foreign companies and letting them set up joint ventures with

[1] The automobile industry, including Toyota Motor Corporation, performed relatively well during this period because they established manufacturing bases in various countries around the world.

[2] The development of ICT (Information and Communication Technology) from the late 1990s to the early 2000s was accompanied by an increase in investment in so-called net ventures, and a number of star companies were born such as Rakuten which operates an online shopping mall. Most of these net ventures, however, did not show a profit on their investments and the transient boom ended with no real end in sight to the recession. Just as the Japanese economy seemed to be on a track to recovery resulting from an increase in exports, it was hit very hard again by the 2007 global financial crisis triggered by the US subprime loan issue. The Japanese market has slumped because of the recession and expectations that domestic demand may fuel economic growth are low.

domestic companies. Having established itself so firmly in the manufacturing field that it is called the world's factory, China has now become a strong rival to Japanese business. Meanwhile, large South Korean companies such as Samsung and LG have developed their global strategies since their country received support from the IMF during the 1997 Asian financial crisis. They have made such rapid progress that they have swept past their Japanese rivals and taken a corner of the world market. Although Japan's economy is on a gradual recovery trend, the rise of Korean and Chinese companies means that Japanese manufactured products cannot be expected to be as internationally competitive as before.

Added to the domestic and overseas issues of a prolonged recession and weakened competitiveness, the economic globalization is moving further ahead worldwide and various products and services have been commoditized. The industrial products of Japan, proud of its high cost performance of high quality and low price, have also been caught up in this trend. To survive the recession, Japanese businesses have been carrying out downsizing and restructuring. However, conditions have made it difficult for them to create a sustained competitive advantage. Now Japan needs to find itself at a turning point where it must reexamine its industrial structure.

What is the way out for Japanese industrial? Toffler *et al.* have suggested that although Japan remains in a long recession, its potential is really not low because it has some of the most advanced science and technology in the world (Toffler *et al.*, 2006). But they also point out that it will be difficult to succeed economically by relying solely on the manufacturing industry, and that what is needed in future is the emergence of an advanced service industry that can take advantage of Japan's scientific and technological advantage. Toffler *et al.* also mention that in order to raise the competitiveness of Japanese companies' service industries to the standard of their manufacturing industries, they must place more importance on the creation and accumulation of knowledge[3] in their business and should adopt a form of organization that can flexibly cope with new information and changing circumstances.

[3] Toffler at al refer to assets and resources that can only be used by one person and not others, and assets or resources that can be used simultaneously by any number of people, as noncompetitive

Toffler's proposal is not limited to Japan, and there are others who emphasize the need for companies to seek knowledge as the source of competitiveness. Drucker has argued that although the enterprise resources of land, capital, and workforce have been emphasized in the industrial society, knowledge will emerge in the future as an important means of production to pick up on signs of social change in the next generation (Drucker, 1993). Such social change[4] has a great impact on the business operations of companies. Companies have seen this as a business challenge, arguing for the importance of seeking improved productivity in intellectual production activities, such as by creating an environment that enables their members to work more productively.

Common to both sides is the view that knowledge is important as a managerial resource and that companies can gain competitiveness by having an organization that produces, gathers, and utilizes knowledge. This is probably one direction that should be taken by Japanese companies aiming to strengthen their competitive strength.

commodities. Moreover, they state that knowledge is a noncompetitive commodity that also has the characteristic of producing new knowledge when used by many people (Toffler et al. 2006).

[4] In Drucker (2002), the three main factors worldwide in the shift towards a society that places knowledge as a core resource are a change in population formation, a diversification of workforce, and a fall in the relative position of the manufacturing industry within GDP.

1.2. Issue Awareness

A social change is underway that knowledge is gaining major significance as a managerial resource to companies. According to Toffler, this social change has been induced by innovations to the way people use their time, the increased space that people can use, and the way in which knowledge is used (Toffler *et al.*, 2006). And underpinning these factors behind the change has been the development of Information and Communication Technology (ICT) which realizes human communication beyond time-space.

The world's first digital computer, ENIAC, which was built at the University of Pennsylvania in the US in 1946, was a huge system of 17,468 vacuum tubes (Rheingold, 2000). Nowadays, people use various forms of computer in their daily lives such as personal computers, mobile phones, and information appliances, and this downsizing of computers has led to the saturation of Japan with low-priced, high-performance information terminals. Connecting all these devices via telecommunication has led to the formation of a gigantic network, the Internet[5]. Networking technology utilizing the Internet has been aggressively installed into companies' information systems to support their business activities. Furthermore, companies in the ICT industry have been developing technologies and services that have made the utilization forms called ubiquitous computing[6] and cloud computing[7] a reality.

Such advances in ICT have made it easier to reform the external environment around companies, such as the connection between companies and consumers and the alliances between companies. This provides a business opportunity for emerging start-up companies or companies thinking about new business deployment, but poses a

[5] In the commercialization of the Internet in Japan, type 2 carriers such as Nifty and PC-Van, which had been providing computer communications services, launched full-scale Internet connection services aimed at ordinary companies and individuals in 1994.

[6] Ubiquitous computing is a concept of utilization form proposed by M. Weiser in 1991 of "the universal existence in our daily lives of various forms of computers according to their intended use to assist people's activities."

[7] Cloud computing is a utilization form that provides a service to users of information processing via a network. The origin of the term is not completely clear but it may derive from the clouds that were conventionally drawn by those in the ICT industry to represent a network.

threat to the business continuity of companies that have already established a position within their industry.

From the 1980s to the early 1990s, a period of relative strength for Japan's manufacturing industry, many companies adopted a business strategy based on the theory of industrial organization. The proponent of this theory, Poter, believed that the structure of a market is regulated by the technology of the times. He also explained the five forces at work in a market, namely, the intensity of competitive rivalry, the threat of the entry of new competitors, the threat of substitute products or services, the bargaining power of suppliers, and the bargaining power of customers (buyers). Poter argued that a company could secure a competitive advantage by gaining a favorable position over its rivals in regard to the forces that have the greatest impact on the company's own industry (Poter, 1980). He also indicated the "Value chain" framework for sustaining this competitive advantage, that is to say, understanding the entire process[8] of the company's business from start to finish and examining whether its enterprise resource distribution, cost reduction, and supplied value are meeting market needs (Poter, 1985).

However, this kind of strategy theory assumes a rather static industrial environment and may be unsuitable for the present situation in which barriers between industries are being lowered by the utilization of ICT. The online virtual bookstore Amazon, for example, broke into the book retail industry without owning any actual shops by directly linking its information system and its giant distribution centers. Instead of the rich, specialist literary knowledge of bookstore staff, Amazon's weapon was its innovative function of recommendations based on the purchase history of consumers. Now even bookstore staff refers to Amazon's recommendation function and consumer reviews. This is an example of a company with a completely different business method than before making a new entry because industry barriers were lowered by advancements in ICT, and suggests the limits of a business strategy based on the theory of industrial

[8] Poter says that if we generalize the process of a company's provision of a product or service, there are five stages: (1) purchasing logistics, (2) manufacture, (3) shipping logistics, (4) sales and marketing, and (5) service. He also states that the roles of management in supporting this value chain are procurement activity, technical development, human resource management, and general management (Poter, 1985).

organization which perceives the market as being static. If a company cannot utilize the knowledge of its individual members as an organization, it will be left behind by start-up companies however specialized that knowledge may be. The knowledge created from a dynamic flow of information now has an impact comparable with that of natural resources or conventional enterprise resources such as land, machinery, capital, and workforce.

Meanwhile there are those who claim that companies should be seeking sources of competitive strength within rather than in their increasingly complex external environment. Hamel *et al.* describe core competence, or the central ability of an organization to deliver its inherent value, and argue that building core competence prevents imitation of products and services by rivals (Hamel *et al.*, 1989, 1990, 1994). There are various ways to achieve core competence, but one is to focus on member training activities with the aim of elevating personnel skills and strengthening competitiveness. Senge has coined the concept of “Learning organizations”, organizations that continually seek to improve their operating capacity by promoting self-learning among their members from a business management perspective (Senge, 1990). Furthermore, Nonaka has demonstrated the SECI model, a framework of knowledge creation: “Knowledge created by individual members is converted into organizational level knowledge by interaction with colleagues based on communication. The accumulation of such organizational level knowledge then creates knowledge among new individual members” (Nonaka, 1991, 1995). This is the arrangement of organizational learning into the concept of a “Place” of knowledge management. Nonaka’s theory has been followed by expansively developed discussions including practical studies with cross-organizational communities that share interests (Wenger *et al.*, 2002) and the linking of an organization’s attributes – its structure, membership, relations, strategy, etc. - to its knowledge management such as the gathering, accumulating, and sharing of knowledge (Magnier-Watanabe *et al.*, 2009).

If focusing an internal organization, main role of management are a general manager or a field manager, not a top management. An aim is set and a strategy is drafted in a company organization. An environment of the operation is built by designing

an organization to carry out the strategy. And according to a strategy, a manager takes various roles to raise an organizational effectiveness. A tool to grasp a situation of an organization or tasks is necessary for such a managerial activities (Mintzberg, 1973, Daft, 2001). A management to focus knowledge resource is a work to raise an organizational effectiveness for a purpose of a value creation.

Knowledge is one form of information, and the idea of knowledge is highly compatible with ICT. There have been reports of an ICT environment and office design being devised at several companies to achieve a knowledge creation spiral of the SECI model, and being implemented with Nippon Comsys Corporation (Ushioda, 2007). However, issues still remain with the system of this management method. The biggest problem when introducing it in business is how to quickly understand the current situation of knowledge creation and maintain a direct management approach other than constructing an environment. At present, such issues are dealt with by a general manager in charge of the organization who manages based on personal experience and intuition. But allowing mid-level managers to understand the purpose and play a practical role requires a more scientific managerial method of dealing with the above points.

Meanwhile, Kokuryo has stressed that the cost incurred by enterprise organizations due to communication among members has decreased dramatically due to advances in ICT and their application. He explains the impact of this as follows: “Apart from 1 x N type organizational structures (like a hierarchy) in which information is gathered in one place to be processed and subsequent instructions are issued to members, it has also become possible to create N x N type organizational structures whose members perform their own information processing independently while cooperating with one another” (Kokuryo, 2001). Based on this recognition, he has also proposed a business strategy called “open architecture strategy” which focuses on the value produced by the flow of information (Kokuryo, 1999). Kokuryo also argues that, “An enterprise organization can be split up into highly independent modules according to function, and communication between these modules can be set up with open interface rules to ensure the versatility of information. If, based on this, the various modules can connect

freely to one another (i.e. networking), information distributed within the enterprise organization will be interlinked and new value will be produced."

Kokuryo goes on to point out that in a network with a dispersed structure of modules within the company that communicate together and perform each other's information processing, the key points to business management are that (1) the whole network can be made more efficient by increasing the volume of information passing through it, and (2) new value can be produced by increasing the information processing capacity of individual modules (Kokuryo *et al.*, 2003). Conventionally, companies try to build an organization to supply products and services economically under an overheads department with a high coordination capability, whereas Kokuryo's proposal is for a dynamic business strategy of dealing with the external environment, which makes it easier to produce new value by dividing the organization into highly independent modules and coordinating them in the field as necessary.

The concept of creating knowledge by combining function modules can also be applied to management of the whole organization depending on whether it's aimed at the level of function modules or the level of members. In other words, the role of gathering together the various information and experiences of individual members is taken on by a social network made up of the connections among all the individuals. A network consists of node and links between nodes. A "social" network consists of nodes that are persons and links that are specific connections (interactions that affected each other). In a company organization that is a finite set, it is considered that nodes are members and links are some kind of collaborative relationships about business. Communication in a place such as a company is performed by a set of common rules, and this leads to collaboration. The result is the stimulation of the accumulation of shared internal knowledge such as new ideas and criteria. The function modules of this kind of open architecture strategy can be read instead of individual members to bridge the gap with Nonaka's argument on knowledge management.

Although there have been huge changes in the internal and external communications environment of organizations due to advances in ICT, most companies are still clinging to the hierarchical type of organizational structure that was necessary in

the days when communications transaction costs were high. But if we seek knowledge work of the members within an enterprise organization as the source of competitiveness in the next generation, it should be possible to greatly change how businesses are organized in the current ICT environment. Can we consider a management method that activates knowledge work by embracing companies as social networks of members with a variety of knowledge and capabilities, and coordinating their participation in information flow and their connections with one another? That is the issue awareness of this research.

1.3. Objectives

It is difficult to use knowledge effectively in society. One of the difficult cases is "the planner's dilemma." The planner's dilemma is a trade-off phenomenon, and is not an argument limited to a company organization. Generally, an on-site knowledge is important. But an on-site plan is easy to become suboptimal. Adversely, a viewpoint that overlooked from a center is important. But a center plan is easy to lack important knowledge. Hayek explained this society phenomenon from the adjustment mechanism of a price (Hayek, 1999). However, Hayek's explanation was assuming a hierarchical organization (a field is hard to grasp a total situation, and a center of decision making is far from a field). But when development of ICT is considered, the administration of an organization that a center of decision making and a field are close in will be possible with an aspect of the communication.

Imai *et al.* have asserted that for a company to respond to a market with diversified consumer needs, it should not only conduct business operations with information conveyed from its senior management but also shape its organization to be able to utilize on-the-spot knowledge (Imai *et al.*, 1988a, 1988b). In fact Imai *et al.* made this argument more than 20 years ago, but they recognized that the internal communications environment of organizations was being enhanced by the use of ICT which was already becoming more and more advanced at that time. They also believed the stage had been reached where organizations other than hierarchical ones could be formed and operated, and presented their concept of a network organization. They further described how an organization could be constructed for the next generation by giving its members management knowhow in order to generate interaction among them and thereby producing new knowledge. Furthermore, Teramoto also mentions the term “Network organization” as opposed to hierarchy organization (Teramoto, 1990). Teramoto asserts that the independence of individual members and the self-organization in which the organizational structure changes according to the environment are characteristics of a network organization. This is relatively close to what Imai *et al.* proposed and is broadly the same kind of idea about the operation of the network organization. It may have been difficult for most companies to accept this

concept within the ICT environment of those days. But nowadays it should be possible for them to construct a network organization.

Miles *et al.* have proposed the creation of a network organization for companies from a different perspective than Imai *et al.* and Teramoto (Miles *et al.*, 1986). Miles *et al.* assert that in an enterprise organization in which skilled and able personnel gather to concentrate their knowledge, a balance is required between high organizational efficiency on the one hand and a sense of work satisfaction among members on the other, without creating differences in authority given to members. They also propose "_Network organizations" as one of the ways ahead for enterprise organizations, in which work is processed efficiently by combining the personnel most suitable for each new issue as it arises rather than by predetermined key personnel. Because the network organization of Miles *et al.* has a relatively flat structure due to the characteristics of its operation, there is less stress among members caused by orders received from above. They also point out that ICT systems such as e-mail and groupware are powerful tools for supporting the realization of a network organization. In contrast to Imai *et al.* who have focused on the activities of the members of the network organization, Miles *et al.* discuss the relationship between the network organization's operation and structure. Yet all of these assertions propose an organizational format that conducts dynamic management in order to produce knowledge work among its members, and embrace the same concept of a network organization but from different angles.

There are issues, however, with the management of such network organizations as well. It would be difficult for a method of giving orders from above, which is normal in a conventional hierarchical organization, to prevail in the management of a network organization. In companies aspiring to a network organization, members mostly cooperate with each other and operations are carried out by communications with relatively equal relationships, even if the organizational structure has a relaxed pecking order. Malone mentions the importance in organizations with a relaxed hierarchy of "Coordination and cultivation" rather than "Commands and progress management" (Malone, 2004). This probably indicates that even in a network organization, a

management method of coordinating the social network itself and cultivating its members is required rather than previous management methods of orders from above and budget and performance control.

There are currently a number of examples in which extremely capable and richly experienced managers have successfully constructed and operated a network organization (such as IBM Business Consulting, Nippon COMSYS, and Softbank Telecom). However, it is difficult for mid-level managers to have the same point of view as such excellent managers. It is essential that this management method be carried out with the cooperation of mid-level managers to enable coordination, rather than by simply ordering them. However, it is more difficult to see the effects of implementing "Coordination and cultivation" than that of the direct management method of " commands and progress management." For instance, even if a company's management has a flexible idea of aiming for a network organization, differences in capability and experience within the ranks of its members means that work will actually be concentrated on the more highly skilled members. Meanwhile the situation is likely to develop in which members with lower skill levels are asked to do fewer tasks and it is even likely that work will be assigned to fixed combinations of personnel without utilizing the characteristics of the organization. It is a significant management issue for companies aspiring to a network organization to develop a social network of members[9] as opposed to conducting short-sighted management leading to the above business scenario, and to deal with organizational management based on operations being supported by that social network.

Considering the direction in which ICT has advanced, namely ubiquitous computing and cloud computing, the ways in which people work are likely to become even more diverse in the future. In contrast, it will gradually become meaningless to restrict members with working hours and working places and difficult to understand the work performance of members without an ICT system. Accordingly, the management of a network organization also calls for ICT utilization as a precondition. In light of such

[9] Developing a social network of members is one method of cultivating members in a network organization. See Chapter 4, 4.1. Creative Core.

discussions on network organizations and ICT, this dissertation has a precondition that an enterprise organization is treated as a social network with its members as nodes and interactions between members as links, and poses the following three research questions.

Research Questions of this dissertation

RQ1: Can it get any clues of changing a structure of a social network by analyzing acts of members who are nodes?

RQ2: Can it find effective combinations for assignment to tasks by evaluating relations (which are links) between members?

RQ3: What kind of method is new management for a network organization?

Concretely, RQ1 was confirmed by the following Hypothesis 1 (cf. Chapter 4.1) and Hypothesis 2 (cf. Chapter 4.2). In addition, it is Hypothesis 3 to be related to confirmation of RQ2 (cf. Chapter 5). RQ3 was proposed by comprehensive considering analysis of Hypothesis 1, Hypothesis 2 and Hypothesis 3 (cf. Chapter 6).

Hypothesis of this dissertation

Hypothesis 1: A degree or size of the egocentric collaboration network of members grows large by activating communication acts of a member of a creative core.

Hypothesis 2: A collaboration network of a whole organization changes into a small world by activating communication acts of a key person.

Hypotheses 3: The quality of the relation affects outbreak of the collaboration in an over three-way relationship.

The aim of this dissertation is to answer these research questions[10] and put forward a scientific method of management for network organizations.

[10] Not all of the research questions are treated in the same way in this dissertation, which presupposes the answer to RQ1 and discusses the answers to RQ2, RQ3 and RQ4.

1.4. Research Approach and Structure of Dissertation

We have explained above the management idea of creating a network organization as one method of organization for a company aiming to strengthen its competitiveness based on knowledge. In a network organization, value is produced by members connecting to each other as necessary, based on the ICT environment, and cooperating mutually in the execution of their work. In other words, it is a management concept that is aware of and attempts to effectively utilize a social network in which individual members are the nodes and the relationships between members are the links. Within this concept, the central role of management is not giving orders or managing performance but coordinating how to achieve collaboration among members and controlling the conscious process of human resource development. However, as we have seen above, the concept of a network organization is dependent on an awareness of the status of relations between its members, and a management method has yet to be established for conducting coordination and process control from the overall perspective of the entire organization.

For the managers of an organization, it is difficult to accurately obtain a complete picture of a social network themselves. And even supposing they did manage to see the complete picture, they would have to just stand by and watch if they had no means of knowing the management items conducive to the organization's competitive strength, or knowing the control drivers that would let them start work on those management items. Furthermore, because running a network organization gets more difficult as the organization gets bigger, network organization-oriented management is also needed at the middle management level.

This dissertation examines management methods for network organizations and so considers from a theoretical point of view methods that take account of social networking in enterprise organizations. More specifically, it examines methods from a management perspective of generating member collaborative activities from member communication, treating enterprise organizations as social networks. Because a social network is composed of nodes connected by links, this dissertation separately examines the management methods for an organization's members, the nodes, and the

management methods for the collaborative relations between those members, the links. It then gives an overview of the approaches to these two management methods and summarizes how they can be introduced into an enterprise organization utilizing ICT.

Chapter 2 reviews past researches of related works. In this dissertation, social network theory is introduced in order to understand the status of network organizations. This chapter therefore takes up and critically considers past research in which social network analysis was conducted on enterprise organizations. In conclusion, these researches revealed the orientation of core members making a network structure such that collaborations readily occur by grasping the structure of the social network. And, it was discovered that harness for links is the key to management.

Chapter 3 connects communication and collaboration in theoretical terms. A network organization brings together the members best-suited to deal with an issue, and the collaboration between those members generates competitiveness. Management methods are therefore envisioned that can help communication between members and activate collaboration within an organization. Theories are then set out to form a base for examining specific management methods. Then, based on a role of communication in a social system of Luhmann (1973, 1984) and the Habermas (1981), "Communication" was defined as "an interactive process aimed at forming a consensus while conveying information such as knowledge, feelings, and opinions through the medium of language and other signs and acquiring the rules of mutual semantic understanding." "Collaboration" was defined as "activity accompanying communication acts within a group of people with relations of mutual assistance that produces emergent results through the reconstruction of the body of knowledge of an individual or organization or through the sharing and efficient use of enterprise resources." In the case of Company Y, a company organization could be grasped as a social network by data of the Thanks-cards. On the other hand, Company D's organization could be grasped as a social network by using the RFID system.

Chapter 4 examines management methods for the members of an organization, or the nodes. It describes social networks through two example companies and proposes a management method for social networks. It also discusses ways of improving the

state of a partial social network that focuses on its core members and ways of improving the state of a whole organization's social network through key persons. About the first analysis viewpoint, when the creative core members increased the message sent of their communication, the degree[11] and the size of their ego-centric network increased. About the second analysis viewpoint, when the member of the key person increases message reception, the collaboration network of the whole organization has that the eigen-path length become short and approaches the environment that collaborative activities are readily produced.

Chapter 5 examines management methods for collaboration, or links, between members. An index is presented in order to understand whether the merits and demerits of relations between members have an effect on the generation of collaboration around them. Based on the results of analysis using this index, methods are discussed for harnessing the effect of others not involved in the collaboration. It proposed the index of "k-hops closure link incidence rate" by quoting the concept "Triadic closure." As a result, the quality of relations affected occurrence of collaboration on the 1-hop distance relations and 2-hops distance relations. Furthermore, it clarified the timing of the communication act that influence to form collaboration links from the third person or the fourth person. If the ICT system understanding such information is built, the management of the network organization is supported by an ICT system.

Chapter 6 summarizes the conclusions that can be made from the results obtained regarding the aims of this research and offers a vision for the future. On the basis of analysis, it compiled a proposal of concrete management method for network organization.

The management method that it developed in this dissertation is based on interaction between members (not based on the workflow). And, the management method can harness a network organization by supporting individual interaction and grasping information of the whole organization at the same time.

[11] In analysis software UCInet, it defines "Size" as "The number of actors (alters) that ego is directly connected to", and "Ties" as "The total number of ties in the ego network (not counting ties involving ego)." This dissertation defines "Degree" as "UCInet's Size", and "Size" as "UCInet's Ties" (cf. 1.5. Definitions of Technical Terms). But, Yuhashi *et al.* (2,008, 2009a, 2010a, 2010b) used the definitions of UCInet.

1.5. Definitions of Technical Terms

This research examined the methods of business management to produce organizational collaborative activities with the communication act of members as a key driver. On this occasion, this dissertation used a social network theory for the basics of examination. In this research, the company organization was grasped as a social network, which was made from nodes of members and links of collaboration. Therefore, it uses the technical terms of the social network theory for the case analyses. The terminology of social network theory used in this dissertation is explained in the following section.

At first, it is necessary to define "Network" to grasp an organization as a network. In addition, "Sub-network" is necessary to mention some characteristics about a part of an organization. It defines "Network" and “Sub-network” as follows:

Definition 1. Network

A network is $<V,E>$. Here, V is a finite set $E \subset V \times V$ which is not empty. The element V where $(v,v') \in E \Rightarrow v \neq v'$ and $(v,v') \in E \Rightarrow (v',v) \in E$ is called a node and the element E is called an edge.

Definition 2. Sub-network

The sub-network of a network G is $G'=<V',E'>$. Here, $V' \subset V \wedge E' \subset E \cap (V' \times V')$.

Next, some indexes to grasp a structural characteristic of a network are necessary. These indexes to be able to measure about a size of a network (Order and Size) or a situation of connection between nodes (Adjacency, Neighborhood, Degree, Path, Path Length and Eigen-Path Length) are defined as follows:

Definition 3. Order, Size

The number of nodes in network G is called the order ($n = |V(G)|$) and the number of edges is called the size ($m = |E(G)|$)

Definition 4. Adjacency, Neighborhood, Degree

When $(v_i, v_j) \in E$, v_i and v_j have adjacency.

$\Gamma(v) = \{v' | (v, v') \in E\}$ is called the neighborhood of v. The degree of node v is $k(v) = | \Gamma(v) |$.

Definition 5. Path, Path Length, Eigen-path length

In a pair of nodes (v, v'), the line connecting nodes with adjacency from v to v' is called a path and the number of edges in the path is called the path length (The nodes in a path are usually considered to be minimal).

$$L(v, v') = | \{E | (v, v_1, v_2, ..., v') \in E\} |$$

The Eigen-path length L in network G is the average minimum path length of all node pairs.

$$L(G) = \frac{1}{n(n-1)} \sum_{i=1}^{n} \sum_{j=1}^{n} L(v_i, v_j)$$

In addition, a situation about a concentration expresses one of characteristics of a network. It defines an index of this viewpoint “Clustering Coefficient” as follows:

Definition 6. Clustering Coefficient

The clustering coefficient $C(v)$ of node v is the number of adjacent pairs selected from points adjacent to node v divided by the combined number of two selected adjacent points.

$$C(v) = \frac{| E \cap (E(v) \times E(v)) |}{{}_{k(v)}C_2}$$

(Density of adjacent points: $E(v) = \{v' | (v, v') \in E\}$)

The clustering coefficient for the whole network C is the average of the local clustering coefficients $C(v)$ of the vertices n.

$$C = \frac{1}{n}\sum_{i=1}^{n} C(v_i)$$

As one of indexes to express a characteristic about a positioning of a node, it defines "Betweeness" as follows:

Definition 7. Betweenness

The betweenness $Cb(v_i)$ of node v_i is shown by the following formula, where the number of paths $L(v_j, v_k)$ between node v_j and node v_k is G_{jk} and the number of paths from $L(v_j, v_k)$ that include node v_i is $G_{jk}(v_i)$.

$$Cb(v_i) = \frac{G_{jk}(v_i)}{G_{jk}}$$

2. Review of Past Research

The network organizations proposed by Imai *et al.* and Miles are an organization management concept that uses the metaphor of a network to represent the relations between members in an enterprise organization (Imai *et al.*, 1988; Miles, 1986). At companies which have introduced ICT, the network division of labor in which members cooperate together is straightforward. The scene information produced from the site of such division of labor has the potential to create new value. Scene information includes the ingenuity and so on of members on site which can be linked together to form a foundation from which new value is generated. The activity of linking scene information is called a micro-macro loop. In a micro-macro loop, the network organization is reconfigured by sorting out information while the whole organization and parts of the organization provide mutual feedback on an organization level or an individual member level. Imai *et al.* state that this kind of self-organization process strengthens the competitiveness of an enterprise organization. However, some aspects of the concept of network organizations are still revolutionary ideas for the future and hardly any actual methods have been presented for understanding an organization's status which is needed for management. To instill this concept from executive to local managerial level and use it to operate an organization will require a method of management that enables the organization's status to be understood and harnessed.

Meanwhile, social network theory focuses on relations between individuals and links personal phenomena with collective phenomena, and has been positioned between micro theory, which clarifies individual phenomena by an approach within the individual, and macro theory, which explains collective phenomena in terms of social relations (Collins, 1988). That early research consisted mostly of analysis of the power structures of relatively small-scale groups such as isolated settlements. In social network analysis, the number of links (or size) in the group concerned increases exponentially with the number of people (or order), so it was difficult to apply to large groups or time-series changes. Recent advances in computer technology, however, have enabled the

handling of much larger volumes of data, and the introduction of ICT into the social environment of groups being analyzed has broadened the range of application[12].

In general, in social networks within enterprise organizations, members are the nodes and the relations between them are the links. This is exactly what a network organization is[13]. According to the aforementioned developments in social network theory, therefore, we can assume that an analysis based on such a theory could be the key to studying management methods for network organizations.

This chapter therefore provides a review focusing on existing research into social networks within enterprise organizations. Section 2.1 Social Network Structure and Members takes up past research into the relationship between individual members (nodes) and company network structure and section 2.2 Social Network Links and Effects deals with that past research from a management perspective and mentions the links that should be focused on. Then, section 2.3 Management of Social Networks envisions enterprise organizations as social networks and critically considers past research into methods of management. Finally, 2.4 Use of ICT Systems examines similar cases to the RFID system used in one of the case companies, the case study in this dissertation, and related research.

[12] It is known that for the commonly shared physical characteristics of humans (height, weight, etc.), the values of individual bodies in most cases show normal distribution or close to normal distribution and so can be approximated. On the other hand, the results of social network analysis of various collective phenomena reveal that in many cases the number of human relationships (degree) of members, which is social nature, shows power-law distribution rather than normal distribution.

[13] Imai et al. are critical of the view of networks being formed of nodes and ties because it assumes that individual nodes all have an equivalent presence. As for the image of network organizations as networks, they do not envisage a structure formed of nodes and ties. They think of groups of relations in which specific information is exchanged, and where those groups overlap is what they call a network (Imai et al., 1988). They state that such groups of relations are linked to one another by members, and that individual members are recognized by other people by the relations they have made themselves. The character of the members is reflected in the overlap. The assertion of Imai et al. is ontological, that is whether members exist a priori (realism) or whether they only exist because they are recognized by others (nominalism), and is a completely different concept from the idea that a network in an enterprise organization is composed of nodes and ties. These can be thought of instead as situations in which members function by (1) overlapping two or more networks that have different kinds of ties or (2) linking together networks that have different kinds of ties. In other words, if the aim is management, even if a network is viewed with limited specific ties it does not deviate from the concept of network organizations presented by Imai et al. Rather, it is difficult to understand an enterprise organization as a multi-layered network, and in order to study scientific management methods it is necessary to restrict ourselves to networks composed of ties that match the purpose.

2.1. Social Network Structure and Members

There is a variety of research into social networks in enterprise organizations taken up here. Early research stemmed from that of Granovetter (1973, 1983, 1995). Granovetter randomly sampled 282 white collar workers (professionals, technicians, and managers) who had experience of changing companies and investigated the kind of sources of important information they obtained when moving to their current jobs. The results revealed that 56.0% of all the people sampled used personal connections as an information source, more than the 18.8% who used newspapers or employment agencies. Granovetter also defined a strong link as a relation in which the frequency of meeting the person who was the information source was twice or more per week, and a weak link as one in which the frequency was under twice a week. When the contact frequencies of the people changing jobs and the information sources was investigated, it was found that the proportion who obtained information related to their job change from a weak link was 83.4%. Granovetter called this function of weak links in conveying important information “the strength of weak ties (links)[14].” In social network theory, this kind of weak link is a bridge[15] connecting sub-networks that have no closeness. Most people changing jobs received job information from a bridge that they normally would not have found out[16].

The person who applied Granovetter’s “strength of weak ties (links)” hypothesis to a social network in an enterprise organization was Burt (Burt, 1992). With a high-tech company as the subject matter, Burt investigated whether a social network that included senior management had an impact on career success. By strategically adding a bridge to a sub-network to which a member of the organization was not close, he thought the member would gain some advantage in terms of information flow. He then called locations with a very low density of links in a social network “Structural holes.” Acquiring

[14] The researchers of the field of the complex network tend to use the technical term "link." On the other hand, the researchers of the social science tend to use the technical term "tie." This dissertation used the "link."

[15] In a social network, a tie exclusively connecting two nodes is called a bridge.

[16] There is also criticism of the “strength of weak ties” hypothesis. Normally, among the number of people one meets on a daily basis, there are more weak ties than strong ties. Friedkin expresses the opinion that weak ties became the information source for the person changing job as a result of there being many weak ties, not because bridges have a good information conveying function (Friedkin, 1980).

a link that filled a structural hole gave a member a personal contact that other members did not have. Obtaining important information from the personal contact resulted in the member performing better and being promoted more quickly. This clarified that the member's various relations and position within the social network impacted his business performance, rather than his individual ability and amount of invested resources alone determining his business performance.

However, a serious problem remains with Burt's experimental study, which implies that a member should strategically select whom to form relations with in order to gain a more important position within a social network. But in a situation in which a particular member occupies many bridges, it means the social network will be disrupted if that member is removed for any reason. There is also a high risk of the social network being disrupted as an organization if a member tries to create a strategic hole in order to keep their favorable position. In other words, Burt's suggestion contributes to the existential value of an individual member within an organization but does not improve the performance of the organization as a whole. Rather, there is a risk of a specific member becoming a bottleneck.

So what kind of member would it be whose individual performance was connected to the overall performance of an organization? Prusak has analyzed the internal social networks (communications networks) of more than 50 companies and found that there are four types of role of members who contribute to the improved performance of their overall organization (Prusak, 2002). These four roles are described below.

Roles of Members who Contribute to Improvements in Organizational Performance

(1) Central Connectors

A central connector has links to most members within a social network (high degree) and knows where business information and knowledge are located. A central connector links members to one another and helps to raise the performance of other members. However, central connectors can fall into the trap of overwork in which case they become a bottleneck for the flow of

information within the organization. Important steps to avoid dysfunction include making them focus on their area of specialty and encouraging them to utilize ICT.

(2) Boundary Spanners

A boundary spanner fulfills the role of assessing the situation in an enterprise organization and connecting to people outside the social network. Members who take on this role should have a combination of lively intellectual curiosity, extensive contacts, and the personality to be able to blend in with people from various other groups. Conversely, from a management perspective, there is no way to directly encourage this kind of member and they need to be encouraged by indirect means such as acknowledging their contribution.

(3) Information Brokers

An information broker fulfills the role of connecting small groups (sub-networks) within a social network to each other. In other words, an information broker exists to fill the structural holes proposed by Burt. As a means of managing information brokers, Prusak has proposed giving the role to central connectors in order to avoid the risk of tying information brokers to each other so that they become like central connectors, and of the information brokers lacking in some way.

(4) Peripheral Specialists

Peripheral specialists have a low degree and no leading presence within a social network. In other words, they communicate with few other members within the organization and exist comparatively at the fringes of the network. However, even if they are not good at communication with other members, they can be selected for their expertise and make a contribution to business. Prusak states that those who manage this kind of member should respect the working style of individual members.

Prusak has not presented an effective method of managing boundary spanners and peripheral specialists that places importance on the inherent qualities of such members. For the information brokers proposed by Burt, on the other hand, Prusak has suggested that central connectors take on that role instead to avoid the risk of disrupting the social network. He goes on to paint a growth scenario of improving organizational performance by bringing out the potential of members with scarce personal connections through cooperation with the key role members within the social network (central connectors, etc.).

Prusak goes even further, expecting more from central connectors who have direct relations with a lot of members than from information brokers who fill structural holes in the social network with bridges. This is a big point to make as a position on management aimed at improving organizational performance. But each member has his or her own inherent nature and not all of them can be a central connector. What is therefore needed is an active approach of how to direct the state of the social network while obtaining the cooperation of central connectors. But Prusak's work contains no ideas about trying to managing social networks themselves.

From a management perspective, what kind of social network should be aimed for? Cross *et al.* have focused on member collaboration in order to study methods of achieving organizational performance that exceeds the combined performances of its individual members (Cross *et al.*, 2005). They then collected cases of more than 60 social networks from various industry sectors and classified them. The results revealed a coupling of the business challenges that should be handled by the organization with the structure of the social network. This classification is shown below.

Types of Social Network in Enterprise organizations

(1) Customized Response Social Network

The aim of a customized response social network is to respond to situations of vague organizational issues and their solutions by quickly understanding the problems and trying to find breakthrough solutions. In this kind of social

network, members from inside and outside the organizations are free to participate and there is no agreement on network borders, decision making power, or information access rights.

(2) Modular Response Social Network

The aim of a modular response social network is to respond to situations in which the organizational issues are understood but the procedures for solving them have not been clarified, and to concentrate the expertise of members and provide a solution. In this kind of social network, members interact regardless of their work skill and usual work content, and decision making power and information access rights are set for each role within the organization.

(3) Routine Response Social Network

The aim of a routine response social network is to work out effective and coherent solutions to a series of problems when the organizational issues and solutions are clear. For the members of this kind of social network, restrictions on communication with others are set and decision-making power and information access rights are prescribed beforehand.

Cross *et al.* have given a detailed description of this classification of social networks, taking Novartis as an example of a customized response social network, the Federal Aviation Administration as an example of a modular response social network, and student loan provider Sally Mae as an example of a routine response social network.

Because customized response social networks include members from outside the enterprise organization, they extend beyond the scope of discussion of this dissertation which focuses on internal enterprise organizations. Modular response social networks and routine response social networks, however, exist within an organization and so a comparison of these two types provides valuable clues to the management of network

organizations. What this research suggests is that the management of an organization is paired to the structure of its social network[17].

A network organization brings together some of its members as necessary to seek and implement solutions to organizational issues. Creating a lot of collaboration between members therefore becomes the direction of management. The proposed ways of doing this include introducing collaboration tools such as groupware, establishing a reimbursement system, and reforming the corporate culture, but the idea of directly constructing a social network is not put forward.

Meanwhile, from an analysis of case studies, Gloor states that a social network in a company is the soil that yields innovation, and he calls the ideal social network in terms of favorably impacting business activities a Collaborative Innovation Network (COIN) (Gloor, 2006). He also introduces specific cases in IBM and DaimlerChrysler. A social network envisioned as a COIN is characterized by being a cyberteam which utilizes ICT to share information and work visually via a Web interface.

Definition of Collaborative Innovation Network (COIN)

> According to Gloor, a COIN is defined as a "Cyberteam of self-motivated people with a collective vision, enabled by the Web to collaborate in achieving a common goal by sharing ideas, information, and work."

Although not an enterprise organization case, Gloor *et al.* found and considered the structure of a COIN in the social network of communication between members in a remote academic collaboration project between Massachusetts Institute of Technology in the US and Helsinki University of Technology in Finland (Gloor *et al.*, 2008). Their observations of this project found that in a COIN the core members are densely connected together while at the periphery there is a relatively low density of interconnection via the core members. The COIN as a whole was in a small world state

[17] Relations between members can, depending on the time and on the case, benefit an organization or individuals, but they can also have the demerit of causing superfluous operations. As an example of such a demerit, in an organization such as a call center where individual work efficiency is required, communication among members can be wasteful. Depending on an organization's business issues, it is not always desirable to have many ties within a social network.

of a high clustering coefficient together with short Eigen-path lengths. As for its internal activities, member collaboration was generated by communication at the center of the COIN and this spread to the periphery as other members learned too, leading to greater innovation. The members at the periphery of the center of the COIN functioned by supporting the core members' activities. Furthermore, the collaborative work done through this kind of social network produced high degree leader-type members while also recursively shaping the social network structure.

A COIN and a network organization have the superficial difference of being a cyberteam based on the Web and a social network within an organization. Gloor's reasons for limiting COINs to cyberteams are twofold: it is a cross-organizational measure, and collaboration generated at the center of the COIN is linked by an ICT environment and produces innovation. From the perspective of examining management methods for network organizations, cross-organizational social networks are not categorized according to argument and there is no need to restrict methods to online communications even when using an ICT environment to support social networks. Rather, in this dissertation, it is important to point out that collaboration is born from communication and propagated through relations so that the organization is enhanced by innovation.

In the above, we have looked at the relationship between the members of a social network and the network structure, from which the following two points have become clear. First, in social networks within an enterprise organization, is the way in which interactions like the collaboration born from communication between members are linked, and the importance of realizing a structure that facilitates this linkage. Second is that the members who make up the core of a social network should have many direct relations with the other members (high degree).

2.2. Social Network Links and Effects

In research into enterprise organizations based on social network theory, there are those who focus not on the members of social networks but on their other component, their ties.

Ustuner focuses on the fact that the desired role of a company's sales personnel varies depending on how negotiations are proceeding, and shows that the social network required at each stage of the process in response to that role also differs (Ustuner *et al.*, 2006). He has divided the sales process into the following four chronological steps: (1) identifying prospects, (2) gaining buy-in and identifying up-selling opportunities, (3) creating solutions, and (4) closing the deal.

In the identifying prospects step, the salesperson collects a wide range of industry-related information and narrows down the potential clients to be targeted. The social network that helps activities at this stage is the "industry network" of contacts, an industrial information source expanded inside and outside the enterprise organization which is connected in a radial and multilevel fashion and centered on the salesperson. At the next step, gaining buy-in and identifying up-selling opportunities, the salesperson makes the prospective client understand the company's products and services while gathering information on the needs of the prospective client. At this point, the person who was first contacted provides inside knowledge about that company and introduces the appropriate people to deal with and other senior personnel. The social network required at this stage is the "prospective client network" which connects to members of the prospective client company, and it extends within the prospective client company starting from the person who was first contacted. At the next step, creating solutions, the company's own products and services are coordinated or developed to meet the client's needs. In most cases the salesperson cannot arrange this alone and must get help from experts within the organization. The social network required at this stage is an "internal contacts network" connecting to key persons within the organization and is synergistically strengthened by these key persons connecting to one another. The closing the deal step is the final stage of the sales process and so requires close communication with the client. At this point, telling the prospective client information

such as how previous clients feel about the company's products and services and how external experts endorse the quality of these products and services is invaluable for making the prospective client sign a contract. What helps activities at this stage is a "client network" made up of past clients and external experts for the purpose of introducing to and further convincing the prospective client.

In the above way, Ustuner *et al.* have classified social networks required for sales activities according to the type of links. However, this classification is not based on the nature of the links themselves but on who those links connect with. This classification is also related to virtually all communication, or collaboration generated from communication. Where it overlaps with the network organization is the internal contacts network, although this indicates a collaboration network within the enterprise organization.

In Ustuner *et al.* (2006), cases are referred to and combined in the form of the above sales process. They also present three ways from a management position to support the salesperson's formation of each social network: upgrading the sales system to place more importance on opportunities to form social networks; establishing a compensation plan that provides incentives for forming social networks; and developing the skills required by salespersons for forming and maintaining social networks. But the scope and content of the above social networks presented by Ustuner *et al.* vary so ordinary, uniform management would probably be ineffective. In fact Ustuner *et al.* themselves did not make their proposal after actually practicing this kind of management and measuring its effect. Its effectiveness is unknown as a method of managing a collaboration network that envisages a network organization.

There is research other than Ustuner *et al.* (2006) that views different kinds of relations in an enterprise organization as a network. Krackhardt *et al.* point out the existence in companies of formal hierarchical organization structures related to management responsibility and power delegation and networks of formal relations, and state the importance of understanding the network of formal relations and applying it to management (Krackhardt *et al.*, 1993). The work of enterprise organizations is conducted based on advice relations, trust relations, and communicating relations.

Krackhardt *et al.* explain that a social network needs to be mapped out for each of these three kinds of relations in order to understand the network of informal relations within an organization, in other words, the overall picture of social networks. The features of each kind of social network based on Krackhardt *et al.* (1993) are described below.

Social Networks Forming the Basis of Work Operations

(1) Advice Networks

An advice network represents how the members within an organization provide their knowledge and skills to the resolution of work-related issues. It means the central members of such a network excel in terms of knowledge and experience.

(2) Trust Networks

A trust network represents which members share political information (such as personnel affairs related information) with which other members within an organization and support each other in difficult circumstances. It means the central members of such a network have political influence within the organization.

(3) Communication Networks

A communication network represents relations between members exchanging work-related information on a daily basis. It means the central members of such a network communicate with a large number of other people within the organization.

Krackhardt *et al.* describe the above three types of social network in the case of a computer manufacturer and unravel their meaning. Viewing the status of these networks from a management perspective enables the following discussion. An advice network makes it possible to find out which relations have led to political conflict or failed measures. A trust network can confirm relations of trust and reveal the cause of mistrust

when a team that has been set up ad hoc within an organization performs poorly or an extraordinary problem arises. Meanwhile, a communication network can be used to check when operational performance is low, for instance, in order to show the cause of an information bottleneck or a failure to collect knowledge, information or data.

Viewing the research of Krackhardt *et al.* broadly, however, their discussions on advice networks and trust networks merely refer back and point out the gap in how much individual members, including managers, haven't grasped the whole social network they are in, and contain no suggestions for management in the currently ongoing circumstances. In their discussions on communication networks, on the other hand, they check problems that occur within the organization against the network status and of course see structural holes as a problem from a management perspective. Krackhardt *et al.* have divided the links in social networks into advice related, trust related, and communication related links, but have not presented a basis for dividing them into these three types. Perhaps instead we should think of advice and trust as having emerged from communication, so either they are part of the communication network or advice relations and trust relations have developed as the upper layers of a communication network.

Krackhardt *et al.* assume that formal hierarchical structures and informal social networks are completely different systems. Because various organizational structures are adopted depending on the industry and sector, in most cases those systems are probably not consistent with social networks. But in network organizations, because there is a concept of dynamically changing the organizational structure, its ties are seen as collaborative work between members or the outcome of such collaborative work, which amounts to the concept of aiming for consistency between social networks and organizational structures.

Moreover, there is the case of company that visualizes the social network in the company organization and uses this data of the social network for daily tasks (Yamamoto, 2010). NTT DATA CORPORATION introduced its SNS product into whole office, and acquired requirements of function improvement more than 400. Subsidiarily, it discovered that SNS was effective as a management tool. Yamamoto made a social

network from comment among members in SNS. The hub member in the social network had sent much intermediation information. This intermediation information was connected to performance closely. Yamamoto proposed to promote to use intermediation information by some improvements that are a search approach and a visualization of the usage etc. It can judge that this research arrived at business implication from practice. But management methods are environmental arrangement about a member's information action. It is considered that it is hard to harness to a field manager, because a concrete control driver is not shown.

Research has been done by Ahuja (2000) on the significance of links in social networks. From an analysis of the case of an international chemical engineering corporation, Ahuja concludes that structural holes have a negative impact on a company’s innovation for total optimization, and that the optimum structure of social networks within the organization varies depending on the management of that organization. The research by Ahuja (2000) deals mostly with the relationship between structural holes and organizational success, but his comments about the mechanism by which links are connected to an organization’s performance provide a reference.

According to Ahuja, links between members in social networks within an enterprise organization can follow the flow route of business information while simultaneously being used to share the various enterprise resources required for collaboration (from software which includes knowledge to hardware like facilities and machinery). Consequently, increasing the number of links in a social network (the size) makes information flow more smoothly and promotes enterprise resource sharing. This results in the generation of collaboration. Ahuja made the following observations of direct connections between members (in the case of members A and B, a link that exists between member A and member B) and indirect connections between members (in the case of members A, B and C, a path connecting members A and C where links exist between members A and B and between members B and C but no link exists between members A and C). Regarding the effect that links between members have on organizational performance, direct links are used for sharing enterprise resources and collaboration on knowledge work whereas indirect links enable access to information

but are not used for sharing other enterprise resources. Ahuja also states that the structure of a social network in an enterprise organization is prescribed according to the split of work and the information access rights of its members.

Although not an observation limited to enterprise organizations, Lin has also mentioned the function of links as the reason why social networks can generate organizational performance (Lin, 2000). Links are the routes by which members obtain information and can affect unconnected members via other directly connection members and enable the sharing of different resources of various. Lin also states that if certain members are focused on, the existence of other members connected to them creates a higher level of trust from third parties.

References to trust need to be examined for their authenticity together with other documentation, but Ahuja and Lin are basically in accord regarding other indications. Ahuja sees the difference in whether enterprise resources are shared or not as the difference between direct links and indirect links, and the difference between whether as much knowledge and information as possible can be accessed and whether collaboration on knowledge work is generated. From this view of the links in social networks within enterprise organizations, and as discussed later in this dissertation, collaborative activities cannot occur with indirect links and it is appropriate to press forward with studies into the connection between direct collaboration links and organizational performance.

To restate the discussion, section 2.1 reviewed previous research focusing on nodes (members) which are the components of a social network and section 2.2 has reviewed previous research focusing on links (collaboration). In the earliest research to focus on nodes (Burt, 1992), it was found that position within a social network influenced the performance of individuals, and having structural holes was recommended for attaining a favorable position within the organization. However, structural holes hold the risk of dividing a social network, and Prusak argues that instead high degree members, or central connectors, will contribute to the improved performance of the organization (Prusak, 2002). Meanwhile Cross, Gloor and others have developed arguments for the need for an organization structure that generates interaction between members (such

as a small world network) for an organization to perform well in knowledge work (Cross *et al.*, 2005; Gloor, 2006).

Meanwhile section 2.2 has shown how Krackhardt *et al.* see links as relations of advice, trust and communication in relation to business operations, and how Ustuner *et al.* see links as relations that enable cooperation in sales activities and have conducted an analysis of social networks in enterprise organizations (Krackhardt *et al.*, 1993; Ustuner *et al.*, 2006). In these kinds of links, enterprise resources required for business are shared by communication, resulting in collaboration such as cooperation in business activities and advice on business operations. In other words, the links in the social networks of an enterprise organization can be seen in collaboration.

Sections 2.1 and 2.2 have confirmed the validity of treating the organization of a company aspiring to a network organization as a social network. However, regarding the management aspect of a social network, no effective methods can be found in the past research mentioned above. This is because all past research that treated an enterprise organization as a social network was a static analysis of the enterprise organization at a specific point in time, and there have been hardly any dynamic perspectives that capture the changing status of an organization and link it to management. The concept of network organizations assumes their dynamic use and this dissertation must examine the feasibility of dynamic management methods.

2.3. Management of Social Networks

This section first removes the limits of enterprise organizations and examines past research into methods of managing social networks.

Barabasi grasped human activities from a mobile phone and an e-mail etc., and discussed that there was identical reflection pattern "Bursts". Then, it insisted that Barabasi could predict the action of people from the grasp of this pattern. The idea to become the base of the prediction was shown with that the time-spacing of many events of human follows a power law distribution (Barabasi, 2010). Focusing on a company organization about Barabasi's insistence, it might be necessarily predictable a group behavior which made from human activities on a routine work in a company. But, an enough scientific argument whether the prediction can be made in such as the network organization was not accomplished in Barabasi (2010), because a routine work is not main task in a network organization. Rather it is considered that grasping causation about a change of a social network from a micro-viewpoint is more important than a prediction of a group behavior from a macro viewpoint, for the management.

On the other hand, there may be a management method to getting a performance from interaction between various players. Milward *et al.* have put together a management guide for utilizing social networks in which citizens take part in public services (Milward *et al.*, 2006). They divide social networks utilized in the provision of public services into four types, service implementation networks, information diffusion networks, problem solving networks, and community capacity building networks, and describe the precise form of management tasks. The original form of a social network is made by the people or organization who provide that network, and the structure is shaped depending on the influence of that form. Milward *et al.* go on to describe how harnessing the flow of various resources leads to an improvement in performance of the core members of the network and the production of organizational results. This kind of observation corresponds with the revelations of the social network analysis in enterprise organizations reviewed above.

Milward *et al.* also point out that a fundamental difference exists between managers of organizations with hierarchical structures and managers of social networks. That

difference is that managers of organizations with hierarchical structures work within a chain-of-command structure whereas managers of social networks do not. Because of this, say Milward *et al.*, social network managers must support relations between members in order to encourage collaboration between the members. To be specific, they have described the following five tasks.

Tasks Required in Managing Social Networks

(1) Management of Accountability

When any activities are conducted in a social network, it is necessary to clarify where accountability lies inside and outside the network.

(2) Management of Legitimacy

When any activities are conducted in a social network, risk management must be conducted in order to avoid compliance violation problems.

(3) Management of Conflict

The different members of a social network have different individual goals and values, and so conflict can arise during the course of shared activities. It is therefore necessary to ask the opinions of the members who are the central players to resolve any conflict.

(4) Management of Organization Design

It is necessary to indicate the kind of members and structure a social network will have for conducting its activities, taking into account its relationships with other organizations and the nature of its individual members.

(5) Management of Commitment

It is necessary to adjust individual members' levels of commitment to the activities of a social network, in consideration of total optimization and other factors.

An enterprise organization is very different from a social network of citizens participating in a public service. Even if, say, a company adopts the flat organizational structure of a network for its operations, a hierarchical structure of responsibility still exists in the organization and management can be conducted by a simultaneously used hierarchical chain-of-command system. Because of this, management of accountability, management of legitimacy, and management of commitment put forward by Milward *et al.* can be conducted via a chain-of-command system. Conversely, among the tasks needed for managing a social network, management of conflict and management of organization design are the first required. A network organization brings together suitable members as needed and sets them to the task of dealing with business issues. Because of such management, if a network organization itself is treated as a social network then concrete methods are required to handle management of conflict and management of organization design. In other words, in a network organization, an impact can be expected from operating without fixing the network structure, whereas a network structure aimed at constantly improving organizational performance will be altered. In the process, there is a growing possibility of conflicts as relations between various members are utilized, and if these conflicts are not resolved as they occur, the network organization cannot operate. Scientific management methods are required for these two points.

As described above, past research has shown that it is possible to view network organizations as social networks and manage them. This section has suggested some management roles that have not previously been carried out (management of conflict and management of organization design) when viewing an enterprise organization as a social network. The study of such specific methods could be the key to the dynamic operation of network organizations.

2.4. Use of ICT Systems

To introduce social network theory into the management of a network organization, it is essential to understand the daily behavior of its members in a timely manner and map out a social network. There are various possible specific ways of doing this, but one effective method is the use of ICT. A typical application of ICT is an RFID system[18] of identifying people and objects using IC chips called RFID (radio frequency identification) tags, which contain a unique identification and can communicate wirelessly. Movement tracking ICT such as RFID tags has primarily been used in the distribution field such as in supply chain management (SCM). This dissertation attempts to treat enterprise organizations as social networks by using a movement tracking ICT system to track the movement of its members. (The actual method of use is fully described in Chapter 3.)

The use of RFID used to be focused mainly on the distribution field, but recently there are quite a few cases of movement tracking of people. The largest scale application is at the Whistler Blackcomb ski resort, venue for the 2010 Winter Olympics, where transmitters with a built-in GPS (global positioning system) can be rented out. A transmitter is wrapped around the skier's leg enabling his or her position on the very large slopes to be tracked in real time. It plays a role in preventing child skiers, for example, from getting lost.

In the business field, corporations such as Fuji Xerox and Hitachi have combined analysis methods and technological development in performing demonstration experiments within their organizations. Massachusetts Institute of Technology in the US launched its Auto-ID Center where it has been carrying out standardization of RFID system development and technology and conducting demonstration experiments with its sponsor companies. Ueda has carried out movement tracking of members using RFID tags and a statistical analysis in Fuji Xerox's sales organization (Ueda, 2006). Although this analysis is not based on social network theory, it does show how organizations and job positions can be compared and how helpful suggestions for management can be obtained from location and time information.

[18] In Company D, the case study in this dissertation, social networks were found by collecting the identification data transmitted periodically from RFID tags worn by members.

In a similar study, Yano *et al.* developed "Business microscopes," small business card-size computers installed with acceleration sensors and other things for tracking the activities of members in offices (Yano, 2009). These devices can record the body movements of members such as walking and gesturing with acceleration sensors, detect face-to-face interaction with other members via close-range infra-red communication, and collect voice data. The collected data can then be transmitted by wireless LAN and gathered at a data center. Having all the members within an organization wear these devices enables the communication-related social network of the entire organization to be mapped out. These business microscopes have been developed by Hitachi High-Technologies as an ICT solution to support organizational reform[19]. In combination with analytical tools, they enable the tracking of central connectors etc. within communication networks and enable the comparison of members' communication qualities such as whether they are outgoing or prefer to work individually. They have also been experimentally introduced in private enterprises outside the Hitachi Group such as Osaka Gas.

As a social network theory approach, Counts *et al.* have reported on cases of the use of movement tracking at international conferences (Counts *et al.*, 2005). Businesspeople taking part in international conferences wore RFID tags and their current position tracked by a number of receivers located around the conference venue. By generating a social network from the positional information of the participants and combining this with pre-recorded profile information, this ICT system recommended people with high collaboration potential as business partners to the participants. Such an approach has led to the management concept of trying to set up relations between members that could yield collaboration.

Eagle *et al.* have used the Bluetooth function of the mobile phones[20] of individual members to map the social network of an enterprise organization (Eagle *et al.*, 2004).

[19] Business microscopes are provided as rental devices. Data is collected at Hitachi High-Technologies' data center and handled by an analytical tool via a network.

[20] In today's enterprise organizations, a high proportion of members have a mobile phone. According to "Mobile Society White Paper 2011" by the Mobile Society Research Institute, the rate of ownership of mobile phones among individual members (that is, not shared ownership) is 72.7% and there is a high possibility that mobile phones will be used as client terminals for ICT systems for movement tracking, etc.

Specifically, the ICT system contained an application installed into each mobile phone to enable Bluetooth communication so that a terminal-specific number (Bluetooth ID) and time stamp were transmitted at 30-second intervals. By capturing this signal with a receiver in the office and considering members in the same location to be communicating, a communication social network was created. Similarities in member profiles were assumed to be a required condition of collaboration between members, and the ICT system notified individual members of which relations they should develop in the social network. Although the experiment by Eagle *et al.* was innovative, however, it was limited to technical verification, and the effect of using an ICT system and the development of a management method have been insufficient.

As explained above, there are a number of approaches using ICT systems to try to see social networks within enterprise organizations. But these approaches still have a strong element of technical development and have not sufficiently matured as management methods. Nevertheless, to dynamically capture the status of an enterprise organization and link it to management, the use of an ICT system is essential. Particular in a company aspiring to value creation through knowledge work, introducing and operating a network organization could produce sustainable competitiveness. To that end, a scientific method of managing the network organization is needed and an ICT system designed based on a scientific management method would support management by capturing situations in a timely manner. With this vision, this dissertation embraces RFID systems as a means of understanding the status of network organizations.

3. Communication and Collaboration

Moving on from Chapter 2 Review of Past Research, Chapter 3 considers theoretical concepts of collaboration, which is the aim of management in network organizations, and communication, which is required for generating such collaboration, and clarifies the relationship between the two. Based on these theoretical considerations, this chapter also examines the operational definitions of communication and collaboration used in the company case studies in Chapters 4 and 5.

In the following, communication is primarily defined as es the relationship between the two. Based on these theoretical considerations, this chapter also examelings, and opinions through the medium of language and other signs and acquiring the rules of mutual semantic understanding" and collaboration as "activity accompanying communication acts within a group of people with relations of mutual assistance that produces emergent results through the reconstruction of the body of knowledge of an individual or organization or through the sharing and efficient use of enterprise resources."

3.1. Theoretical Considerations of Communication

People have been communicating since before the dawn of history. Our ancestors survived the battle for existence by expressing their intentions through primitive languages and collaborating in groups in hunting, gathering, and farming. On the emergence of primitive languages, Dunbar states that “Human ancestors maintained group solidarity by physical contact such as grooming. However, as it became necessary to sustain larger populations through a process of adapting to changes in living environment, communication by speech emerged to make up for having less physical contact.” (Dunbar, 1996) Leakey has explained, “Language plays a mediating role in forming social interactive behavior and, together with the capacity to learn, allows an individual within a group to convey the thoughts and actions of the group.” He also states that this abstract concept and the existence of grammar have enabled a clearly distinct existence from that of other animals (Leakey, 1994). Although discussion about such prehistoric communication is, after all, mere conjecture, most theories agree on the point that language has contributed to the formation of groups of people.

Below are some theoretical considerations that focus on communication between members within the groups that we call enterprise organizations.

3.1.1. Enterprise Organizations and Communication

The formation of groups by our human ancestors is relevant to organizing in the business world. Explaining this organizing[21] from the process of formation, Weick says, “Various actions involving other people in the course of communal life are convergent on common means[22], and an organization is the stable set of interdependent relationships produced by the combined action using such means.” (Weick, 1979) Such a concept of an organization being formed by the social actions of individuals being linked as

[21] Weick’s discussion about organizing can be applied to organizations other than enterprises. In organizations other than enterprises, individuals do not always aspire to organizing with common aims and intentions from the outset. Even without common aims, behaviors may converge and mutually dependent relationships may be built.

[22] When the interconnected behavior of individuals converges on common means, people extract some parts of their experience (enactment) to which they have given some significance (selection), assume they can apply them to some other event sometime in the future, and accumulate them (retention). Weick explains that an organization reaches a stable existence through the function of connecting together such retained means (Weick, 1979).

mutually interactive behavior also applies to social system theories which try to understand the social behavior of an entire system.

Parsons, a pioneer in social systems theory, stated that a social system with a specific structure must, in order to continue to exist, meet the four functional conditions of (1) adaptation, (2) goal attainment, (3) integration, and (4) latent pattern maintenance-tension management (Atarashi *et al.*, 1979). Called structural functionalism, this perspective focuses on the correlation between organization structure and functional conditions and includes a structural framework which controls the actions of individual members inside an organization. It also attempts to understand how the actions of members function and whether a social system will be maintained and continued. Peters *et al.* (1982) have analyzed enterprise organizations from this perspective. They focus on the sense of values unique to companies relevant to Parson's argument about (2) goal attainment, and call a company that shares those values as part of its organizational culture an "Excellent company" (Peters *et al.*, 1982). They go on to empirically demonstrate that such a company exhibits superior ability resulting in favorable performance. However, the perspective of structural functionalism presupposes the existence of a stable social system (including enterprise organizations) and considers organizations to have a more static structure than that in Weick's theory on organizing. For a company to exist, it is given that its members work. An organization within a company, however, is not so innate that its existence is a prerequisite, but is characterized particularly in network organizations by a structure that is constantly being rearranged.

Since then, Luhmann has come up with a social system theory based on structural functionalism which reverses the cause and effect relationship of structure and function and says that function precedes structure (Luhmann, 1984). Luhmann calls the state in which several possibilities exist when people select their own actions "Complexity". He also takes the position that there is a limit to a person's cognitive capacity, the judgment of which is based on limited rationality. He goes on to argue that a social system plays the role of narrowing down the options to make complex situations easier to assess, enabling people to make better selections even with limited knowledge in a complex

society. He calls this “Reduction of complexity” and asserts that having this function enables a social system to exist and provides direction to the activities of the group. The reality of a company setting targets and rules for its members to make them work hard at their tasks is a perfect example of reduction of complexity.

Luhmann’s idea of a social system makes communication the constituent element, and communication is repeated to normalize relationships and form the structure. The social system is then maintained and operated by the continuation of communication. Conversely, the social system cannot survive if communication ceases because it is a self-reference type structure. Within a social system, the various behaviors that emerge along with communication are governed by rules, and their formation process is the same sort of idea as Weick’s organizing. Below, as a way of getting the relationship between enterprise organizations and communication straight, is confirmation from Luhmann (1973) of the details of the role of communication in Luhmann’s social system theory.

According to Luhmann (1973), at the border between a social system and its surrounding environment is a gap in complexity, with the situation inside the social system always being less complex than the external environment. What creates the border between this social system and the external environment is communication. Luhmann considers the communication that can be understood by other members within the group as being the constituent element of the social system. Inside the social system, there are rules shared by members, the meaning of communication is understood, and responses can be received from other members based on communication. This produces a state of low complexity. In contrast, the range of understanding by other people of the communication creates the border of the social system.

Luhmann defines communication as the sum whole of its three constituent elements of information, utterances, and their understanding, and states that the content of communication must convey meaning in three dimensions, namely, the physical, temporal, and social dimensions. The physical dimension is what the communication signifies and what it is related to, the temporal dimension is whether the communication

will be understood after the passage of time, and the social dimension is whether other people can understand it or not. If the communication has all three of these dimensions of information, it is a message that can be dealt with by the members of the group. However, since establishing communication depends on individuals' ability to understand, misinterpretations inevitably occur. Although this can sometimes lead to an uncertain response, in other cases communication is performed reproductively, giving rise to "Trust" as the other person's understanding is generalized. If this trust becomes stable, certain unique understandings and unsure responses can be disregarded so that communication is linked together and the structure of a functioning social system is produced.

Enterprise organizations are also a kind of social system, and there is no doubt that communication is an important element for an enterprise organization to function. In Luhmann's social system theory, however, whether this succeeds or not depends on the trust between members, and he gives no indication of how to relate this to management. To find a way of involving the above in the communication acts of members from an enterprise organization management perspective, first a review of various discussions on bilateral communication is needed.

3.1.2. Communication Models

Communication is a mediating action connecting different types of agents, whether it is people with other people, people with machines, or machines with other machines, and can take various forms depending on the circumstances at the time. Recently, ICT has progressed rapidly and numerous technical means of communication have become available transcending the space and time of the telephone and email. Because communication is a mediating action with so many technical means, events are seen superficially and it is difficult to grasp their essence. Consequently, without getting caught up in the above considerations on communication, in order to capture and manage communication within an enterprise organization it is important that it be based on fundamental theory at an earlier stage. To understand such fundamental theory,

below is a rearrangement of the threads of research that have added improvements to sequence models representing the communication process in diagram form.

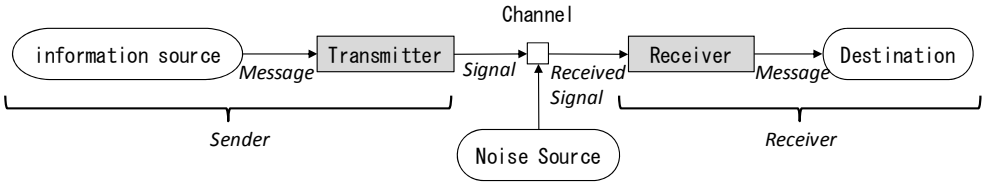

Figure 3.1 Communications engineering style communication model by Shannon *et al.* (Partly Modified by the Author[23])

The communication model[24] of Shannon *et al.* is an early typical example of a sequence model (Shannon *et al.*, 1949). In their model, the sender encodes the message to be conveyed and sends it through an information transmitting channel (such as a telecommunication line), and the recipient decodes the signal and receives the message (Figure 3.1). Essentially, this model was devised for machine-to-machine communication but after its release its simple sequence was applied to interpersonal communication. But there are several problems with representing interpersonal communication by this model. If communication fails in the model, noise may be generated when a signal passes through a channel, making communication more difficult. However, precisely because this is a human action, there is a possibility of failure due to the encoding of the message into a signal by the sender or the decoding of the message from a signal by the recipient. Shannon's model does not go much beyond signal transmissions between machines and does not deal with the interpretation of the meaning of information within communication. It is therefore an inadequate model for handling interpersonal communication.

[23] To compare the levels of abstraction of communication models with each other, the terminology used in the communication model of Shannon et al. has been replaced as follows: transmit → encode, receive → decode, destination → target.

[24] Shannon's communication model was envisaged for use in communications engineering. Furthermore, Shannon himself clearly stated that it did not include sufficient processing of the content of information held by messages Conway *et al.*, 2005). Interest among communications engineers was in quality improvement by eliminating increased noise in transmitter-receiver channels of telecommunications services.

Matsuo has extended the model of Shannon *et al.* and presented an interpersonal communication model (Figure 3.2) into which are built the conditions required for conveying meaning during encoding by the message sender and decoding by the message receiver (Matsuo, 1999). To establish communication, encoding and decoding must be performed according to rules that are shared by the sender and the receiver. Matsuo calls such language and other knowledge needed for communication "propositional knowledge." Also, even if the language system, for instance, is shared, deciphering a message requires information such as social context or the circumstances of the persons involved. Matsuo calls this "cue information." Expert knowledge in specific areas helps information connection and knowledge structuring and establishes communication with a high level of difficulty. Matsuo calls this cognitive framework a "schema". He goes on to explain that the sender and the recipient select a schema from cue information in each communication and generate a frame of thought, or "mental model[25]," to process the message.

The propositional knowledge, cue information, and schema needed for such message processing is called meta-information which is prepared all together as a prerequisite for communication. For the meaning of a message to be accurately conveyed from sender to recipient, sharing this meta-information is important. But to share meta-information fully, some such communication needs to have been carried out already at an earlier stage and a certain amount of meta-information shared. Matsuo's communication model extends the interpretation of messages when examining a particular instant, and can be applied to communication between members of an enterprise organization. However, to be able to convey the meta-information of communication to another person, communication that has already conveyed meta-information at an earlier stage is needed, and for that prior meta-information to have been conveyed, communication that has already conveyed meta-information at an

[25] In Matsuo's communication model, he explains that the four constituent elements of the rules for interpreting meaning are propositional knowledge, cue information, schema script, and mental models. Propositional knowledge is the grammar and so on of language and the schema script is the body of knowledge for interpreting a message, and together those contents are, in general, knowledge. Mental models are generated from the schema script each time there is a communication, and as they are so vaguely classified they should be considered to function together as one.

even earlier stage is needed. Such reasoning leads to infinite regression. In an enterprise organization, the possibility of infinite regression must be excluded in order to deal with daily generated communication. To this end, it would be better to consider a model in which an interpretation frame is formed and supported within the interaction of communication and communication is conducted recursively.

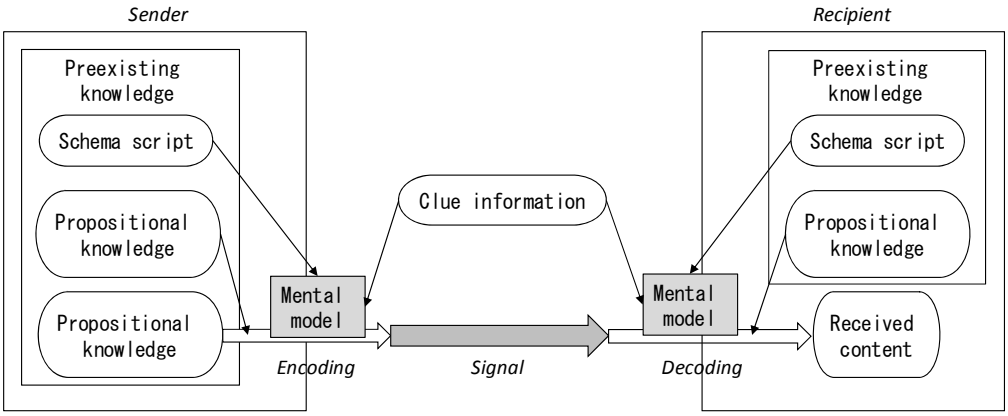

Figure 3.2 Matsuo's Communication Model (Partly Modified by the Author [26])

As a model in which an interpretation frame is formed by communication, Kuriki has presented a marketing communication model between company and consumer (Figure 3.3) (Kuriki, 2003). Although Kuriki's model does not deal with interpersonal communication, an interpretation frame is formed when a company (sender) tries to communicate to a consumer (recipient) via the mass media. Exposed to product and service information, the consumer acquires a perspective[27] for assessing the value and the need to consume the advertised product or service. The formation of the same kind of perspective is also expected on the company side where promotion activities are conducted. Although Kuriki's marketing communication model is one-directional, limited to making the sender of the message the company and the recipient the consumer, a message related interpretation frame in the recipient is not a given but an interpretation

[26] To compare the levels of abstraction of communication models with each other, the terms "language," "diagram" and "non-verbal language" used in Matsuo's communication model have been replaced with the all-inclusive term "signal."

[27] Kuriki calls the perspective for assessing the value of products and services "required perspective" (Kuriki, 2003).

frame is formed on the recipient side as communication is carried out. Such a mechanism can also be a reference in interpersonal communication.

In response to the one-way communication models examined so far, Schramm has presented a bidirectional communication model (3.4) which switches perspective according to conditions without fixing the roles of the sender and recipient of a message (Schramm, 1954). In communication in an enterprise organization, although there is direction in ask-receive relationships in problem tasks, people involved in communication confirm and execute task details while reciprocally taking on the roles of sender and recipient. Also, in this model each individual has the two simultaneous functions of encoding and decoding, which is close to the real ability of humans.

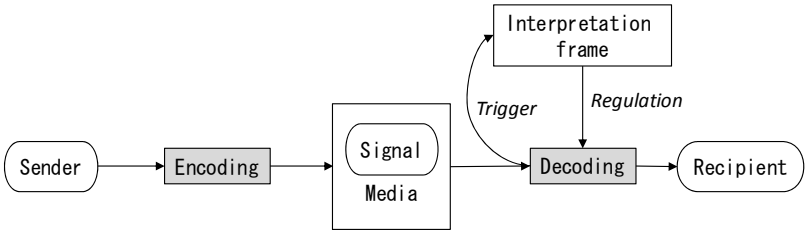

Figure 3.3 Kuriki's Marketing Communication Model

(Partly Modified by the Author [28])

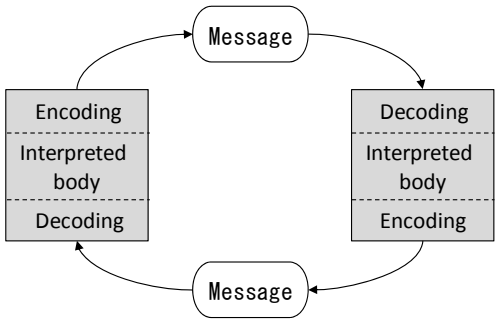

Figure 3.4 Schramm's Communication Model (Partly Modified by the Author[29])

[28] To compare the levels of abstraction of communication models with each other, the terminology used in Kuriki's marketing communication model has been replaced as follows: express → encode, read → decode, symbol → signal, required perspective → interpretation frame

[29] To compare the level of abstraction of communication models with each other, the terminology used in Schramm's communication model has been replaced as follows: coding body → encoding, decoding body → decoding

Takeuchi has presented a model with a built-in feedback process (Figure 3.4) for acquiring the interpretation frame from Kuriki's marketing communication model in the bidirectional communication model presented by Schramm (Takeuchi, 1973). This model envisions the people involved in communication incorporating information from each other into their own knowledge, reading the other person's attitude during communication and changing their own reaction, and so on.

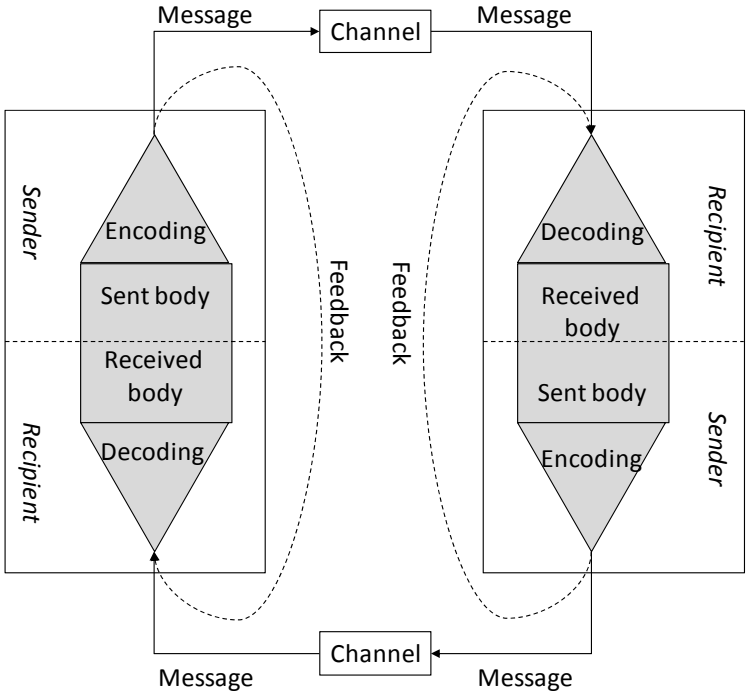

Figure 3.5 Takeuchi's Communication Model (Partly Modified by the Author[30])

The model of people involved in this kind of communication process acquiring a method of responding to one another is known as the "double bind theory" of Bateson *et al.* (Ruesch *et al.*, 1968; Watzlawick *et al.*, 1967). Bateson *et al.* argue from a pragmatic perspective[31] that "Communication requires interpretation of meaning applied to the

[30] To compare the levels of abstraction of communication models with each other, the term "signal decoding" used in Takeuchi's communication model has been replaced with "decoding."

[31] The core academic areas of linguistics are its five components, phonetics, phonology, morphology, syntax, and semantics, and the perspective of pragmatics. Pragmatics attempts to understand how language is interpreted by a recipient and differs conceptually from syntax, which views language in terms

situation therein, and the ability to interpret meaning is cultivated by learning during the process of communication[32]." Implementing training so that the members of an enterprise organization learn appropriately from communication is one management method. Because the theme of this dissertation is the organizational collaboration that emerges from communication, the relationship between the learning of individual members and the outcome of communication is not dealt with here. Rather, it is necessary to clarify what kind of communication is linked to the organization and in what way it is linked. However, all of the communication models examined above consider relationships between two people. Therefore, even if the people involved themselves acquire an interpretation frame from bidirectional communication, these arguments are generally insufficient for arriving at the formation of rules on how this frame can be shared within a group. The next section examines the relationship between communication and organization formation

3.1.3. Organization Formation by Communication

In fieldwork at a bazaar where people gather to carry out business dealings, Geertz has discovered a process in which the entire system is formed from bidirectional communication (Geertz, 1979). Basically, the relationship between sellers and buyers of products and services shows a conflict of interest, but by repeated communication to exchange information and negotiate price, quantity, and quality, the communication method (units of price and quantity, expressions of quality, and so on) become stable and the relationship between the two parties is normalized. A normalized relationship means fixed rules on trading, resulting in a smoother flow of information. Geertz describes how such partial relationships are brought together to form an entire system. In other words, bidirectional communication in trading negotiations normalizes relationships and that defines the communication interpretation frame. He explains that repeating this interaction is the mechanism that recursively builds an organization.

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of grammatical structure, and semantics, which views language as a combination of symbols containing meaning.

[32] Bateson et al. explain that in a relationship between two people, if either person does not learn then communication is not properly formed, which creates a pathological response or situation of harassment.

Regarding the organizing of a bazaar suggested by Geertz, Fukao *et al.* point out that although there is a time order of seconds or minutes for negotiation communication in what are basically one-time transactions, that time order becomes relatively large if the normalized relationship is long and continues for several years (Fukao et al., 2003). In other words, normalized relationships can be sustained for longer than dealings of temporary communication. As a result, if effective relationships can be formed they can have a lasting impact on the activation of communication in an entire organization. A bazaar and a company are different organizations, but in both of their business dealings the activation of communication inside their organizations will develop their business. But whatever the communication, it may not always contribute to organizational formation. In terms of communication quality, too, there is a need to examine the relationship between communication and organizational formation.

The messages going back and forth in communication do not only express things directly with language but often include extremely abstract concepts and images. The meaning of language is not produced directly from communication between two people but is formed by a group of a certain large size customarily using that language. On the other hand, it is fully possible that subtle nuances and very regional interpretation rules[33] will be generated in communication between two people. Looking at these differences on a timescale, the generation and alteration of interpretation rules within a group requires time in the order of years but between two people the interpretation rules can be created or changed in a matter of minutes.

Assuming the meaning of language is commonly prescribed in the above way, there is a concept of “speech act theory”[34] which treats the use of language as a form of action (Austin, 1962). In speech act theory, communication is not simply an exchange of utterances and language but has the ability to be received by another person as a specific act such as a proposal, request, or promise, and when that communication is

[33] The information processing guideline when an individual conducts encoding and decoding during communication is called the “interpretation frame” and the guideline of information processing during communication shared in a group is called the “interpretation rules.”

[34] Austin divided speech acts into locutionary acts, illocutionary acts, and perlocutionary acts (Austin, 1962). A locutionary act is the act itself of saying something, an illocutionary act is the act performed simultaneously to an act of saying something, such as a promise, and a perlocutionary act is act such as pleasing someone that is performed as a result of an act of saying something.

accepted the act of a promise, for instance, is formed. If communication is not established, it means the required conditions behind that speech act were not in place. Furthermore, even after a promise is made, it may be broken if those conditions of context are not satisfied. Based on this speech act theory, Grice points out the need to perform communication according to the conditions of context at that time such as the flow and the aim of the communication, and has presented the following “conversational maxims”, principles for carrying out proper communication (Grice, 1975).

Conversational maxims

(1) Maxim of Quantity

Give all the information that is required. Do not give more information than required.

(2) Maxim of Quality

Do not say anything that is false. Do not say anything for which evidence is lacking.

(3) Maxim of Relation

Do not say anything irrelevant.

(4) Maxim of Manner

Avoid unclear expressions. Avoid ambiguity. Speak in a concise and orderly way.

The communication desirable for management is not mere utterances (such as mumbling) but acts connected to tasks. Especially in an enterprise organization, it would be fair to say that individual members follow the conversational maxims and perform reasonably good communication, and we do not have to consider situations where there is no sharing of message interpretation rules. Without addressing the content of

individuals' conversations, it is enough to understand the fact that communication for the purpose of a task was not performed.

To study communication as a cue for management, it is valid to view it in terms of speech act theory. It is also necessary to position members' communication within the multilateral relations of an enterprise organization, in accordance with the environment in which tasks are performed. The key to this is in the theory of communicative action[35] of Habermas who, like Luhmann, sees communication as a constituent element of society (Habermas, 1981). Habermas discusses rationality through communication based on a pragmatic way of capturing meaning, which he has developed into a social theory[36]. Below is a look at the gist of his theory.

Habermas states that social actions cannot be fully understood by only knowing the symbolic and grammatical meaning built into a message itself, since communication has composite meaning representation[37]. Rather, because interpersonal communication is the issuing of messages based on relations under certain constant conditions, he argues there is a need to consider communication pragmatically in order to understand social actions. Focusing on what is done as a result of communication rather than what communication means has the function of generally helping to coordinate people's actions and develop interaction. Communication in an enterprise organization is carried out between the people concerned with the aim of consensus building in order to execute tasks. This becomes the cornerstone of the social actions of the people concerned that continue after the communication. Moreover, the important thing for members when interpreting meaning is not the symbolic or grammatical meaning contained in messages themselves but the validity of messages linked to social actions. Habermas says there are three kinds of validity that people require in communication for

[35] Habermas calls interaction using language "communicative action", but this dissertation refers to it as "communication" for the sake of consistency of terminology with other previous research.

[36] Habermas's theory of communicative action develops the arguments of social theory, political theory, and discourse ethics from communicative rationality. The main point of this dissertation, however, is the organizational collaboration that arises from communication, and so excludes from this review any political theory related to political assertions and any discourse ethics for deepening philosophical considerations.

[37] Habermas argues, from linguistic considerations, that the meaning of communication is represented in three stages, (1) the expressive function when a sender conveys a message, (2) the cognitive function when some event is portrayed, and (3) the appeal function when the recipient understands (Habermas, 1981).

consensus building, a validity claim to truth, a validity claim to rightness, and a validity claim to truthfulness. If the other person in a communication accepts these three different claims, consensus is built and they move on to the next act. But if validity is not accepted or a validity claim rejected, the people involved in the communication enter a "discourse"[38].

Based on this pragmatic view of communication, Habermas then links it to social theory. One of the two approaches to this is to discuss the classification of communicative and instrumental action and the other is to discuss the style of society.

Habermas makes a broad categorical distinction between communicative action and instrumental action. An instrumental action[39] is one which involves an individual agent forcing another person to do something as a means to bring about a desired end. An enterprise organization differs from Habermas's communication[40] in that consensus is not built between the people involved when an order is given without any explanation. He also argues that the existence of consensus built through communication is vital for successful social action. Based on this notion, an enterprise organization is not a gathering of members with their own independent aims but an aggregate that produces organizational collaboration while building consensus through communication.

On the style of society, meanwhile, Habermas believes the world comprises two spheres, namely lifeworld and system, each with its own different systems and patterns of behavior. He has gone on to develop an argument focusing on the lifeworld. The lifeworld is a concept of the world in which people lead their daily lives. All human technical, practical, scientific and ethical knowledge passes through the lifeworld and

[38] A discourse is a theoretical or practical discussion on the validity of a message with the aim of reaching consensus even if consensus is not built immediately, and functions as a mechanism for a group to maintain or control social order by resolving the various conflicts that occur in daily life and rebuilding consensus. Furthermore, people implicitly learn the rules on discourse in the course of their social lives. The five rules of discourse that participants should follow are as follows. (1) Everyone with the competence to communicate is allowed to take part in the discourse. (2) Everyone is allowed to question any assertion whatsoever. (3) Everyone is allowed to introduce any assertion whatsoever into the discourse. (4) Everyone is allowed to express his attitudes, desires, and needs. (5) No speaker may be prevented from exercising his rights in (1) to (4) above.

[39] On the relationship between communication and instrumental action, Habermas in principle places communication above instrumental action as a concept, because communication accompanying consensus is valued more than instrumental action (such as commands.)

[40] Habermas links illocutionary acts of speech act theory to communicative action, which are acts that produce rationally motivated consensus, and links perlocutionary acts to instrumental action, which is an effect of speech acts different from achieving consensus building.

furthers communication. Consensus built by communication are built into and stored in the lifeworld as knowledge and experience. The system, meanwhile, is a concept referring to sedimented structures and patterns of instrumental action. It imposes specific aims upon agents through money and power. In enterprise organizations, things such as salary systems and personnel systems come within the system[41]. On the relationship between the lifeworld and the system, Habermas warns that if the system operates too far from the lifeworld, instrumental action becomes excessive and pathologies occur. He goes on to argue that for an entire society to operate healthily, the functioning of a mechanism that regulates actions through communication in the lifeworld is important. Looking at companies as small societies, management is required not to excessively order members through a chain of command but to take on a coordinating role so that consensus is built through communication between members. This point is a theoretical necessity when considering management methods that employ communication as a key.

Next is a comparison[42] with the previously mentioned social system theory of Luhmann. Luhmann treats an enterprise organization as a social system but believes its members are positioned in the external environment of the system and that the system is formed by communication alone. Habermas's view, however, is that enterprise organizations are small societies. An enterprise organization has a lifeworld sphere and a system sphere, and the knowledge work of members and so on is positioned as social action in the lifeworld sphere. In other words, the creation of value accompanying

[41] Rather than by members performing tasks while being directly conscious of money and power, it is more normal for tasks to be performed within personal connections and by indirect targets being set. This vagueness of the boundaries of targets is because of the system's nature of operating built into the lifeworld.

[42] Luhmann and Habermas both focus on communication and develop arguments for social systems. However, Habermas criticizes Luhmann's social system theory because its assertion that a social system functions by reducing complexity justifies the corrosion of the life world by the social system. A social system should fundamentally operate built into the life world, but by thinking of this as a given, people become obedient to the social system and become liable for keeping it going. In the end, the system of money and power functions independently from the lifeworld so its influence gets stronger, companies' strategic decisions are left to the market, and government bureaucrats take hold of the real power. Habermas then points out that democratic governance stops working and a pathological state is created in the lifeworld. This has certainly turned out to be a good guess of the negative aspects of modern society. But there are too many political assertions at the forefront of criticism of Luhmann's theory and scarce scientific causal relationships. Instead, political implications should not be sought in Luhmann's social system theory.

communication is an activity of the lifeworld and instrumental action such as business processing is based on the structured system. Reflecting on both of these ideas, this dissertation considers an enterprise organization to be a social system like that of Luhmann but with its members incorporated within it. This dissertation takes this social system to have Habermas's two-layer structure of lifeworld and system and focuses on the lifeworld aspect in order to examine the relationship between communication and organizational collaboration.

So let's rearrange the above into a theoretical definition of communication. Although the role of communication is essentially unaffected by ICT, the mediation means and transmitted content must be considered separately since messages are also constrained by the channels that use information transmission. As seen in 3.1.2 Communication Models, bidirectional communication is also required along with the incorporation of feedback in order to form interpretation rules for the sequence of such communication. In addition, discussions on the social systems of Luhmann and Habermas show that an enterprise organization handles communication aimed at the building of consensus for interaction. From the above conditions, communication in this dissertation is defined as "an interactive process of transmitting information such as knowledge, feelings, and will through the medium of symbols such as language, aimed at establishing reciprocal interpretation rules while building consensus."

3.2. Theoretical Considerations of Collaboration

Schrage has set off in the new direction of value creation, in which a company improves its organizational performance by rearranging the environment of collaboration among its members. Looking at how collaboration has actually been performed on-site in the company, he then discusses strategies for ICT methods of stimulating collaboration (Schrage, 1990). Evans *et al.* assert that, “close relations in a business organization create mutual trust between members and reduce work communication costs. This enables large volumes of communication, and as a result collaboration is easier to produce.” They also propose concrete measures such as the use of collaboration tools utilizing ICT, the visualization of results, and the promotion of team meetings (Evans *et al.*, 2005).

The ease or difficulty of generating collaboration is influenced by the assumed communication cost and communication amount of the relations. Not only does organizational performance rely on the ability of individual members, as Schrage and Evans *et al.* show, but management is also expected to play a role in the idea of being able to improve such performance through collaboration among members. The point about collaboration being produced from communication also means that there is a possibility of developing new management methods of inducing involvement in communication acts. However, if this is directly linked to the introduction of an ICT system or strategy for ICT use, it will be difficult to understand the key points of harnessing the generation of collaboration from a management perspective. Accordingly, this dissertation conducts theoretical considerations of collaboration based on past research.

Kameda describes collaboration from the two viewpoints of interaction and interdependent structure (Kameda, 2000). According to Kameda, before the interaction of members linked to collaboration, there is a relaxed system of division of labor among members, or “interdependent structure.” Drawing on the knowledge, information, will and so on of its individuals, this interdependent structure fulfils the roles of organizational decision making and generation of group performance. Kameda also expresses the opinion that member interaction within an organization is not very free or

flexible but is constrained by things such as corporate culture and system. He goes on to assert that the structure existing among members should be considered as a trigger for interaction and that an environment is required in which knowledge on an individual level can be transformed smoothly to the organizational level. Such an assertion is related to the pursuit by Schrage and Evans *et al.* of a success factor in the overhauling of the ICT environment. The essential issue, however, is not the ICT environment itself but whether or not the transformation to organizational knowledge can be performed effectively.

To explain this kind of interdependent structure, Kameda identifies the mechanism by which organizational collaboration is produced. However, his argument lacks a concrete description of the interaction that initiates the structure. As a clue to this interaction, Matsushita *et al.* mention the environmental conditions[43] that make collaboration happen. Matsushita *et al.* state that for collaboration to occur, each person must know of the other (awareness) and they must be in the same place, if not physically in the same place then using ICT and other means of working together (co-presence), and communication must take place (Matsushita *et al.*, 1995). But it is hard to say whether mere information transmission is interaction. If the conditions of awareness and co-presence are met, what kind of communication needs to be conducted for collaboration to occur?

Tanaka *et al.* explain below that communication is not merely the transmission of information but that it links the status of development of interaction to the interpretation of the meaning of messages (Tanaka *et al.*, 1998). When communication becomes complex the meaning of a message is not determined in advance and there is a greater degree of dependence on the other person's interpretation. In communication, when an unexpected message is issued by the other person, the recipient's normal way of thinking is jolted and they have to recognize it as being different from any previously comprehended knowledge and to link it to different knowledge. Tanaka *et al.* state that

[43] By thinking of communication as a prerequisite to collaboration, the idea of trying to support communication with an ICT system (Computer Supported Cooperative Work, or CSCW) arises. The approach in this area is with groupware used by agglomerations to try to support collaboration by supporting knowledge work or promoting automation and labor saving in group work, and much commercial groupware has already been introduced into companies.

new meaning is created by such a reconstruction of one's body of knowledge. The imparting of meaning that accompanies communication is not called collaboration by Tanaka. However, adding new meaning to knowledge or reconstructing one's body of knowledge is per se a source of creation of value and can very much be considered collaboration between members. Discussions to date have clarified the content of interaction and interdependent structure which generate collaboration, and the relationship between interaction and communication. But to deal with this as a management issue, it must be connected further to business organizations.

Yasutomi has discussed the connection of collaboration[44] to social systems (Yasutomi, 2006). He believes that in a social system of interdependence such as an enterprise organization, new value is produced by creating communication that links, for instance, knowledge conveying members to knowledge acquiring members or members who have useable resources to members who do not. He goes on to assert that building favorable relations between members is the key to collaboration generation. Yasutomi presents this management method: "To connect members to each other, first of all physical, social, cultural, and technical resources are focused on to form a group of members into a communication core. Then, connections are combined as the direction of focus changes. In this manner, collaboration is greatly reproduced." Parsons explains the efficacy of social systems by saying that although a society is an aggregation of individuals, its efficacy as a whole exceeds the total sum of that of individuals because of the emergent property of individuals (Atarashi *et al.*, 1979). This is a way of using communication between members to stimulate intellectual activity and mutually exploit resources. Axelrod states that building relations of trust and reciprocity for the future provides motivation for collaboration among people (Axelrod, 1997).

Tanaka's collaboration is related to the intellectual innovation of members themselves and the resulting value creation activities, while Yasutomi's collaboration indicates value creation activities brought about by the effective use of resources beyond the limits of individual members. Both are triggered by communication and result in value creation activities. Also, because knowledge and resources are so

[44] Yasutomi calls it symbiotic value creation rather than collaboration.

closely related, collaboration on both often takes place in enterprise organizations at the same time. Accordingly, this dissertation considers these two as the same type of collaboration whenever they are presented and does not distinguish between them.

Meanwhile, here is another look at the differences between value creation activities which we call collaboration and similar joint work. Lepper *et al.* state that neither coordination, that is, joint activities that automatically emerge to deal with the activities of the members of a group (e.g. sorting work), nor cooperation, that is, the emergence of interdependent results from the collation of results that can be broken down to an individual level, in spite of there being no mutual intervention (i.e. just work assignments), is collaboration. They explain that although no differences exist at the level of the aims of these acts, there is collaboration where interaction on activities and results exists between members (Lepper, 2000). This opinion of Lepper *et al.* is consistent with previous discussions that collaboration is born from interaction accompanying communication. It also draws a sharp contrast with similar joint work without interaction.

So what contribution can be made from a management point of view to on-site collaboration generated by mutual communication between members? In communication within an organization, members learn about each other's knowledge, personality, and emotions in the course of exchanging messages. Therefore at first glance there seems to be no doubt from a management perspective that they participate. Yasutomi, however, states that prior to communication a "place" exists to which generated context is attached after communication, and identifies intervention in the place which is separate from the intentions of the people concerned (Yasutomi, 2006). Yasutomi himself does not consider the place to exist with a clear structure like an enterprise organization. This is because turning the place into an organization holds the risk of making the maintenance of that organization the aim. However, the concept of a network organization primarily addresses the issues of rearranging the structure so it is difficult to see Yasutomi's fears as being valid. It is probably all right to replace the place by a network organization. In other words, the involvement of management is possible before or after individuals' communication. Specifically, Weick states that the

role of management is to control the symbols and images that give meaning to organizational activities, one part of which is the setting and sharing of things like organization objectives (Weick, 1979). However, such a broad method as setting organization objectives does not fit the bill as a dynamic management method aspired to by a network organization. One more thing Weick mentions about organizational activities is the approach to setting the rules of a group so that member interaction is linked and action is connected to results. This approach is not being developed much at present and can hardly be found in past research. Barnard, however, has named three points, overall common goals, a desire among members to serve, and communication linking members, as the three elements for building an enterprise organization so that promoting such communication and contributing to the structuring of links between members also makes the stimulation of collaboration possible (Barnard, 1938).

Now let's rearrange the above into a theoretical definition of collaboration. Kameda points out that a structure of interdependency between members is assumed in order to generate collaboration (Kameda, 2000). Tanaka states that discrepancies in interpretation of meaning in communication are linked to the reconstruction of bodies of knowledge, and Yasutomi urges more efficient mutual exploitation of resources. In light of these arguments, collaboration can be defined as "activity accompanying communication acts within a group of people with relations of mutual assistance that produces emergent results through the reconstruction of the body of knowledge of an individual or organization or through the sharing and efficient use of enterprise resources."

3.3. Operational Definitions of Communication and Collaboration

In this dissertation, the relationship between communication and collaboration within an organization is analyzed, giving the case examples of two companies which aim at becoming the network organization. One of these, Yamazaki-buneidou Co.,Ltd. (Hereinafter, Company Y), runs a mail-order business and has achieved high performance by upgrading its business operations using ICT. It is an excellent small to medium sized company that has received the highest award in the Ministry of Economy, Trade and Industry's "Top 100 IT Management" for two years in succession. The other, DOCOMO Systems, Inc. (Hereinafter, Company D), is a large firm within the business group of a leading mobile network operator. One of its main operation departments of roughly the same scale as Company Y was analyzed.

The idea behind examining two companies from different industries and of different scale is to discover common phenomena within both companies and thereby give the findings from the study of their cases a certain degree of generality. Based on the aforementioned theoretical definition, below is a study of operational definitions of practical and measureable communication acts and collaborative activities in each company.

In addition, a formal social network (a hierarchical structure of the power) and an informal social network (a collaborative relationship) are generally distinguished in the hierarchical organization. But in a network organization, an informal society network is unified with a formal social network by reducing hierarchical structure or assigning members. Rather, in each company, grasping an organization based on social connection for an organizational performance (a collaboration etc.) is important in development of a management method.

3.3.1. Communication and Collaboration in Case of Company Y

Company Y runs a mail-order business supplying the office goods of the biggest office goods supplier in Japan. Dealing with the eastern area of central Tokyo, they have a large customer base of around 25,000 companies. These days, however, since office

supplies are almost all commodity goods and business competition between mail-order trading and store trading is severe, it is difficult to expand sales simply by having an attractive catalog. Business efforts are the lifeline for agency companies as favorable conditions are unlikely for all enterprises concerned.

In these circumstances, Company Y has carried out business reform using its own ICT and, using that knowhow as a weapon, developed proposal-based sales aimed at large corporate clients and improved the added-value given to clients. It has also expanded its sales outside the field of office supplies through the agency company's own new business of office paper recycling service. The company has only 26 members, but with sales of 3.2 billion yen in fiscal 2008, its performance has placed it in the top ten agencies nationwide (as of August 2008). The use of ICT includes an excellent site on the internet and the application of groupware within the company. Additionally, a voicemail system using mobile phones, a system distinctive to Company Y, has also been introduced.

[Information of Company Y]

The official name of Company Y is Yamazaki-buneidou Co.,Ltd. (Location: Shibuya-ku, Tokyo). It is the agency of domestic largest office equipment mail order business "ASUKL." It has Capital (OTC stocks): 100 million yen, Sales: 35 billion yen (August, 2010 period) and Members: 33 (April, 2011).

In 1934, the Stationery shop "Yamazaki-buneidou" opened. It got an opportunity of a business expansion, by starting an agency of "ASUKL" in 1995. Noboru Yamazaki who developed agency business took office as Representative Director in 2003, and he performed tasks improvement in the whole company organization. Thereafter, the sales amount consecutively increased for seven years from 2004. It consecutively got the commendation object in "Top 100 IT business in 2005 and 2006" of Ministry of Economy, Trade and Industry.

Company Y had the agency of office equipment mail order business "ASUKL" as the core, and developed an original business of a representation recycling of secret documents and a lecture of a filing method of documents. The average age

of members is young (26), because corporate scale spread with an agency business. Therefore, it has a member's training which is a trip of inspection to other companies on company owner's human relations.

This dissertation defines communication as “an interactive process aimed at forming a consensus while conveying information such as knowledge, feelings, and opinions through the medium of language and other signs and acquiring the rules of mutual semantic understanding.” In Company Y, apart from face-to-face communication, indirect communication via voicemail is frequently used. A manager can quantitatively grasp about members' voice mails. The voicemail system is a means of asynchronous communication that passes through the same server as emails, but using voice recordings instead of text enables the sender to convey more subtle nuances in their own spoken voice than in written form. Some of voicemail numbers of sales personnel are available to customers, but in the case of Company Y they are mainly used internally for one-to-one exchanges between members or for general memos within specific work teams or across the whole company. The company’s way of using voicemail is fully bidirectional, and it is even a rule to reply to such memos with a confirmation. Furthermore, because voice mail is used more frequently than face-to-face communication as a means of connecting the sales personnel who are often outside to the office staff, they also exchange information outside the framework of the task they are currently handling. Because the content of communication exchanged between members via these voice mails involves such a wide range of work, it is the type of content that shapes the rules for interpretation through mutual learning by those communicating. There are also communication acts for producing collaborative activities aimed at raising operational performance. That is why communication in Company Y is taken to be inter-member communication using voice mails. An indirect communication of using the ICT tool (the voicemail system) does not occupy the whole of the communication between members in Company Y. But only as for this use situation mentioned above, it does not have large problem to consider that the communication acts have possibility to create collaborative activities.

In September 2007, the average daily number of voice mails sent per member for internal communication was 29.3 and the average time of use was 46.0 minutes. The graph in Figure 3.6 shows the numbers of voice mails sent by individual members during September 2007 in decreasing order, starting with the highest number on the left. (There were 27 members at that time.) Although there was a member who sent a prominently high number of voice mails, the first 16 members from the left all sent a high number and even the remaining members sent about 350 each. According to businesspeople, nearly all their indirect communication via communications devices is done not by email but by voice mail. Considering the overall trend among companies with offices in Japan, the large number of voice mails sent in Company Y cannot be accounted for, whereas in the overheads department of major mobile network operator Company N, the average number of emails sent in March 2009 was 193.4. In Company N, the email system is used daily as the major means of indirect communication, while compared with this, the number of voice mails sent in Company Y is relatively high. Considering using the voice mail system on a daily basis, then, poses no problem.

This dissertation defines collaboration as “activity accompanying communication acts within a group of people with relations of mutual assistance that produces emergent results through the reconstruction of the body of knowledge of an individual or organization or through the sharing and efficient use of enterprise resources.” The operational definition is below. Although not a mechanism using ICT, there is a so-called Thanks Card system in which a member who receives cooperation or advice on a work matter from another member writes a message of thanks on a card the size of a business card and hands it to the other person (Figure 3.7). The exchange of these cards provides an incentive for members to collaborate with each other and has actually resulted in collaboration. A certain number of the exchanged cards may be due to the timing of the reconstruction of the body of knowledge within the organization, or expressing thanks for sharing enterprise resources. The degree of emergence is not clear, but the number of Thanks Cards exchanged is taken as the expectation value for collaboration generation.

The average number of Thanks Cards issued per member during the month of September 2007 was 43.9, the highest number being 126 and the lowest being 12. Implementing this rule shows that operation within the company is being thoroughly carried out.

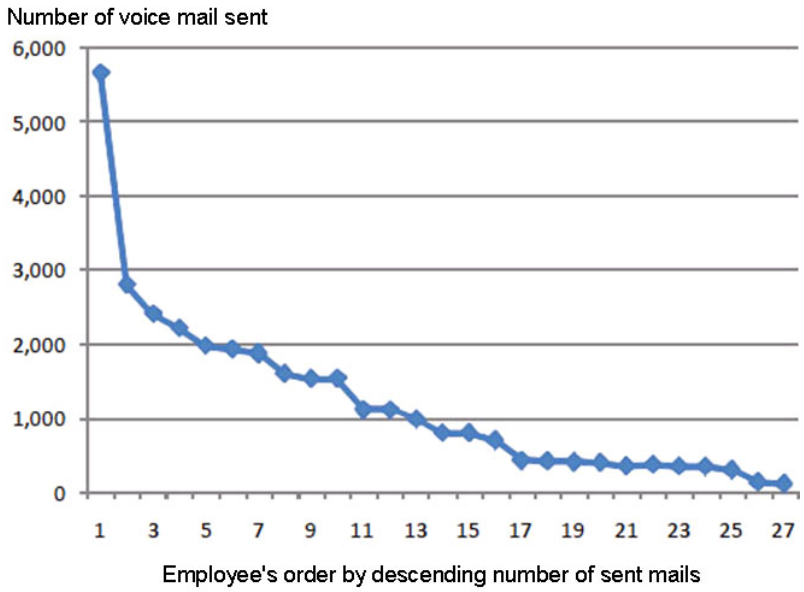
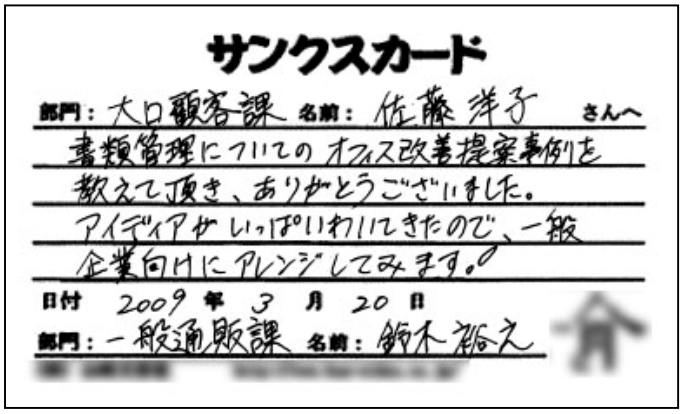


Figure 3.6 Numbers of Voice Mails Sent (September 2007)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書類管理についてのオフィス改善提案事例を
教えて頂き、ありがとうございました。
アイディアがいっぱいわいてきたので、一般
企業向けにアレンジしてみます。

日付 2009 年 3 月 20 日

部門：一般通販課 名前：鈴木裕之

Figure 3.7 Sample of Thanks Card

The number of members continuously enlisted during the period of analysis from October 2005 to September 2007 was 21, and the total number of Thanks Card exchanged between these members during that 24-month period was 16,638 (an average of 693.3 per month). Under the Thanks Card exchange rule, the members are the nodes and the relationships of handing over Thanks Cards are the links between the nodes, which is represented in Figure 3.8. This figure is a graph of the relationships of exchanging Thanks Cards, and only shows those links with 30 or more Thanks Cards exchanged between nodes during the period concerned.

The analysis in the next two chapters is limited to the above analysis period and subjects and takes the voicemail system log as communication and the Thanks Card exchange records as collaboration data.

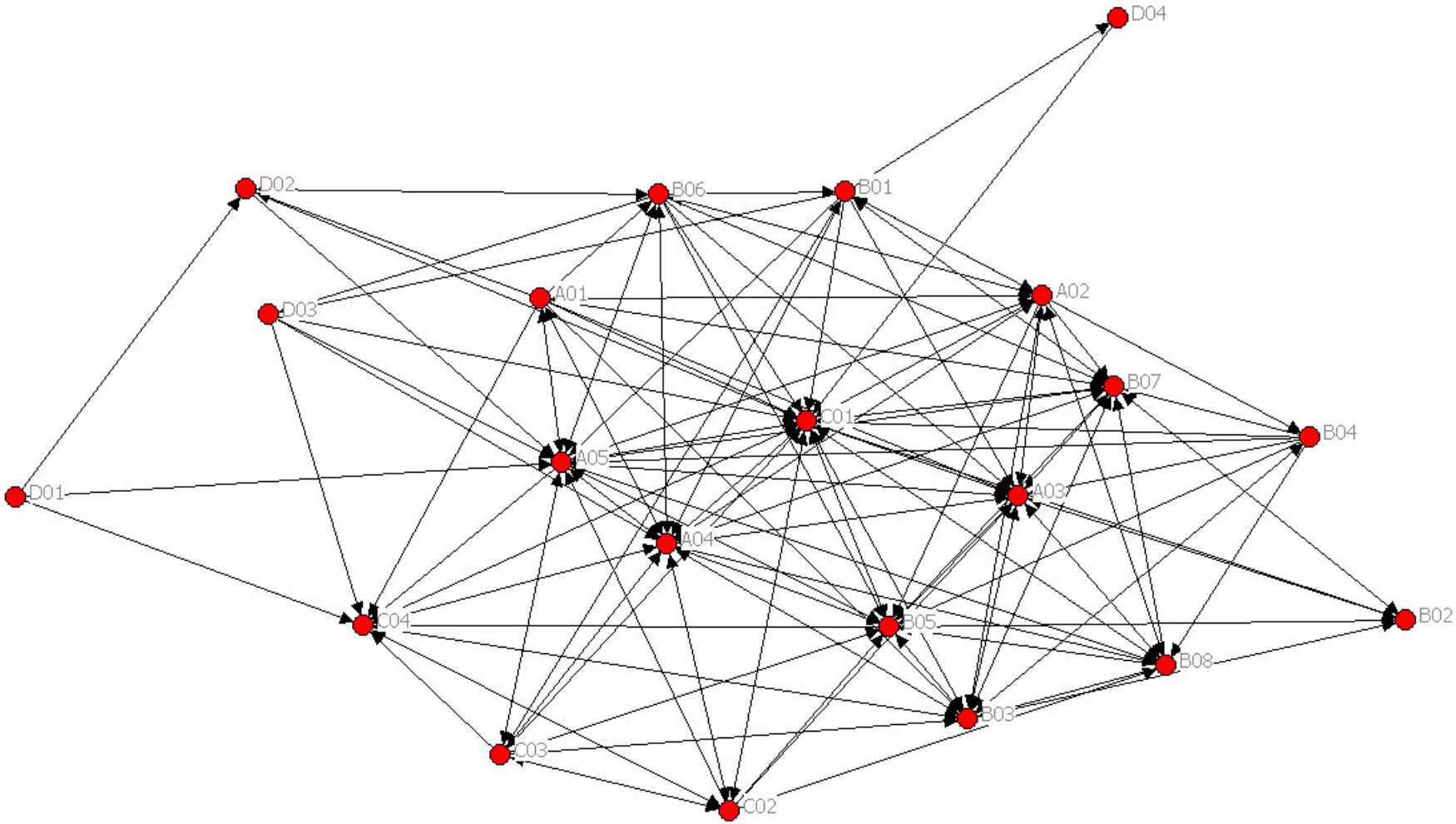


Figure 3.8 Collaboration Network of Company Y

3.3.2. Communication and Collaboration in Case of Company D

The other subject of analysis, Company D, is part of a major mobile network operator group and conducts development and maintenance of information systems (as of March 31, 2009, total members: 696, annual sales: 34.1 billion yen). Its position as a company within a major mobile network operator group gives it a distinct advantage in providing mobile solutions. However, the business of building information systems to suit the needs of customer has been hit by the global financial crisis, leading to less ICT investment in companies and creating a harsher competitive environment.

Company D is involved in all aspects of the ICT systems business from equipment sales to development and maintenance. Its core business, however, is the system integration business of building information systems for client companies. In ordinary companies engaged in system integration, their sales personnel and system development personnel work in different departments with separate tasks and responsibilities. Company D's system integration business section, however, brings its sales personnel and systems development personnel together under one roof, making it easier to reflect customer needs in system development while simultaneously reducing internal procedures and speeding up operations. System development in the mobile solutions field, which introduces mobile phones, smart phones, and other mobile devices, is a relatively new area. This means there are few package solutions for existing companies and various technologies have to be combined to give customers what they want. In other words, if members from various areas of expertise can stimulate collaboration among themselves, it will lead directly to improved operational performance.

[Information of Company D]

The official name of Company D is DOCOMO Systems, Inc. (Location: Minato-ku, Tokyo). It is the group company where NTT DOCOMO, INC. (the domestic largest mobile network operator) invested (100%). It has Capital: 652.6 million yen, Sales: 32.9 billion yen and Members: 697 (March, 2011).

In 1985, Company D started a business as joint enterprise of four companies which are Nippon Telegraph and Telephone Corporation, Mitsui Engineering and

Shipbuilding Co., Ltd., NEC Corporation and MITSUI & CO., LTD. An early core competence is the technical skill of Computer Aided Design (CAD) which used for the design of the ship, it ran business of design of construction of telephone wires for parent companies by using CAD skill. In the late 1990s, as many personal computers spread and a data communication environment became high-speed, the system integration business for companies except the parent company grew large. The big client "NTT DOCOMO" bought stocks from each parent company and made Company D its subsidiary in 2001. Thereafter Company D has changed the main business toward a synergy with the mobile phone business.

The current main business is a system development and maintenance for NTT DOCOMO's customer information system and customer charge system. The mobile phone business of NTT DOCOMO has about 58 million users. Furthermore, the communication services and the charge plans change every year because market competition is severe. Company D offers the information systems to support mobile phone business.

And, Company D performs a system integration of a mobile solution for a general company by cooperation with the corporate marketing division of NTT DOCOMO. It makes package sale and Application Service Provider (ASP) from common technical element among much system integration.

Because Company D handles the large-scale information system that is indispensable for mobile phone business, the financial standing is likely stable. But, there are a ubiquitous computing and a cloud computing as trends in the whole ICT market, and a smartphone appears. Probably, the system integration business fuses with the mobile phone business. It is a future management problem to create new value by taking in these technical trends.

Communication between members is not only direct (face-to-face conversation, meeting etc.) but indirect communication by using an ICT tool. In Company D, there is much direct communication because they have tasks to develop system integration contents. Members have indirect communication by an opportunity of a direct communication. There is its reverse phenomenon. Therefore, direct communication and

indirect communication are not completely independent acts. Although there is the individual difference by a member, a quantitative grasping of an indirect communication represents a communication activity between members to some extent. Looking at communications in Company D, nearly all their indirect communication via communications devices is done by email. This dissertation defines communication as “an interactive process aimed at forming a consensus while conveying information such as knowledge, feelings, and opinions through the medium of language and other signs and acquiring the rules of mutual semantic understanding,” and since members in Company D are assigned on a system development project basis, they routinely conduct communication on business by indirect communication using email. Advanced content such as introducing technical knowledge, seeking advice, and decision-making is also exchanged and consensus building in business operations achieved. This being the situation, Company D’s sent and received email log can be taken as its communication data. Because the content of communication exchanged between members via these emails involves such a wide range of work, it is the type of content that shapes the rules for interpretation through mutual learning by those communicating. There are also communication acts leading to collaborative activities aimed at raising operational performance.

Next, a look at collaboration, which has already been defined above as “activity accompanying communication acts within a group of people with relations of mutual assistance that produces emergent results through the reconstruction of the body of knowledge of an individual or organization or through the sharing and efficient use of enterprise resources.” In the system integration business section of Company D, most members work inside the office apart from a few sales personnel. Therefore nearly all collaboration is produced within the office during working hours. The methods of producing it are by communicating via task-related reports, memos, and consultations and by utilizing discussions in meetings to share expertise and resources. Collaboration in Company D was therefore produced at a characteristic rate based on communication exchanged within the office, the rate depending on things such as the use of locations. In this dissertation’s research, the expectation value for collaboration generation is

calculated using an RFID system (Figure 3.9) which can identify the whereabouts of members.

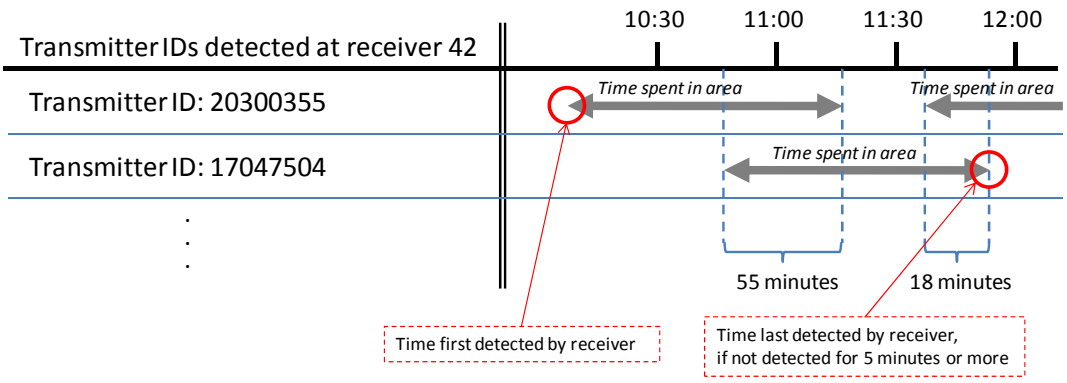
The method of calculating the expectation value for collaboration generation was as follows. The members were allocated with unique IDs and fitted with RFID tags which transmit the ID number at 30-second intervals[45]. In the office, antenna were installed in 17 locations throughout the main room where all the members' desks were arranged, the various meeting rooms, and the two break rooms (one smoking, one non-smoking) so that they could pick up the ID number from each specific RFID tag and its current location (detection area) together with a time stamp. Then the consecutive timestamps were transposed to show the time members were within the detection area (about 5m diameter) of the same receiver, as in Figure 3.10. Some form of collaboration was deemed to have occurred when members were in the same detection area at the same time.

Figure 3.9 RFID System (Left: RFID Tag, Right: Receiver)

We also focused on differences in members' use of shared time and space in the main room where they did their work, the meeting rooms, and the break rooms. It is assumed that people with a very similar organizational culture (in the same organization, etc.) use the various spaces in the same way. The RFID tags used in the experiment were fitted with buttons which, when pressed, could send a different signal from the regularly transmitted one. The rule on pressing these buttons was "press once for each

[45] In experiments by Eagle *et al.*, signal transmission was set to 30-second intervals as a balance between limitations of continuous operating time depending on the power source and accurately understanding the actions of people (Eagle *et al.*, 2004).

time collaboration occurs," and the number of times buttons were pressed at each antenna location was totaled (Table 3.1). The value of this total, standardized with the total number of times all the buttons were pressed, was taken as an indication of the ease of generating collaboration in a specific space. The value for each location was then discussed and weighted. This value was taken as a virtual expectation value for collaboration generation. Hereafter it is considered as collaboration. By compiling the discussion mentioned above, the theoretical definition of collaboration's "relations of mutual assistance" is that the members belong to the same company organization. "Communication acts within a group of people" was grasped as shared time when the members stayed at same place where they can have a direct communication in the office. And, it was considered that "the reconstruction of the body of knowledge of an individual or organization, or through the sharing and efficient use of enterprise resources" depended on the usage of the place where communication was performed. Thus, it can guess "activity that produces emergent results" by taking "the time when the members shared the same place" and "the heaviness charges based on usage every place."



**The employees with transmitter IDs 20300355 and 17047504 spent 73 minutes (55 + 18) together in the area of receiver 42.*

Figure 3.10 Example: Time Spent Visiting Receiver 42 Area

Data was gathered by monitoring one section of the system integration business section (with 27 members) for a total of seven weeks divided into two periods, four weeks from November 23 to December 20, 2008 and three weeks from March 8 to March 28, 2009. By representing the collaborative relationships from this period in a graph, the network in Figure 3.11 was obtained. The analysis in the following chapters

takes the log of email system use as communication and takes the virtual expectation value for collaboration generation obtained from the sharing of time and space in the office as collaboration data.

Table 3.1 Where and How Often RFID Tag Buttons Pressed

Ranking	Antenna installation location	No. of times button pressed
1	Around general managers's desk	141
2	Break room (smoking)	128
3	Employee desk workspace	117
4	Meeting area (small)	94
5	Employee desk workspace	37
6	Meeting area (small)	24
7	Employee desk workspace	21
8	Employee desk workspace	20
9	Meeting room (medium)	17
10	Employee desk workspace	11
11	Meeting area (small)	9
12	Meeting area (small)	9
13	Meeting room (medium)	9
14	Meeting room (medium)	8
15	Meeting area (small)	7
16	Meeting room (medium)	5
17	Meeting room (large)	5
18	Meeting room (large)	5
19	Meeting area (small)	2
20	Employee desk workspace	2
21	Break room (non-smoking)	2

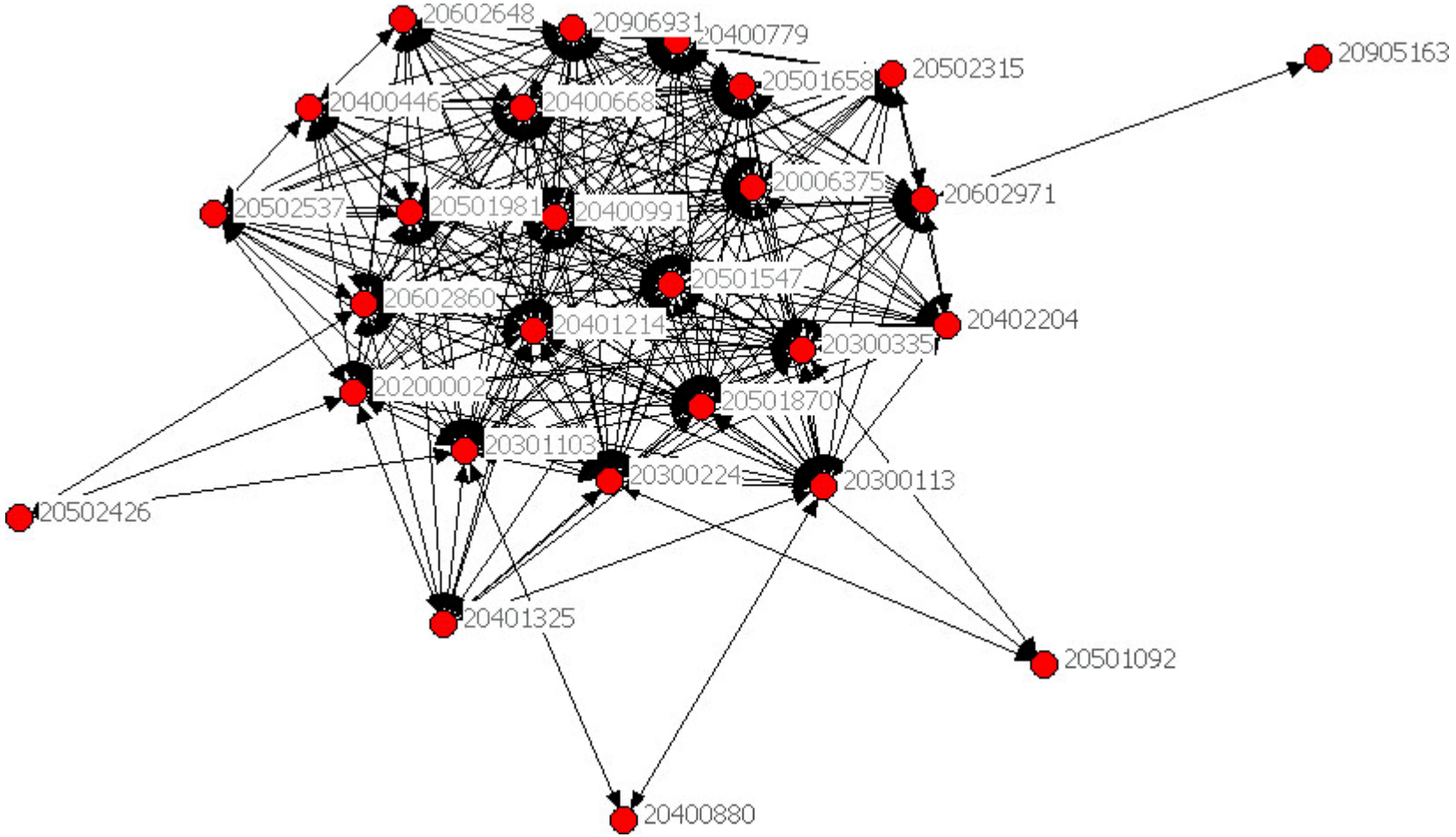


Figure 3.11 Collaboration Network of Company D (Entire Period)

4. Management Approach Focusing on Members

For Japanese companies to maintain their competitiveness in the coming era, there are some opinions such as that of Toffler *et al.* (2006) that the source of such competitiveness is not manufacturable work efficiency, and that what is needed is value creation through intellectual production activity. One type of organization suitable for such an orientation is a n orientationle for ct that views members as nodes and interactions as links. The network organization is a concept for generating value from the interaction between members by dynamically rearranging the enterprise organization according to the business issues it faces. However, there is still insufficient preparation for a scientific management method based on this concept.

To develop a scientific management method for the network organization, Chapter 2 "Review of Past Research" critically examined research that has attempted to involve management in a social network. In addition, Chapter 3 "Communication and Collaboration" theoretically considered the emergence of collaborative activities from communication acts between members. The importance of support from management for collaborative activity via communication between members was confirmed, because the intellectual production activity of an organization can be activated by collaboration.

The collaborative relationship among members can be visualized as a network, by recognizing such collaborative activity as links of social connection. Such a collaboration network is itself a source of competitiveness in corporate management focused on knowledge, and is an important subject of management. Based on the theoretical considerations of Chapter 3, internal collaborative activities can be activated by involvement in communication acts which are a necessary condition for producing collaboration. As confirmed in Chapter 2, however, there is hardly any previous research into concrete methods of activating collaboration by encouraging communication.

This chapter therefore examines the correlation between collaborative activities and communication acts in two case studies, and finds the common tendencies of the two examples to develop a concrete method of management. In doing so, it considers two

phenomena within an enterprise organization in which there is a relation between the communication acts of members and the collaborative activities of the organization: (1) when a member's own communication generates collaboration with neighboring members and (2) when the communication of certain members of the organization influence other members to make collaboration easier to produce.

Regarding the first phenomenon, if a manager can exert some kind of pressure on members (described later as the creative core) who are engaged in the main value creation tasks, more improvement in their performance can be expected. As described in more detail later, in this approach management is performed after having grasped the relationship between the communication acts of the creative core and their collaborative activities. This relationship is confirmed by a statistical analysis of whether communication acts are connected to collaborative activities among the core members who try to create value. From this viewpoint, verification is performed by analysis 1 on Company Y and analysis 2 on Company D, as shown in Table 4.1.

Table 4.1 Relationship between Case Studies and Analyses

	Communication and Collaboration of Creative Core	Communication of a Key Person and Collaboration of a Whole Organization
The case of Company Y	Analysis 1	Analysis 3
The case of Company D	Analysis 2	Analysis 4

In the second phenomenon, meanwhile, there may be a certain member (described later as a key person) who has a strong influence on the other members. When that member activates communication acts, collaborative activity within the whole organization can be expected. This is also described in more detail later, but in this approach, management is performed after having grasped the relationship between the key personrs communication acts and the collaboration environment of the whole organization. This relationship can be confirmed by seeing whether an increase in communication volume by the key person in the organization changes the state of the collaboration network of the whole organization. From this viewpoint, too, verification is performed by analysis 3 on Company Y and Analysis 4 on Company D, shown in Table

4.1. This chapter analyzes four combination patterns for the two phenomena in both case studies, and the relationship between analyses 1 to 4 is shown in Table 4.1. Generalizing these analyses can provide a clue to developing a concrete management method.

Analysis 1 and analysis 2 are given in 4.1 "Creative Core" below and analysis 3 and analysis 4 in 4.2 "Key Person".

4.1. Creative Core

Florida, on the other hand, asserts that the rise of a new social class, a "creative class," has effected massive social changes over the past few decades (Florida, 2002, 2005). The creative class is a socioeconomic class which is a key driving force in the economic development of post-industrial society. Members of the creative class engage in work that creates meaningful new forms, and they derive much of their value from their role as purveyors of creativity. Since they have already had a huge economic impact, Florida observes that the business results of a company determine how its workplace is organized for its creative class in the future. He also calls particularly innovative people (for example in the fields of science, engineering, education, computer programming and research) the "super-creative core". The super-creative core's work entails problem finding along with problem solving. The work that the people of the super-creative core perform goes beyond simple tasks and problem resolution. They also produce value by actually finding and then solving problems. The economic activities of this class set precedents for judgments, such as lifestyle choices, for people throughout the world. The member of an ordinary company may not be called a super-creative core because they do not have as advanced specialist knowledge as the people whom Florida called a super-creative core. But if an organization performs management while attaching great importance to knowledge, there is, to one degree or another, a creative core of members forming an internal core of value creation.

In most cases, however, management is carried out in the same way as for the other mass of members, which cannot create an environment for the members of the creative core to sufficiently show their ability. One reason for this is a lack of clarity in management methods of activating the creative core by interaction between members. Companies need to bring members who are good at knowledge work into the organization, and to let them develop their abilities as a source of competitiveness. But companies cannot know such a method at present. How should a creative core be managed?

Management Using Degree

As a clue to this, Moody had analyzed three sociological collaboration networks (from 1963 to 1999) and found that a structurally cohesive core characterizes co-authorship networks (Moody, 2004). Their structural analysis shows that in any technical field there is a core community of researchers with a cohesive strength whose research forms a dynamic force that generates new research activity. The phenomenon of a central community leading a whole network is seen in a collaboration network. It has become clear that a total collaboration network is formed by collaborative research in which a core group works together with various researchers according to the research theme.

As described in Chapter 2, the Massachusetts Institute of Technology and Helsinki University of Technology formed a virtual interdisciplinary team collaborating on a common theme. In this team, innovations rippled from the innermost COIN core to the next larger collaborative network and these had core/periphery structures with a small-world network. Their core teams formed a high-density network (Gloor, 2008). And it was recognized that important information and innovative ideas were handed down to neighboring members. In addition, their periphery was a network forming a ring around the core team, and had comparatively low density. They functioned to support the activities of the members who formed the core. Gloor observed the social network of communicating relations. But important information and innovative ideas circulate in this network. The social network was recognized by regarding collaborative activities accompanying communication acts as links, like Moody. Collaborative activity in an enterprise organization includes interactive intelligence work, making it subject to management. When collaborative activity between members is taken as a link in a social network, it can be assumed from Moody (2004) and Gloor (2008) that there is a group of members who are the core in that social network. Conversely, if a member of a creative core is not in a central position of the social network, he or she cannot produce a sufficient performance. It is necessary to perform tasks at the center of the collaboration network so that a member plays an active part as a creative core. Therefore, for a member expected to shine as a creative core, a possible managerial

approach is to provide support so that the member occupies a central position in the collaboration network.

Central positioning can be seen using the concept of degree in social network analysis. Whether a certain member has a central existence in which he or she collaborates with many other members can be understood by his or her "degree", or the number of collaboration links with neighboring members. The degree can be an index of management to mean the ability of a member to perform collaboration with neighboring members.

Management Using Size

Besides the number of links which a member in a social network has, there is an index that provides a clue for management from the perspective of ease of collaboration in a member's surrounding area. Gloor proposes the concept of "Collaborative Innovation Network (COIN)" as explained in Chapter 2 "Review of Past Research" (Gloor, 2006). This concept shows how to raise the performance of a whole organization by intelligence work, with core members of a social network as the key. There are three common steps in the COIN process outlined in their research. In the first step, a small core team learns about the idea of COIN. In the second step, the idea of COIN is shared among a larger team by increasing the number of members and their activities. In the third step, the team develops communication with outside members of a broader social network, thereby further expanding the social network. The members of this social network then communicate with one another and form a base that generates innovation.

The core team in COIN is a creative core of the enterprise organization. It is important to have a lot of collaboration links with members around a core. Regarding the members expected to be the creative core, they as well as members directly connected to them are brought together as a sub-network or "Egocentric network[46]". The ease of collaboration in the proximity of the creative core can be thought of as the "Size" of the egocentric network, the index for measuring how many links exist between members. A

[46] An egocentric network is a sub-network composed only of members who are connected by a direct tie to one particular member being focused on within a social network, and the relationships between such members.

large egocentric network means a high possibility of the collaborative activities of members functioning by connecting with neighboring collaborative activities. One approach is to regard this as a managerial index.

Besides degree and size, there are some indexes that pay attention to a certain member node and grasp the situation of the social network in his or her surroundings. The representative indexes are betweenness and density. The betweenness shows a high value when a certain member node forms a link to a low degree member node and is the positioning of a bridge between sub-networks. If the member is a key person of the enterprise organization, the characteristic of betweenness is necessary to some extent. But for a creative core, it is not necessarily an important characteristic, as shown in the review of structural holes in Chapter 2. As for density, it is an index with the total number of pairs of combinations between all members on the egocentric network as the denominator, and the size as the numerator. In essence, because the number of pairs is the power of the degree, the indexes of size and degree need to be considered in order to know the state of the creative core.

From the above discussion, the management indexes for supporting collaborative activities of the creative core are degree and size. On the basis of the theoretical consideration of communication and collaboration in Chapter 3, a necessary condition of collaboration occurrence is communication. The communication acts of members are assumed to be a clue to the management of collaboration. Therefore, the correlation between communication acts and the degree or size of the egocentric collaboration network of members is checked in the two case study companies.

In the cases of Company Y and Company D below, core member teams for creating value were chosen. With each team as a creative core, a check was done by a multiple regression analysis on whether communication acts and degree or size of collaborative activities were related. The analysis result for the following hypotheses provides a clue for developing a management method.

Hypothesis 1: A degree or size of the egocentric collaboration network of members grows large by activating communication acts of a member of a creative core.

4.1.1. Analysis 1: Creative Core of Company Y

The members of Company Y were divided into four job groups[47]. Group A was management, Group B was solution sales, group C was support staff at call centers, and group D was all others. The breakdown of each group was as follows:

Group A: 2 executives, 1 accounting manager, 2 regular accounting staff = total 5
Group B: 2 sales managers, 4 regular sales staff = total 6
Group C: 1 information system manager, 5 part-time staff at call center = total 6
Group D: 2 ex- executive advisors, 2 part-time service workers = total 4

Table 4.2 shows the quantity of communication and collaboration in each group (Count period: January 2006 to October 2007). Figure 4.1 is a relationship diagram showing the state of collaboration generation per group by the number of Thanks Cards exchanged. The number is the number of exchanged Thanks Cards, and the arrows are drawn from the issuer of the Thanks Card to the receiver. Where the number of Thanks Cards exceeds 1,000, the arrow of the exchange route is shown in bold.

Group A did work that required communication, because they sent a great deal of voice mails. This group was in a position to support the duty accomplishment of other groups, because it received Thanks Cards as a result of cooperating with the tasks of other groups. Group B had the next highest number of voice mails after Group A, and B issued Thanks Cards to other groups. This shows how Group B operated by receiving assistance from other groups. Group C had little voice mail communication but a lot of internal circulation of Thanks Cards. This is because Group C members worked within their group without using voice mail (doing routine tasks, for instance). Because Group

[47] Yuhashi et al. focused on the structural equivalence of members of the same type of job within the social network of collaboration and divided members from Company Y into groups by CONCOR (convergence of iterated correlations) (Yuhashi et al., 2008). The result was the same classification as if members of Company Y had been divided into four groups according to their type of job.

D had few voice mails and Thanks Cards, it is assumed that Group D did few tasks that create value based on connections between members.

In fact, Group B had the leading role in value creation among these four groups. Group B's sales activities were not simply selling office supplies but also proposing methods of use to their customer companies to accompany sales. Based on their expertise on office supplies, practical experience of improvement, and analyses of their customer companies, they performed proposal-style solution sales to big customers. They offered added value in a wide field, their proposal contents ranging from filing systems using office supplies to ICT system introduction and the disposal of confidential documents. Group B itself was a creative core of Company Y, the reality of its work reflected in the number of voice mails sent and Thanks Cards issued.

Table 4.2 Summary of Communication and Collaboration in Job Groups in Company Y

	The average number of voice mails sent per month	The average number of voice mails received per month	The average number of Thanks-cards sent to outside own group per month	The average number of Thanks-cards received from outside own group per month	The average number of Thanks-cards sent and received inside own group per month
Group A	49,055.8	21,474.6	795.0	597.2	974.8
Group B	25,544.8	13,322.0	616.8	329.7	623.0
Group C	9,681.3	3,738.7	1,051.5	383.3	921.2
Group D	6,076.3	6,254.3	337.3	282.3	298.8

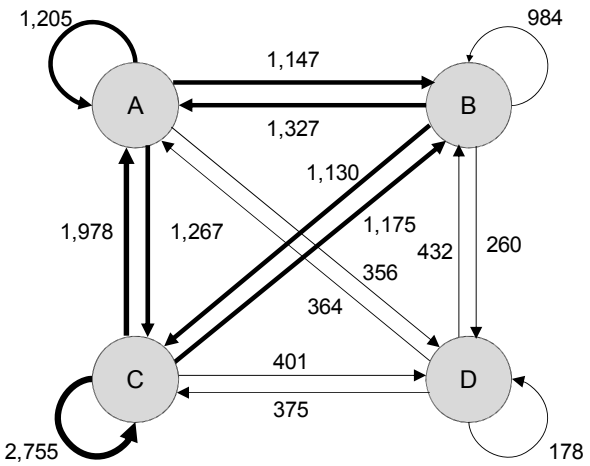


Figure 4.1 Exchange of Thanks Cards between Job Groups in Company Y

Analysis Method

The analysis attempted to clarify whether the values of degree and size of the egocentric collaboration network change together when communication acts by the creative core members of Group B increased or decreased.

At first, the numbers of voice mails sent and received from the voice mail system log data were set as explanation variables for factors that change a collaboration network. In Company Y, nearly all indirect communication between members via communication devices is done by voice mail. The use log of the voice mail system can therefore be taken to represent indirect communication. Sent voice mails and received voice mails are mutually independent variables because they are different communication acts.

Next, a collaboration network was considered in which the exchange relationships of Thanks Cards were represented in graph form. As network indexes for evaluating the positioning of creative core members, the degree and size of the egocentric network, that is, a collaboration network within one link of the member concerned, were set to be the objective variables. Degree means whether that member is in the central position of the collaboration network. If this value is high, the member will have a strong influence over other members. On the other hand, size means that the member has a lot of human resources available for his or her tasks in the collaboration network. If this index is high, the member easily shows a good performance in his or her tasks.

From the above, the explanation variables and objective variables of the analysis of Company Y were as follows:

[Explanatory Variables]

- Number of voice mails sent per month
- Number of voice mails received per month

[Objective Variables]

- Degree of egocentric network
- Size of egocentric network

Using these variables in a multiple regression analysis confirmed whether communication acts (voice mails sent and received) changed the state of the collaboration network (the degree and size of the egocentric network) around the creative core. The data collection at Company Y was done on a monthly basis for 22 months from January 2006 to October 2007. There were 6 creative core members in Group B, so the total number of monthly data records was 132. This amount of data was enough to perform a multiple regression analysis.

The regression equations of these multiple regression analyses are:

$$(Degree\ of\ egocentric\ network) = a\ (Number\ of\ voice\ mails\ sent\ per\ month) + b\ (Number\ of\ voice\ mails\ received\ per\ month) + c$$

where a and b are the regression coefficients, c is the intercept, and

$$(Size\ of\ egocentric\ network) = a'\ \ (Number\ of\ voice\ mails\ sent\ per\ month) + b'\ \ (Number\ of\ voice\ mails\ received\ per\ month) + c'$$

where a' and b' are the regression coefficients, c' is the intercept.

Analysis Results

A multiple regression analysis was conducted by the least-square method to identify the correlation between the objective variables of collaboration and the explanation variables of communication. The regression formula for the degree of the egocentric network using the two explanatory variables of number of voice mails sent per month and the number of voice mails received per month indicated 0.97, which is extremely correlative, and the multiple determination coefficient adjusted for the degrees of freedom was 0.93, so the regression formula closely matches the real data (Table 4.3). Looking at the explanation variables in Figure 4.4, the number of voice mails sent and

received has a sufficiently large absolute t value, which confirms that the explanation variables have a strong influence on the objective variables (number of voice mails sent/month: t^2=26.05>2, number of voice mails received/month: t^2=67.63>2). Because the P value (risk rate) was sufficiently small, these explanation variables were suitable (number of voice mails sent/month: P=1.67 × 10-6<0.05, number of voice mails received/month: P=1.76 × 10-13<0.05).

These results reveal that when the creative core's sent and received voice mail increases, the degree of the egocentric network becomes linked and gets higher.

The regression formula for the size of the egocentric network gave a multiple correlation coefficient of 0.95, which is strongly correlative, and the multiple determination coefficient adjusted for the degrees of freedom was 0.89, so the regression formula closely matches the real data (Table 4.5).

As for the explanation variables in Table 4.6, the number of voice mails sent and received has a sufficiently large absolute t value, which confirms that the explanation variables have a strong influence on the objective variables (number of voice mails sent/month: t2=30.82>2, number of voice mails received: t2=17.97>2). Because the P value (risk rate) was sufficiently small, these explanation variables were suitable (number of voice mails sent/month: P=1.52 × 10^{-6}<0.05, number of voice mails received/month: P=4.22 × 10^{-5}<0.05).

These results reveal that when the creative core's sent and received voice mail increases, the size of the egocentric network becomes linked and gets higher.

Table 4.3 Multiple Regression Analysis Results

of Degree of Creative Core in Company Y

	Correlation coefficient (R)	Coefficient of determination (R2)	Adjusted R2	Standard error
Degree of egocentric network	0.97	0.94	0.93	3.87

Table 4.4 Explanation Variables for Degree of Creative Core in Company Y

	Regression coefficient	Standard error	t-value	P-value
Number of voice mails sent per month	0.008	0.001	5.019	1.67E-06
Number of voice mails received per month	0.013	0.002	8.224	1.76E-13

Table 4.5 Multiple Regression Analysis Results of Size of Creative Core in Company Y

	Correlation coefficient (R)	Coefficient of determination (R2)	Adjusted R2	Standard error
Size of egocentric network	0.96	0.90	0.89	43.18

Table 4.6 Explanation Variables for Size of Creative Core in Company Y

	Regression coefficient	Standard error	t-value	P-value
Number of voice mails sent per month	0.093	0.017	5.552	1.52E-07
Number of voice mails received per month	0.075	0.018	4.239	4.22E-05

When the number of voice mails a creative core member in Company Y sends or receives is increased, the degree and size of the egocentric network grow. Therefore encouraging creative core members to aggressively send information through tasks and ensuring a smooth flow of communication information to creative core members are effective harness methods for management[48].

[48] cf. Yuhashi *et al.* (2008).

Table 4.7 Multiple Regression Analysis Results in Job Gropus in Company Y

	Degree of egocentric network		*Size of egocentric network*	
	Correlation coefficient (R)	Coefficient of determination (R2)	Correlation coefficient (R)	Coefficient of determination (R2)
Group A	0.96	0.92	0.95	0.90
Group B	0.97	0.94	0.96	0.90
Group C	0.82	0.68	0.83	0.69
Group D	0.81	0.65	0.81	0.66

For additional confirmation, it compared the positioning of Group B with other groups. Table 4.7 is the result of the multiple regression analysis about all groups. All groups showed high correlation (Group C and Group D are weak slightly). It seems that the communication of Group A strongly influences to build up the collaboration network, because Company Y is a small company. However, Group A is a management class. This research aims to activate collaborative activities at a field. Thus, the clue is the communication of Group B.

4.1.2. Analysis 2: Creative Core of Company D

Next to be considered is the case of Company D. The system integration section of Company D receives demands from their customer companies for various mobile solutions proposals. It therefore assigns appropriate members to form a project team for every request to take on the tasks of system integrations. Close communication is indispensable for the successful development of an ICT system in the project team, because members with various skills must cooperate according to customer needs.

The members of the system integration section are composed of the general manager of the section, senior managers, field managers, chief engineers, a lot of programmers, sales staff and administrative support staff. Like Company Y, the members of the system integration section in Company D are divided into four job groups. The breakdown of each group is as follows:

Group A: 1 general manager, 5 senior managers = total 6

Group B: 3 field managers, 2 chief engineers = total 5

Group C: 9 programmers = total 9

Group D: 2 sales staff, 2 administrative support staff = total 4

As for the members of this section, the general manager and senior managers were divided into Group A, field managers and chief engineers into Group B, programmers into Group C, and sales staff and administrative support staff into Group D.

The sales staff takes on the role of inputting the demands of customers to project teams which develop the ICT systems. The staffs of Group B and Group C examine the contents of proposals to customers. Indeed, their role is close to that of the administrative support staff as intermediary for tasks requested by other sections about communication acts.

Table 4.8 shows the quantity of communication and collaboration in each group. Figure 4.2 shows the relationships between all groups about expected generation of collaboration, and the thicker lines indicate where a greater number of generated collaborations are expected. There is not a large difference in the number of e-mails sent in each group (Groups A, B, C, D). The characteristic of each group appears in the number of e-mails received. Many e-mails are sent to the members of Group A by the members of other groups. The members of Group A have a lot of e-mails (reports, communications, consultations) that have been sent by the members of Groups B, C, and D, because the members of Group A have a managerial role. Group C is characteristic, too, with high numbers of e-mails sent and received because it conducts a large amount of collaboration inside and outside the group. But looking at this situation on an individual member level, they do not occupy the central position of a collaboration network. They belong to specific projects and frequently generate collaboration between the members of the same project. From this situation, the programming site of ICT system development can be thought of as being in a comparatively activated state. However, Group B, which should basically be at the core of system integration development, has a smaller numbers of e-mails sent and received and a lower expectation value for collaboration generation than the other groups. In the case of

Company D, it is envisaged that the activation of members in Group B needs to be activated.

Usually, a field manager or chief engineer of Group B is in charge of a project in Company D and, depending on the scale of the project, programmers from Group C may also join. Project members are not fixed and the formation of members varies from project to project. Multiple projects are progressing at the same time, and members participate in multiple projects during the same period. In such an environment, a field manager and a chief engineer design the main part of the system solution based on their technical knowledge and experience, and take on the role of creating added value by knowledge work. Field managers and chief engineers are considered to form the creative core because of their roles.

Table 4.8 State of Communication and Collaboration in Job Groups in Company D (first period)

	Communication		Collaboration	
	The average number of e-mails sent per week	The average number of e-mails received per week	The expected generation of collaboration outside own group	The expected generation of collaboration inside own group
Group A	79.0	121.0	928,398.0	370,129.0
Group B	62.0	39.3	462,486.0	29,978.0
Group C	73.0	69.5	608,330.0	502,648.0
Group D	69.0	30.2	999,789.0	112,490.0

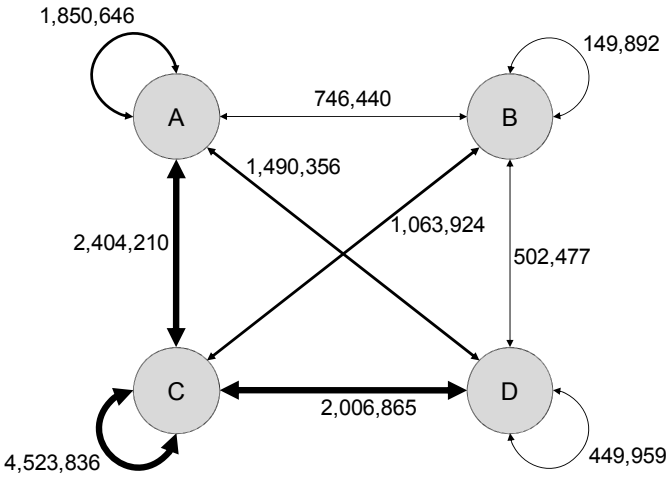


Figure 4.2 Collaboration State between Job Groups in Company D

Analysis Method

A multiple regression analysis was attempted to clarify the relationship between the communication acts and collaboration network in the creative core of Company D's system integration section. The means of communication between members in Company D is its e-mail system. The local log of the e-mail system is taken as the main data representing indirect communication between members. This local log is collected and set as the quantity of communication in explanatory variables, which are factors that change the collaboration network. Two variables are used for the weekly number of e-mails, one for sent e-mails and one for received e-mails, because they are independent communication acts.

Members were made to wear a transmitter type RFID tag. The positional information collected from these RFIDs added the characteristic of location to derive the expectation value for collaboration generation. This was used to consider the collaboration network as a graph drawn from links between members. As network indexes for evaluating the positioning of creative core members in the collaboration network, the degree and size of the egocentric network within one link of the member concerned were set to be the objective variables.

[Explanatory Variables]

- Number of e-mails sent per week
- Number of e-mails received per week

[Objective Variables]

- Degree of egocentric network
- Size of egocentric network

Using these variables in a multiple regression analysis confirmed whether communication acts (voice mails sent and received) changed the state of the collaboration network (the degree and size of the egocentric network) around the

creative core. Data collection at the company was divided into two stages. The first stage was for gathering the facts, and was for four weeks from November 23 to December 20, 2008. The second stage was a practical experiment of management methods, and was for three weeks from March 8, 2009 to March 28, 2009. In the practical experiment, the state of the collaboration network was changed by intentionally increasing the volume of creative core communications (detailed description later).

The regression equations of these multiple regression analyses are:

$$(Degree\ of\ egocentric\ network) = a\ (Number\ of\ e-mails\ sent\ per\ week) + b\ (Number\ of\ e-mails\ received\ per\ week)\ +\ c$$

where a and b are the regression coefficients, c is the intercept, and

$$(Size\ of\ egocentric\ network) = a'\ (Number\ of\ e-mails\ sent\ per\ week) + b'\ (Number\ of\ e-mails\ received\ per\ week)\ +\ c'$$

where a' and b' are the regression coefficients, c' is the intercept.

The number of data records obtained from the experiment on 5 creative core members in Company D for 7 weeks was 35, which was not sufficiently big. Therefore, using the results of a multiple regression analysis conducted by the least-square method as prior information, the confidence interval of the explanatory variables was found by a multiple regression analysis based on the Markov Chain Monte Carlo (MCMC) method of Bayesian statistics.

Analysis Results

A multiple regression analysis was conducted using the first period data (from November 23 to December 20, 2008) to identify the correlation between the objective variables of collaboration and the explanation variables of communication (Table 4.9).

The regression formula for the degree of the egocentric network using the two explanatory variables of number of e-mails sent per week and the number of e-mails received per week indicated 0.70, which is very correlative. The multiple determination coefficient adjusted for the degrees of freedom was 0.42, so here too the regression formula can be expected to match the real data.

Using this regression formula as prior information, the confidence interval of the explanatory variable was found by the MCMC method. For the number of emails sent weekly, the median value of the regression coefficient was 0.152 and the 95.0% confidence interval was from 0.040 to 0.265, which is a valid variable (Figure 4.3). Meanwhile, for the number of emails received weekly, the median value of the regression coefficient was 0.061 and the 95.0% confidence interval was from -0.228 to 0.353. This explanatory variable is not valid because the confidence interval includes zero. (Figure 4.4).

These results reveal that there was correlation between the number of e-mails sent per week by the creative core and the degree of the egocentric network.

Table 4.9 Multiple Regression Analysis Results of Degree and Size of Creative Core in Company D (First Period)

	Correlation coefficient (R)	Coefficient of determination (R2)	Adjusted R2	Standard error
Degree of egocentric network	0.70	0.49	0.42	4.46
Size of egocentric network	0.73	0.54	0.47	79.23

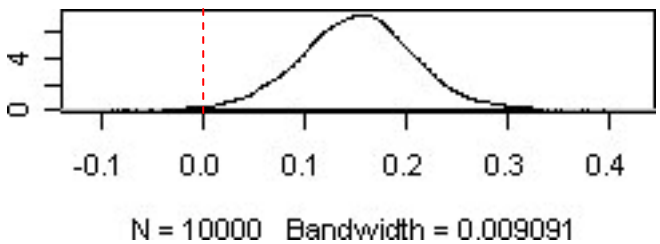


Figure 4.3 Density of Number of E-mails Sent regarding Degree of Creative Core in Company D (First Period)

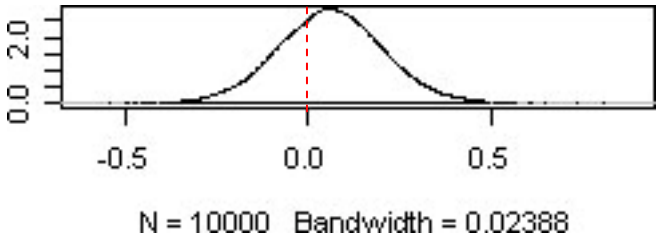


Figure 4.4 Density of Number of E-mails Received against Degree of Creative Core in Company D (First Period)

The results of the analysis of the egocentric network size showed a high multiple correlation coefficient of 0.73, and 0.47 when adjusted for degrees of freedom. The regression formula can therefore be expected to match the real data. Using this regression formula as prior information, the confidence interval of the explanatory variable was found by the MCMC method. As a result, regarding the size of the creative core egocentric networks, the median value of the regression coefficient for the number of emails sent weekly was 2.529 and the 95.0% confidence interval was from 0.656 to 4.398, which is a valid variable (Figure 4.5). For the number of emails received, meanwhile, the median value of the regression coefficient was 1.359 and the 95.0% confidence interval was from -3.443 to 6.216 (Figure 4.6). The explanatory variable of the number of emails received is not valid because the confidence interval includes zero.

These results reveal that there was correlation between the number of e-mails sent per week by the creative core and the size of the egocentric network.

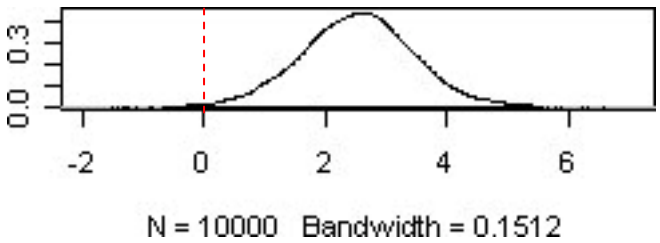


Figure 4.5 Density of Number of E-mails Sent against Size of Creative Core in Company D (First Period)

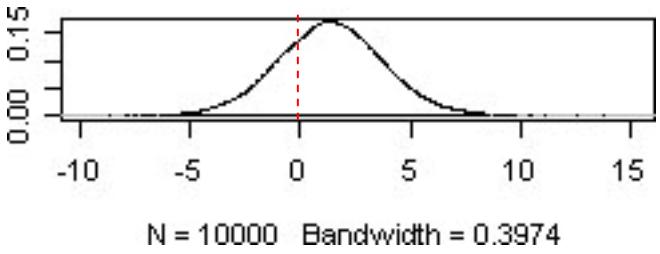


Figure 4.6 Density of Number of E-mails Received against Size of Creative Core in Company D (First Period)

Management Experiment

In the second period, from March 8 to March 28, 2009, a practical experiment was performed to verify whether the state of the collaboration network was changed by intentionally inducing communication acts among influential members by managerial involvement. To be specific, a mailing list for discussing ideas for a new mobile solution was set up and used. The system integration section's general manager increased the quantity and scope of the information about the strategy of the company organization or other linked organization for the members of the section. As a result of these two actions, the number of e-mails sent by the creative core members greatly increased, as seen in Figure 4.7. However, the number of e-mails sent fell sharply in the week of March 15. This phenomenon occurred for one week only for the specific seasonal reason of shortened working hours during that week's annual labor negotiations.

The results in Table 4.10 show the correlation between the communication acts of the creative core (the number of e-mails sent and received) and the state of the collaboration network (the degree and size of the egocentric network) through the first and second periods, as reconfirmed with a multiple regression analysis by the least-square method. The regression formula for the degree of the egocentric network using the two explanatory variables, the number of e-mails sent per week and the number of e-mails received per week, showed a multiple correlation coefficient of 0.67, which is very correlative. The multiple determination coefficient adjusted for the degrees of freedom was 0.40, so the regression formula can be expected to match the real data.

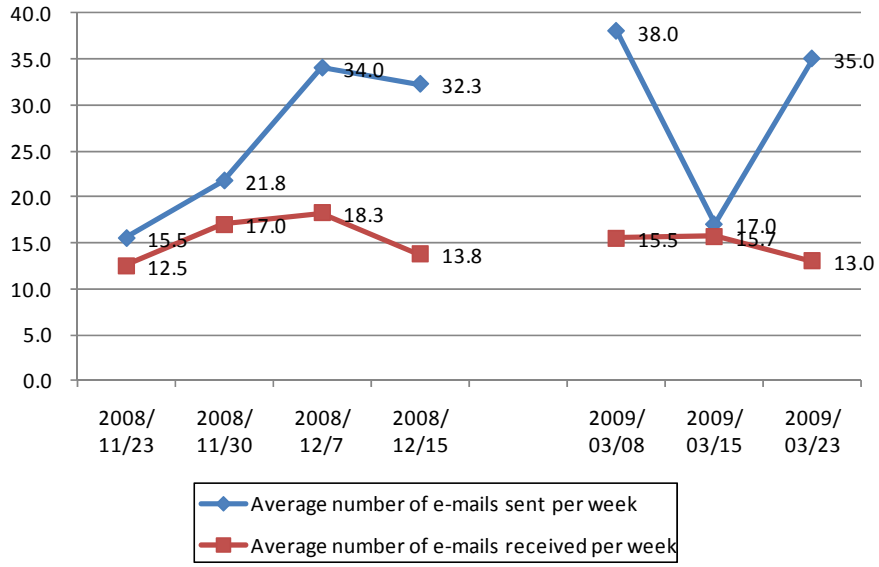


Figure 4.7 Number of E-mails Sent per Week by Creative Core

Using this regression formula as prior information, the confidence interval of the explanatory variable was found by the MCMC method. As a result, regarding the degree of the creative core egocentric networks, the median value of the regression coefficient for the number of emails sent weekly was 0.124 and the 95.0% confidence interval was from 0.036 to 0.212, so the explanation variable was valid (Figure 4.8). For the number of emails received, meanwhile, the median value of the regression coefficient was 0.112 and the 95.0% confidence interval was from -0.104 to 0.327 (Figure 4.9). As in the first period, the explanatory variable of the number of emails received is not valid because zero is included in the confidence interval.

Table 4.10 Multiple Regression Analysis Results of Degree and Size of Creative Core in Company D (First and Second Periods)

	Correlation coefficient (R)	Coefficient of determination (R2)	Adjusted R2	Standard error
Degree of egocentric network	0.67	0.45	0.40	4.98
Size of egocentric network	0.71	0.50	0.46	81.79

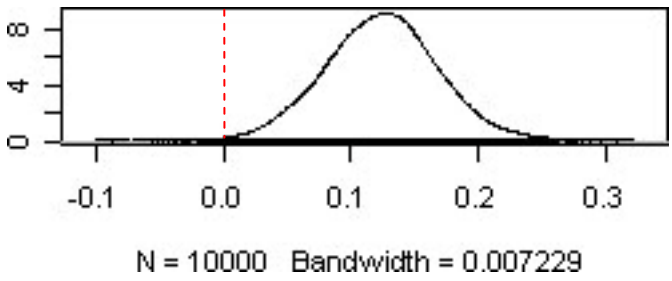


Figure 4.8 Density of Number of E-mails Sent against Degree of Creative Core in Company D (First and Second Periods)

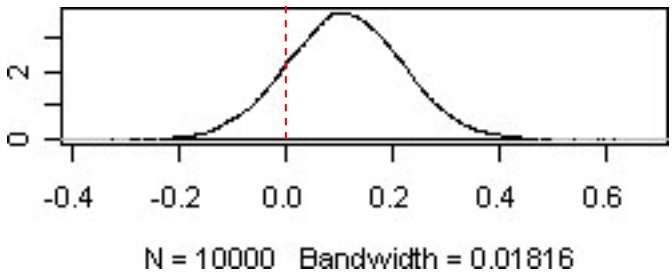


Figure 4.9 Density of Number of E-mails Received against Degree of Creative Core in Company D (First and Second Period)

The regression formula analysis produced a multiple correlation coefficient of 0.70, which indicates a high level of correlation. The multiple determination coefficient adjusted for the degrees of freedom was 0.46, so the regression formula can be expected to match the real data.

Using this regression formula as prior information, the confidence interval of the explanatory variable was found by the MCMC method. As a result, the median value of the regression coefficient for the number of emails sent weekly was 2.901 and the 95.0% confidence interval was from 0.656 to 3.549, so the explanation variable was valid (Figure 4.10). For the number of emails received, meanwhile, the median value of the regression coefficient was 2.509 and the 95.0% confidence interval was from -1.028 to 6.045 (Figure 4.11). As in the first period, the explanatory variable of the number of emails received is not valid because zero is included in the confidence interval.

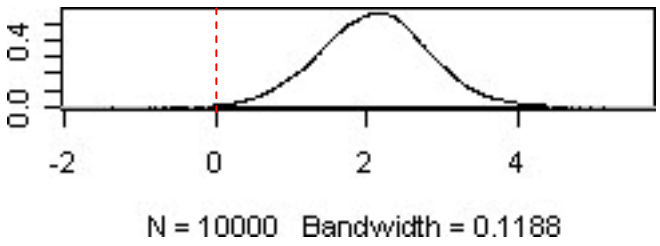


Figure 4.10 Density of Number of E-mails Sent against Size of Creative Core in Company D (First and Second Periods)

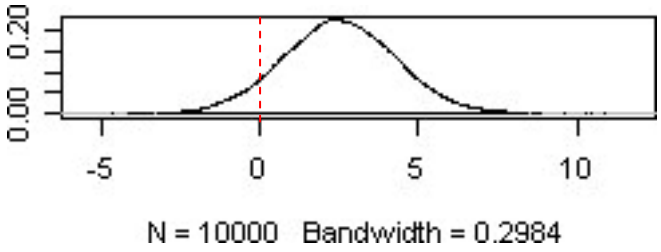


Figure 4.11 Density of Number of E-mails Received against Size of Creative Core in Company D (First and Second Periods)

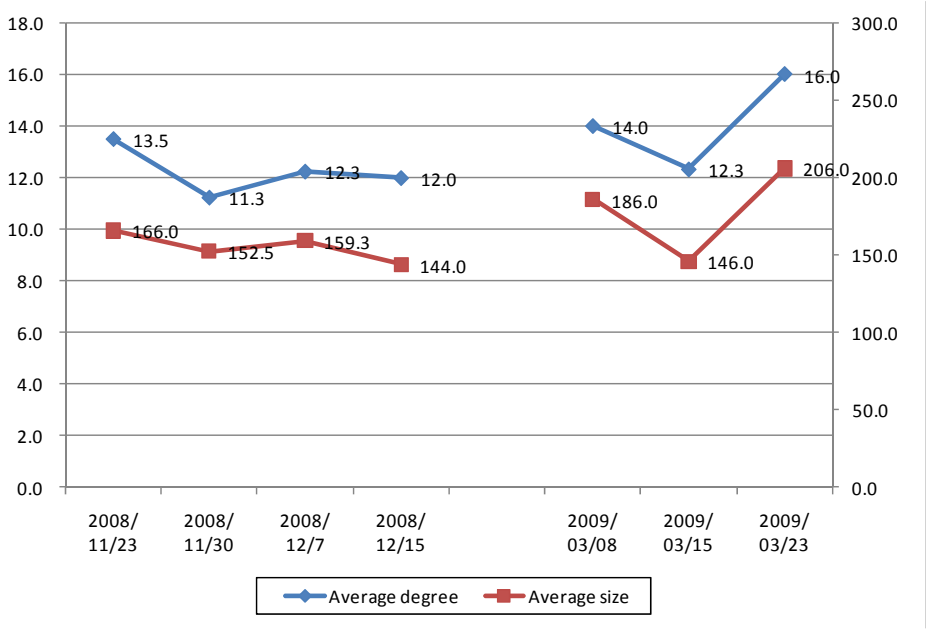


Figure 4.12 Chronological Order Change of Degree and Size of Egocentric Network

From the change in chronological order (Figure 4.12), the degree and the size of the egocentric network show higher numerical values in the second period than in the first period.

Through monitoring of the first period, a strong correlation was shown between the number of e-mails sent by the creative core members and the degree or size of the egocentric network. Through the practical experiment of the second period, it was confirmed that the number of e-mails sent functioned as a control driver which increased or decreased the degree and size[49].

Until this point, the collaboration networks of creative cores in Company Y and Company D have been analyzed. In Company Y, there was high correlation between the communication acts of the creative core members (in terms of voice mails both sent and received) and the degree and size of the egocentric networks in the collaboration network. In Company D, it was confirmed that the communication acts of the creative core members functioned as the control driver which changed the degree and size of an egocentric network. However, in the case of the creative core in Company D, the only communication act which was effective in changing the state of the egocentric network was the number of e-mails sent[50].

When seeking common points among these variables, it is necessary to go back to their communication acts because the explanation variables in both case studies are not exactly the same. The common point in both cases is that among indirect communication acts using ICT media, message transmissions are the key to changing the state of the collaboration network. In other words, a collaboration link can be formed by a creative core member communicating to other members. Such communication also promotes collaborative activities between neighboring members. For a company which wants to create competitiveness through the knowledge work of its members, an effective management method is to activate collaboration between members by

[49] The analysis of the creative core of the system integration section in Company D is reported in Yuhashi et al. (2010b).
[50] cf. Yuhashi *et al.* (2010b).

encouraging creative core members to aggressively send messages (communication acts) via ICT media. The Hypothesis 1 was proved by the above-mentioned discussion.

Table 4.11 Multiple Regression Analysis Results

in Job Gropus in Company D

	Degree of egocentric network		*Size of egocentric network*	
	Correlation coefficient (R)	Coefficient of determination (R2)	Correlation coefficient (R)	Coefficient of determination (R2)
Group A	0.85	0.73	0.74	0.54
Group B	0.70	0.49	0.73	0.54
Group C	0.38	0.15	0.35	0.12
Group D	0.98	0.96	0.90	0.82

For additional confirmation, it compared the positioning of Group B with other groups. Table 4.11 is the result of the multiple regression analysis about all groups. Group A and Group D showed high correlation. The administrative support staff of Group D supports management. And the sales staff of Group D asks Group B and group C for work from their customers side. The tasks of Group D are almost management of Group A. This research aims at activation of collaborative activities in a field. Thus, it is important for management that the correlations of Group B and Group C. Rather Group B and a difference of the group C are important. It is considered that Group B is the clue of management.

4.2. Key Person about Information Sharing

The previous section 4.1 considered a method of increasing the degree and size of an egocentric network (of a collaboration network) which supports the activities of core members who have the role of value creation. The case analysis of Company Y and Company D illustrated how the degree and size of an egocentric network were raised by the creative core members sending messages by indirect communication acts via ICT media. But even in an environment in which only the creative core members work easily, it does not mean that other neighboring members disturb such work. It is therefore necessary to consider the performance improvement of the whole organization, including members working around the creative core. This section 4.2 examines some kinds of management methods regarding the status of the collaboration network of the whole organization.

A clue to this is provided by Nishiguchi, who points out the importance of let a social network become a small world for utilizing various resources beyond the limits which members can recognize (Nishiguchi, 2007). In a company organization, the state in which a social network is a small world occurs when two phenomena occur simultaneously, (1) a high clustering coefficient of the whole network because members are connected closely within an organization, and (2) short Eigen-path lengths in the whole network, so members have close relationships with each other because relations exist between members of different sections. The members supplement each other and cope with various demands by being connected closely. Also, a response may be possible by tracing a relation between members even for a demand that is not found in ordinary tasks. Clearly in this case it is more efficient if there are few intermediaries. In this way, various resources are connected by linking communication beyond the constraints of the range recognizable by members themselves. The performance of the whole organization then improves. A company that aims for value creation through the knowledge work of its members should let a collaboration network become a small world. Specifically, however, how can the collaboration network of the whole organization be made into a small world?

The mechanism of word-of-mouth communication in the field of marketing can be used as an analogy for creating awareness of this issue. Gladwell comments that a word-of-mouth communication occurs when some members of a particular nature participate in the circulation of information (Gladwell, 2000). This mechanism of this occurrence of word-of-mouth communication resembles communication links beyond the cognitive limits of members. The details of the mechanism are as follows. First, an "maven" with a lot of communication and knowledge gets hold of original evidence of the word-of-mouth communication and becomes the starting point of information transmission. Next, a "connector" spreads the information by becoming the contact of the information exchange between a group that knows the information and another group that does not know. Then, a "salesman" with a different background from other people adds trust to that information and prompts them towards the action suggested by the information. In particular, a connector can create shortcut links in a social network depending on the information content because he or she has many directly connected acquaintances. This role contributes greatly to the formation of a small world of a social network.

If this analogy is applied to information circulation within an enterprise organization, a maven can be interpreted as being a member with abundant technical skills, knowledge and experience who conducts a large amount of communication. On the other hand, it is thought that a connector is a member with a high degree and high betweenness of an egocentric network. The numerousness of acquaintances, which is one of the characteristics of a connector, means that he or she is directly connected to many members of a collaboration network. This can be understood from the degree of the egocentric network. Furthermore, the role of bridging to a different group requires a high betweenness, which means the frequency of existence on the shortest path between any member pair in the collaboration network. It means the higher the value, the more likely mediation is between collaborative activities. But because a connector has a high betweenness even if a mediating member is at the periphery of the collaboration network, it is important that the degree is simultaneously high. Furthermore, the salesman can be interpreted as a member with a management role

who has a different perspective from ordinary members. A company creates value by moving enterprise resources with information. Particularly in knowledge work, output often exceeds the level corresponding to the skills of the members and the actual work done, and the reverse often happens, too. When the output level exceeds expectations, the collaboration generated by communication between members (information flow) has gone beyond the limitations of the individual members and added strength to the knowledge work.

The above maven, connector and salesman, who play important roles in a word-of-mouth communication event, can have their roles switched within a company organization. Managerial control over the members with these roles could possibly improve the performance of an organization. In a word-of-mouth event created in the market, the three roles of maven, connector and salesman may be taken in some cases by separate people and in other cases by only one person. In enterprise organizations, roles or positions are given to individual members and it is rare for a member to take on an important role of information circulation that exceeds his or her role or post. An enterprise organization therefore hopes its members will have the characteristics of a maven, connector or salesman. In actuality, such members are thought to influence collaborative activities of a whole organization. This dissertation calls a member with all three characteristics of maven, connector and salesman a "key person", and examines two cases to find whether there is any link to the formation of a small world in the collaboration network of a whole organization when a key person makes communication acts increase.

Below, a key person in information circulation is chosen from the members of Company Y and Company D based on conditions taken from the analogy of marketing. For the following hypotheses, the correlation between the collaboration network of the whole organization and the communication acts of the key person is also checked. Furthermore, an attempt is made to find some way of examining management methods from the analysis results of both case studies.

Hypothesis 2: A collaboration network of a whole organization changes into a small world by activating communication acts of a key person.

4.2.1. Analysis 3: Key Person of Company Y

Using the mechanism of the outbreak of a word-of-mouth communication event proposed by Gladwell as an analogy, candidates for members to take on roles similar to maven, connector and salesman were selected in Company Y. The maven's characteristic of conducting a lot of communication means that such a member will send and receive a large number of voice mails. The characteristics of abundant technical skills, knowledge and experience were understood from the accumulated number of message transmissions via the groupware. The characteristics of a connector were understood by the indexes of social network analysis. A connector is thought of as having the highest degree and the highest betweenness of egocentric network among all members in the collaboration network drawn from the Thanks Card exchange relationships. Considering the characteristics of a salesman, a condition was whether a member had a managerial post with a different perspective from ordinary members.

Table 4.12 Index List for Key Person in Company Y

	Maven			Connector		Salesman
Employee ID	Total number of voice mails sent	Total number of voice mails received	Accumulation number of comments on groupware	Total degree (in and out)	Standardization betweenness	Job position
A01	79,990	27,112	0	58	4.8	Officer
A02	13,585	27,301	6	83	7.5	Officer
A03	21,074	18,900	3	53	2.2	Manager
A04	27,014	19,385	5	90	7.9	Manager
A05	19,034	19,246	13	103	14.8	Manager
B01	6,541	15,503	2	101	17.0	Staff
B02	9,810	14,110	3	30	0.0	Staff
B03	15,589	15,763	3	70	11.0	Staff
B04	10,566	144,452	2	54	14.5	Staff
B05	16,211	15,168	2	100	3.3	Staff
B06	10,694	16,534	1	2	0.0	Staff
B07	20,680	15,991	8	62	15.2	Staff
B08	13,424	18,211	5	96	5.6	Staff
C01	8,475	5,317	0	125	15.0	Part time staff
C02	Null	4,001	0	42	3.8	Part time staff
C03	6,651	3,856	0	65	1.5	Part time staff
C04	6,558	4,075	0	43	5.9	Part time staff
D01	1	2,633	0	20	1.7	Other
D02	1,714	2,940	0	10	5.0	Other
D03	1,527	2,910	0	1	0.0	Other
D04	1,986	5,183	0	36	13.7	Other

Next, candidate members with combined characteristics of maven, connector and salesman were chosen as candidates for key person by checking the indexes established above. Table 4.12 shows the whole list with the indexes of all members regarding the characteristics of the key person in Company Y. Among the indexes related to the characteristics of maven and connector, the top 25% (top 5) are shaded. Regarding job position, those at managerial level and above were also marked. Based on the selection conditions of being within 25% of the first place in at least one category among the characteristics related to maven and connector, and being at managerial level or above, Member A04 and Member A05 were selected as key person candidates. Below, a multiple regression analysis is used to confirm whether a collaboration network forms a small world when the two key person candidates stimulate communication acts.

Analysis Method

The correlation was clarified between the explanatory variables of the communication acts of the two candidates for key person and the objective variables of the collaboration network of the whole organization in Company Y. First, as a factor in changing the collaboration network, the communication acts of the key person candidates were taken as explanation variables. The voice mail system log was taken as communication act data and the two items of "number of voice mails sent per month" and "number of voice mails received per month" were set as explanation variables. These variables are considered to be independent from each other because they are different communication acts.

Clustering coefficient and Eigen-path length are used to understand the structural characteristics of the collaboration network of the whole organization. The clustering coefficient means the density of the connection between members and the Eigen-path length means the size of the diameter of the network (See "Definitions of Technical Terms of Social Network Theory" in Chapter 1). A collaboration network is in a small world condition when clustering coefficients are high while at the same time Eigen-path lengths are short. That is why these two indexes were set as the objective variables.

[Explanatory Variables]

- Number of voice mails of key person sent per month
- Number of voice mails of key person received per month

[Objective Variables]

- Clustering coefficient of collaboration network
- Eigen-path length of collaboration network

A multiple regression analysis using these variables confirmed whether communication acts of the key person candidates (voice mails sent and received) changed the collaboration network status of the whole organization (clustering coefficient and Eigen-path length). The data collection period of Company Y was 22 months on a monthly basis from January 2006 to October 2007.

There were two key person candidates (members A04 and A05) so the total data was composed of 44 records. This was a sufficient amount of data perform a multiple regression analysis.

The regression equations of these multiple regression analyses are:

$$(Clustering\ coefficient\ of\ collaboration\ network) = a\ (Number\ of\ voice\ mails\ sent\ per\ month) + b\ (Number\ of\ voice\ mails\ received\ per\ month) + c$$

where a and b are the regression coefficients, c is the intercept, and

$$(Eigen-path\ length\ of\ collaboration\ network) = a'\ \ (Number\ of\ voice\ mails\ sent\ per\ month) + b'\ \ (Number\ of\ voice\ mails\ received\ per\ month) + c'$$

where a' and b' are the regression coefficients, c' is the intercept.

Analysis Results

Looking first at key person candidate Member A04, a multiple regression analysis by the least-square method was performed to identify the correlation between objective variables of collaboration and explanation variables of communication. The regression formula for the clustering coefficient of the collaboration network, using the two explanatory variables of sent and received voice mail, produced a multiple correlation coefficient of 0.45, which indicates a weak correlation. The multiple determination coefficient adjusted for the degrees of freedom was 0.12, so the regression formula does not match the real data well. Meanwhile, the regression formula for the Eigen-path length of the collaboration network produced a multiple correlation coefficient of 0.22, which indicates an extremely weak correlation, and the multiple determination coefficient adjusted for the degrees of freedom was -0.05, so the regression formula does not match the real data at all (Table 4.13). In other words, Member A04 was a key person candidate for information circulation, but actually did not have correlation because his or her communication acts do not change the state of the collaboration network of the whole organization. For this reason, Member A04 is not the key person.

Table 4.13 Multiple Regression Analysis Results of Clustering Coefficient and Eigen-path Length of Key Person Candidate Member A04 in Company Y

	Correlation coefficient (R)	Coefficient of determination (R2)	Adjusted R2	Standard error
Clustering coefficient of collaboration network	0.45	0.21	0.12	0.32
Eigen-path length of collaboration network	0.22	0.05	-0.05	0.12

The correlation between communication and collaboration was also checked for key person candidate Member A05. A multiple regression analysis on the clustering coefficient of the collaboration network produced a multiple correlation coefficient of 0.47, which indicates a weak correlation. The multiple determination coefficient adjusted for the degrees of freedom was 0.14, so the regression formula does not match the real

data well. Meanwhile, the regression formula for the Eigen-path length of the collaboration network produced a multiple correlation coefficient of 0.59, which indicates a certain amount of correlation, but the multiple determination coefficient adjusted for the degrees of freedom was 0.27, so the regression formula does not match the real data so well (Table 4.14).

Although these results showed weak correlation, the values of the multiple determination coefficients adjusted for the degrees of freedom in the multiple regression analysis of the two key person candidates were the highest combination. After further checking of the explanatory variables (Table 4.15), it was found that the explanatory variables influence the objective variables because the absolute t-values are large enough for the numbers of voice mails both sent and received (number of voice mails sent per month: t^2=8.82>2, number of voice mails received per month: t^2=2.57>2). But the number of voice mails received per month is invalid as an explanatory variable because the P-value (risk rate) is too large (number of voice mails sent per month: P=0.008<0.05, number of voice mails received per month: P=0.125>0.05).

The above analysis was unable to provide sufficient correlation that could be utilized to find a management approach in the case of Company Y. In a similar multiple regression analysis, however, Yuhashi *et al.* (2009) checked for correlation in four explanatory variables, adding "accumulated usage time of the voice mail system per month" and "number of times logged on to the voice mail system per month" to the above "number of voice mails sent per month" and "number of voice mails received per month". As a result, the regression formula for the Eigen-path length of Member A05 produced a multiple correlation coefficient of 0.81, which is strongly correlative, while the multiple determination coefficient adjusted for the degrees of freedom was 0.57, so the regression formula closely matches the real data. Also, a comparison of the standardization partial regression coefficients of the explanatory variables confirmed that the accumulated usage time of the voice mail system per month and the number of voice mails received per month were the main factors.

In other words, when the explanatory variables[51] were increased, a high correlation was achieved by the regression formula for Eigen-path length. However, because the purpose of this dissertation is to seek the common points between Company Y and Company D, the numbers of mails sent and received (which is common to the system of both companies) is taken to represent communication acts. We already know based on past research that it is possible to shorten the Eigen-path length of a collaboration network via the number of voice mails received by the key person in Company Y. In addition, we will look afresh for a clue to management by an analysis of the key person in Company D[52].

Table 4.14 Multiple Regression Analysis Results of Clustering Coefficient and Eigen-path Length of Key Person Candidate Member A05 in Company Y

	Correlation coefficient (R)	Coefficient of determination (R2)	Adjusted R2	Standard error
Clustering coefficient of collaboration network	0.47	0.22	0.14	0.32
Eigen-path length of collaboration network	0.59	0.34	0.27	0.10

Table 4.15 Explanatory Variables for Eigen-path Length of Key Person Candidate Member A05 in Company Y

	Regression coefficient	Standard error	t-value	P-value
Number of voice mails sent per month	0.00061	0.00021	2.96912	7.88E-03
Number of voice mails received per month	-0.00035	0.00022	-1.60383	1.25E-01

[51] Although the use of e-mail in Company D resembles the use of voice mail in Company Y, differences in the specifications of these systems mean the data that can be collected is different.
[52] cf. Yuhashi *et al.* (2009a).

4.2.2. Analysis 4: Key Person of Company D

Moving on from Company Y to Company D, using the mechanism of the outbreak of a word-of-mouth communication event as an analogy, candidates for members to take on roles similar to maven, connector and salesman were selected in the system integration section. The maven's characteristic of conducting a lot of communication means that such a member will send and receive a large number of e-mails, and the characteristic of abundant technical skills was understood from the length of his or her development experience in ICT systems. The knowledge required to be the key person does not simply mean a lot of technical information but includes the wisdom of knowing how to implement technology in system integration, and so experience as an engineer is important. Candidates were therefore asked to give the length of their experience in ICT system development as an engineer by selecting one of five lengths (from "less than 1 year" and increasing in three-year increments to "11 years or more"). Like Company Y, the characteristics of a connector were understood by the indexes of social network analysis. A connector was thought of as having the highest degree and the highest betweenness among the egocentric networks centered around on the key person candidate members. The characteristics of a salesman reflect his or her position and so this person was taken to be a manager with a different perspective from ordinary members.

Using data from the first period (from November 23 to December 20, 2008), the key person characteristics of all members are listed in Table 4.16. For each item, the top 25% (up to the 6^{th} position) are shaded darkly and the remainders of the top 45% (up to the 11th position) are shaded lightly. Because no members fell within the same selection conditions as Company Y (within 25% of the first place), the selection conditions were being within 45% of the first place in all characteristics related to maven and connector, and being at managerial level or above. Based on this, members A'02 and A'03 were selected as key person candidates expected to take on the roles of maven, connector and salesman. However, because Member A'03 was absent on a long-term business trip during the second period, this dissertation only performs the following analysis on member A'02. In addition, Member A'05 showed comparatively good index values for all

the roles of maven, connector and salesman. But Member A'05, who had an average degree and high betweenness, was located towards the periphery of the collaboration network. An interview with the general manager revealed that the member had advanced technical skills and abundant experience in ICT system development but was something of a loner. From such qualitative information and the analysis data, Member A'05 was therefore not considered as a key person candidate.

Table 4.16 Index List for Key Person in Company D

	Maven			Connector		Salesman
Employee ID	Average number of e-mails sent per week	Average number of e-mails received per week	Years of experience of system engineer	Degree	Betweenness	Job position
A'01	4.6	29.5	More than 11 years	280	6.70	General manager
A'02	31.1	43.8	More than 11 years	264	4.20	Manager
A'03	39.6	78.6	More than 11 years	282	5.53	Manager
A'04	29.8	87.8	2 – 4 years	200	0.50	Manager
A'05	102.3	78.0	More than 11 years	214	3.07	Manager
B'01	57.3	13.3	More than 11 years	182	0.00	Field manager / Chief engineer
B'02	8.1	9.1	More than 11 years	6	3.00	Field manager / Chief engineer
B'03	31.6	22.4	No answer	Null	Null	Field manager / Chief engineer
B'04	53.8	35.5	5 – 7 years	276	1.37	Field manager / Chief engineer
B'05	12.0	23.0	More than 11 years	182	0.00	Field manager / Chief engineer
C'01	60.9	16.6	5 – 7 years	280	6.70	Field manager / Chief engineer
C'02	15.3	11.1	8–10 years	258	0.53	Staff
C'03	10.3	8.6	Less than 1 year	276	1.37	Staff
C'04	5.8	10.4	More than 11 years	90	0.00	Staff
C'05	38.9	9.6	More than 11 years	276	1.37	Staff
C'06	17.9	8.9	2 – 4 years	276	1.37	Staff
C'07	30.4	17.3	5 – 7 years	282	5.53	Staff
C'08	23.4	5.6	8 – 10 years	258	0.53	Staff
C'09	20.3	23.1	More than 11 years	0	0.00	Staff
D'01	98.8	27.4	2 – 4 years	182	0.00	Field manager / Chief engineer
D'02	45.4	17.3	Less than 1 year	258	0.53	Staff
D'03	33.0	7.8	Less than 1 year	280	6.70	Temporary employee
D'04	4.1	27.0	5 – 7 years	12	0.00	Temporary employee

Analysis Method

To clarify the correlation between the communication acts of the key person candidate member and structural characteristic of the collaboration network in Company D, explanatory variables and objective variables were set. First, regarding the communication acts, the local logs of all members were gathered from the e-mail application and the amount of indirect communication via ICT media measured. As factors in changing the collaboration network, the "number of e-mails sent per week" and "number of e-mails received per week" were taken as explanation variables.

Members also wore transmitter RFID tags from which positional information was collected, so the characteristic of location could be added and the expectation value for collaboration generation derived. The network was displayed by using this expectation value for collaboration generation as the data of links. To understand the structural characteristics of the collaboration network of the whole organization, the clustering coefficient and the Eigen-path length from social network theory were set as the objective variables. When these indexes are both high, it means the collaboration network is in a small world condition.

[Explanatory Variables]

- Number of e-mails of key person sent per week
- Number of e-mails of key person received per week

[Objective variables]

- Clustering coefficient of collaboration network
- Eigen-path length of collaboration network

A multiple regression analysis using these variables confirmed whether communication acts of the key person candidate (voice mails sent and received) changed the collaboration network status of the whole organization (clustering coefficient and Eigen-path length). Data collection at the company was divided into two stages. The first stage was for gathering the facts, and was for four weeks from

November 23 to December 20, 2008. The second stage was a practical experiment of management methods, and was for three weeks from March 8, 2009 to March 28, 2009. In the practical experiment, managerial measures were taken to try to increase the volume of communications among core members (Details in analysis 2).

The regression equations of these multiple regression analyses are:

$$(Clustering\ coefficient\ of\ collaboration\ network) = a\ (Number\ of\ e-mails\ of\ key\ person\ sent\ per\ week) + b\ (Number\ of\ e-mails\ of\ key\ person\ received\ per\ week) + c$$

where a and b are the regression coefficients, c is the intercept, and

$$(Eigen-path\ length\ of\ collaboration\ network) = a'\ (Number\ of\ e-mails\ of\ key\ person\ sent\ per\ week) + b'\ (Number\ of\ e-mails\ of\ key\ person\ received\ per\ week) + c'$$

where a' and b' are the regression coefficients, c' is the intercept.

Because the total data gathering period in Company D was seven weeks and there was one key person candidate, there were seven data records, which is insufficient data to confirm correlation. An analysis of only the data from the first four-week period would have been meaningless, so it was decided to conduct the key person analysis in Company D using the seven weeks' data (first and second periods combined). Initially, a multiple regression analysis was conducted by the least-square method, the results from which were then used as prior information in a multiple regression analysis based on the MCMC method of Bayesian statistics to find the confidence interval of the explanatory variables.

Analysis Results

Looking at key person candidate Member A'02, a multiple regression analysis was performed using the data from the first and second periods to identify the correlation

between objective variables of collaboration and explanation variables of communication (Table 4.17). The regression formula for the clustering coefficient of the collaboration network, using two variables of number of emails sent weekly and number of emails received weekly as prior information, produced a multiple correlation coefficient of 0.499, and the multiple determination coefficient adjusted for the degrees of freedom was -0.126, so the regression formula cannot be expected to match the real data.

On the other hand, the regression formula analysis of the Eigen-path length of the collaboration network produced a high multiple correlation coefficient of 0.911, which is strongly correlative. The multiple determination coefficient when adjusted for degrees of freedom was 0.746, so the regression formula can be expected to match the real data.

Table 4.17 Multiple Regression Analysis Results of Clustering Coefficient and Eigen-path Length of Key Person Candidate Member A05 in Company D (First and Second Periods)

	Correlation coefficient (R)	Coefficient of determination (R2)	Adjusted R2	Standard error
Clustering coefficient of collaboration network	0.499	0.249	−0.126	0.019
Eigen−path length of collaboration network	0.911	0.831	0.746	0.053

Using the regression formula for the Eigen-path length of the collaboration network of the whole organization as prior information, the confidence interval of the explanatory variables was found by the MCMC method. As a result, the median value of the regression coefficient for the number of emails sent weekly was -0.003165, and the 95.0% confidence interval was from -0.004983 to 0.01107. Because the confidence interval includes 0, this explanatory variable is not valid (Figure. 4.13). On the other hand, the median value of the regression coefficient for the number of emails received weekly was 0.007792 and the 95.0% confidence interval was from 0.002762 to 0.02396, which means this explanatory variable is valid (Figure 4.14). The above result

demonstrates that the Eigen-path length of the collaboration network grows short when number of e-mails received by the key person candidate Member A'02 increased.

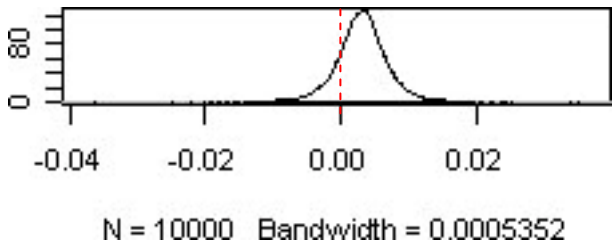


Figure 4.13 Density of Number of E-mails Sent against Eigen-path Length for Candidate Member A'02 in Company D (First and Second Period)

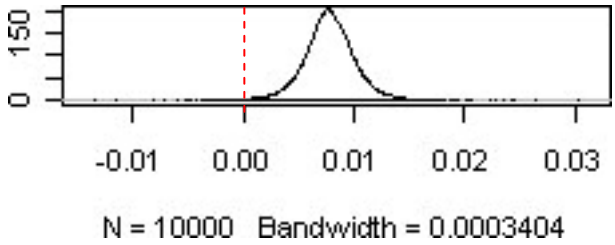


Figure 4.14 Density of Number of E-mails Received against Eigen-path Length for Candidate Member A'02 in Company D (First and Second Period)

Member A'02 was also interviewed to qualitatively check the content and intent of his or her communication acts in the office. This interview revealed that the member intentionally separated communication into two roles, one from the perspective of supervisor in system integration projects and the other from the perspective of following the general manager. The tasks of system integration projects are accomplished by a leader from middle management such as a field manager or a chief engineer. Member A'02 had a senior managerial post which is higher than such middle management, and has responsibility for ICT system development projects for customers. In this role, he or she is careful to try to communicate closely with internal members of projects.

This department's formal general manager is another member, but Member A'02 has the No. 2 post within the organization. Thus, Member A'02 behaves as a substitute for the general manager in the organization. To be specific, Member A'02 introduces market trend information and information on the system integration business from other

sections to the other members. Even on projects in which Member A'02 is not directly involved, he or she provides coaching to the field manager and chief engineer based on his or her own experience. Even if a member who is not a key person exists at the core of the collaboration network, his or her communication acts will not necessarily influence the collaborative activities of the whole organization. Communication intended to encourage the whole organization such as by Member A'02 has the power to change the structure of the collaboration network. He or she can also be expected to take action such as following up on tasks subsequent to communication by other members who do not have such awareness of contributing to the company as a whole. Indeed, Member A'02 is the key person of the system integration section and exerts influence on the whole organization by behavior based on an awareness of holding the No. 2 post of this section[53].

Until this point, the relationship between the communication acts of the key person and the collaboration network of the whole organization has been analyzed in the cases of Company Y and Company D. In Company Y, the correlation was weak so only the possibility of correlation between the quantity of voice mail received by the key person and the Eigen-path length of the collaboration network can be pointed out. The results of the analysis of Company D, however, showed a strong correlation. The Eigen-path length of the collaboration network of the whole organization shortened as the number of e-mails to the key person from other members increased. By shortening its Eigen-path length, an organization can link its collaborative activities and expect enhanced performance. However, message receiving in communication is not a voluntary action by the key person himself or herself, and is therefore called a control driver in which is difficult for management to participate. The specific management method should therefore be to build a system of information circulation and shape its operation, such as by giving the key person a role that makes it easier for the members

[53] The analysis of the key person of the system integration section in Company D is reported in Yuhashi et al. (2010a).

within an organization to communicate. Than the above-mentioned argument, the Hypothesis 2 had possibility to some extent.

4.3. Review of Management Methods

Invested capital and member ability alone do not necessarily produce business results for an enterprise organization. The performance of each member in a company, which is a premise of corporate performance, is influenced by the structural characteristics of the social network. Companies in particular need to bring collaboration relations leading to knowledge work into the realm of management in order to adapt to future markets. Therefore a method of management that can be considered is getting involved in the communication acts of members when collaboration is generated. A level of competitiveness greater than that of the total output of individual members is produced by exchanging knowledge, information and data through communication in an organization and by activating collaboration using members' expertise and individuality. However, this requires a management method that visualizes and takes into account the state of collaboration being generated within the organization.

This chapter has attempted some analysis of this point. The analysis of creative cores in section 4.1 revealed that a central member group that creates value by knowledge work can expand their range of connection (or degree) within a collaboration network and increase the links with neighboring members (size) by increasing their messages sent by indirect communication using ICT media. A management method aimed at activating the communication of such creative core members could be effective.

On the other hand, it is desirable for a collaboration network to be in the condition of a small world in order for organizational performance to be improved by knowledge work. In section 4.2 Key Person, members were chosen as candidates to be the key person on information circulation. It was confirmed that increasing the quantity of communication to the key person was linked to the shortening of the Eigen-path length of the collaboration network of the whole organization. A possible management method was shown of making the collaboration network of the whole organization more compact via the communication acts of the key person. It could be effective to create a system of operational rules and improvements on information flow in order to make it easier for ordinary members to communicate to the key person. Continually maintaining a state in

which collaboration can easily be generated through communication acts performed to the key person leads to sustained competitiveness.

It is difficult to visualize a state in which in which collaboration is easily generated and to conduct management on that basis of that state. This dissertation does not go so far as to evaluate the influence of such an approach. But, it proposed the management method arrived at by these analyses to the president of Company Y and the general manager of Company D, and got the following evaluations.

[Comments of the president of Company Y]

I understood the proposal of forming a human relation around him / her by activating a message sent of a member of a creative core. Actually, a member who takes neighboring members in his / her work can expect growth. In addition, it is the same as the recognition of the manager to have chosen member A04 as a key person. The member concerned is the middle manager of accounting and information, but his / her behavior is not a watchdog usually.

However, there is a point that it should pay attention to measure an organized performance by Thanks-Cards. It carried out exchanging thanks-cards for motivation improvement of the member. The exchanging Thanks-cards is not directly connected with sales and profit of company. The acquisition number of Thanks-cards is one of the job performance evaluation indexes. However, there is an actual situation that a short-term business quota must be given priority in the small company.

[Comments of the general manager of Company D]

An organization's Members who are hoped to become a creative core are replaced by exchanging staffs between organizations in the big company organization. For such a member, coaching from the experience is performed till now. But in future, grasping and assessing a positioning of a member may support to develop a creative core member.

On the other hand, it understood that an organizational performance deteriorated from experience by ordering many reports and routine tasks to a key person.

Therefore, after adequately offering information from a general manager to a key person, it had better leave the real tasks to discretion of a key person. In addition, the suggestion that had better share information from other members (not only general manager) to a key person is an interesting management method.

The research calculated outbreak expectation of collaboration from the positional information of members in the office. It was surprising that the collaboration network of the calculation result reflected the actual situation of duties in detail. Because a structure to make competitiveness was visualized, a mobile solution can be produced by a collaboration network.

From evaluations of such company organizations' top managements, it confirmed that a management method made from the analyses of this chapter was proper.

From evaluations of such company organizations' top managements, it confirmed that a management method made from the analyses of this chapter was proper. It does suggest that there are management methods for affecting the status of a collaboration network by harnessing the communication acts of its creative core or key person.

5. Management Approach Focusing on Relations between Members

Chapter 4 looked at management methods from a member-orientated approach to facilitate the generation of collaboration within an organization. The aim was to achieve a state called a “small world” where members of a collaboration network are mutually connected by short personal paths, or in other words, where there is both a structurally high clustering coefficient together with short Eigen-path lengths.

But while an organization should aim to turn its collaboration network into a small world, it would be difficult for local managers to accept a management method that did not consider the quality of the relationships between members on the premise that all the nodes were members with the same abilities. Indeed funneling work to highly skilled members is more likely to produce short-term results. However, if tasks are continually allocated to fixed personnel combinations, in the long term only the highly skilled members will further expand their skills, or they will become exhausted due to overwork. On the other hand, members with lower skill levels will not be given the opportunity to develop. Then the problem arises that such members could lose their motivation because they cannot feel they are developing.

Behind such short-sighted management lies another fact that no method has been presented for combining theoretically backed and suitable personnel in the running a network organization. Based on case study analysis, this chapter examines management methods for theoretically understanding the effects of personnel combinations and introducing those effects into the operation of the organization.

5.1. Method Development for Maintenance of Links

5.1.1. Communication and Collaboration in Multilateral Relationships

According to Evans *et al.*, the ease or difficulty of generating collaboration is affected by the necessary cost of conducting communication in relations between members and the amount of communication in those relations (Evans *et al.*, 2005). To harness the generation of collaboration from a management perspective, therefore, requires prior understanding of the nature of relations between members.

Chapter 3 examined the relationship between communication and collaboration, but most previous research assumed communication was two-way and developed arguments that ignored the influence of a third-party in the background or other connected members. However, in the operation process of an enterprise organization, communication is performed on a daily basis within relationships of three or more people, and the possibility of a third person becoming involved in the communication of a two-person relationship cannot be eliminated. It is therefore necessary to look at collaboration arising from communication in relations of three or more people.

In this research which focuses on relations between members, the present chapter examines the following two points: (1) understanding the nature of individual relations, and (2) understanding the conditions for generating collaboration from communication in relationships of three or more people. In general, interaction such as collaboration is more likely to happen between a pair with similar social or cultural attributes such as gender, age, or economic class, or similar mentalities (Heider, 1946; McPherson *et al.*, 1992). On this tendency, based on the discussion about the unbalance of a two-person relationship (Harary, 1646; Cartwright *et al.*, 1956), Rapoport has developed an argument about triadic relationships within social network theory called the “theory of similarity” (Rapoport, 1953). The theory of similarity develops the phenomenon in triadic relationships of “triadic closure,” where two strangers meeting through a shared acquaintance become acquaintances themselves. Taking people as nodes, a triadic relationship is a network with one link between each node and each other node. Rapoport *et al.* empirically confirm this tendency towards a triadic closure with their study of personal associations among secondary school pupils which shows that in fact

"the friend of a friend is a friend," (Rapoport *et al.*, 1961). According to Yasuda, while a two-way relationship is a mutual relationship between individuals, in a triadic relationship a third person is added who can take an objective stance. He states that the existence of such a third person makes the people involved in the two-way relationship aware of their social conduct (Yasuda, 1997, 2001). If this is a triadic closure of positive relations linked by the theory of similarity, a socially stable group[54] is formed, which we can say is the preferred state of an enterprise organization.

Axelrod also points out the tendency for people to communicate more easily with each other when they share a level of social and cultural attributes, and for two people's shared attributes to increase as they communicate (Axelrod, 1997). If this is a relationship of three or more people, frequent communication along their intermediary nodes leads to a state in which their attributes come to resemble each another and a previously non-existent relationship emerges.

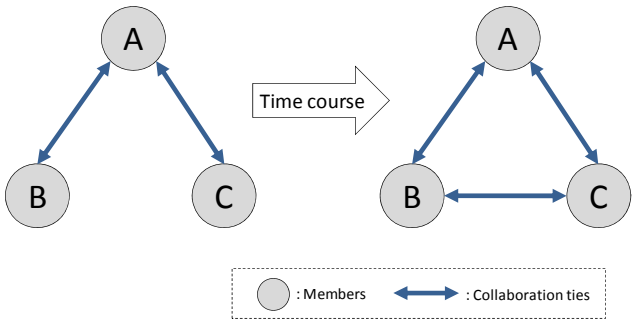


Figure 5.1 Formation of Triadic Closure

The formation of a triadic closure in a collaboration network is shown below in Figure 5.1. First, in the initial status (left side of Figure 5.1) two collaboration links extend from member node A to the two end member nodes B and C. Member node B communicates with member node A and so their mutually shared attributes increase. Meanwhile, member node C also communicates with member node A, thereby increasing the shared attributes of those two. Eventually the attributes of the two end member notes B and C, connected via member node A, come to resemble each other. Then

[54] An unstable group is in a state of combined positive and negative human relations, such as a love triangle.

communication is conducted in a relationship between the two end member nodes B and C, and before long a new collaboration link is formed (right side of Figure 5.1).

In a company, Axelrod's point about shared attributes being increased by communication is not a phenomenon limited to direct communication between two people but can occur in daily business life as a result of larger meetings, messages from a third party, rumors within the organization, and so on. In other words, the formation of collaboration links resulting from communication in triadic relationships can also occur in four-way or five-way relationships.

5.1.2. Management and k-hop Closure Link Incidence Rate

Iba argues that due to the occurrence of a “communication chain”, where one communication is stimulated by the previous communication and then leads to the next communication, human activities associated with the information content and communication increase and the direction of collaboration of the group is formed (Iba, 2006). Based on Iba’s argument, the trend of triadic closure discussed by Rapoport *et al.* does not stop at the triadic relationship but, because of the communication chain, spreads beyond (to a fourth person, then a fifth person, and so on). Gloor *et al.* also observe the spread of innovation produced by core members of a social network in an observed case study to nearby members via communication (Gloor *et al.*, 2008). In other words, the phenomenon probably proceeds thus: “A task within a collaboration network is performed centered around relations with a relatively low communication cost. Next, that communication becomes linked making collaboration more likely to occur in neighboring relations.” Conversely, since relations that do not generate much collaboration on a daily basis have a relatively high communication cost, those relations themselves or other neighboring relations may hamper collaboration.

Collaborative links for more easily produced when members have similar social and cultural attributes or similar mentalities. Shared attributes are increased by communication so collaborative links are formed as a consequence of communication. Apart from direct communication between the people concerned, people can also increase their similarities in indirect communication through a third party. In other words, the previously discussed concept of closure in a triadic relationship can also be used to reveal the degree of surrounding influence of the attributes of a specific relation, even with a relationship of four or more people. To be more specific, by focusing on a particular inter-member relation and finding the extent to which links have been formed by its closure of surrounding relations, it may be possible to determine whether that relation has a positive surrounding effect on collaboration generation due to its low communication cost or a negative surrounding effect on collaboration because of its high communication cost.

There are qualitative differences between individual relations which emerge depending on member combinations. In a network organization that combines the most suitable personnel for its tasks, relations with the easiest communication are placed at the core of a task to enable the smooth flow of information between the members handling that task. Avoiding relations with difficult communication when allocating a task can also reduce the possibility of conflict among the members handling that task. A possible management method for very important tasks would be to accelerate collaboration organizationally by combining multiple relations that have low communication costs and easily produce collaboration rather than simply using the qualities of a single relation.

Regarding the above idea, if a numerical index for the ease of generation of collaboration could be obtained, it would enable a study of ways of activating collaboration based on the nature of individual relations. Triadic closure means when the situation called a “3-clique” is reached, when the end nodes of two connected links in a social network become joined by another link (a complete sub-network in which the edges between nodes in a network are all connected). Here, we focus on a specific relation and consider a triadic relationship in which one more arbitrary member other than the members at the ends of that relation is added. By fixing the focal relation that is focused on and adding another member, all combinations of members are investigated to see whether a triangle with the three nodes of a triadic relationship at its apexes has been closed by a link. This expresses the degree of ease with which the relation being focused on forms a triadic closure. Furthermore, extending it to relationships between four, five, or more people may reveal the extent of the influence the relation has on its surroundings.

Given this perspective, a definition of the “k-hop closure link incidence rate” numerical index that can evaluate the nature of a relation is given below. The k-hop closure link incidence rate is an index focusing on a specific combination of members of a collaboration network within an enterprise organization which enables the existence of a closure link around that relation to be confirmed.

Definition of k-hop Closure Link Incidence Rate

By focusing on a specific relation between members of a collaboration network within an enterprise organization and confirming the existence of a closure link around that relation, the kind of effect the nature of individual links have around them can be determined. This index is called the k-hop closure link incidence rate and is defined below.

First, we focus on the relation between members X_0-Y_0. When $(v_i, v_j) \in E$, v_i and v_j are adjacent (Figure 5.2). In the apex pair (v, v'), the connection along the line of adjacent apexes from v to v' is called a path. Here we introduce the notation for paths. If there is a path from node $X_0 \ldots X_l$, that is to say, when the following are satisfied:

where $0 \leqq i < l$ and i is arbitrary, $(X_i, X_{i+1}) \in E$

where $0 \leqq i,j < l$ and l and j are arbitrary, $X_i \neq X_j$ if $i \neq j$

this path is represented by the connection of those nodes $X_0 \ldots X_l$. However, E is the aggregate of links in the given network.

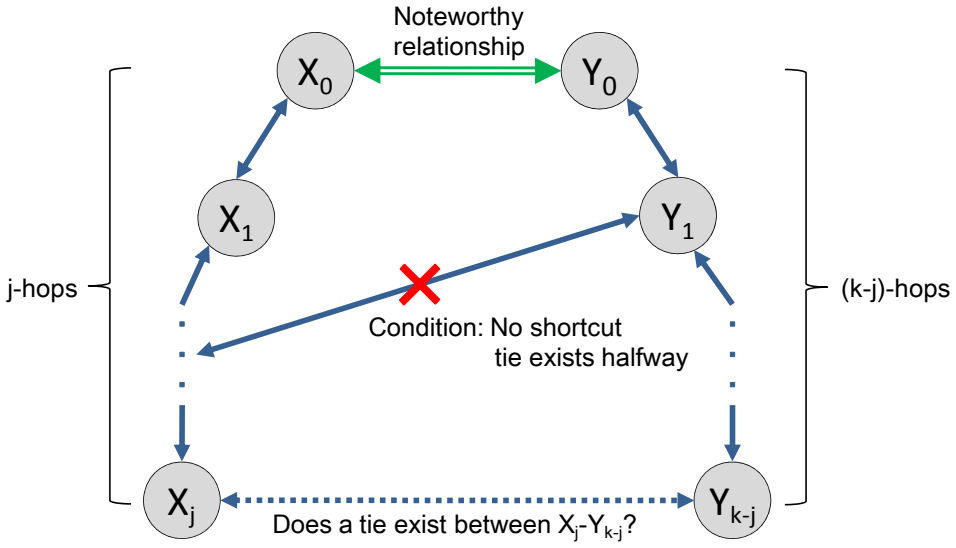


Figure 5.2 K-hop Closure Link

The following two concepts between the two paths at this time are defined.

Definition 1. Mutual independence

For path $X_0...X_{l\ and\ path}\ Y_0 \cdot \cdot \cdot Y_{k-l}$ to be *mutually independent*, the following conditions must be met.

1) There is no overlapping between nodes. In other words, $\{X_0,\ldots,X_l\} \cap \{Y_0,\ldots,Y_{k-l}\} = \varphi$
2) There is no short$_c$ut b$_e$twee$_n$ $X_{0\ldots Xl}$ and $Y_0...Y_{k-l}$. In other words, for an arbitrary $0 \leqq i<l$ and $0 \leqq j<k-l$, $(X_i, Y_j) \notin E$

Definition 2. End connectivity

If the paths $X_0...X_{l\ and}\ Y_0 \cdot \cdot \cdot Y_{k-l}$ have end connectivity, there is a link at the end of a path. That is to say, $(X_l, Y_{k-l}) \in E)$ is satisfied.

In a network, the number of sides included in a path is called the path length (usually considered to be when the concentration of apexes included in a path is at a minimum).

$$L(v, v') = |\{E \mid (v, v_1, v_2, ..., v') \in E\}|$$

The number of links between nodes is counted in units called hops. As illustrated in Figure 5.2, a node connected from node X_0 by a collaboration link of 1 hop is called X_1, a node connected by 2 hops is called X_2, and a node connected by i hops if called X_i.

Where there is mutual independence between path $X_0 X_1 \ldots X_l$ connected by a link from node X_0 to X_l and path $Y_0 Y_1 \ldots Y_{k-l}$ and a collaboration link exists between node X_l connected l hops from node X_0 by a collaboration link and node Y_{k-l} connected (k-l) hops from node X_0 by a collaboration link, that is to say, if end connectivity between the paths is met (definition 2), the link between node X_l and node Y_{k-l} is called a k-hop closure link. Based on these two definitions, the k-hop closure link incidence rate between two nodes is defined as below.

Definition 3. K-hops closure link incidence rate

When X_0 and Y_0 are nodes, the k-hop closure link incidence rate between X_0 and Y_0 is the rate at which end connectivity is met among the pairs of mutually independent paths which are apexes with a total length k, as stipulated below:

$$k-hops\ closure\ tie\ incidence\ rate = \frac{\#\bigcup_{l=0}^{k}\{(X_0\ X_1\cdots X_l,\ Y_0\ Y_1\cdots Y_{k-l})\,|\,(Mutual\ independence\ between\ paths)\wedge(End\ connectivity\ between\ paths)\}}{\#\bigcup_{l=0}^{k}\{(X_0\ X_1\cdots X_l,\ Y_0\ Y_1\cdots Y_{k-l})\,|\,(Mutual\ independence\ between\ paths)\}}$$

Based on the above definition of k-hop closure link incidence rate, Figure 5.3 shows some examples of methods of calculating the k-hop closure link incidence rate in a social network. Looking at the social network at the top of the diagram, there are four patterns of achieving mutual independence between paths in which the existence of a 1-hop closure link should be checked, as shown in the bottom left of the diagram. For instance, taking X_0Y_0 as a noteworthy relationship, pattern 1 can confirm the existence of a closure link between node A, which is connected 1 hop from node X_0, and node Y_0, that is to say, a link between AY_0. In pattern 2, there is no closure link between node B, which is connected 1 hop from node X_0, and node Y_0. Among the four patterns, only pattern 1 has a closure link that achieves end connectivity between paths. Consequently, the 1-hop closure link incidence rate is 0.25. With a 2-hop closure link, meanwhile, there are two patterns of achieving mutual independence between paths. For example, in the bottom right of the diagram, where X_0Y_0 is a noteworthy relationship, the existence of a closure link can be confirmed between node E, which is connected 2 hops from Y_0, and node X_0. Among the six patterns, only pattern 1 achieves end connectivity between paths. This means that the 2-hop closure link incidence rate is 0.17.

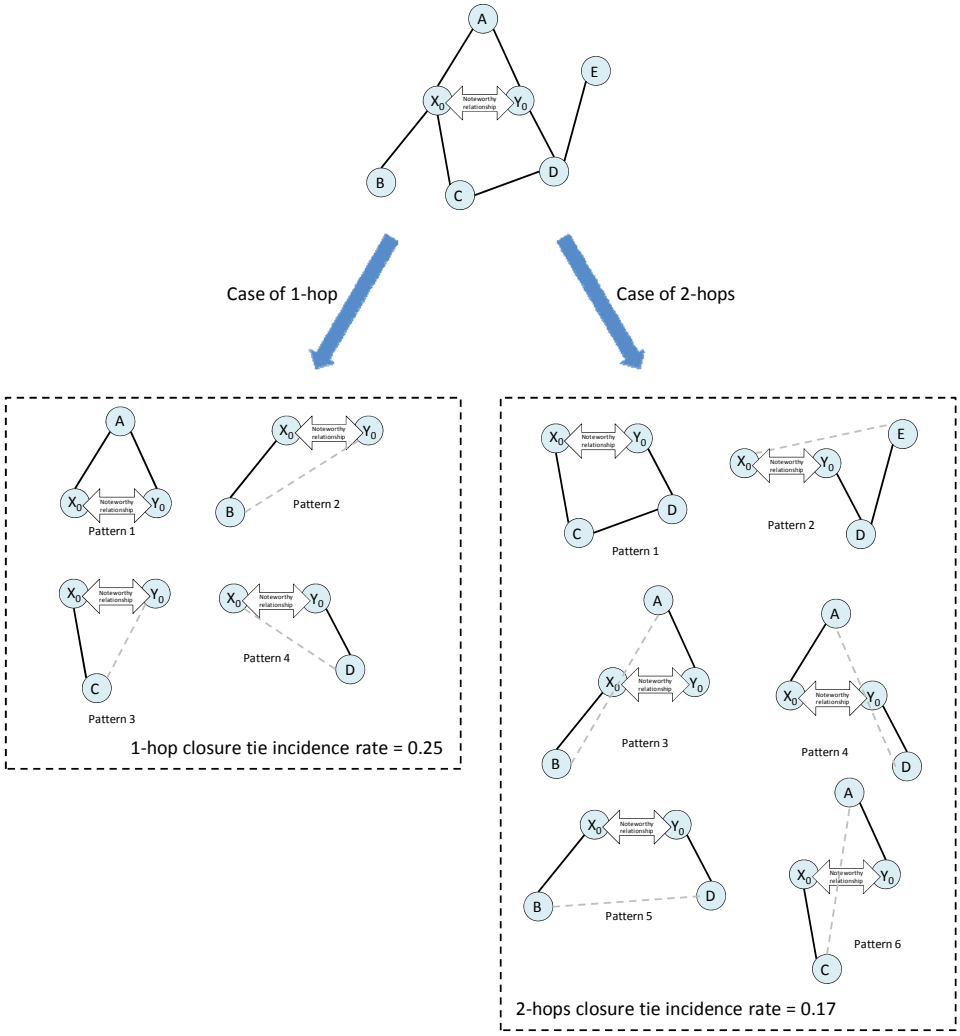


Figure 5.3 Examples of k-hop Closure Link Incidence Rate

This index can be used to obtain the status of positive or negative influence exhibited by noteworthy relations in an enterprise organization on their surrounding collaborative activities. The index was then verified the following hypotheses using a collaboration network within the case study Company D.

Hypotheses 3: The quality of the relation affects outbreak of the collaboration in an over three-way relationship.

5.2. Verification through Case Study of Company D

The k-hop closure link incidence rate of a collaboration network within the case study Company D was sought and the results analyzed. The collaboration network used for verification was in one section (of 27 members) of the system business integration department of Company D, and was formed (by the same method described in Chapter 4) from seven weeks of monitoring data gathered during four weeks from November 23 to December 20, 2008 and three weeks from March 8 to March 28, 2009.

5.2.1. Nature of Relations

A questionnaire survey was conducted on members in the system integration section of Company D to find out their social attributes and job motivation (conducted May 2009, 100.0% collection rate). One of the questions was “Name 1 to 3 people who are easy to work with as project members” in order to ascertain the positive relations within the organization, and another was “Name 1 to 3 people who are difficult to work with as project members” in order to ascertain the negative relations.

The results were able to confirm 49 positive relations and 16 negative relations in that department. An interview with the general manager also revealed the existence of four particularly clear negative relations that he was aware of (all four of which were included in the 16 negative relations revealed by the questionnaire). However, there were some uneven cases in which the two members concerned had different impressions as to whether their relation was positive or negative. In such cases, it is assumed that if either one member sees the relation as positive or negative, the same effect is produced. Consequently, if one of the members thought the relation was positive, it was taken as positive, and if one person thought it was negative, it was taken as negative. There were no cases in which one member thought their relation was positive and the other member thought it was negative.

5.2.2. K-hop Closure Link Incidence Rate of Relations

All combinations of the above-mentioned 49 positive relations, 16 negative relations, and four clearly negative relations of which the general manager was aware were

checked for the existence of collaboration links that become closure links at the k-hop point in order to find the k-hop closure link incidence rate and calculate the average incidence rate in each type of relation. Referring to the values of the average k-hop closure link incidence rates of different types of relations, the k-hop closure link incidence rates of the relations of every combination of members was found as well as the average value of the whole organization. This overall relation average is taken as a comparative criterion. Table 5.1 shows the average k-hop closure link incidence rates (minimum value: 0.00, maximum value: 1.00) of relations of a positive and negative nature.

Table 5.1 Average k-hop Closure Link Incidence Rates

	1-hop	2-hops	3-hops	4-hops	5-hops	6-hops
Positive relations	0.40	0.89	0.44	0.29	0.22	0.00
Negative relations	0.14	0.63	0.33	0.23	0.17	0.00
Strongly negative relations	0.00	0.12	0.10	0.09	0.08	0.00
Average of all relations	0.31	0.78	0.39	0.26	0.19	0.00

The average value of the average 1-hop closure link incidence rates of all combinations of relations was 0.31, corresponding to a 31% average probability throughout the whole organization of a closure link occurring across 1 hop from a noteworthy relation. Among the 49 positive relations, however, the average 1-hop closure link incidence rate was 0.40, equivalent to a 9% higher incidence rate of closure links across 1 hop compared with the whole organization. On the other hand, the average 1-hop closure link incidence rate among negative relations was 0.14, indicating a 17% lower incidence rate of closure links across 1 hop than the overall average. Furthermore, the average 1-hop closure link incidence rate among the four negative relations noticed by the general manager was 0.00, revealing that there are absolutely no closure links across 1 hop.

The results for 2-hop closure link incidence rates were 0.89 for positive relations, 11% higher than the overall average, and 0.63 for negative relations, 15% lower than the overall average.

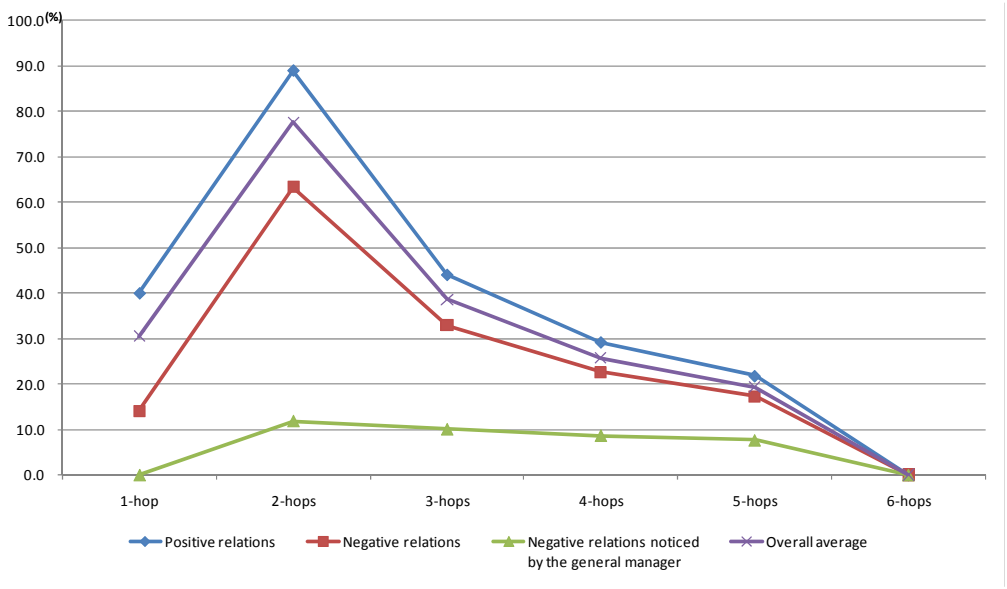


Figure 5.4 K-hop Closure Link Incidence Rates

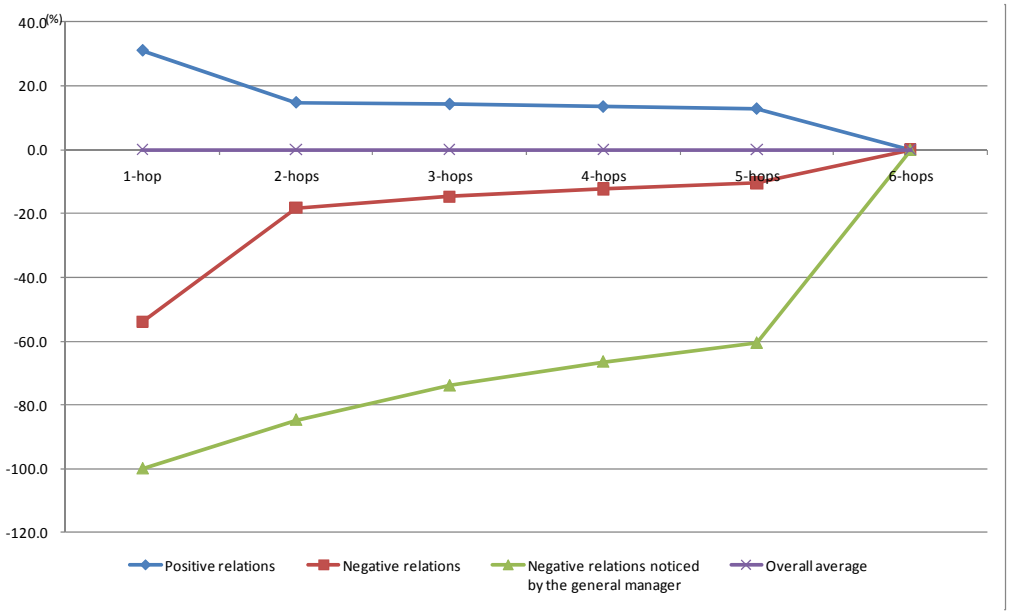


Figure 5.5 Standardized K-hop Closure Link Incidence Rates

These calculation results of k-hop closure link incidence rates were plotted on a graph in Figure 5.4, showing average 3-hop closure link incidence rates of 0.44 for positive relations and 0.33 for negative relations. The gap between the overall rate and the closure link incidence rates across 3 hops contracts by about 5% for both positive and negative relations. This gap keeps contracting beyond 3 hops until there is no large gap between the averages. In other words, the nature of a relation (positive or negative) in Company D's system integration section exerts a strong effect on its surroundings until a distance of 2 hops, but from 3 hops onwards this effect is less significant (not including the negative relations noticed by the general manager). Also, the size of the social network was limited because there were only 27 subject members, and there were no collaboration links of 6 hops or more. Therefore the average 6-hop closure link incidence rate among all types of relations was zero.

Figure 5.5 shows the result of standardization using the average k-hop closure link incidence rate of all combinations of members. The overall trend is for the nature of relations (positive or negative) to influence their surroundings up to 2 hops away while from 3 hops away onwards the difference is less than 5%, although the four negative relations noticed by the general manager do not follow such a trend. Although the difference between these clearly negative relations and the overall relation average gradually diminished as the hop number increased, there remained a significant difference when the 5-hop point was reached. This revealed that the clearly negative relations were still exerting a negative effect on their surroundings 5 hops away.

In positive relations, the transaction cost of communication between such members is low. Communication via these relations can therefore be utilized for collaborative activities up to 2 hops away, and the resulting increase in quality and quantity of information distribution makes collaboration more likely to occur. In other words, finding a way to introduce the beneficial effects of a positive relation into a task in a three- or four-way relationship will enable activation of collaboration from a managerial perspective.

In a negative relation, on the other hand, the transaction cost of communication is high. Collaborative activities up to 2 hops away from that relation are therefore

negatively impacted, with communication via the negative relation being difficult. In some cases, information may even be distributed that inhibits collaborative activities. As for the negative relations noticed by the general manager, all of the members in the organization are probably aware of the extremely high communication related transaction cost. The members near these relations must be aware of their strong negative effect and do not conduct collaboration. Radical measures need to be considered to deal with the people who had created such a situation, such as reassignment to a different location.

The above results show how the incidence rate of k-hop closure links that extend triadic closures in case study Company D can be an index for determining the effect of positive or negative relations on their surroundings. Does the implication that the quality of the relation influences the outskirts has universality in a three- or four-way relationship? At this stage, the analysis result was the level that the possibility of the hypothesis was shown because it is the analysis of only Company D. It is originally necessary to have analyses of plural companies. Although it is not a case of a company organization, there is the related research that a property of node spreads in its outskirts on a network. Christakis *et al.* (2009) examined whether a feeling of happiness of a person influenced his / her outskirts. It was discovered to form a group between happy people or a group between unhappy people. There are many people who are happy around a happy person. The finding is that a direct acquaintance of a high person of a feeling of happiness was more acquaintances (15%) of feeling of happiness than average (To fall under 0-hop in this dissertation). The results of others are an acquaintance of an acquaintance: over 10% (To fall under 1-hop in this dissertation) and an acquaintance of an acquaintance of an acquaintance: over 6% (To fall under 2-hops in this dissertation). Unlike this dissertation, the research paid attention to a property of a node. But a 2-hops range of the influence is a common point both research. Christakis guessed that unhappy influence and happy influence were denied each other, about an acquaintance more than 3-hops. The concrete data about this guess were not shown. But, it is considered that there is some universality for analysis of Company D, because a similar result was given about a range of the influence.

So how can the k-hop closure link incidence rate be utilized from a management perspective? Until now we have discussed the type of nature of relations from the average values of the k-hop closure link incidence rates in the 49 positive relations and 16 negative relations. Because this k-hop closure link incidence rate enables a calculation for each individual relation, basic information about assigning personnel to project tasks in a network organization can be obtained by not only seeing the overall trend but going one step further and finding the k-hop closure link incidence rate of each relation. Specifically, for management to take advantage of the positive relations within the organization, the method for choosing someone to handle a project task is to place two members who form a positive relation at the core of the project and have a favorable effect on the collaboration among members with whom they link up with. To reduce the unfavorable effects of a negative relation, meanwhile, the method is not to position the members involved in that relation at the core of a project.

Other methods can be suggested for daily management other than when assigning personnel to project tasks. Help for communication activities in daily management could be achieved by a solution of incorporating a collaboration formation support function into communication tools using ICT. The reality of a collaboration network revealed using k-hop closure link incidence rates is that the existence of a third person other than those involved has an effect on collaborative activity. An organization’s collaboration is born from communication among its members. In other words, it is possible for management to be involved in encouraging interference from third persons who have a positive effect on collaborative activities, and in communication activities to avoid negative effects being applied.

Implementation of a management method such as that above requires a more concrete study than the case analysis of Company D, to examine ways for management to get involved in relationships of up to 2 hops away which are strongly affected by positive and negative relations, or in order words, three- or four-way relationships. As above, the problem of generalization was left unfinished, because the examination of

Hypothesis 3 was performed in only one case of company. But it was shown that Hypothesis 3 was convincing if based on the analysis of Chapter 5.1 and 5.2[55].

[55] cf. Yuhashi *et al.* (2009b)

5.3. Possibility of Implementing Communication Support System

From the verification results of the case study, if the mechanism of producing collaboration from communication in a three- or four-way relationship is understood, it should be possible as a management method to deliberately use the positive effect from a third or fourth person and try to eliminate any negative effect, and to harness that positive effect to a certain extent. To introduce these findings into the daily operations of enterprises requires a study of the possibility of implementing a communication support system referring to the basic conversation model of language / action perspective.

5.3.1. Incorporating a Language / Action Perspective

According to Geertz, the normalization of a relation is performed by interaction with communication. A communication based approach is also therefore taken to positive and negative relations that affect nearby collaborative activities in a three- or four-way relationship (Geertz, 1979). Also, as Fukao *et al.* point out, the semi-continuous existence of normalized links makes it difficult from a managerial perspective to reset and reconstruct a relation once it has been formed (Fukao *et al.*, 2003). For this reason, it is important that management be involved on a daily basis in the process of producing collaboration from communication, which is the prior stage to the normalization of links. It is also essential to use a versatile model to study at what point in the communication between members to get involved in the process.

One highly versatile communication model, presented by Winograd *et al.*, is a state transition diagram of a two-way conversation conducted for some cooperative action and is based on a language / action perspective which views speech as the execution of a social act (Winograd *et al.*, 1986). Figure 5.6 shows the basic model of a conversation before a cooperative action in which the speakers exchange ideas and the situation changes.

This basic conversation model is of a two-way relationship, but extending it to three- and four-way relationship communication can also reveal the act of a third party exerting a positive or negative effect on the two-way collaboration.

Figure 5.6 shows the transition in a hypothetical case of a requestor A and a receiver B. Each circle shows the state of a possible conversation and the arrows represent speech acts. First, requestor A makes a request for cooperative action to receiver B. The response from receiver B is to accept the request and make a promise, make a counterproposal to requestor A, or refuse the request. With these negotiations on prior conditions completed, the task is carried out in state 3. When it is finished, receiver B issues a completion report or asks for a cancellation of the work request, which requester A confirms before making a completion announcement. This is the state transition of a cooperative action, that is, a conversation aimed at collaboration in a workplace environment, as discussed here.

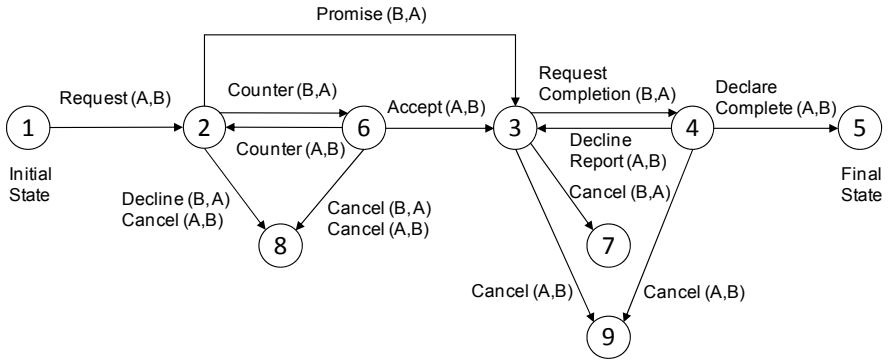


Figure 5.6 Basic Model of Conversation

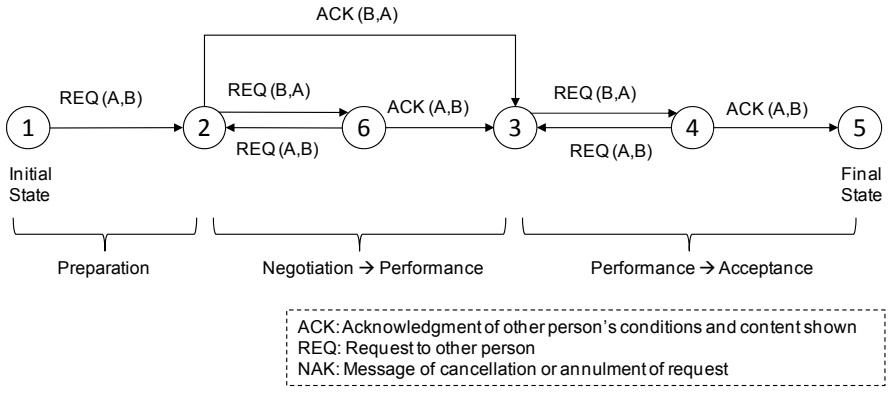


Figure 5.7 Simplified Basic Conversation Model

The basic conversation model of Winograd *et al.* can be divided into the three processes of “Preparation”, “Negotiation to Performance,” and “Performance to Acceptance.” As Kobayashi *et al.* point out regarding the basic conversation model, there is a high level of individuality in “refusal or cancellation” exception handling in actual business scenarios, and no pattern can be formed for studying measures for situation improvement and so on, so they suggest obtaining a more practical model by simplifying exception handling (Kobayashi *et al.*, 2004). Taking the basic conversation model of Winograd *et al.*, Komura *et al.* have divided speech acts into three types: REQ (request to other person,) ACK (acknowledgment of the conditions and content presented by the other person,) and NAK (cancellation or annulment of the request) (Komura *et al.*, 1991a,1991b). They present a model in which a request refusal or cancellation message can be issued in all states except the initial state or final state, and in which an NAK message is omitted because the speech act is completed by the issuing of that refusal or cancellation message (Diagram 5.7).

This basic conversation model is essentially of a two-way relationship, but extending it to three- and four-way relationship communication can also reveal the act of a third or other party exerting a positive or negative effect on the two-way collaboration.

Meanwhile, collaboration networks discussed up until the previous section were undirected graphs but in actual collaborative activities there is in fact a requester and a receiver so basically directionality exists. If a noteworthy relation influences collaborative activities around it, there is also the direction of that influence, and in the same way as a ask-receive relationship at work, one side exerts an influence and the other side receives the influence. If a member on the side that exerts influence communicates a request to a member on the side that receives influence, the member on the influence receiving side may detect a positive or negative relation and respond independently, but whatever the case, the direction of the influence remains the same and the act resulting from the influence is of the same type. Therefore the member on the influence exerting side takes the position of a requester and the member on the influence receiving side takes the position of a receiver.

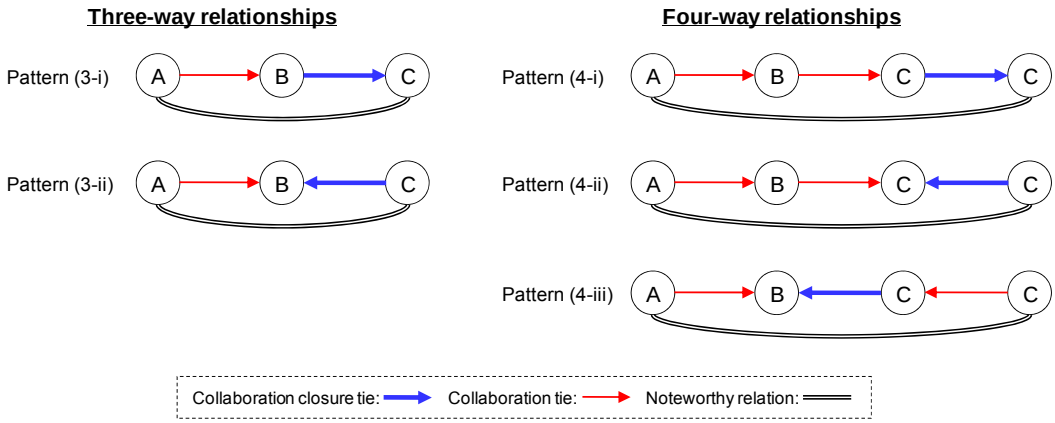


Figure 5.8 Patterns of Three- and Four-way Relationships Influencing Collaboration

Figure 5.8 shows the five different "patterns of three- and four-way relationships influencing collaboration," the patterns of three-way relationships and four-way relationships which exert a positive or negative effect on collaboration around a specific relation.

Patterns of Three- and Four-way Relationships Influencing Collaboration

Consider the structure of a case in which a specific relation affects the surrounding collaborative activities in a triadic relationship. Among members A, B, and C, a noteworthy relation exists between members A and C which exerts a positive or negative influence. In addition, there are ask-receive relationships between members A and B and members B and C. Here, an ask-receive relationship is relevant to a desired collaborative activity or the influence from a noteworthy relation, but first, before distinguishing between different ask-receive relationships, the permutation combinations of their directions are (direction of the A-B ask-receive relationship: 2 ways) x (direction of the B-C ask-receive relationship: 2 ways) = 4 ways (Figure 5.9). Pattern 1 and pattern 2 are mirror images of each other but otherwise structurally the same, so only pattern 1 is considered here. Pattern 4 is also excluded because although the direction of influence should start from the noteworthy relation, its

constituent members A and C are both on the receiving end of influence which means no influence is exerted by the relation.

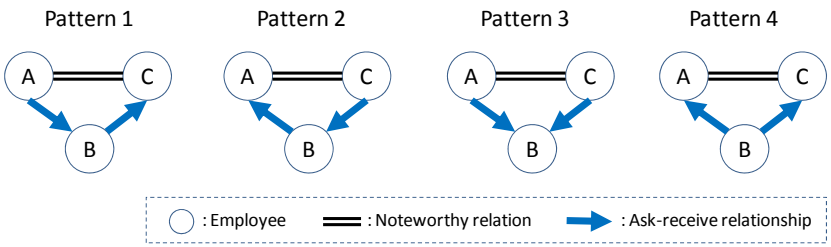


Figure 5.9 Directional Patterns of Ask-Receive Relationships in Triadic Relationships

Next, Figure 5.10 is the result of separating pattern 1 and pattern 3 into “desired collaborative activities” and “influence from a noteworthy relation.” In Pattern 1-B, the direction of influence does not originate from the noteworthy relation, so this pattern is excluded as being unsuitable for this research. Also, pattern 3-A and pattern 3-B are mirror images of each other but otherwise structurally the same, so only pattern 3-A is considered here. In other words, pattern 1-A or pattern 3-A are the triadic relationships in which the noteworthy relation exerts an influence on collaborative activity.

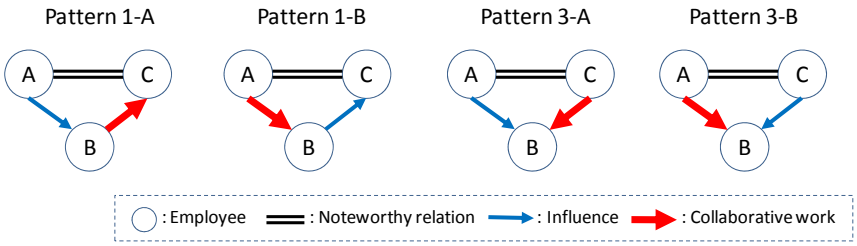


Figure 5.10 Patterns Influencing Collaboration in Triadic Relationships

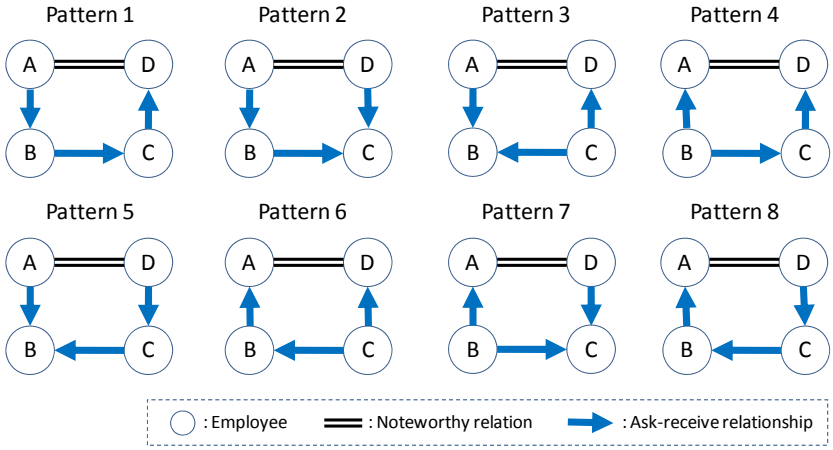


Figure 5.11 Directional Patterns of Ask-Receive Relationships in Four-way Relationships

Next, we consider the structure in a four-way relationship in which a specific relation influences its surrounding collaborative activities. In the relationship between members A, B, C, and D, a noteworthy relation exerting a positive-negative influence exists between members A and D. Furthermore, there are ask-receive relationships in the three relations between members A and B, members B and C, and members C and D. Ask-receive relationships have direction, and the permutation combinations of these patterns are (direction of the A-B ask-receive relationship: 2 ways) x (direction of the B-C ask-receive relationship: 2 ways) x (direction of the C-D ask-receive relationship: 2 ways) = 8 ways (Figure 5.11). Patterns 1 and 8 are symmetrical as are patterns 2 and 5, patterns 3 and 7, and patterns 4 and 6, and so only patterns 1 to 4 need to be considered. Furthermore, pattern 4 is excluded because both members at the ends of the noteworthy relation are on the receiving end of influence which means no influence is exerted by the relation.

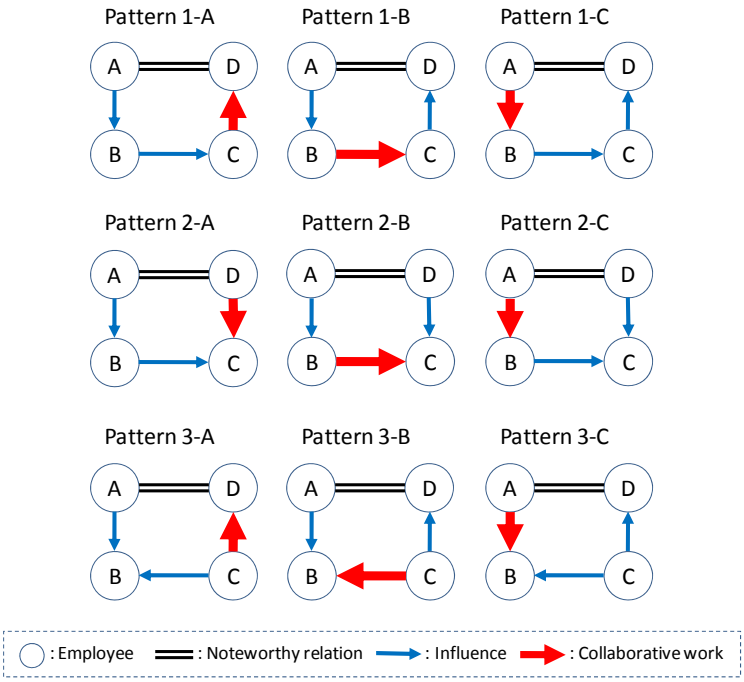


Figure 5.12 Patterns Influencing Collaboration in Four-way Relationships

Then patterns 1 to 3 are separated into “desired collaborative activities” and “influence from a noteworthy relation” as in Figure 5.12. Patterns 1-B, 1-C, 2-C, 3-A, 3-B, and 3-C are excluded as being unsuitable for this research because they include influence that does not originate from the noteworthy relation. The remaining patterns 1-A, 2-A, and 2-B are four-way relationships in which noteworthy relations have an effect on collaborative activities.

Next, we extend the patterns of three- and four-way relationships based on the simplified basic conversation model (Figure 5.8). In the sequence below, when the agent of the conversation shifts to being the receiver in the conversation model, communication with the requester is considered to be contained within that process, and each process is extended by the addition of the communication with the requester (Figure 5.13).

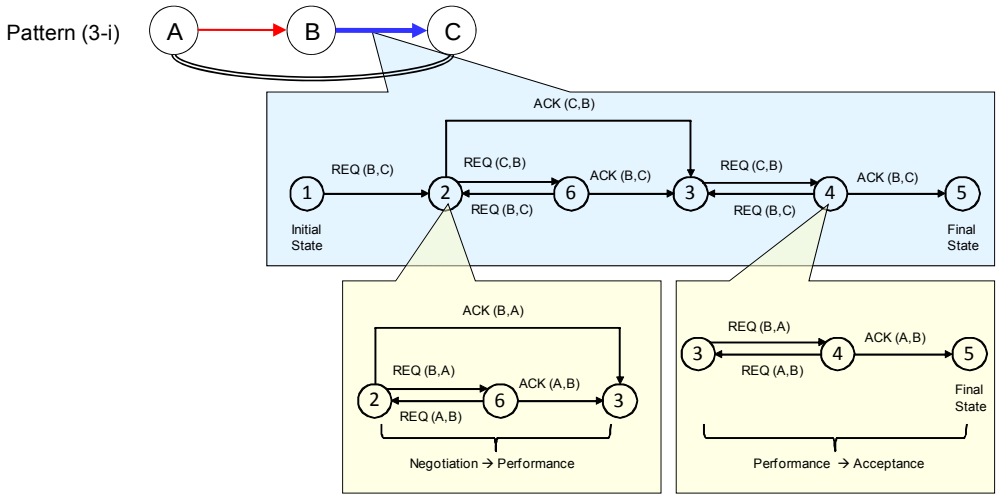


Figure 5.13 Image of Extension of Triadic Relationship

Procedure of Extending Simplified Basic Conversation Model to Three- and Four-way Relationships

(1) The three- and four-way patterns to be extended are selected.

(2) The simplified conversation model's "Preparation" process is performed between each member contained within the three- and four-way relationships and other members with whom they have a relationship. If a member has work requesting relationships from two directions, the "Preparation" process is performed for each relationship.

(3) The sequence of the communication act is arranged so that the communication of the work requester temporally precedes the communication of the receiver. If requests are received from two directions, the state transition is split depending on which of the relationships is processed first.

(4) The same process is performed in "Negotiation to Performance" as in "Preparation" in (2) and (3).

(5) The same process is performed in "Performance to Acceptance" as in "Preparation" in (2) and (3).

The following rules are also applied to extending. Figures 5.14 to 5.18 show the extended conversation models of the patterns in Figure 5.8.

Rules for Extending Conversation Models

(1) Start and end of conversation model

・The conversation model starts from the requester in the collaboration closure link.

・The conversation model ends with the report from the receiver in the closure link.

(2) Timing of process transition of conversation model

・In each of the three processes, “Preparation,” “Negotiation to Performance,” and “Performance to Acceptance,” a communication process between the relationship members must be finished before moving to the next process.

・The move to the next process is decided by the requester or the receiver in the collaboration closure link.

(3) Communication

・No communication may be performed that skips a relationship in a link.

・In the conversation model, no communication may be performed in the noteworthy relation.

(4) Members

・The work receiver shall represent the conversation with that requester and include the intentions of the requester of the same process.

・Members in the conversation model shall independently decide their response to speech acts from other people, and can perform speech acts. (As well as the previous condition, they can respond to another relationship without asking their own requester.)

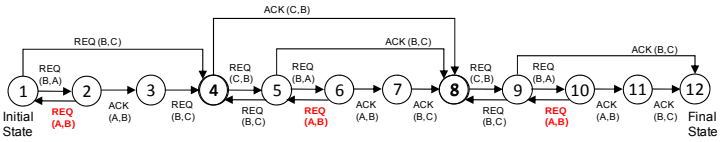


Figure 5.14 Conversation Model of Triadic Relationship – Pattern (3-i)

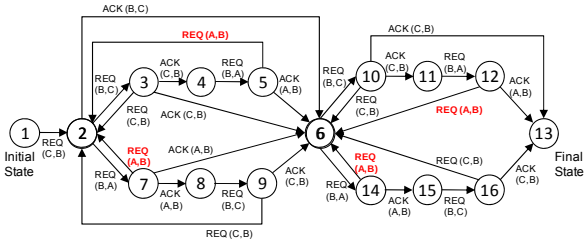


Figure 5.15 Conversation Model of Triadic Relationship – Pattern (3-ii)

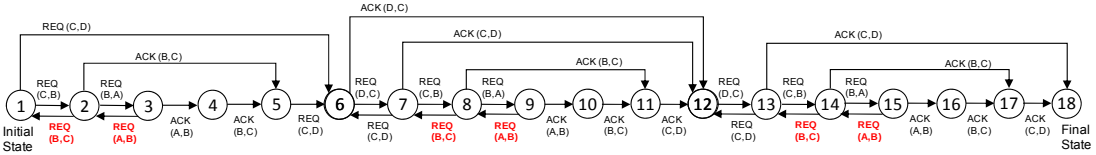


Figure 5.16 Conversation Model of Four-way Relationship – Pattern (4-i)

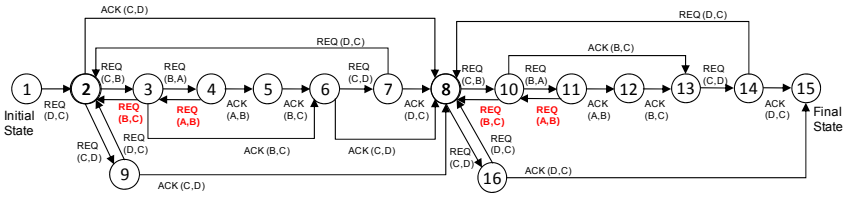


Figure 5.17 Conversation Model of Four-way Relationship – Pattern (4-ii)

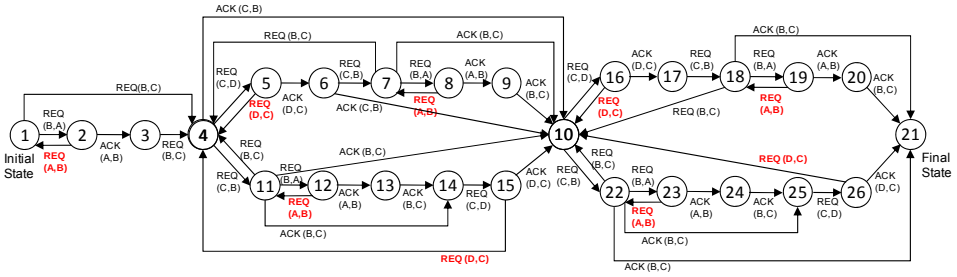


Figure 5.18 Conversation Model of Four-way Relationship – Pattern (4-iii)

5.3.2. Applying to Management and Inserting into System

In the conversation model of a triadic relationship, the positive or negative influence of a third party takes the form of “REQ: request to other person.” Member A is a third party not directly related to the collaboration and member B receives the interest from member A, so the point is that message REQ(A, B) from the third party in Figures 5.14 and 5.15 exerts an influence on the collaboration.

Looking at Pattern (3-i) in Figure 5.14, there is third-party influence in one place per process, but this always takes the form in a closure link of a counter-request REQ(A,B) to request REQ(B,A) from the task requester. Influence from a third party could be either positive or negative, and if is a positive influence then it is good for the task requester to encourage a counterproposal from the third party, but if the influence is feared to be negative it is vital to take measures so that no counterproposal from the third party is accepted. For managerial control, in this pattern the content of the communication from the task requester to the third party is important, and grasping the situation and providing support is a part of management.

In pattern (3-ii) in Figure 5.15, on the other hand, the point is that the receiver gets requests from two directions (task request REQ(C,B) and a request from the third party, REQ(A,B)) and it is important for the receiver to coordinate both. Particularly in the case of a negative relation, there is a risk of a large reversal, such as redoing a task, if a request exerting a negative influence around it is dealt with before coordinating with the requester of the collaborative activity. Conversely, a positive relation can be expected to contribute to implementing a collaborative activity or improving work quality. Regarding the utilization of positive relations, it is important for the receiver of a collaborative activity to be motivated to induce support from a positive relation when allocating personnel to a project task.

In a four-way relationship too, as in a three-way relationship, the “REQ: request to other person” message of a positive or negative relation influences a collaboration closure link.

In pattern (4-i) in Figure 5.16, a positive or negative influence is involved directly as a REQ (B,C) message and indirectly as a REQ(A,B) to the task requester. Like in a

three-way relationship, if there is a positive influence then it is good for the task requester a encourage a counterproposal from a third party, but if the influence is feared to be negative, communication is needed so that no counterproposal from the third party is accepted. From a management perspective, therefore, it is important to understand the level of interest shown by others in the work requester, and to provide suggestions on the content of the communication as well as provide follow-up support.

In pattern (4-ii) in Figure 5.17, the task receiver receives influence from the direct message REQ(B,C) and the indirect message REQ(A,B). There is particular concern about a negative relation, and with no resolution to issues due to a conflict of interest between the requester and a third or fourth party, there is a risk of a large reversal such as redoing a task. Conversely, a positive relation means strong support for implementing a collaborative activity. Managing the effect of both positive and negative relations is crucial when allocating personnel for project tasks.

In pattern (4-iii) in Figure 5.18, the task requester and receiver are dealt with simultaneously. Basically the role of management does not change even in a four-way relationship, but is a combination of roles in three-way relationships. Management needs to provide support in each process by understanding the content of a request made by the requester of a collaborative activity to a third party and the following counter-request, and should help to coordinate different interests so that a receiver in a collaborative activity who gets task requests from two directions can perform the collaborative activity smoothly.

The managerial methods of involvement in all of the above five patterns are set out in Table 5.2. When the object of managerial involvement is the task requester, he or she is encouraged during task implementation to bring out the positive influence of noteworthy relations and restrain the negative influence. However, when the object of involvement is the task receiver, it is difficult for that person to bring out the influence of positive relations and to eliminate the influence of a negative relation at the task implementation stage, because he or she is usually in a weak position in terms of

authority. It is therefore very important to allocate personnel based on the influence of positive and negative relations[56].

Table 5.2 Managerial Involvement Methods

Type of relationship	Object of Managerial Involvement	Effective Involvement Timing	Nature of Noteworthy Relation	Management Method
Pattern 3-i	Requester	During task implementation	Positive	Encourage the work requester to actively seek suggestions from the third party.
			Negative	Encourage the work requester not to develop the relationship so that demands are not received from the third party.
Pattern 3-ii	Receiver	During personnel allocation	Positive	Associate with the third party to get their help conducting the task.
			Negative	Help to coordinate the interests of the requester and the third party.
Pattern 4-i	Requester	During task implementation	Positive	Encourage the work requester to actively seek suggestions from the third party.
			Negative	Encourage the work requester not to develop the relationship so that demands are not received from the third party.
Pattern 4-ii	Receiver	During personnel allocation	Positive	Associate with the third (or fourth) party to get their help conducting the task.
			Negative	Help to coordinate the interests of the requester and the third (or fourth) party.
Pattern 4-iii	Requester	During task implementation	Positive	Encourage the work requester to actively seek suggestions from the third party.
			Negative	Encourage the work requester not to develop the relationship so that demands are not received from the third party.
	Receiver	During personnel allocation	Positive	Associate with the third (or fourth) party to get their help conducting the task.
			Negative	Help to coordinate the interests of the requester and the third (or fourth) party.

Next is a review of the connection to previous research described in Chapter 2 and an examination of the discussions about implementation within ICT systems. Ahuja describes the link with collaboration, saying that sometimes work is divided based on the sharing of knowledge, technology, and resources but that other times only knowhow and information are conveyed, and points out the importance of considering both separately (Ahuja, 2000). Influence from a third party falls under the latter rather than

[56] cf. Yuhashi *et al.* (2010c).

the former because it does not include sharing. Consciously being involved only through communication makes it possible for management to exert harnessing. It is clear that extending the conversation model for collaboration to three- and four-way relationships helps to promote the influence of positive and negative relations in collaborative activities from a management perspective. Milward *et al.* have described five roles for management in a social network, (1) responsibility management: arranging where responsibility lies and assigning resources, (2) compliance management: spreading the purpose of existence and social significance of the network, (3) conflict management: resolving disputes between members, (4) organization design management: network structure selection and human resource allocation, and (5) involvement management: controlling forms of involvement through member training and teamwork (Milward *et al.*, 2006). Surely the k-hop closure link incidence rate could be used as basic information in these network management roles (3) to (5) proposed by Milward *et al.* Specifically, in role (3) a negative relation could be discovered using the k-hop closure link incidence rate and potential conflict between members could be prevented beforehand or a negative relation could be removed in order to eliminate a state of conflict already taking place. In role (4), positive and negative relations could be identified during human resource allocation and work given to members who collaborate more easily. Furthermore, in role (5), organization training could be possible using positive relations. Having considered role (5) in depth, Takada states the importance of information transmission from members who form the hub[57] of a social network in an enterprise organization, and of organization training through collaborative activities with such members (Takada, 2007). This is different from previous organization training methods of conveying knowledge from senior level staff to lower level staff by using immediate bosses as training personnel. Rather, in this dissertation it means implementing training through positive relations by members who are key persons or who form a creative core.

[57] Takada defines a hub as something that fulfills the role of an internal information focal point composed of staff with high information-gathering and information-transmitting capacity with a large network enabling information exchange.

Apart from utilizing k-hop closure link incidence rates in the areas of social network management presented by Milward and Takada's coordination of organization training, there is also the method of applying them to information systems used in a workplace environment. Based on their own basic conversation model, Winograd *et al.* have developed groupware called "The Coordinator[58]" which supports the exchange of messages (Winograd *et al.*, 1986). With this groupware, information content tags (e.g. request, denial, etc.) can be added to messages and replies exchanged in an ask-receive relationship in the workplace, enabling the members of the organization to confirm their own and the other people's speech acts. It also extends the possible ways for managers to get involved apart from just monitoring work progress, such as giving them with a chance to think of an alternative plan if work isn't going smoothly (Flores, *et al.*, 1988). Te'eni *et al.* have introduced "kMail", a communication support system based on such speech acts, which links knowledge base to communication context (Te'eni, 2006). With this kind of approach as a reference, it may be possible, having understood the nature of individual relations within a social network, to stimulate collaboration generation with a mail system that encourages managerial support as necessary according to the status of the conversation model. Although existing communication support systems do not take into account three- and four-way relationships, they can be extended to show the communication status of such relationships by introducing the k-hop closure link incidence rates described in this dissertation. In the coming network organization era, this kind of communication support system could be an effective solution to producing enterprise value through collaboration.

[58] Apart from being a guide based on the conversation status mentioned in this dissertation, "The Coordinator" groupware shows the work status such as deadlines of work being done by users themselves.

6. Conclusion

This research examined the methods of business management for a company aiming to implement network organization in order to produce organizational collaborative activities with the communication act of members as a key. On this occasion, a social network theory was used for the basics of examination. The company organization was taken as a social network, which was made from a node of members and links of collaboration. The two cases of companies of different scales and different industries were covered for this research, and a management method was developed from two approaches. One is the approach to focus on nodes of members. The other is the approach to focus on links of relations between members. This chapter compiles the results of the research.

6.1. Summary of Results

Because Japanese industry was affected by the globalization of the economy and by the diversification of market needs, this is an era when the business environment of a company is constantly changing, and the evolution of the ICT brings innovations for business in various industries. For a company faced with such a situation, the concepts which demand the source of the competitiveness to the internal organization and create new value and new knowledge through interaction among members were shown by Hamel or Nonaka (Hamel *et al.*, 1989, 1990, 1994; Nonaka, 1991, 1995). Furthermore, Imai *et al.* and Miles *et al.* suggested "network organization" as one of the concepts of the company organization by using ICT as a precondition (Imai *et al.*, 1988a, 1988b; Miles *et al.*, 1986). The network organization assigns appropriate members for business issues in a timely fashion and accomplishes their work through interaction among them.

In fact, however, the work is likely to center on members who have a high level of skill in the real world of business. Members who have a low level of skill, on the other hand, are seldom given work requiring responsibility. The operation of rebuilding the organization for business issues is difficult. It is vital to eschew such myopic management in improving operational performance. This research was examined to develop a scientific management method of network organization, because the perspective is essential for a management base.

Members are connected as needed for business issues with an ICT environment as a foundation, and they accomplish work through mutual cooperation. This form of organization is a social network that has individual members as nodes and collaborative relationships between members as links. To reinterpret the concept of network organization based on a social network theory, researches treating mainly social networks in the company organization were reviewed in Chapter 2 "Review of Past Research."

It was regarded as desirable for a core member of a social network to have a great deal of direct relations with the other members in the research in order to focus on member nodes as a component of the social network. This research examined methods of connecting interaction such as collaboration occurring through communication

among members, and they discussed the importance of realizing the structure that interaction is occurs readily. These works revealed the orientation of core members making a network structure such that collaborations readily occur by grasping the structure of the social network.

Research focused on links, on the other hand, treated various relations based on communication (cooperation on business and an advice of work). Those relations were all of collaboration that occurred by sharing business resources via communication. It was pointed out that conflict management and design management were necessary for management work in the social network. It was discovered that control for links is the key to management from these related works by grasping a company organization as a social network of collaboration.

On the basis of a review of related works, theoretical consideration was devoted to communication and collaboration in Chapter 3 "Communication and Collaboration".

On communication, an argument about the modeling of two persons communication started from Shannon (Shannon *et al.*, 1949) was initially critically reviewed. The results confirmed that the interaction in the communication act among members and the feedback in grasping the situation of communication were important. Weick and Geertz commented that an organization was built by repeating communication, and connected a group with two persons' communication acts (Weick, 1979; Geertz, 1979). On the other hand, Luhmann considered that the function of a social system prescribed the structure of the organization (Luhmann, 1973, 1984). Based on an argument of Weick and Luhmann, the structure of a company organization is changed by the communication act of members. This means that there is operational potential for a company to manage its organization by controlling member communication act in a network organization. But, Luhmann considered that a social system consists of only interaction caused by communication. Thus According to Luhmann, there are people in the external environment of a social system. Luhmann's means of grasping an organization lacked a node (a member), which is the one of the components, when it grasps a company organization as a social network. In this connection, Habermas showed the perspective of society system based on pragmatics, and included people in

the scope of the social system (Habermas, 1981). On the basis of such an argument, Communication was defined as "an interactive process aimed at forming a consensus while conveying information such as knowledge, feelings, and opinions through the medium of language and other signs and acquiring the rules of mutual semantic understanding."

As a key to considering collaboration, on the other hand, there is the purpose of interaction that is the reason why people communicate in the Habermas' perspective of social system based on pragmatics. Differences in interpretation on mutual communication increase new meanings in an existing knowledge system. Enterprise resources are used effectively in communication, and in this way, Tanaka and Yasutomi thought that value creation activities were themselves collaboration (Tanaka *et al.*, 1998; Yasutomi, 2006). Kameda also pointed out that interactions to attract knowledge or information from members were created by an organizational structure (Kameda, 2000). Thus, there is a management method that is setting the rules of a place (a company organization) or the coordination of people to activate collaborative activities. On the basis of such an argument, collaboration was defined as "activity accompanying communication acts within a group of people with relations of mutual assistance that produces emergent results through the reconstruction of the body of knowledge of an individual or organization or through the sharing and efficient use of enterprise resources."

Next, based on theoretical definitions, methods for grasping communication acts and collaborative activities in a company organization were examined. In the case of Company Y (a small company), it set the number of voice-mails sent and received per month for communication, and the exchange of thank-you cards for collaboration. In the case of Company D (a large company), it set the number of e-mails sent and received per weeks for communication. In terms of collaboration, the anticipated occurrence of virtual collaboration was calculated from the positional information of members and the travel time by using a RFID system. Through such an operational definition, it was able to grasp a company organization as a social network.

Chapter 4 "Management Approach Focusing on Members" devoted attention to a node among nodes and links that build a network. It tried analysis for two phenomena that the communication acts of members are related to organizational collaborative activities. The first phenomenon is the scene generating collaboration between neighboring members with communication as a trigger. Quoting the concept "creative class" that was proposed by Florida, it confirmed whether there was a correlation to make collaboration links between neighboring members, when the creative core increased communication acts with an index of the degree and the size (Florida, 2002, 2005). As a result, the knowledge was common to the cases of Company Y and Company D as following: when the creative core members increased the message sent of their communication, the degree and the size of their ego-centric network increased.

The second phenomenon is the scene to readily generating collaboration at the organization because the communication of the specific member affects other members. Quoting the mechanism of the word of mouth that Gladwell proposed, when the member candidate for the key person increased communication acts, it confirmed whether the social network has the situation of the small world for easy circulation of information in the organization by the indexes of the clustering coefficient and the eigen-path length (Gladwell, 2000). As a result, the knowledge was common to the cases of Company Y and Company D as following: when the member of the key person increases message reception, the collaboration network of the whole organization has that the eigen-path length become short and approaches the environment that collaborative activities are readily produced.

In Company D, the experiment to practice confirmed the effect of the management method to control the members' communication acts from the general manager. Thus, it confirmed the factors which the company organization is grasped as a social network, and which the organizational structure is able to change from management in Chapter 4.

In Chapter 5 "Management Approach Focusing on Relations between Members," attention was focused on a link among nodes and links that build a network, and the process that collaborative activities were made from communication between nodes

was considered. Evans *et al.* insisted that the ease of collaboration occurring was prescribed by the transaction costs about the communication on the relation between members (Evans *et al.*, 2005). In other words, the quality of relations among members affects the formation of the collaboration link. It was assumed that the quality of relations affected the formation of neighboring collaboration links because of the communication chains in an organization. Conversely, it considered whether the quality of certain relations could be measured from the situation of occurrence of the collaboration link in the outskirts, when it devoted attention to the certain relation. It proposed the index of “k-hops closure link incidence" by quoting the concept "Triadic closure." Through the analysis that applied this index for the case of Company D, the quality of relations affected occurrence of collaboration on the 1-hop distance relations and 2-hops distance relations.

The methods of management that use positive relations for positive influence in the outskirts are necessary in triadic relations and four part relations. And the methods of management through avoidance of negative relations for negative influence in the outskirts are necessary in triadic relations and four part relations. These methods of management are connected to the tasks called "Management of Conflict" and "Management of Design" that were shown by Milward (Milward *et al.*, 2006). Therefore, the conversation model between two people for collaboration based on the language / action perspective that Winograd proposed was expanded for three or four persons' relations (Winograd *et al.*, 1986). The business conversation model of three or four persons' relations is divided into 5 patterns. It clarified the timing of the communication act that influence to form collaboration links from the third person or the fourth person in each model. This is the point that should be controlled by the management. In communication between members with the same task, it performs the management of conflict by devoting attention to the member from a general manager and middle managers when it is timing with the potential for negative relational influences. Foreknowledge was also obtained for contributing to the management of design by extracting the list of the positive / negative relations of the internal organization from the

k-hops closure link incidence. If the ICT system implementing such an idea is built, the management of the network organization is supported by an ICT system.

It was able to show the concrete management method for network organization through examination from Chapters 1 through 5. The content of the method was significantly different from the management of the conventional "Command" and "Process control." A routine work that a manual is systematized has the small range of a member's direction and limited enterprise resources. Therefore, a manager can easily predict his or her staff's work content and the results because the procedures are determined in advance. A manager can control his or her staffs by identifying the instructions of at the start of the task, the confirmation of the task end, and the progress on the way. But, network organization has a lot of atypical tasks (not routine tasks) that are mainly performed. It accomplishes tasks by assigning assign for business issues at each time. Accidents in task situations and accidents in combinations of project members are high. Therefore, it cannot arrest in the instruction of the start of the task, the confirmation of the task end and the progress on the way. It is important that there is a manager at the process of the task adjustment or the staff training.

The management methods that were examined in this research were not based on the workflow, but rather were based on interaction among members. There were few ICT systems designed based on such an idea yet. But, the method is useful for management by information offered from grasping the total organization, not only in supporting the individual interaction. This is a frontier of management methods and ICT systems for management.

And as an approach, grasping interactions among members by using an ICT system with mobile devices is effective for management. In this research, positional information and a sojourn time were collected using transmitter type RFID tags in Company D. This was the system that the burden on member was small. From the review of Eagle *et al.* (2004), there is a way to use mobile phones in the system. It can utilize mobile phones that are already used in the reduction of initial costs for ICT system and the grasping of members' situations outside, by using a mobile phone to a platform of ICT system. On

the occasion of real introduction, it is necessary to examine the pros and cons that the choice of the device brings.

6.2. Implications for Management

In this research, the actual situation of network organization was grasped. On the basis of the actual situation, the concrete management method was examined. It explains concrete methods which a field manager should practice in the following.

At first, as a precondition for using the management method of this dissertation, a company aiming at the value creation by the interactions of the members is necessary. Interactions among members may lose the efficiency of the tasks in the case of an organization that handles routine tasks such as a call center. The environment that can measure the members' communication acts and the collaborative activities of the internal organization is essential for management. If that environment is built from ICT system, the manager is timely and can grasp the situation. Furthermore, it is vital that the network organization have ample scale (the number of members) in order to recombine project members for assigning appropriate members depending on business issues. It gathered these up in the following.

The precondition of management method for a network organization

(1) A company aims at value creation through interaction among members.

(2) Management can measure the communication act of members by the ICT system or other ways.

(3) Management can measure collaborative activities of the internal organization by the ICT system or other ways.

(4) A company organization is enough scale to recombine members for depending on business issues.

Under such premise, the four management methods were shown from the analysis of this research, and it enumerates them in the following.

- The performance improvement method for the core members

(The enhancement of the ego-centric network of the creative core members)

About core members to the value creation on business, their relations to cooperate can be widened by increasing communication acts which are the message sent. The increase of relations leads to acquisition of new knowledge or sharing of enterprise resources. As a result, the performance of members improves[59]. It is one method to be concrete to have a place (meeting, bulletin board and mailing list etc.) that exchanges ideas about works.

- The information circulation activation method of the internal organization

(Small world of the network organization via the key person about the information circulation)

It chooses a key person member who has strong influence about the information circulation based on the conditions (Maven, Connector and Salesman). The organization easily circulates information through communication among members[60]. To set the rule that communication is performed from other member to a key person member or to increase reporting from a general manager are thought as a concrete method.

− The organization design method based on data

(The discovery of the positive / negative relations by using the k-hops closure link incidence)

It can get the list which understands the positive relations to give good influence and the negative relations with the possibility to obstruct for neighboring collaboration, by using this index. If it refers to this list, it can activate the

[59] It is effective to promote the message sent of the communication acts so that the creative core member for value expands his or her ego-centric network about collaboration from management. The number of members who linked to other members is increased by this behavior (the high degree of the ego-centric network). And links of the collaboration are set up between those members (the high size of the ego-centric network). Because available enterprise resources for the creative core members are taken up by this, a performance as the organization improves.

[60] It chooses the candidate member who has the characteristics of a key person (Maven, Connector and Salesman) about the information circulation in company organization. The eigen-path length of the collaboration network of the whole organization is shortened by attracting information to the member. The support is performed from a key person member for the members who are not the creative core, because they do not stand alone on a network. the short eigen-path length of the collaboration network of the whole organization means that the collaboration network has structure that time and cost are not spent for the activities of information circulation. This circulation of information supports performance as an organization.

collaborative activities by arranging positive relations in the core of the project team when it organizes a project team. Likewise, it can prevent a trouble by not incorporating a member who has a negative relation into the project team[61]. In addition, this list is useful as basic information of the consulting firm of Personnel affairs.

- **The method to prevent and to cancel conflict between members**

  (The control of the conflict that used the conversation model of three or four persons' relations)

  In the environment in which members communicate each other by using a communication support system (a groupware, an e-mail etc.), coming under negative influence tasks are disturbed of the third or fourth person except the person concerned is concerned when an acceptor communicates with a client. It devised an approach to notify of timing when management could control to cancel from the bad situation on this occasion[62]. A company which sells a communication support system can develop a new function by adopting this knowledge.

In this way, as for the management method based on the interaction of the collaborative activities made from the members' communication act (not the management based on a workflow), means is an adjustment (not a command). Such the way of thinking can become the ground for an organization that is not able to fix its value chain or a company that is in the intense industry of the change.

[61] The relative influence (positive or negative) of the relation for neighboring collaborative activities can be grasped by comparing between the k-hops closure link incidence of the certain relation and the average of the k-hops closure link incidence of the whole organization. This information is useful for the assignment of members to a project for business issues. It can evade conflict between members beforehand by avoiding a negative relation for organizing a project. It is given good influence in the outskirts by incorporating a positive relation in a project, and activates a project member.

[62] This management method requires an ICT system supporting the members' communication. The project members assigned depending on business issues register to an ICT system beforehand. In human relations in which project members communicate with one another, an ICT system can send an alert to general manager or middle managers for the situation that influence is concerned about the negative relations, and, there is a management method to notify a member that it uses a positive relation positively, when it can expect the influence of the positive relation.

6.3. Future Works

In this chapter, It reaffirms whether the result was significant to the objectives of this research. Based on examination of Hypothesis 1, 2 in Chapter 4 and Hypothesis 3 in Chapter 5, a practical management method was developed in Chapter 6.2 (The examination results of the Hypothesis 1 to 3 were mentioned in Chapter 4 and Chapter 5). The answers for each research question are as follows:

Answers of this dissertation

A1: It showed that a management could change a situation of a social network by participating in communication acts of a creative core and a key person (cf. Chapter 4).

A2: It can recognize an existing positive / negative relation in an organization by using the index "k-hops closure link incidence" (cf. Chapter 5).

A3: It showed new approach to let collaboration activate by participating in communication of core members or considering nature of relations between members for assignment (cf. Chapter 6.2).

Four items younger than for contribution are raised when it compiles the scientific contribution of this research.

(1) In a company aiming at the acquisition of network organization, it enabled the situation grasp based on the social network theory by grasping the communication act of members and the collaborative activities of the whole organization (Chapter 3 and Chapter 4).

(2) The method to focus on nodes (members) was shown from the results of two cases involving a small company and a large company in different industries (Chapter 4).

(3) It proposed the index “k-hops closure link incidence," which can evaluate the quality of the relation by expanding the concept "Triadic closure," and the case analysis using the index confirmed that it expressed the actual situation (Chapter 5).

(4) Based on the language / action perspective, the timing when the third person or the fourth person participated in a collaborative activity was clarified. It was able to show a new idea to support management by the ICT system (Chapter 5).

However, this research has three points of limits. It explains those contents with future themes.

The first point of limit is that communication is a necessary condition of collaboration, but communication is not a sufficient condition of collaboration. In other words, even if the internal communication increases, depending on contents of the communication, there are cases in which the collaborative activities do not activate at all in a company organization. For this possibility, it is necessary to confirm the communication contents to contribute to outbreak of the collaboration. But this research only grasps the quantity of communication. It developed an argument after assuming that organizational performance improves by activation of the collaboration. In fact, it is necessary to inspect the effect between the method and the corporate earnings. But how can the performance of the company organization be measured? There are many factors which influence the performance of the company organization. To make a decision in this event, it is necessary to adopt measurement methods that remove uncertain factors about knowledge work.

The second point of limit is that a range of the company organization accords with a range of the social network in an argument of network organization. However, the society network which is necessary for tasks may open in the outside of the organization. When it changes an object of the management from the network organization, there is the case that a social network expands forth organization. It is assumed that a result unlike the analysis of this research is provided. It is necessary to rebuild the research method to analyze an object unlike the network organization.

The third point of limit was confined to theoretical consideration in the management method to focus the links between members. This research was not to perform a practical trial, and It is necessary to confirm the effectiveness of the suggestion provided from this approach by a practical trial. For example, the experiment to implement the

knowledge to ICT system or the field trial in a company that has the free-address office are needed to inspect the effect.

Reference

[1] Ahuja, G. (2000). “Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study,” *Administrative Science Quarterly*, Vol. 45, No. 3, pp. 425-455.

[2] Atarashi, M., Ohmura, E., Hogetsu, M., Nakano, M., Nakano, H. (1979). *History of Sociology (in Japanese)*, Yuhikaku Publishing Co., Ltd. (新睦人, 大村英昭, 宝月誠, 中野正大, 中野秀一郎(1979)『社会学のあゆみ』有斐閣新書.)

[3] Austin, J. L. (1962). *How to Do Things with Words*, Oxford University Press.（坂本百大 訳(1978)『言語と行為』大修館書店.）

[4] Axelrod, R. (1997). “The dissemination of culture,” *Journal of Conflict Resolution*, Vol. 41, No. 2, pp. 203-226.

[5] Axelrod, R., Cohen, M. D. (1999). *Harnessing Complexity: Organizational Implications of a Scientific Frontier*, Free Press. (高木晴夫 監訳, 寺野隆雄 訳(2003)『複雑系組織論 - 多様性・相互作用・淘汰のメカニズム』ダイヤモンド社.)

[6] Barabasi, A. (2010). *Bursts: The Hidden Pattern Behind Everything We Do*, Dutton Adult.

[7] Barnard, C. I. (1938). *The Functions of the Executive*, Harvard University Press.（山本安次郎, 田杉競, 飯野春樹 訳(1968)『新訳・経営者の役割』ダイヤモンド社.）

[8] Burt, R. S. (1992). *Structural Holes: The Social Structure of Competition*, Harvard University Press.

[9] Cartwright, D., Harary, F. (1956) “Structural balance: A generalization of Heider's theory D Cartwright,” *Psychological Review*, Vol. 63, Issue 5, September, pp. 277-293.

[10] Christakis, N. A., Fowler, J. H. (2009). *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives*, Back Bay Books. (鬼澤忍 訳(2010)『つながり – 社会的ネットワークの驚くべき力』講談社.)

[11] Collins, R. (1988). *Theoretical Sociology*, New York: Harcourt Brace Jovanovich.

[12] Counts, S., John Geraci, J. (2005). “Incorporating Physical Co-presence at Events into Digital Social Networking,” *Late Breaking Results: Posters, CHI 2005*, April 2-7, Portland, Oregon, USA.

[13] Conway, F., Siegelman, J. (2005). *Dark Hero of the Information Age: In Search of Norbert Wiener, The Father of Cybernetics*, T. S. Eliot.（松浦俊輔 訳(2006)『情報時代の見えないヒーロー - ノーバート･ウィナー伝』日経 BP.）

[14] Cross, R., Liedtka, J., Weiss, L. (2005). “A Practical Guide to Social Networks,” *Harvard Business Review*, Vol. 83, pp. 124-132.

[15] Daft, R. L. (2001). *Organization Theory and Design, 2nd Edition*, South-Western College.（高木晴夫 訳（2002）『組織の経営学 – 戦略と意志決定を支える』, ダイヤモンド社.）

[16] Drucker, P. F. (1993). *Post-Capitalist Society*, Butterworth-Heinemann. (上田惇生訳(1993)『ポスト資本主義社会 - 21 世紀の組織と人間はどう変わるか』ダイヤモンド社.)

[17] Drucker, P. F. (2002). *Managing in the Next Society*, Griffin.（上田惇生 訳(2002)『ネクスト･ソサエティ – 歴史がみたことがない未来がはじまる』ダイヤモンド社.）

[18] Dunbar, R. (1996). *Grooming, Gossip and Evolution of Language*, Faber & Faber.（松浦俊輔, 服部清美 訳(1998)『ことばの起源 - 猿の毛づくろい, 人のゴシップ』青土社.）

[19] Eagle, N., Pentland, A. (2004) “Social Serendipity: Proximity Sensing and Cueing,” *MIT Media Laboratory Technical Note*, 580, May.

[20] Eagle, N., Pentland, A. (2005) “Social Serendipity: Mobilizing Social Software,” *IEEE Pervasive Computing*, April - June, Vol. 4, No. 2, pp. 28-34.

[21] Evans, P., Wolf, B. (2005) “Collaboration Rules,” *Harvard Business Review*, July-August, pp. 96-104.

[22] Flores, F. (1988) “Computer System and the Design of Organizational Interaction,” *ACM Transactions on Office Information Systems*, Vol. 6, No. 2, April, pp. 153-172.

[23] Florida, R. (2002). *The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community and Everyday Life*, Basic Books, Inc.

[24] Florida, R. (2005). *The Flight of the Creative Class: The New Global Competition for Talent*, HarperCollins Publishers, Inc.

[25] Fukao, Y., Yasutomi, A. (2003). “The dynamics of networking in a Chinese rural village,” *Journal of the Institute of Oriental Culture (in Japanese)*, Vol. 144, pp.

358-319. (深尾葉子, 安冨歩(2003)「中国陝西省北部農村の人間関係形成機構 <相夥>と<雇>」『東洋文化研究所紀要』第 144 冊, pp. 358-319.)

[26] Friedkin, N. (1980). “A test of the structural features of Granovetter’s ‘strength of weak ties’ theory,” *Social Networks*, 2, pp. 411-422.

[27] Geertz, C. (1979). “Sug: The Bazaar Economy in Sefrou,” Geertz *et al.* (eds.), *Meaning and Order in Moroccan Society*, New York, Cambridge University Press, pp. 123-264.

[28] Gladwell, M. (2000). *The Tipping Point: How Little Things Can Make a Big Difference*, Back Bay Books.

[29] Gloor, P. A. (2006). *Swarm Creativity: Competitive Advantage through Collaborative Innovation Networks*, Oxford University Press.

[30] Gloor, P. A., Paasivaara, M., Schoder, D., Willems, P. (2008). “Finding Collaborative Innovation Networks through Correlating Performance with Social Network Structure,” *International Journal of Production Research*, Vol. 46, Issue 5, pp. 1357-1371.

[31] Granovetter, M. (1973). “The strength of weak ties,” *American Journal of Sociology*, 78(6), pp. 1360-1380.

[32] Granovetter, M. (1983). “The strength of weak ties: A network theory revisited,” *Sociological Theory*, 1, pp. 201-233.

[33] Granovetter, M. (1995). *Getting a job: A study of contacts and careers, 2nd ed.*, Chicago: University of Chicago Press.

[34] Grice, P. (1975). “Logic and Conversation,” *Syntax and Semantics*, Vol. 3, Academic Press, pp. 41-58.

[35] Habermas, J. (1981). *Theorie des kommunikativen Handelns, Bde. 1-2*, Suhrkamp Verlag, Ffm. (河上倫逸, M・フーブリヒト, 平井俊彦 訳(1985)『コミュニケイション的行為の理論(上)』未来社。藤沢賢一郎, 岩倉正博, 徳永恂, 平野嘉彦, 山口節郎 訳(1986)『コミュニケイション的行為の理論(中)』未来社.)

[36] Hamel, G. and Prahalad, C. K. (1989). “Strategic Intent,” *Harvard Business Review*, May-Jun, pp. 63-76.

[37] Hamel, G. and Prahalad, C. K. (1990). “The Core Competence of the Corporation,” *Harvard Business Review*, May-Jun, pp. 79-91.

[38] Hamel, G. and Prahalad, C. K. (1994). *Competing for the Future*, Harvard Business School Press.

[39] Harary, F. (1946) “Attitudes and Cognitive Organization,” *Journal of Psychology*, Vol. 21, pp. 107-112.

[40] Hayek, F. A. (1999). "The Use of Knowledge in Society," *The Knowledge Management Yearbook 1999-2000*, Butterworth-Heinemann.

[41] Heider, F. (1946) “Attitudes and cognitive organization,” *Journal of Psychology*, Vol. 21, pp. 107-112.

[42] Iba, T. (2006). Made in collaboration!: Emergence of a chain of communication (in Japanese), Kokuryo, J. (eds.), *Emergent society (in Japanese)*, pp. 68-85. (井庭崇（2006）「コラボで作る！ - コミュニケーションの連鎖による創発」國領二郎編著『創発する社会』日経 BP 企画.)

[43] Imai, K., Kaneko, I. (1988a). *Theory of Network Organization (in Japanese)*, Iwanami Shoten, Publishers. (今井賢一，金子郁容（1988a）『ネットワーク組織論』岩波書店.)

[44] Imai, K., Shiobara, T., Matsuoka, S. (1988b). *Organizational Strategy in Era of Network (in Japanese)*, Dai-Ichi Hoki co.ltd. (今井賢一，塩原勉，松岡正剛（1988b）『ネットワーク時代の組織戦略』第一法規出版.)

[45] Kameda, T. (2000). “Collaboration and Social Interaction: Examining from a Structural Perspective,” In Ueda, K., Okada, T. (eds.), *In Search of Collaboration: Cognitive Science on Creative Collaboration*, Kyoritsu Shuppan Co., Ltd., pp. 50-77. (亀田達也（2000）「協同行為と相互作用 - 構造的視点による検討」植田一博，岡田猛編著『協同の知を探る - 創造的コラボレーションの認知科学』共立出版, pp. 50-77.)

[46] Kobayashi, T., Komoda, N. (2004). “Business Process Design Method Based on Business Event Model for Enterprise Information System Integration,” *IEEJ Transactions on Electronics, Information and Systems*, Vol.124, No.5, pp. 1068-1075. (小林隆，薦田憲久（2004）「企業情報システム統合のための業務イベントモデルにもとづくビジネスプロセス設計技法」『電気学会論文誌C（電子・情報・システム部門誌）』Vol.124, No.5, pp.1068-1075.)

[47] Kokuryo, J. (1999). *Open Architecture*, Diamond, Inc. (國領二郎(1999)『オープン・アーキテクチャ戦略 - ネットワーク時代の協働モデル』ダイヤモンド社社).

[48] Kokuryo, J. (2001). “Organizing of Cooperation in Era of Network (in Japanese),” *Organizational Science*, Vol.34, No.4, pp. 4-14. (國領二郎(2001)「ネットワーク時代における協働の組織化について」『組織科学』第 34 巻, 第 4 号, pp. 4-14.)

[49] Kokuryo, J., Kataoka, M., Nonaka, I. (2003). *Knowledge Management in Networked Society (in Japanese)*, NTT Publishing Co., Ltd. (國領二郎, 片岡雅憲, 野中郁次郎(2003)『ネットワーク社会の知識経営』NTT 出版.)

[50] Komura, S., Shibasaki, M. (1991a). “An Extension of the Winograd's Basic Conversation Diagram to the Case of Three Members,” *Proceedings of the 42th Information Processing Society of Japan (6)*, pp. 301-302. (小村誠一, 柴崎雅史(1991a)「Winograd の基本会話ダイアグラムの三者への拡張」第 42 回情報処理学会全国大会講演論文集(6), pp. 301-302.)

[51] Komura, S., Shibasaki, M. (1991b). “An Extension of the Winograd’s basic conversation diagram,” *IPSJ SIG Technical Report*, No. 50-16, pp.119-126. (小村誠一, 柴崎雅史(1991b)「Winograd の 2 者会話ダイアグラムの他者への一般化について」『情報処理学会研究報告 - マルチメディア通信と分散処理(DPS)』No. 50-16, pp.119-126.)

[52] Krackhardt, D., Hanson, J. R. (1993). “Informal networks: the company behind the chart,” *Harvard Business Review*, October-November, pp. 104-111.

[53] Kuriki, K. (2003). *Reflective Flow*, Hakuto-Shobo Publishing Co. (栗木契(2003)『リフレクティブ・フロー - マーケティング・コミュニケーション理論の新しい可能性』白桃書房.)

[54] Leakey, R. (1994). *The Origin of Humankind*, Harper Collins Publishers, Inc.（馬場悠男 訳(1996)『ヒトはいつから人間になったか』草思社.）

[55] Lepper, M. R., Whitmore, P. C. (2000). “Collabotation as a Problem for Cognitive Science: Definitions and Approaches,” In Ueda, K., Okada, T. (eds.), *In Search of Collaboration: Cognitive Science on Creative Collaboration*, Kyoritsu Shuppan Co., Ltd., pp. 2-8. (Lepper, M. R., Whitmore, P. C.（2000）「協同 - 社会心理学的視点から」植田一博, 岡田猛 編著『協同の知を探る - 創造的コラボレーションの認知科学』共立出版, pp. 2-8.)

[56] Lin, N. (1982). “Social resources and instrumental action,” *Marsden, P. V., Lin, N. (eds.), Social structure and network analysis*, pp. 131-145.

[57] Luhmann, N. (1973). *Vertrauen, ein Mechanismus der Reduktion Sozialer Komplexitat, 2. erweiterte Auflage*, UTB, Stuttgart.（大庭健, 正村俊之 訳（1990）『信頼 - 社会的な複雑性の縮減メカニズム』勁草書房.）

[58] Luhmann, N. (1984). *Soziale Systeme: Grundrib einer allgemeinen Theorie*, Suhrkamp.（佐藤勉 訳（1993, 1995）『社会システム理論（上・下）』恒星社厚生閣.）

[59] Magnier-Watanabe, R., Senoo, D. (2009). “The Effect of Institutional Pressures on Knowledge Management and the Resulting Innovation: The Case of the Smartcard in France,” *International Journal of Intelligent Enterprise*, Vol. 1, No. 2, pp. 177-197.

[60] Malone, T. W. (2004). *The Future of Work: How the New Order of Business Will Shape Your Organization, Your Management Style, and Your Life*, Harvard Business School Press.

[61] Matsuo, T. (1999). *Psychology of Communication (in Japanese)*, Nakanishiya Shuppan. (松尾太加志（1999）『コミュニケーションの心理学 - 認知心理学・社会心理学・認知工学からのアプローチ』ナカニシヤ出版.)

[62] Matsushita, Y., Okada, K. (1995). “Support coordination of people (in Japanese),” *Collaborarion and Communication*, Kyoritsu Shuppan Co., Ltd., pp. 1-25. (松下温, 岡田謙一（1995）「人々の協調の支援」『コラボレーションとコミュニケーション』共立出版.)

[63] McPherson, J. M., Popielarz, P. A., Drobnic, S. (1992) “Social networks and organizational dynamics,” *American Sociological Review*, 57, pp. 153-170.

[64] Miles, R. E., Snow, C.C. (1986). “Organizations: New conceptual for new forms,” *California Management Review,* 28, pp. 62-73.

[65] Milward, H. B., Provan, K. G. (2006). *A Manager’s Guide to Choosing and Using Collaborative Networks*, IBM Center for The Business of Government.

[66] Mintzberg, H. (1973). *The Nature of Managerial Work*, Harper Collins Publishers, Inc. (奥村哲史, 須貝栄 訳（1993）『マネージャーの仕事』, 白桃書房.)

[67] Moody, J. (2004). “The Structure of a Social Science Collaboration Network: Disciplinary Cohesion from 1963 to 1999,” *American Sociological Review*, Vol. 69, No. 2, pp. 213-238.

[68] Nishiguchi, T. (2007) *Global Neighborhoods: Strategies of Successful Organizational Networks*, NTT Publishing Co., Ltd. (西口敏宏（2007）『遠距離交際と近所づきあい - 成功する組織ネットワーク戦略』, NTT 出版.)

[69] Nonaka, I. (1991). “The Knowledge-Creating Company,” *Harvard Business Review*, Nov-Dec, pp. 96-104.

[70] Nonaka, I., Takeuchi, H. (1995). *The Knowledge Creating Company,* Oxford University Press.

[71] Peters, T. J., Waterman, R. H. (1982). *In Search of Excellence*, New York: Harper and Row.（大前研一 訳（1983)『エクセレントカンパニー』講談社.）

[72] Poter, M. E. (1980).*Competitive Strategy: Techniques for Analyzing Industries and Competitors*, Free Press.

[73] Poter, M. E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*, Free Press.

[74] Prusak, L., Cross, R. (2002). “The People Who Make Organizations Go or Stop,” *Harvard Business Review*, June, pp. 104-112.

[75] Rapoport, A. (1953) “Spread of information throught a population with socio-structual bias: I. Assumption of transitivity,” *Bulletin of Mathematical Biophysics,* 16, pp. 75-81.

[76] Rapoport, A., Horvath, W. J. (1961) “A Study of a Large Sociogram,” *Behavioral Science*, 6, pp. 279-291.

[77] Rheingold, H. (2000). *Tools for Thought revised edition*, MIT Press. (日暮雅通 訳（2006）『新・思考のための道具 - 知性を拡張するためのテクノロジー - その歴史と未来』パーソナル・メディア.)

[78] Ruesch, J., Bateson, G. (1968). *Communication: The Social Matrix of Psychiatry*, Norton.（佐藤悦子, ロバート・ボスバーグ 訳（1989)『コミュニケーション』思索社.）

[79] Senge, P. M. (1990). *The Fifth Discipline: The Art & Practice of The Learning Organization,* Doubleday.

[80] Schrage, M. (1990). *Shared Minds: The New Technologies of Collaboration*, Random House.（藤田史郎 監, 瀬谷重信, コラボレーション研究会 訳（1992)『マインド・ネットワーク - 独創力から協創力の時代へ』プレジデント社.）

[81] Schramm, W. (1954). *The Process and Effects of Mass Communication*, University of Illinois Press.

[82] Shannon, C. E., Weaver, W. (1949). *The Mathematical Theory of Communication*, The University of Illinois Press.（長谷川淳，井上光洋 訳(1969)『コミュニケーションの数学的理論』明治図書.）

[83] Takada, A. (2007). “The Effective Scheme of Modeling for Human Resource Development: Theoretical Framework centered on Hub Persons,” *Journal of the Japan Society for Management Information*, Vol.15, No.4, March, pp.77-87. (高田朝子(2007)「人材育成のための効果的観察学習 - ハブパーソンを中心とした理論的枠組みの構築」『経営情報学会誌』Vol.15, No.4, March, pp.77-87.)

[84] Takeuchi, I. (1973). “Structure of Social Communication (in Japanese),” In Uchida, Y., Okabe, K., Takeuchi, I., Tsujimura, A. (eds.), *Modern society and Communication 1 (in Japanese)*, University of Tokyo Press, pp. 105-138. (竹内郁郎(1973)「社会的コミュニケーションの構造」内川芳美，岡部慶三，竹内郁郎，辻村明 編『講座 現代の社会とコミュニケーション 1 基礎理論』東京大学出版, pp.105-138.)

[85] Tanaka, S., Fukaya, M. (1998). *Evolution on Theory of Meaning (in Japanese)*, Kinokuniya Company Ltd. (田中茂範，深谷昌弘(1998)『<意味づけ論>の展開』紀伊國屋書店.)

[86] Te'eni, D. (2006) “The Language-Action Perspective as a Basis for Communication Support Systems,” *Communications of the ACM*, Vol. 49, Issue 5, pp.65-70.

[87] Toffler, A., Toffler, H. (2006). *Revolutionary Wealth*, Curtis Brown, Ltd. (山岡洋一 訳(2006)『富の未来 上巻・下巻』講談社.)

[88] Teramoto, Y. (1990). *Network Power*, NTT Publishing Co., Ltd. (寺本義也(1990)『ネットワーク・パワー – 解釈と構造』NTT 出版.)

[89] Ueda, M. (2006). “An Attempt to Capture the Behavior Change of a Sales Organization,” *Hitotsubashi Business Review*, Vol. 54, No. 1, pp. 51-69. (植田学(2006)「営業組織の行動変化を捉える試み」『一橋ビジネスレビュー』54 巻 1 号，東洋経済新報社, pp. 51-69.)

[90] Ushioda, K., Senoo, D. (2007). *Magical Office Revolution (in Japanese)*, Kawade Shobo Shinsha, Publishers. (潮田邦夫，妹尾大(2007)『魔法のようなオフィス革命 - 社

員が活きる!会社が伸びる!いま注目の究極の職場スタイル「クリエイティブオフィス」の全ノウハウ』河出書房新社.)

[91] Ustuner, T., Godes, D. (2006). “Better Sales Networks,” *Harvard Business Review*, July-August, pp. 102-112.

[92] Watzlawick, P., Bavelas, J. B., Jackson, D. D. (1967). *Pragmatics of Human Communication: A Study of Interactional Patterns, Pathologies, and Paradoxes*, Norton.（山本和郎，尾川丈一 訳（1998)『人間コミュニケーションの語用論 - 相互作用パターン，病理とパラドックスの研究』二瓶社.）

[93] Weick, K. E. (1979). *The Social Psychology of Organizing, 2nd ed.*, Addision-Wesley.（遠田雄志 訳（1997)『組織化の社会心理学 [第 2 版]』文眞堂.）

[94] Wenger, E., McDermott, R. A., Snyder, W. (2002). *Cultivating Communities of Practice: A Guide to Managing Knowledge*, Harvard Business School Press. (野村恭彦 監修，野中郁次郎 解説，櫻井祐子 訳（2002)『コミュニティ・オブ・プラクティス - ナレッジ社会の新たな知識形態の実践』翔泳社.)

[95] Winograd, T., Flores, F. (1986) *Understanding Computers and Cognition: A New Foundation for Design*, Ablex Publishing Corporatopn.

[96] Yano, K., Ara, K., Ara, K. Moriwaki, N., Kuriyama, H. (2009). ”Measurement of Human Behavior: Creating a Society for Discovering Opportunities,” *Hitachi Review*, Vol. 58, No.4, pp. 139-144.

[97] Yasuda, Y. (1997).*Network Analysis: What does decide to human activities? (in Japanese)*, Shin-yo-sha. (安田雪（1997)『ネットワーク分析 - 何が行為を決定するか』新曜社.)

[98] Yasuda, Y. (2001). *Practice of Network Analysis: Theory and Technique for interpreting human relations (in Japanese)*, Shin-yo-sha. (安田雪（2001)『実践ネットワーク分析 - 関係を解く理論と技法』新曜社.)

[99] Yasutomi, A. (2006). *Complexity of Life (in Japanese)*, Iwanami Shoten, Publishers. (安冨歩（2006)『複雑さを生きる - やわらかな制御』岩波書店.)

[100] Yamamoto, S. (2010). *Computer-Mediated Communication*, NTT Publishing Co., Ltd. (山本修一郎（2010)『CMC で代わる組織コミュニケーション – 企業内 SNS の実践から学ぶ』NTT 出版.)

[101] Yuhashi, H., Iijima, J. (2008). “How Can We Manage Collaboration Network via Communication?,” *Proceedings of the 12th PACIS*, No. 130, Suzhou, July, pp. 347-358.

[102] Yuhashi, H., Iijima, J. (2009a). “How Can We Manipulate a Communication Network to Create Collaboration?,” *AMCIS 2009 Proceedings*, No. 97., San Francisco, August.

[103] Yuhashi, H., Iijima, J. (2009b). “How Can We Manage a Collaboration Network by an Effect of Relations?,” *The Japan Society for Management Information National Conference of JASMIN 2009 Autumn*, A1-3. (遊橋裕泰, 飯島淳一「リンクの性質に着目したコラボレーション・ネットワークのマネジメントに関する一考察」経営情報学会 2009 年秋季全国研究発表大会, A1-3, 2009 年 11 月.)

[104] Yuhashi, H., Iijima, J. (2010a). “How to Activate a Collaboration Network via a Core Member's Communication?,” *Integrated Uncertainty Management and Application*, AISC68, Springer, pp. 511-522.

[105] Yuhashi, H., Iijima, J. (2010b). “The Power to Activate a Creative Core in Enterprise,” *Pacific Asia Journal of the Association for Information Systems*, Vol. 2, No. 2, pp. 67-88.

[106] Yuhashi, H., Iijima, J. (2010c). “How Can We Manage Positive / Negative Relations in Enterprise?,” *The Japan Society for Management Information National Conference of JASMIN 2010 Spring*, F1-3. (遊橋裕泰, 飯島淳一「組織内のポジティブ／ネガティブ・リレーションを考慮したマネジメントに関する一考察」経営情報学会 2010 年春季全国研究発表大会, F1-3, 2010 年 6 月.)

Appendix 1: Data Set of Company Y

It shows a data set of the Company Y which it used in the analysis of Chapter 4.1. Table A is summary data that has the communication acts of the members (Log of voice mails) and their situations (Degree and Size) around their outskirts in the collaboration netweok of Company Y from Janualy 2006 to October 2007. The Table B is the matrix to make the collaboration network of Company Y (cf. Capter 4.1.1 and 4.2.1).

Table A Communication and Collaboration of Members in Company Y

		Communication		*Collaboration*	
Employee ID	Job Position	Average number of e-mails sent per week	Average number of e-mails received per week	Degree per week	Size per week
A01	Officer	1232.4	3635.9	105.8	14.5
A02	Officer	1241.0	617.5	137.0	16.2
A03	Manager	859.1	957.9	148.8	17.4
A04	Manager	881.1	1227.9	202.0	22.7
A05	Manager	874.8	865.2	176.8	20.7
B01	Staff	704.7	297.3	84.0	13.2
B02	Staff	641.4	445.9	73.4	11.5
B03	Staff	716.5	708.6	122.5	14.9
B04	Staff	656.9	480.3	78.3	11.1
B05	Staff	689.5	736.9	139.7	16.1
B06	Staff	751.5	486.1	110.5	15.5
B07	Staff	726.9	940.0	149.9	17.1
B08	Staff	827.8	610.2	121.1	14.7
C01	Part Time Staff	241.7	385.2	195.9	22.1
C02	Part Time Staff	181.9	272.8	92.3	13.7
C03	Part Time Staff	175.3	302.3	76.4	12.1
C04	Part Time Staff	185.2	298.1	97.0	15.0
D01	Other	119.7	0.0	17.6	5.2
D02	Other	133.6	77.9	24.9	7.1
D03	Other	235.6	90.3	56.4	10.3
D04	Other	132.3	69.4	15.8	4.8

Table B Network Matrix of Company Y (All period)

		Employee ID																			
		A01	A02	A03	A04	A05	B01	B02	B03	B04	B05	B06	B07	B08	C01	C02	C03	C04	D01	D02	D03	D04
Employee ID	A01	0	62	47	66	86	0	17	67	32	27	41	74	38	69	20	4	69	22	68	20	8
	A02	62	0	143	100	107	21	25	116	94	79	53	90	130	105	9	2	24	18	16	4	15
	A03	25	62	0	58	70	23	39	88	29	45	29	87	48	135	17	11	15	25	10	5	28
	A04	38	83	80	0	81	28	32	66	38	133	48	63	79	337	76	113	75	26	16	6	31
	A05	39	67	66	57	0	17	24	40	27	51	40	100	52	247	12	31	32	25	32	10	23
	B01	28	48	71	48	55	0	40	26	19	26	35	53	22	43	11	4	18	23	26	51	37
	B02	10	28	73	34	30	23	0	59	24	63	16	51	15	40	1	12	6	14	16	1	24
	B03	24	44	61	48	36	15	42	0	55	45	17	54	42	104	6	16	51	17	7	1	22
	B04	20	39	42	31	43	9	28	90	0	45	11	62	44	42	3	4	9	17	5	0	12
	B05	21	39	50	63	30	14	51	48	34	0	21	111	38	88	24	28	44	18	11	1	22
	B06	24	49	49	44	77	48	21	24	16	41	0	40	26	71	11	16	22	26	70	29	46
	B07	25	38	87	40	57	37	36	67	26	92	30	0	42	57	8	10	21	19	11	2	10
	B08	26	67	66	66	77	28	16	64	30	61	23	64	0	196	21	14	20	24	16	12	22
	C01	27	49	73	102	76	33	4	72	15	40	26	41	64	0	209	212	192	26	13	8	23
	C02	25	25	38	96	43	35	7	26	6	48	23	32	43	455	0	109	116	25	10	10	33
	C03	21	18	29	53	44	47	18	44	9	43	28	34	23	390	62	0	62	26	4	1	38
	C04	16	23	29	51	31	32	4	37	3	31	26	27	19	298	91	34	0	26	8	14	29
	D01	7	0	10	25	44	0	8	7	0	2	18	14	3	11	4	0	38	0	90	3	17
	D02	7	7	12	30	46	1	13	9	0	11	46	14	6	33	6	0	18	15	0	9	12
	D03	6	0	16	15	20	29	3	4	0	3	23	2	1	38	20	2	29	0	16	0	8
	D04	10	14	28	56	49	5	26	19	6	30	22	24	10	91	19	7	52	20	21	4	0

Appendix 2: Data Set of Company D

It shows a data set of the Company D which it used in the analyses of Chapter 4.2. and Chapter 5.2. Table C is summary data that has the communication acts of the members (Log of voice mails) and their situations (Degree and Size) around their outskirts in the collaboration netweok of Company D. It is the data of total seven weeks (the first stage: from November 23 to December 20, 2008, the second stage: from March 8, 2009 to March 28, 2009). The Table D is the matrix to make the collaboration network of Company D (cf. Capter 4.1.2, 4.2.2 and Chapter 5.2).

Table C Communication and Collaboration of Members in Company Y

		Communication		*Collaboration*	
RFID Tag ID	Job Position	Average number of e-mails sent per week	Average number of e-mails received per week	Degree per week	Size per week
20200002	General Manager	4.6	24.1	15.6	219.1
20400446	Manager	78.7	57.0	18.3	268.7
20300335	Manager	43.9	24.6	17.6	261.1
20300224	Manager	27.1	71.9	16.0	223.1
20300113	Manager	6.0	28.2	14.6	212.6
20006375	Manager	–	–	16.0	224.0
20502537	Field Manager	61.0	29.3	14.3	188.0
20402204	Field Manager	42.5	11.0	15.5	211.8
20400880	Field Manager	42.0	11.0	10.0	91.0
20502426	Field Manager	5.4	8.2	6.6	49.2
20006264	Field Manager	0.0	7.5	10.5	117.0
20400991	Chief Engineer	37.7	23.3	18.3	273.3
20602648	Chief Engineer	17.2	15.5	9.2	87.0
20501870	Chief Engineer	0.0	3.3	17.9	266.6
20301103	Staff	40.9	11.9	18.9	274.6
20400779	Staff	33.1	13.6	17.0	250.0
20501547	Staff	30.6	7.3	17.6	254.3
20502315	Staff	27.2	16.6	13.0	152.8
20906931	Staff	25.6	4.4	12.6	165.6
20501981	Staff	19.7	11.3	18.0	269.6
20401214	Staff	13.0	7.5	17.2	254.8
20400668	Staff	12.6	8.7	16.6	232.7
20501658	Staff	10.3	8.0	16.3	231.0
20401325	Staff	5.0	8.3	10.3	136.7
20602759	Staff	4.3	18.3	2.7	10.0
20905163	Staff	0.0	17.3	3.0	6.7
20806608	Staff	0.0	8.0	11.0	108.0
20602971	Staff	–	–	13.7	181.5
20602860	Temporaly Employee	28.4	7.3	19.7	282.6
20501092	Temporaly Employee	3.0	20.0	17.0	232.0
20006042	Temporaly Employee	–	–	14.0	180.0

Table D Network Matrix of Company D (All period)

		RFID Tag ID									
		20200002	20300113	20300224	20300335	20400557	20400779	20400880	20400991	20301103	20401214
RFID Tag ID	20200002	0	11925	6446	13695	0	0	8785	9929	0	0
	20300113	11925	0	11142	15930	0	0	0	22191	0	0
	20300224	6446	10815	0	17242	50671	9330	55251	28204	26971	12257
	20300335	13695	16162	17865	0	35018	7223	56151	41380	29241	15222
	20400557	0	0	50492	34540	0	30609	133546	82405	259129	117549
	20400779	0	0	9324	8050	30366	0	71716	35856	53675	36076
	20400880	8785	0	55030	55341	133739	72404	0	200552	263736	194871
	20400991	9929	22044	28193	40370	81844	35192	201090	0	88510	58011
	20301103	0	0	26994	29317	258875	53061	263778	88692	0	78747
	20401214	0	0	12437	15081	117467	35854	194871	57689	79129	0
	20401325	13349	27284	20421	35498	6749	0	34693	41347	15887	6573
	20501547	14897	48145	32778	67479	5185	0	35813	54599	9800	0
	20501658	0	0	13480	15906	63083	31394	166334	56800	69226	50877
	20501769	0	6371	30571	49850	112987	96840	372326	180997	185418	131746
	20501870	0	0	0	0	9407	0	8654	6632	12192	7163
	20501981	5546	5234	12713	12178	49432	17991	80477	42063	56899	37073
	20402204	0	0	10697	6650	179467	9500	68720	13751	61319	18001
	20602648	0	0	10921	6733	45208	7915	25627	20078	56014	16052
	20602860	20400	27034	42288	54433	86488	34559	153648	112861	115408	68127
	20602971	0	0	19948	17335	282758	33164	150228	43117	121654	35448
	20602082	0	0	0	0	14739	0	5640	0	0	0
	20602193	0	0	0	0	108930	0	42380	0	19168	5201
	20503305	0	0	0	0	7723	0	0	0	6643	0
	20603416	0	0	0	0	75978	0	28650	5768	26573	6504
	20603638	0	0	0	0	76893	0	28530	5857	28493	7465
	20703961	0	0	0	0	33442	0	12843	0	10755	0
	20703072	0	0	0	0	37302	0	14540	0	8178	0
	20703183	0	0	6153	0	71823	5161	27420	7304	28102	7326
	20703294	0	0	0	0	0	0	0	0	9261	0
	20604406	0	0	6229	0	57245	0	21190	8149	27613	7506
	20704517	0	0	8358	5620	59763	11814	33705	14805	40032	10231
	20704628	0	0	10370	12420	0	21110	0	29850	75370	9030
	20704739	0	0	0	0	32513	0	12000	0	13245	0
	20804840	0	0	7530	0	27329	5480	9978	9869	30649	8709
	20804951	0	0	16258	11949	229281	18787	86890	24712	93233	22591
	20804173	0	0	0	0	0	0	0	0	0	0
	20804395	0	0	0	0	30366	0	11650	0	7657	0
	20705507	0	0	0	0	7929	0	0	0	17097	0
	20805729	0	0	0	0	10515	0	0	0	0	0
	20905941	0	0	0	0	35886	0	13950	0	9718	0
	20905052	0	0	0	0	48982	5831	18800	6374	22185	0
	20905163	0	0	0	0	9387	0	0	0	6838	0
	20905274	0	0	6474	0	32982	5506	24937	9085	23854	9689
	20905385	0	0	7187	6424	5062	10713	0	15731	47717	9487
	20905496	13760	11170	14329	21633	0	0	8863	27656	5427	0