Inter-firm Relationships in the Development of the Japanese Telecom Industry

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Abstract
Telecom services have been developed massively in the last ten years. The telecom companies offered not only telephone services but also data exchanges like streaming services. Therefore, they now offer telecom services as packaging into which layered services are integrated. Telecom services are closely influenced by developing technologies. Additionally, the processes of service development have involved many companies. Therefore, inter-firm relationships are emphasized in the management of technology in these areas. This paper shows that the interactions between the marketing concept and the nature of inter-firm relationships led to the development of telecom services. The relationships derived from business resources which originated from an exchange of technological knowledge and specialized skills. This research uses the NTT-centred collaboration system in Japan, which features relational exchanges and high mutual dependence. This case shows that developments in technology resulted in an expanded domain of applicability. Consequently, the existing market was forced to change. As a result, indirect exchanges occurred when inter-firm relationships changed. With increasing integration of the market, the number of firms grew and they concentrated on specific technologies, having superior competitive advantages in each layered business area.

Keywords: Telecommunication, R&D, innovation, Japan

1. Introduction

This paper explores the relationship between inter-firm relationships and developments of telecom services, focusing on R&D activities in the Japanese telecom industry.

Telecom services have been developed massively in the last ten years. In the past, the telecom industry offered only telephone and telegram services, but now they offer not only voice switching but also a variety of data transfer related to text, pictures and movies. In addition, a variety of terminals are connected with telecom networks. Therefore, they now are offering telecom services as packaging into which layered services are integrated. As a result, the structure of the industry has become more complex and scale increased. Furthermore, telecom services are closely related to technologies. Recent rapid changes of technologies enable realization of these services, at the same time, influencing ways R&D activities are undertaken.

The telecom industry consists of a variety of companies, which undertake many processes of service development. Therefore service developments have been carried out not only by using telecom relevant technologies but also with input from other sources. Previously, R&D activities in the telecom industry took place by close relationships between a telecom operating firm and specified manufacturing firms. The relationship between AT&T and Western Corporation is the good example with AT &T operating the telecoms and Western Corporation manufacturing the technology. Firms developing the technology however, expanded their domain of applicability. As a result, the existing market was forced to undergo change. New firms and technologies came to the telecom market from other business areas. Consequently, these close relationships have changed.

This paper shows that under these conditions the interactions between the marketing concept and the nature of inter-firm relationships influences methods of service developments in the telecom sector. Particular attention is paid to R&D activities, focusing on business resources which originate from an exchange of technological knowledge and specialized skills. Research on the Japanese telecom sector is used to illustrate these situations. Focusing on the NTT-centred collaboration system, the paper describes how developing technologies influenced the telecom market and inter-firm relationships.

The article is organized as follows. First, the theoretical background considers the characteristics of R&D activities based on the discussions of inter-firm relationships and business resources. Next, by describing R&D activities in the Japanese telecom industry in the post war period, the article aims to clarify how technological developments have affected inter-firm relationships in R&D activities. Finally, managerial and future research implications of the findings are discussed.

2. Theoretical Background

2.1 Industrial network

The telecom industry comprises of a variety of firms originating not only from pure telecom activity but also other business activities. Firms are involved with many processes of service development. The links amongst these firms that together create the telecom sector often emphasize relational exchanges (Dweyer, Schurr and Oh 1987), which are based on the importance of sustained long term mutually supportive relationships between firms (Arndt 1979). Although the nexus of links is considerable, each of the firms or departments operates in a relational environment which involves only a limited number of identifiable organizational firms (Hakansson and Snehota 1989).

By focusing more on value creation than value adding [1](Normann and Rameiz 1993), it could be pointed out that close, cooperative and interdependent relationships make greater

[1] Normann and Rafael (1993) emphasized that not simply adding a value to their products or services but reinventing a value is a key factor for companies to success their businesses.

value than purely transactional exchanges (Kalwani and Narayandas 1995). Consequently, along with the increase in competition and internationalisation, growth of many partnering relationships such as industrial groups (Keiretsu), strategic alliances and cooperative marketing ventures takes place (Sheth and Parvatiyar 1992).

Inter-firm relationships take a long time to develop, while substantial resources are used to establish, adjust, maintain and develop relationships between firms (Johanson and Mattsson 1985). Long period continuous exchanges result in adaptations to each relationship, resulting in high mutual dependences between firms (Ford 1980). Additionally, a mutual adaptation process affects not only a dyadic relationship but also the overall relationships (Ford 1980). Thus, firms are mutually inter-dependent on their activities within a network.

In these industrial relationships, a firm has a unique identity characterized by resources obtained from its relationships with other firms and the consequences of earlier activities in the network. Organizations are embedded in a network of interdependencies and social relationships (Pfeffer and Salancik 1978). The individual firm is dependent on resources controlled by other firms (Mattsson 1987). A need for resources obtained from the environments make organizations dependent on external resources. The use of an asset in one firm is dependent on the use of assets in other firms (Johansson and Mattsson 1987). The firm obtains access to these external resources through its network positions.

According to Turnbull, Ford and Cunningham (1996), interactions between firms are influenced by the technologies of parties. Most exchange takes place within pre-existing relationships; however, those relationships are changing all the time through interaction among the firms associated with transactions made within the relationship (Johansson and Mattsson 1987). Therefore, it can be argued that changes in technological conditions influence the structure of the overall relationships.

2.2 Business resources and market orientation

These approaches focused on business resources as the origin of competitive advantages. Constantine and Lusch (1994) define two types of resources: Operand resources are the resources on which an operation or act is performed to produce an effect, while operant resources are employed to act on operand resources and other operant resources. Operant resources are likely to be invisible, intangible, dynamic and infinite in nature (Vargo and Lusch 2004). “Resources” can be assumed as not only physical, monetary and human but also skills and knowledge or capabilities. These latter types can be the most important types of resources. Therefore, resources consist of a bundle of potential capabilities (Penrose 1959, Vargo and Lusch 2004), and capabilities are a complex bundle of knowledge or skills (Day 1994). Consequently, developing competitive advantages becomes an issue when dealing with how operant resources are handled (Vargo and Lusch 2004).

Resources can lead to sustained competitive advantages when they possess operant resources that provide superior value to customers and are difficult to initiate (Dierickx and Cool 1989, Barney 1991). In addition, multiple applications of these resources are a significant characteristic (Penrose 1959). They therefore, can be used in different ways to speed up the firm’s adaptation to environment changes (Day 1994, Prahalad and Hamel 1990).

Assuming that resources cannot be exchanged[2], they must be developed within a firm. Therefore, issues focused on activities of firms' business processes (Day 1994). The competitive advantage of firms stems from dynamic capabilities rooted in performance routines operating inside a firm, embedded in the firm's processes, and conditioned by its history (Day 1994). These capabilities are developed by long established firm activities and may depend on the history of the use of resources in an extremely complex process. Capabilities are so deeply embedded in the organizational routines (Pfeffer and Salancik 1978) and practices that they cannot be traded or imitated. Consequently, organizational learning is emphasized to develop business resources.

In the past, only the marketing department was regarded as carrying out marketing activities. By introducing marketing into the strategic management concept, the scope of marketing expanded to include competitors' activities and to company-wide activities (Webster 1988). Consequently, the approach was focusing on understanding the expressed desires of customers in their served markets and developing products and services that satisfy those desires. This approach was termed "customer orientation" (Slater and Narver 1998) and assumed that developing competitive advantages could be created by closer relationships with customers.

However, too much emphasis on customer orientation leads to missed opportunities for adapting innovation (Christensen 1997, Day 1994). Only focusing on specified customers leads to seeing the business through their current customers' eyes and the firm begins to adapt to the customers' way of doing business. In addition, managers tend to avoid the risk of being unwilling to risk displeasing powerful existing customers. As a result, the customer-oriented philosophy is reactive and short term in focus (Slater and Narver 1998), and generally makes difficulties when "product innovation" (Abernathy and Utterback 1978) takes place. The concept of market orientation (Kohli and Jaworski 1990, Narver and Slater 1990) emphasizes continuous interaction with markets and external environments. As a result, the market-driven business is well positioned to anticipate the developing needs of its customers and respond to them through the addition of innovative products and services. Market orientation is an inherently learning orientation (Slater and Narver 1995). Therefore, continuous organizational learning and interaction with markets leads to an increase in the significance of the inter-firm relationship. Resources are defined as the subset of the competences operant resources generated by organizational learning, which allows the firm to create new products and processes and respond to changing market circumstances (Teece and Pisano 1994).

2.3 The characteristics of R&D activities, Uncertainty and Equivocality

A major part of R&D activities is to create technological knowledge, which provides a strategic advantage and an increase in profits for a firm. Recent rapid technological change and the increase in technological complexity have served to emphasize two of the main features of R&D activities: uncertainty and equivocality.

In the technological innovation process, there is a process, termed dominant design Abernathy and Utterback (1978), which states that the basic architecture of a product or process becomes the accepted market standard. Before establishing it, there are many types of technological standards or candidates that have possibilities to become a dominant design.

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[2] Barney (1986) pointed out that resources can be obtained from the "strategic factor markets". They regarded the resource as transactionable in a market. However, Dierickx and Cool (1989) examined the exchangeability of resources in the market from the view of Inimitability. They concluded that competitors tended to imitate the advance business resources from leading companies, but that sustainable resources cannot be imitated and replaced because these resources have a strong tacit dimension. In addition, Barney (1991) indicated that immobility is also the essential characteristic of resources. Hence, the key feature of distinctive competences and capabilities cannot be traded in any market.

R&D departments therefore have to deal with these equivocal situations because they introduce such new technologies into their systems, releasing new superior products as soon as possible. Abernathy and Utterback (1978) termed these situations as equivocal. In the recent rapid changing technological environment, some new technologies appear and are dismissed. How companies select the technological candidates from the total and involve the selected technologies becomes a key point on which to compete.

Uncertainty is another significant feature of R&D. A lack of information and experience is an important factor in creating uncertainty. Under rapidly changing circumstances, information tends to be of questionable accuracy and to be quickly rendered obsolete. A lack not only of quantitative but also qualitative information provides uncertainty. Therefore, more accurate information is needed to evaluate alternatives. The life-time of information is linked with uncertainty when technological change is extremely high (Bourgeous and Eisenhardt 1988), which means that information in a given period loses its value in subsequent periods (Glazer and Weiss 1993). Therefore, strategic decision making is problematic in this kind of environment not only because change is so dramatic but also because it is difficult to predict the significance of a change as it is occurring.

2.4 Two types of partnerships in R&D activities

Managers in R&D departments check technology trends and predict future technological visions. In highly competitive business circumstances, R&D departments face uncertainty and equivocality because R&D activities always deal with new fields which do not exist in a market. Therefore, they have to evaluate new technology and try to identify if it is deemed suitable for the technology plan. In addition, they sometimes change the technology plan, review projects and improve processes of development in order to adapt to rapid technological change.

There are two types of activities for R&D departments when collaborating with others. One is to exchange information with others, in order for the firm to be aware of the latest technological trends and detect the emergence of innovative technology and capability venture companies. To evaluate the technological capabilities, R&D departments sometimes carry out laboratory experiments in collaboration with technology providers. At this level of a relationship, obtaining information and evaluating it is the main priority. This activity takes place within a small hierarchical level of a department and informal communication is sometimes critical. Therefore, the amount of business exchange is relatively small. In addition, indirect relationships can be available and important information can be provided by existing partners at this stage. I shall define these types of partnerships as type 1 partnerships (“informative partnerships”).

On the other hand, there are comprehensive partnerships in which firms consolidate their experience through developing technologies and bringing new products (or services) into a market through long-term collaboration. Relationships are relatively long, involving strong commitments. For example, they share technological knowledge, know-how, and also confidential information. Their technological resources are mutually dependent and the amount of business transaction is significant. Furthermore, each company sometimes exchanges personnel resources. In some cases, a customer firm sends an individual as an executive to the seller. We can look at many situations in which the seller's employees work in a customer’s office. They attend meetings and have informal communications very frequently. I shall define this type of partner ship as type 2 partnerships (“comprehensive partnerships”). This example can be seen at the just-in-time system in the Keiretsu' system. Just-in-time requires extremely close cooperation and scheduling between buyer and seller, so it will usually work much more smoothly with limited suppliers. The characteristics of the two types are summarised in Table 1.

Table 1: Characteristics of two types of partnerships

	Type 1. Informative Partnership	Type 2. Comprehensive Partnership
Purpose	Information	More comprehensive
Time of relationship	Transactional or short	Long-term relationship
Commitment	Weak	Strong
Number of firms	Relatively large	Limited
Interdependence	Independent	Inter-dependent
Unit of firms	Small business unit	Entire R&D department

2.5 The conditions of changing Partnerships with vendors

In order to explain relationships between firms, commitment can be pointed out as a 1994). Relationship commitment can be defined as an exchange partner believing that an significant factor (Anderson and Weitz 1989, Anderson and Narus 1990, Morgan and Hunt ongoing relationship with another is so important as to warrant maximum efforts to maintain it (Morgan and Hunt 1994). With a high commitment between partners, the following situations make changing partnerships difficult.

The first is accumulating investment actions through keeping relationships. Customers invest in their relationships with vendors in a variety of ways: money, time and education of employees to use the offers of vendors efficiently. This means that customers must invest large amounts in adapting new products, services or systems. Relationships that have lasted a long time are more likely to continue than relationships that are younger because over time adjustments are made (Anderson and Weitz 1989).

Investment in the relationship is made by each party. Therefore, there is a high v. low 2 by 2 matrix of investment by customer and vendor. The balance of investment is important and is influencing the nature of the relationship. Low-Low for example gives a very transactional relationship. On the other hand, High-High gives a strategic partnership of the Anderson and Weitz (1989) type. However, a relationship might be assumed based on high and low positions. In fact, perfectly balanced situations rarely occur in a business world. Therefore, in order to keep the balance, the firm with high level investment offers something to another. Supporting R&D fees or opening patents are examples. Or there is a case that keeping the relationship gives huge benefits to another.

Heide and John (1990) indicated incompatibility problems that buyers may have developed routines and procedures for dealing with a specific vendor that will need to be modified if a new relationship is established. Every employee in each partner feels comfortable and is used to their existing way of working. Therefore, they hesitate to change partners because their way of working also has to change. This is essentially an inertia factor.

Above all, it is difficult to change vendors when the commitment to a relationship is so high. The expected benefits of choosing a new vendor could be negligible compared to continuing with existing partners (Heide and Weiss 1995). Therefore, some buyers may manage by relying on existing vendors and opting for alternatives does not occur until collaboration with an existing partner is no longer feasible (Eisenhardt 1989). Additionally, under uncertain business circumstances, it is very difficult to evaluate alternatives. As mentioned by Heide and Weiss (1995), rapid technological change makes it difficult to evaluate acquired information in terms of offering new products. In turn, this gives buyers an incentive to choose an existing vendor, even after having collected information about new ones.

However, current partnerships cannot remain constant, especially in a dynamic marketplace. Relying too heavily on existing relationships creates risk. The decline of a firm is caused by a lack of accurate analysis of business circumstances (Sutton, Eisenhardt and Jucker 1986). Therefore, firms face more risk in not changing for the long run because fear of exposure can interfere with ability to adapt to external changes (Jackson 1985). In other words, changing vendors also takes advantage of strategic opportunities.

As mentioned before, an increase in uncertainty leads firms to having more qualitative information from others. Furthermore, increasing levels of uncertainty will increase the expected benefits of searching for additional vendors (Heide and Weiss 1995). In other words, a firm tends to have more partners involved in the network in order to have more information because a firm wants more accurate information in order to evaluate alternatives. Therefore, the type 1 partnership (informative partnership) will increase if the level of uncertainty is higher. However, in order to adapt to rapid change and change partner rapidly, they avoid making a strong commitment at this stage. Therefore, incentives to changing vendor rarely occur even if the circumstances are uncertain. In summary, even if the business conditions are uncertain, changing vendors with strong commitment hardly ever occurs.

Before establishing a dominant design, there are a variety of non-standard technologies in a market. Every technology has the potential to become the technology standard. Therefore, a firm has to evaluate every form of technology in order to avoid the risks entailed in ignoring it. The evaluation of technology is carried out through obtaining information or by experimentation. Therefore, when equivocality increase, a firm wants to have more information to evaluate, therefore, an increase in equivocality makes a firm engage in a type 1 partnership with others. At the same time, this leads to changing the existing partnership as each firm forms relationships through the experimentation carried out in the evaluation of technologies. As a result, a buyer is sometimes able to enter the customer’s technology relationships. Furthermore, an increase in equivocality means that it is possible to change vendors during the evaluation phase. Therefore, equivocality is an extremely significant factor in changing existing relationships. The type 1 partnership makes it possible for new vendors to enter a type2 partnership. Therefore, a type1 partnership is a process in order to establish type 2 partnerships. In equivocality, type 1 and type 2 partnerships are not independent but linked.

Experience also strongly influences buying-decisions. von Hippel (1986) mentioned that the marketing of a high-technology product does not involve the real-world experience which is needed for problem solving and provides accurate data for market research. In his view, the traditional marketing method's insights into a new product, its service needs and potential solutions are constrained by real-world experience. In the relatively slow-moving world of many consumer products, goods do not often differ radically from their immediate predecessors. In contrast, high-technology industries move so rapidly that the related real-world experience of ordinary users is often rendered obsolete by the time a product is developed or during the time of its projected commercial life. In R&D activities, development processes always face unknown problems that researchers have not experienced before. Therefore, historical experience which is derived from existing relationships sometimes becomes meaningless. As a result, there is a bigger chance of destroying existing relationships even if there is a strong commitment under radically changing circumstances. Consequently, R&D departments have more incentive to change partners than other departments. This suggestion is supported by the results of Heide and Weiss (1995). Their study indicated that experienced buyers are more likely than inexperienced ones to stay with existing vendors. The high level of uncertainty and equivocality causes a weakness of commitment and tends to involve partners changing because the market is less experienced and inexperienced buyers are less committed to historical patterns than experienced ones.

In summary, the following can be shown in R&D activities.

(1) When there is a low level of uncertainty and equivocality, a firm tends to keep existing relationships.

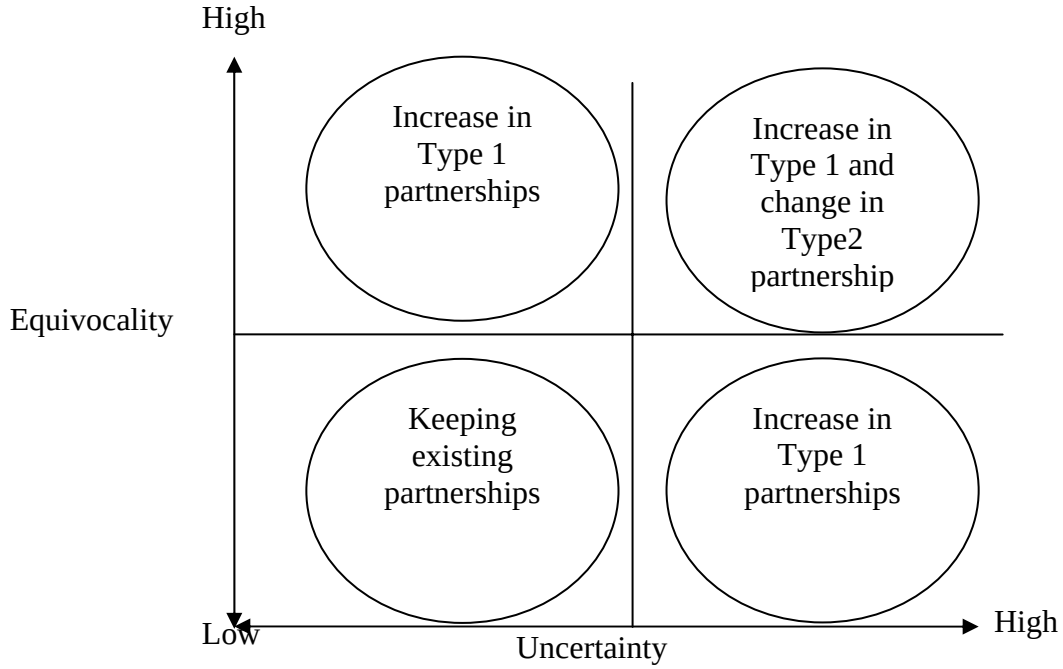
(2) Where there is a high level of uncertainty, a firm tends to have more partners in order to obtain information (increase in type1 partnerships), but switching partners does not always occur.

(3) With high levels of equivocality, a firm tries to engage with more partners in order to evaluate technologies (increase in type1 partnerships). In addition, this movement may change type 2 partnerships.

(4) When there is a level both of uncertainty and equivocality, there is a greater likelihood not only of an increase in type 1 partnerships but also of a change to type 2 partnerships

These issues are shown in figure 1.

Figure 1: Two type of partnership and Uncertainty, Equivocality



In order to clarify the characteristics of R&D activities, it has been shown that two significant environmental factors influence R&D relationships. As competitive circumstances increase, and uncertainty is higher, it is said that firms should concentrate only on their competitive business areas (Hamel and Prahalad1991, 1994) and central competence resources. However, at the same time, firms should seek new partners in R&D activities. In particular, when equivocality is high, R&D departments will increase the possibility of changing vendors as well as seeking new partners. The reason is that a firm on its own cannot develop products or services in conditions where technological complexity is high. This means engaging in partnerships is indispensable for R&D strategy to win the technological competition. Therefore, it can be argued that not general firms but specialized firms which concentrate on specific items will increase.

3. Case study

3.1 Research Question and methodology

Based on these discussions, this study defines R&D activities as ones which create business resources through continuous organizational learning and interaction, not only with

competitors and customers, but also other stakeholders. Consequently, it assumes that these activities of R&D departments originate new telecom services because telecom services are strongly related to technologies. When we assume that business resources can be created through interaction with a market consisting of these players, we should clarify how technological trends influence a market and inter-firm relationships. Consequently, because relationships between firms are not dynamic, a market and inter-firm relationships should be changed along with developing technologies.

The study shows (1) how developing technologies have influenced the market and (2) how inter-firm relationships had to be changed associated with the developing technologies. Specifically, by measuring technological circumstances as the level of uncertainty and equivocally, the study investigates how inter-firm relationships are changed from existing relationships to informative and comprehensive partnerships.

In order to clarify these problems, a qualitative method, case study, is used. This study describes the relationship between inter-firm relationships and technological trends, focusing on continuous organizational learning and interaction in the market for inter-firm relationships. Therefore, this phenomenon has to be investigated over a long period. In addition, studies of R&D activities include many variables: technology trends, business circumstances, the diversity of actor behaviour and policies or regulations. Therefore, a study of causal links and the effects of one factor on another is difficult. In that case, a case study is regarded as a suitable method to explain how events interactively occur over time (e.g. Yin 1994) and in particular describes the 'contexts' of events.

The data are based on published documents; annual reports, company histories and other relevant documents. Informal interviews are used to understand the context of recent events. Information about R&D activities is confidential for firms. Therefore, information gained from interviews is of limited value being circumscribed by confidentiality restrictions.

This study analyses the Japanese telecom industry, focusing especially on switching systems technology projects after 1945. A switching system is one of the most important pieces of telecom equipment, used for connecting telephone calls. The system is required to perform a huge amount of telephone call exchange accurately and within a very short space of time. Therefore, the reliability, scalability and performance need to be very high compared to other equipment. The necessary areas of technology for development are very wide. Additionally, these features necessitate long term development periods of between five and ten years.

3.2 *"Family companies"*[3]

NTT (Nippon Telegram and Telephone Corporation) is the biggest Japanese telecom operator, running the whole Japanese communication business from telecom and mobile to data communication and system integration services. NTT was established as a public corporation in 1952. After NTT became incorporated as a private company in 1985, it split off from its data communication and mobile businesses in 1988 and 1992 respectively. Subsequently NTT's operations reorganized into a holding company structure in 1999. Today, NTT has five main companies[4] and 258 subsidiaries. The five firms are leading companies in each business area despite dealing in very competitive environments.

NTT laboratory belongs to NTT holding company directly. The lab consists of twelve laboratories, dealing with basic and applied research. Three thousand researchers work in the lab and the annual research fee is almost £1 billion, which is co-funded by subsidiaries. The

[3] These are described based on Nakagawa (1990), NEC (2001), Oki (2001), Shimoda (1981), Shindo(1982) and study of the files at NTT

[4] The five companies are two regional telephone companies (NTT-east, NTT west), a long distance telephone company (NTT Communications), mobile (NTT-DoCoMo) and system integration company (NTT-Data).

lab has been involved in most of the big projects NTT has carried out in its history. NTT lab initiated these projects with other business departments and manufacturing companies. One interesting feature is that NTT do not have manufacturing departments. Therefore, manufacturing activities have been carried out in collaboration with other companies.

A characteristic of the Japanese telecom industry was that a limited number of firms took part in R&D activities post-1945. NTT in particular collaborated only with four big companies consisting of NEC, Hitachi, Fujitsu and Oki in all of its main projects. NEC and Fujitsu are the leading companies in the computer, system integration, and communication businesses. Their annual revenues in 2007 were £23 billion and £26 billion with NEC and Fujitsu. Hitachi Ltd is a Japanese general electric manufacturer, whose business covers a variety of areas from nuclear plants and rail systems to general appliances. The revenue in 2007 was £51 billion. Oki is a relatively smaller company compared with the three others, but it produces the relevant components for computer and communications industries with its revenue of £4 billion in 2007.

NTT and these four companies have kept mutual relationships in NTT's procurement, personal exchanges and R&D activities without any capital ties. In addition, because NTT has no manufacturing department, they acted as manufacturing departments of NTT. NTT's strong purchasing power in Japan had contributed to these companies' management. These special relationships can be called as "*family companies*".

There are several reasons why this collaboration system had remained for a long time[5]. Firstly, a telecommunications system consists of millions of interconnected components. As a result, standardization is extremely important. All processes, from design to manufacturing, aim to equalize the quality of products. Attributes and performance have to be standardized. An exchange with limited members is easier for quality management. Secondly, for NTT to receive their requested products, they consulted closely with manufacturing companies. Thirdly, NTT purchased every prototype, so when they decided to introduce a system, the manufacturing companies gained immense benefits from manufacturing the system. As a result, family companies were able to concentrate on studying problems without any risks.

Furthermore, by using technologies created by the collaboration, family companies were able to develop derived systems for civil use and export. This could be realized in that family companies were able to use and exchange patents made by the collaboration and accumulate technological capabilities. The results of collaboration were stored as the patents and specifications belonged to NTT. These specifications did not consist of manufacturing technologies that each company had accumulated through the collaboration. Other companies could use other's technologies by paying a patent fee or exchanging patents. The aforementioned manufacturing companies were exempt from paying NTT's patents[6].

3.3 Establishing the collaboration system [7]

In the immediate post-war period telecom conditions were poor due to the disruption of the network during the war. In order to recover and improve this quickly, NTT decided to develop a new type of switching system, a cross bar switching system. The development was executed by importing and modifying foreign technologies and rationalizing components to fit Japanese telecom conditions. NTT made a thorough study of the imported crossbar switching systems by collaboration with NEC[8]. They disassembled and assembled a Western

[5] These are based on Nakagawa (1990), Shindo (1982). Shindo was the last president of NTT public Corporation and the first president of NTT Corporation.
[6] Hiramatsu (1980)
[7] These are described based on Nakagawa (1990), NTT (1976), NEC (2001), Oki (2001) and study of the files at NTT
[8] NTT (1976), NEC(2001), Nakagawa (1990)

Electric's crossbar system many times, remodelling and improving it for companies to manufacture easily[9]. Naturally, the system NTT developed was completely similar to that of Western Electric's system. However, this trial was very important, especially for a late player, to develop R&D capabilities. These methods are termed 'reverse-engineering'. According to Fujimoto and Ge (2004), we should distinguish between reverse engineering and exact copy. Both activities are similar, imitating the products of a front runner or competitor, but have a greater effect on a firm's accumulating R&D activities from a long-term perspective. By disassembling and assembling a WE system, they studied the design of the WE system as well as how to connect physical components with structural and functional design. By using the experience gained from these studies, they understood the nature of developing switching systems. Consequently, these gained technologies were transferred to other companies. The results of the collaboration between NTT and NEC were made available to OKI, Hitachi and Fujitsu by the contract[10]. As a result, the systems were manufactured by four companies independently. These activities equalized technological levels of family companies, leading to standardizing qualities of the systems.

Cross-bar switching systems could realize direct dialling and reduce the costs of network constructions, greatly contributing to the development of telecom markets. However, telecom companies considered that a new generation of switching systems would be realized by electric switching, not by existing mechanical exchanges like cross-bar switches. By using electric devices, new telephone services could be easily installed and operational costs were expected to be reduced. In addition, more telephone lines could be held in a system. AT&T and other telecom companies aimed to use computer technologies for their switching systems. This meant that electric devices and other computer relevant technologies would be included in the developments of switching systems.

In 1962, Bell Labs released the news that it had succeeded in developing a prototype of an electric switching system. An electric switching system is a kind of computer, using electric devices replacing physical switches. This news triggered NTT's decision to develop an electric switching system for commercial use[11]. However, they did not have enough experience and information to develop an electric switching system. The necessary technological areas were more varied than those of the development of a crossbar switching system. Consequently, NTT tried to contract with Bell Labs directly. This was a cross licence agreement for which NTT paid a large amount[12]. NTT also drafted a technical assistance contract with Western Electric[13]. This contract provided NTT with substantial information about electric switching systems. At the same time, the most important thing was to evaluate Bell's electric switching systems in detail. By using this information, NTT developed a prototype system in 1966, which was based on the Bell system in order to study a stored program system and its applicability for a switching system[14]. At the same time, another prototype was developed in collaboration with NEC[15]. It was a unique and advanced system using new technology. It aimed to evaluate a time division system which was closely related to PCM (pulse code modification) systems. Evaluating results from two systems, NTT and manufacturing companies launched the development of their original electric switching systems, through their ongoing collaboration, in 1967. The design was their original concept.

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[9] Genjiro Shiromizu, who was an engineer at the time mentioned that his team disassembled and assembled a WE crossbar system almost ten times, remodelling it for companies to manufacture easily (Nakagawa 1990).
[10] NEC (2001), Oki (2001). Parallel, other companies (Fujitsu, Hitachi and Oki) also contracted with WE to use patents.
[11] Nakagawa (1990), NTT (1976) referred details of discussions about instalment it.
[12] NTT (1976)
[13] ibid
[14] Nakagawa (1990), NTT(1976)
[15] NTT (1976)

This system used their unique technology, in particular the latest semiconductors. Their original IC, which was developed in collaboration with NEC, was adapted for the CPU devices. In this way, they achieved economization and footprint downsizing.

Both projects show how the collaboration system became established and deepened. In these processes, studying new technologies and how to manage a large scale project were the main issues. Four companies were able to accumulate technological resources through the collaboration. Therefore, each company developed small civil switching systems by using accumulated technologies. As a result, they were able to penetrate the domestic market and succeeded in exporting systems. Consequently, these technologies were used for NTT's systems[16] and *family companies*' products. As a result, *family companies* grew dramatically. This reusability of gained technologies became a feature of the collaboration system.

In addition, they were able to learn how to collaborate with each other, ways of establishing a development plan, as well as project management methods.

During these periods, NTT's business concentrated on telephone services. They only looked at telecom relevant companies, *family companies* and foreign companies like AT&T and Western Electric. The influencing factor to their technological activities was the semiconductor technologies, selecting devices and developing manufacturing technologies. Therefore, equivocally was not high at this stage. It was the first time for NTT and *family companies* to develop large scale switching systems. These situations led to increasing uncertainty. In these circumstances, a company tends to obtain partners in order to gain information. This occurred in both projects. NTT engaged with Bell Labs and Western Electric in order to compensate for their lack of experience in developing and evaluating electric switching systems. *Family companies* also contacted foreign companies in computer and semiconductor businesses[17]. This was not only to use licences but also to obtain advanced technological information. Therefore, under these circumstances, a company needs to find new technologies which will contribute to their future and evaluate the technologies immediately. Even though NTT and the *family companies* made close relationships, they tried to search for and evaluate new technologies existing in other companies, specifically foreign ones. The information obtained was mutually exchanged and helped with their development.

3.4 Integration between data and telecommunication services [18]

Developing computers and relevant technologies brought about a new service allowing computers to connect with each other through a network. Termed data communication services, banking and ticket reservation systems were developed. Telecom operators tried to be involved in this market, studying computers in the early days of their development.[19]

In 1967, NTT decided to enter the data communication services market with Japanese government permission.[20]. Immediately, they collaborated with three *family companies*, Fujitsu, Hitachi and NEC, but not OKI[21]. The project, called DIPS, aimed to develop a Japanese standard general purpose computer by unifying interfaces and standardizing

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[16] Shimazu, chief engineer of NEC at the time, mentioned that accumulated technologies and experiences through developing cross-bar switching systems led to the success of developing electric switching systems (NEC 2000).

[17] Hitachi contracted with RCA, NEC with GE, and Fujitsu with WE

[18] This section is based on Itami (1988), Muraoka (1985), Nakagawa (1990), NEC (2001), NTT(1999), Oki(2001) and Okimoto, et al (1984) and study of files in NTT

[19] For example, NTT succeeded in developing their own computer by using parametron devices in 1957.

[20] At this time, some industrial countries, including Japan, prohibited telecom operators entering the computer business. AT&T was forced to stop computer developments by the Federal Communication Commission because of the antitrust law.

[21] Oki also wished to join the project, but NTT refused as Oki had retreated from their development of large general purpose computers (Oki 2000).

software development methods[22]. This collaboration was different from that of switching systems. The three companies were leading companies in the Japanese computer businesses, having a unique path in growing their computer businesses by taking their cue from foreign companies. This means that each company competed with each other on their own technological specifications. As a result, in the project, the software architecture and interfaces would be standardized while the hardware specifications would be developed by each company's own individual methods[23]. Therefore, *family companies* came to compete within the collaboration. However, the collaboration system functioned well because *family companies* were leading companies both in the semiconductor and computer businesses. They played a significant role because they affiliated with U.S computer makers and had developed semiconductor devices in order to respond to civil demand[24]. At the same time, they took part in almost every project planned by the Japanese government[25]. Through these activities, members exchanged technological information and developed cutting edge technologies through collaboration. Therefore, these results provided NTT and *family companies* with many benefits.

NTT's entry into data communication services meant that a new communication market would be created, integrating the computer market with the telecom market. The emerging online services expanded on these uses, creating a variety of services. As a result, many other firms tried to enter this market - not only firms in the computer industry, but also those involved in telecommunications equipment, business machines, and in the electric industry. Furthermore, these new firms did not come only from existing companies - new companies and new industries appeared. For example, U.S semiconductor companies did not come from existing firms; Intel, TI, Motorola and Fairchild were new semiconductor businesses. Software factories appeared at this time[26]

NTT and *family companies* changed their methods of R&D activities in tandem with the changing telecom market, integrating the computer and semiconductor markets. Previously, NTT had concentrated its resources on the telecom business, only watching the telecom market. In addition, they were only interested in AT&T's activities in order to obtain information on advanced telecom technologies. However, by expanding their telecom market, they had to watch other markets.

By integrating the computer and LSI markets, the Japanese telecom market became more complex. In the computer industry, new technologies were appearing frequently. In the LSI market, along with the development of the calculator business, new technologies and firms appeared. Previously, most telecom relevant technologies had been developed from within the telecom industry itself. Telecom technologies were specialized and very advanced. Therefore, it was not possible for developments to take place outside their networks. However, similar to the way in which the calculator businesses created new LSI[27]s, unrelated markets developed their own relevant technologies. Additionally, these technologies became standards for the relevant technologies because commercialized components were expected to reduce costs by mass production and to maintain high quality by developing manufacturing technologies. Consequently, the numbers of firms involved in telecom markets increased and other factors influenced the market. Therefore, NTT was forced to watch other markets' activities as well as their relevant ones'.

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[22] Muraoka (1985), Nakagawa (1990)

[23] At the time, while IBM dominated the computer markets, there were two managerial methods: IBM compatible or unique. Hitachi and Fujitsu changed their methods so that their developments would be based on IBM compatible architecture in their computer businesses. In contrast, NEC stuck with their own method.

[24] Itami (1988), Okimoto, Sugano and Weinstein 1984

[25] In order to grow up Japanese computer makers, Japanese government guided several projects.

[26] Cusumano 2004

[27] Large Scale Integration circuit

Over the period described in this section, NTT's target apparently changed from AT&T to IBM. Prior to this, when NTT were developing electric switching systems, AT&T was the only target and NTT tried hard to reach and be superior to AT&T's technological levels. However, after deciding to enter data communication services, the target changed to IBM because IBM was the giant of the computer business and had developed advanced technologies which became the standard for components in the computer industry. In addition, the computer industry was very competitive and many firms were concerned with the industry. Therefore, it was very difficult for NTT to watch the activities of all participants and gather technological information from them.

Following from this, *family companies* played a significant role. They had developed computer and relevant technologies by affiliating with foreign companies. Fujitsu were affiliated with Amdahl Corporation which was founded by Gene Amdahl, the former chief designer of IBM. Similarly, Hitachi was affiliated with RCA, and NEC with Honeywell Corporation. They were able to gather new technological information from their partners and evaluate them because they manufactured them themselves. Therefore, they were able to accumulate technological capabilities through these activities. In addition, they were also semiconductor companies. They exchanged closely with calculator businesses and developed and manufactured LSI to respond to the demand of calculator businesses and their own computer departments. Furthermore, they took part in almost every project planned by the Japanese government. Through these projects, members exchanged technological information and developed cutting edge technologies through collaboration. Therefore, these results provided NTT/ NTT's *family companies* with many benefits.

Along with expanding a telecom market, the business circumstances became more complex and the change of technological trends was faster. Therefore, uncertainty and equivocally were higher than before. In spite of that, NTT and *family companies* kept their collaboration systems. In fact, new participants did not enter into their collaboration system. Affiliated foreign companies were only used for providing technological information. The *family companies* were computer and semiconductor companies as well as telecom companies. They had already obtained enough technological capabilities to draw level with foreign telecom companies. In addition, the factor in winning the computer market had changed from excellence in the design of architecture into the development of high performance devices. It means that most of the developing computer and LIS relevant technologies around these days were concerned with increasing chip densities and manufacturing technologies[28]. In other words, technological equivocally was not so high. Therefore, NTT and *family companies* could catch up on these advanced technologies based on their past activities. There was no need for NTT to change partners.

3.5 Emergence of the open system and internet-relevant technologies [29]

The 'open system' and 'networking' changed the computer business in the 1980's and 1990's. This was accompanied by the emergence of the UNIX workstation and the development of personal computers connected to the network through Ethernet. The UNIX operation system, created by Bell Lab, is open-sourced code written in C language. Therefore, UNIX could run on any machine that had a C compiler. Opening the source code allows the development of a variety of applications, for example data base and storage systems. These things were done much more cheaply and therefore customers preferred to construct their systems based on these open system components. Along with these developments, new software companies appeared such as the Oracle Corporation.

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[28] Okimoto, Sugano and Weinstein 1984

[29] This section is based on Ceruzzi (1998), Cusumano (2004), NTT (1996), (1999), (2006) and Yost (2005) and study of files at NTT

Another significant factor was that workstations were designed to be networked. UNIX was developed for researchers who exchanged and shared their files within a local area, i.e. an office or a building. It was achieved using Ethernet protocol, which was developed in Xerox laboratories in 1973. At the beginning, the speed was around three million bits per second when 50 Kbps telephone circuits were considered fast. It was this speed that would alter the computer world. Clusters of small computers, such as workstations and PCs, replaced the legacy world of a large central system. Workers were able to share and exchange information through a cluster of small computers more cheaply than by using a main frame computer.

Consequently, the most important thing for users connecting to LAN was access to the internet using routers. These "downsizing" trends gave new impetus to the development of relevant technologies. For example, in order for computers to work well at low costs with a poor performance CPU, microprocessor technologies underwent major development, which included the introduction of RISC processors. Their performance was almost equal to that of main frames. These developments were damaging for IBM, and they were consequently forced to change their mainframe oriented approach to one of service central management.

NTT believed that optical fibres and ISDN protocols would open a new telecom market.[30] ISDN has two main types based on bandwidth: Narrow band (N-ISDN) and Broadband (B-ISDN). N-ISDN had already been commercialized with the development of digital switching systems in 1986. Because N-ISDN was available using existing copper subscriber lines, the system had already been connected to the public telephone network. On the other hand, B-ISDN was realized using ATM (Asynchronous Transfer Mode) protocols and optical fibres. NTT aimed to expand their businesses by connecting with premises through optical fibres and realizing broadband services. In order to do this, NTT decided to follow three steps[31].The first step was to develop and expand existing telephone services by adding information technologies. Voice mail and telephone conferencing services were examples of computer telephony integration (CTI). The second step was based on internet services. Around this time, the internet was not particularly popular in Japan, but demand was expected to increase. By accepting N-ISDN for the introduction of the internet, NTT tried to stimulate and expand the demand for of network use in businesses and consumer markets. Therefore, NTT planned to reduce the price of N-ISDN and offer relevant services such as internet service provider. The final stage would be when optical fibres and B-ISDN would drive VOD (Video on Demand) services. Specifically, they regarded the Internet as a mere service menu.

Following this plan, NTT started to develop new types of system in 1994, aiming at reducing the cost of N-ISDN and integrating N and B-ISDN. Four *family companies* also participated in the project. The development involved open architecture and Internet technologies as well as existing telephony technologies. For example, SPARC[32] and MIPS[33] processors were used as their main processors and other communication control units[34]. Fujitsu and NEC installed communication functions onto each processor through modifying kernel. OS (Operation System) was developed based on TRON[35] architecture, and C programming language was used for their software development. Workstations[36] were also

[30] NTT (1996), NTT (1999)
[31] NTT (1999)
[32] Developed by Sun Micro Systems. Fujitsu had worked with Sun in the manufacture of Sun's processors (Southwick 1999)
[33] A product of MIPS Corporation NEC affiliated itself to MIPS Corporation, becoming a second source company of MIPS processors.
[34] NTT (1999)
[35] Japanese open standard for a real-time operating system (Sakamura 1987). It is commonly used for Japanese mobiles and appliances as embedded OS.
[36] Sun's workstations were accepted.

introduced for their service management systems and development support systems. In order to integrate with their original communication technologies, these technologies were introduced not by exchanging directly but by mediating through family companies. The project, called MHN (Multi handling Node)[37], released its first version in 1996, consisting of N-ISDN and ATM switching systems. The project continued to improve and add functions until the beginning of the 2000's.

The emergence of innovative technologies brought up from computer and internet industries had a dramatic effect on the collaboration system. Many existing technologies became obsolete[38]; at the same time, new technologies appeared and disappeared in the industry. "Down sizing" trends led to a huge change in the computing market. PCs and workstations eroded the market of mainframe and medium-sized computers. As a result, IBM was forced to change its managerial methods. It meant that these technologies led to increasing uncertainty and equivocally in computer businesses. Therefore, these trends forced NTT to introduce these technologies into their systems.

In spite of these situations, the collaboration system was kept. Although new participants gradually became involved in the development of switching systems, these participants could not exchange with NTT directly, as they did not have telephony technologies and did not know how such large scale developments took place. What they possessed was specialized skills in their business fields. On the other hand, the business areas of *family companies* were very wide-ranging. They were computer and semiconductor companies as well as telecommunication companies. The *family companies* were also influenced by the changes in the computer industry. They therefore concentrated on business resources for open systems and internet technologies.

In addition, these technologies did not have enough reliability. Telecom equipment required high reliability for public services. NTT in particular had a very high quality standard for their equipment. Therefore, the *family companies*' technologies were needed to improve the quality and reliability of internet-relevant technologies. Therefore, *family companies*' technologies were needed for NTT, but they did not replace these new participants. Previously, the *family companies* and NTT had developed their own products using advanced foreign technologies. However, circumstances did not allow them to spend much time on these developments and they were forced to reduce costs as much as possible. Moreover, these R&D costs increased as technologies became more complex and larger-scale. Both NTT and the *family companies* were forced to use vendors' products.

Previously, the telecom industry was completely dominated by NTT. A limited number of companies were able allowed to exchange information with NTT. Also, each relationship and mutual dependency was very strong. The structure was hierarchical because NTT was extremely powerful in every aspect - technology, finance and human resources. However, this trend has changed due to the penetration of internet technology into the telecom industry. New participants exchange through existing companies and new technologies have been introduced through helping existing companies. Each relationship and mutual dependency in the collaboration system has become weaker with the structure consists of direct and indirect exchanges. The hierarchical structure remains although it is becoming obsolete.

3.5 Evolution of the telecom market[39]

[37] MHN systems consists of seven systems: MHN-S/P (N-ISDN), MHN-A(B-ISDN), MHN-F(Frame Relay systems), MHN-SCP(Service control system for intelligent telephone services (IN), MHN-STP(Telephone call transfer system) and SMS(Service Transfer system for intelligent telephone services (IN))

[38] NTT did not accept many of their existing original technologies, e.g., CHILL a programming language specified for switching systems and other software assets that NTT had developed for their past projects.

[39] This section is based on NTT (1999), NTT (2006) and study of files at NTT.

The MHN system series was expected to realize NTT's vision. However, developing internet and new computer relevant technologies gradually eroded telecom based technologies. In essence, telecom technologies had been developed for voice exchange. On the other hand, Internet technologies, Ethernet and TCP/IP protocols, would be used for file sharing and text message communications in small areas. However, along with these developing technologies, both technology areas aimed to integrate voice and data exchange.

In the beginning of Internet technologies, their reliabilities and performance were not enough for using large scale networks because originally Internet relevant technologies were developed for a small network. Their components frequently failed, and because of poor traffic control functions, network congestions were likely to occur.

However, with developments in LSI chips for communication uses and packet switching technologies the performances of internet technologies were drastically improved. Large scale of routers and switches were developed and new Ethernet standard was appeared. These technologies were applied to large scale networks. In addition, protocols for maintenance and operation were established, rapidly becoming commercialised. These developments made internet technologies fully available for telecommunication networks.

Following these situations, the superiority of internet technologies was apparent. Internet-relevant products are much cheaper than telecom oriented components. In addition, Ethernet's high speed data rate overcame the ISDN protocol, which only provided around 60kbps using existing metal subscriber lines. Therefore, these internet relevant technologies gradually led to eroding telecom relevant technologies.

A switching system had been a central of any telecom networks. However, this highly complex system was inflexible, so it was not easy to replace existing components with new technologies or to add new services. Therefore, performance of processors and other components became obsolete quickly even if leading edge technologies were used. As well as these inflexibilities, the very high installation and maintenance cost led to increasing burdens of telecom management. Above all, switching systems became replaced by Internet and computer technologies, combinations of routers or switches and servers.

NTT lab changed their attitude after releasing MHN systems, and they began to develop new types of switching systems. These systems were based on the new concept[40], integrating all data into a packet-transfer network, accepting decentralized architecture and open API[41]. These technologies were based on Internet protocols and international standard signals to control each function. Therefore, the system consisted of vendors' products. NTT purchased relevant products from vendors, Cisco, Nortel or Japanese computer makers. Based on these vendors' products, NTT developed their original communication technologies by collaborating with NEC or Fujitsu's software engineers. Their works mainly tuned these products or added some experimental functions. These activities were similar with those of general information systems.

Previously, *family companies* gained large benefits from NTT's purchasing hardware products because software developments gave little benefits. However, along with NTT fully accepting vendors' products for their systems, NTT's business for *family companies* was no longer such an attractive source of profit. Therefore, *family companies* gradually became distanced from the collaboration system. On the other hand, NTT exchanged with other companies directly in their R&D activities. Increasing needs for computer and internet technologies, their required technological areas were expanded. Therefore, NTT lab had to

[40] The concept is NGN (Next Generation Network), initiated by telecom operators and established in ITU-T. The general idea is based on the fact that all information and services (voice, data, and other sorts of media such as video) can be encapsulated in packets, commonly built around the Internet Protocol.

[41] An application programming interface (API) is a source code interface that OS and applications communicate with each other.

deal with variety of technologies. In order to accept these circumstances, NTT lab engaged with specified companies who have competitive or *de facto* standard technologies in a specific area. NTT purchased these technologies. These activities took place not as a comprehensive policy but by small units, like departments or project. *Family companies* also retailed a strong position in NTT's R&D activities because they had accumulated communication and computer technologies. However, they became a kind of vendor for NTT. Therefore, recent developments do not take place within the existing collaboration systems.

The Internet became a focus of communication services for telecom operators. NTT entered into ISP (Internet Provider) business in 1995, and developed their IP based network (OCN: Open Computer Network) apart from their telephone network. This is the first network for NTT to construct a commercial network based on IP protocols. This service was immediately popular because of low prices and providing access menus. OCN rapidly became the No.1 ISP provider and has retained its leading position in the Japanese ISP sector.

Emergence of ADSL services drastically changed the competitive circumstances in the Japanese telecom market. ADSL can use existing copper lines and provides higher speed than ISDN. Apart from the speed, by splitting voice and data signals, it allows users to share internet and telephone services at the same time. Modems split off high-speed data channel and ISDN or telephone channel. In addition by equipping an ADSL modem at the front of a switching system, a high-speed data channel does not need to go through a switching system, connecting a data network directly. As a result, other companies are able to offer networking services by using NTT subscriber lines. This meant NTT's sales were in decline because of a reduction of access charges from other companies. Additionally, other companies could provide their services because they were not influenced by NTT's network limitations.

On the other hand, NTT did not have a positive attitude for ADSL services[42] because they considered that the next telecom services would be realized by optical fibres and were eager to change subscriber lines from existing copper to optical fibres. However, the demand for high speed access to internet forced NTT to introduce the ADSL systems in 2000. After NTT accepted ADSL services, many new companies provided internet access services because Japanese regulations permitted other companies to use NTT subscriber lines. The speed of ADSL gradually increased, finally reaching 40M kbps. Immediately, ADSL providers began to offer IP phone services by using ADSL access lines and their data networks. NTT had to follow these situations.

Consequently, NTT's benefits gained from telephone businesses gradually reduced. Therefore, in order to compensate the reduction of profits, the telecom operator has tried to integrate services. The telecom market in recent times can be categorized into layered stacks, from network providers (telecom business and internet provider) to application or contents providers. Each category has some strong firms. In order to recover sales volumes, telecom operators tried to offer packaging services that integrated all layered services.

Considering the above, we can see that these technological movements forced a change in the telecom market. NTT's target apparently changed from AT&T and IBM to Internet relevant companies. The number of participants involved in telecom markets dramatically increased. As a result, the collaboration system of NTT and *family companies* had to be changed. NTT exchanged directly with new participants out with *family companies*, collaborating not only with *family companies* but also with these new companies.

4. Discussions and Conclusions

From this study, it can be argued that technological developments have changed the telecom market. In other words, developing the technologies has led to expansion of its

[42] NTT (2006)

domain of applicability. As a result, the existing market was forced to undergo change. Therefore, these technological developments brought about changes in inter-firm relationships and the market.

As the telecom market involved computer industries, telecom firms' control areas increased. New participants and technologies frequently appeared and disappeared because of highly competitive circumstances in the computer industry. However, in spite of this high uncertainty and equivocally, collaboration systems remained strong. *Family companies* had already accumulated technological capabilities to deal with computer and semiconductor businesses through their unique affiliation with foreign companies or Japanese government projects. NTT's target changed from AT&T to IBM, but, NTT and *family companies* could catch up these advanced technologies based on their past activities. There was no need for NTT to change partners.

The emergence of innovative technologies brought from computer and internet industries had a dramatic effect on the computer industry. This also influenced the R&D activities of telecom services. However, the collaboration system was kept. Although new participants gradually became involved in the development of switching systems, these participants could not exchange with NTT directly. The *family companies*' technologies were needed to improve the quality and reliability of internet-relevant technologies. Therefore, these technologies were introduced not by exchanging directly but by mediating through *family companies*.

However, with developing internet and relevant technologies the telecom relevant technologies were eroded. As a result, NTT was forced to accept these technologies for their communication networks. Consequently, NTT's target changed from AT&T and IBM to internet relevant companies. In addition, NTT exchanged directly with new participants without *family companies*, collaborating not only with *family companies* but also with these new companies. However, these activities took place not as a policy but by small units on need-basis. *Family companies* also joined these collaborations, but their positions are treated as a type of vendor having superior communication technologies.

These results emphasize the following two points:

Firstly, with increasing integration of the market, the number of participants in the market has increased. Additionally, these participants tend to concentrate on specified businesses with specialized skills. In the e telecom market, the NTT's business field was limited to telephony services: line controls and network operations. By expanding their business areas to computers, NTT began to deal with upper layer businesses. These new business areas had many firms in computer businesses and system integration companies. Consequently, as NTT involved internet services, many more companies were involved in telecom markets. These companies exist in each layer following the communication protocol stack These firms have dominating power in each layered market by having special technologies or having developed *de facto* standard technologies in specific business areas.

Secondly, indirect exchanges occurred when inter-firm relationships changed. It assumes that changing to comprehensive partnerships is not occurring directly from informative partnerships. Between them, indirect exchanges are taking place. In other words, inter-firm relationships are changed, keeping existing but adding new relationships. There is a process of changing inter-firm relationships. In this case, indirect exchanges emerge to compensate lack of capabilities in new technologies as well as to adjust new technological trends. Through the process, NTT evaluated the applicability of these technologies for their systems and learned how these technologies were used for their future systems. As a result, NTT would exchange and collaborate with new players directly.

However, the case does not indicate the change of inter-firm relationships to comprehensive partnerships. In the recent Japanese telecom industry, NTT collaborates with

other companies on a project basis, not makes special ties with other companies. Therefore, the structure is web-like. Through further observations, we should investigate a change from these “weak-tie relationships” to comprehensive partnerships would be occurred, and clarify mechanisms how and why weak-tie relationships change to comprehensive partnerships. By focusing on changes of technological trends, the study shows how inter-firm relationships are changed along with a developing market.

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