The roles of Inter-firm relationships in R&D: The case of NTT in the Japanese Telecom Industry

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Declaration

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another parson where due reference is not made in the text.

Kenichi Nishioka, September 2009

Abstract

The value and scope of telecom services have increased substantially in the decade from the mid 1990s. The telecom companies have offered not only telephone services but also data exchanges for example streaming services. Therefore, they now offer telecom services as packaging into which layered services are integrated. The number of actors involved in the market has increased due to the expansion of business areas, while rapidly changing technological trends have altered R&D methods. The thesis shows that the adoption of the marketing concept and the development of complex inter-firm technology based relationships underpin the creation and management of new telecom services. The relationships have 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 inter-firm relationships greatly contributed in the development of technological resources in two ways; collecting advantageous technologies from others and mediating in the introduction of new technologies. In addition, developments in technology resulted in an expanded domain of applicability. Consequently, not only the market structure was changed but also the relationship between marketing and R&D changed. With increasing integration of the market, the number of related firms increased as firms concentrated on specific technologies, with additional firms having superior competitive advantages in each layered business area. The case in the thesis also shows mechanisms of changing inter-firm relationships under dynamic business circumstances; indirect exchanges occurred when inter-firm relationships changed. Inter-firm relationships are changed, keeping existing but adding new relationships. The study also indicates a new direction to study service marketing. As the new trend of service development in ICT industry develops so the integration abilities and the management of inter-firm relationships in supply-sides become more focused. The thesis points to the importance of these upstream activities (coordinating inter-firm relationships in a service-oriented approach) and advocates the presence of a facilitator who can bridge both upstream and downstream activities. The results should contribute to both marketing and technology management in academia as well as business practices in R&D management.

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Chapter 1 Introduction

1. Overviews

The activities of Research and Development (R&D) departments in firms have changed dramatically in recent years. These changes are mainly down to the increased scale and complexity of R&D projects. Previously, companies concentrated on developing and accumulating their business resources in-house, aiming to integrate their entire business vertically in order to create competitive advantage. As an example, IBM developed all the components and services for their computer business (hardware, software and maintenance services) in-house, establishing a unique architecture. Their products were designed purely to work on their own unique equipment and other vendor's products could not be connected to IBM equipment. IBM was able to maintain a superior position through their unique architecture as well as by developing all of their own relevant computer technology. Their R&D department ran these activities by using only resources within their own companies or industrial group. However, changing competitive circumstances have not allowed firms to keep their vertical integration. As a result, R&D departments are facing more serious competitive conditions than ever before.

R&D departments are regarded as an incubator for creating innovation, and firms spend substantial amounts of money on R&D to gain competitive advantage in the future. R&D activities are essentially expected to have longer planning periods than other activities such as marketing, manufacturing and so on. That is why R&D departments pay relatively little attention to marketing. R&D activities used to be regarded as something independent of market trends.

However, this situation is starting to change. There are many examples of firms trying to enter other industries. In particular, we can observe this trend in the telecommunications business. The value and scope of telecom services have increased substantially in the decade from the mid-1990s. In the past, the telecom industry offered only telephone and telegram services, whereas 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 is connected to telecom networks. Consequently, the technologies consist not only of voice transport technology but also of other technologies, such as data transport, software, server operations and appliances. These technological developments also integrated the telecom industry with the information industry, creating a new industry, ICT (Information and

Communication Technology). Now, telecom businesses offer telecom services as a package into which layered services are integrated. As a result, the structure of the industry has become more complex and larger in scale. Furthermore, telecom services are strongly related to technologies. Rapid changes in technologies have enabled the realization of these services, while at the same time technological circumstances have become increasingly competitive. This has led to a decrease in the value of existing core technological competence, as existing technologies can be replaced with new emerging technologies in a day. This phenomenon greatly influences current R&D activities.

As a result, R&D activities are more likely to take marketing activities into account. R&D activities are required to collaborate with other companies and universities, rather than staying in their own company. Along with developing technology, R&D projects became more complex and larger scale. Rapid changeable technological circumstances made long-term R&D projects more uncertain and full of risk. Therefore, a single company is no longer able to carry out an R&D project on its own. This results in technological alliances or partnerships being preferred, and inter-firm relationships have become focused on understanding R&D activities.

2. The definition of R&D activities

Technologies can be defined as the application of scientific and engineering findings to achieve a practical result (Roussel, Saad and Erickson 1991). By this definition, science and engineering are embedded in the product or process through technology. In other words, technological resources are knowledge or skills that enable companies to combine science and engineering acquisitions to create products or services. Consequently, R&D activities can be defined as the activities which accumulate and cultivate those knowledge or skills for future core technologies.

. R&D activities can be categorized into three types: basic research, applied research and development. Basic research is aimed at obtaining advanced knowledge and a theoretical understanding of the nature of science and so on. This activity is not expected to lead to practical applications. For academia and those who work in research institutes of Universities or government, research means the revelation of new knowledge about the universe. The objective of research is to advance knowledge and understanding, and the boundaries of this search are limitless (Roussel et al. 1991). On the other hand, research activities in industry also aim to develop new knowledge, but its goals are ultimately far different from those of the academic researcher. In industry, their aim is to create knowledge

applicable to a company's business needs that will enable the company to participate in the forefront of new technology or to develop new products or services. Therefore, the purpose of corporate R&D is to develop new knowledge within a profit-making context by combining scientific and engineering findings, or to apply and connect those principles to develop reliable, high quality, useful products and services.

In principle, the mission of R&D in industry is to develop and accumulate knowledge and skills that contribute to solving practical business problems or developing new products. On the other hand, product development is regarded as the business process which brings products onto the market. This aims to create a complete product or service that is expected to be successful in the market. Improvements are also carried out on existing products or services in terms of their efficiency and features in order to attract more customers through market interaction. In this respect, R&D and product development are different activities and have different roles in companies. However, in practice, these distinctions are vague. Industry R&D stands on the assumption that its activities will contribute to future profit making, and it therefore has to involve product development. Thus, R&D has two roles: (1) to develop and accumulate technological resources that will contribute to future business, (2) to develop new products and services in a market.

Corporate R&D activities can be categorized into three basic types: incremental, radical, and fundamental (Roussel et al 1991). The goal of incremental R&D is small advances in technology, typically based on an established foundation of science and engineering knowledge. A typical example of incremental R&D is work on reducing manufacturing costs, improving reliability and quality. In addition, these activities develop new types of products or services that are released into the market after being integrated with existing technologies. This activity takes place within a relatively short time span (1 to 3 years). Incremental R&D provides a very important contribution to companies' management, and most R&D activities in industry come under this heading.

Radical R&D aims to develop innovative technologies which can destroy existing competitive circumstances and/or result in a brand new market. This activity draws its foundation from existing scientific and engineering knowledge, which alone is insufficient for arriving at a desired practical result. It involves the discovery of new knowledge with the explicit goal of applying that knowledge to a useful purpose (Rosenberg 1990, Roussel et al. 1991, Rosenbloom and Spencer 1996). It has two principal goals: (1) to develop a depth of research competence in fields of potential future technology that the company is convinced will have great strategic impact in the middle term (5 years out); (2) to prepare for future commercial exploitation of these fields. Because this activity involves discovering and

learning something not already known, practical results are achieved through a process of discovery. It therefore tends to involve a substantial amount of money, time and risk.

Fundamental R&D focuses on a more scientific reach into the unknown. This activity aims to contribute towards future companies' management, taking a long-term view (10 years or more). It requires a scientific approach towards discovering new materials, developing new devices or creating new computer architecture. Therefore, this is closely related to academic activity. It takes up a lot of time and money, but the most important aspect to this type of research is that its achievements are rarely linked to any concrete contribution to a company's profits. Large companies categorize this type of activity as belonging to their basic research laboratories, in the expectation that it will result in innovation technologies that will change the future of the industry.

3. R&D and inter-firm relationships

R&D management has passed through several stages. The next part attempts to discuss how R&D management has changed by examining it chronologically.

R&D activities aim to create new technologies or develop new products by combining existing technologies. These activities are commonly known as the concept of 'innovation'. The term 'innovation' originated from 'new combination' and was created by Schumpeter (1926)[1]. He proposed the concept of 'new combination', which meant that the combining of business resources could create new products or services. Corporate R&D came about in order to create such innovation.

3.1 Focusing on fundamental R&D and the linear model

The organized activities of R&D in industry were established in the middle of the twentieth century in the textile industry (Freeman 1982)[2]. After World War Two, companies, especially those in US manufacturing industries, were eager to establish basic research

[1] The concept of "new combination" is not directly referred to R&D activities. He defined five categories of innovation, not only creating new products or services, but also new production methods of existing products and services, marketing to create new markets, business systems and the change of economic organisation.

[2] Of course, R&D laboratories were established in the 1870's. However, their activities mainly aimed to create inventions, not innovations, being independent from other activities in a firm. After the invention of Nylon, which provided huge benefits to Dupont, R&D activities have been managed and organized as a part of the enterprise system (Freeman 1982 and Rosenbloom and Spencer 1996).

laboratories, and spent a substantial amount of money on them (Rosenbloom and Spencer 1996). This movement was based on the ‘linear model’. This model indicates that in-house activities should be conducted by Research and Development through to manufacturing and marketing in order to avoid imitation by competitors. Companies aimed to integrate their functions vertically from upstream to downstream. In this model, R&D activity in a firm is regarded as the origin of innovation. For example, Nylon was made by Dupont (E.I. du Pont de Nemours and Company), and semiconductor materials were invented by the Bell laboratory. Both companies developed products based on their inventions.

3.2 Incremental and collaborative R&D

However, they realized the inefficiency investing in these laboratories. New findings and innovative research resulting from laboratories did not always bring direct benefits to companies, and therefore companies did not concentrate on creation or innovation but rather started to seek other ways in which engage in making a profit.

Utterback and Abernathy (1975) tried to understand the relationship between the patterns of innovation within firms and identify these firms’ characteristics. They discovered that there were two types of innovation: product innovation and process innovation. Product innovation and process innovation are not independent but correlate with each other in the process of developing the industry.

Consequently, incremental R&D was focused. Abernathy and Utterback (1978) pointed out that there was a stage called ‘dominant design’ in developing innovation. They defined the concept of dominant design as a broadly accepted core design principle among a number of incompatible alternatives. The concept of dominant design was more important than initiating innovation, as it influenced its direction. They insisted on the importance of interaction among firms to dominate the market over competitors until the dominant design was completed. Abernathy (1985) categorized innovation in automobile manufacture into four patterns and emphasized the importance of process innovation.

As this research shows, the process of innovation that improves products or services gradually and incrementally has a more significant role in firms than revolutionary product innovation (as Schumpeter insisted). In other words, it was thought that the process of manufacturing was considered to give greater competitive advantage than revolutionary findings. Continuous change is a more obvious explanation of the origin of competitive advantage than discontinuous change. In other words, high quality with low cost and efficiency became the most significant competitive advantage for firms. In this situation, the

aim of innovation research had shifted there was more support for the idea that gradual change could lead to a company obtaining high returns and more competitive advantage. This was discussed mainly in the manufacturing industry. The middle stage of the linear model (developing and manufacturing) has a more significant role than the upper stream (basic research in business).

Along with focusing on incremental R&D activities, companies began integrating R&D activities into their corporate strategies, introducing in-house feedback in other departments. Therefore, with other departments within a firm being involved in R&D activities, the second stage aimed to increase the number of commercially successful R&D projects. Companies conducted R&D activities in areas where they had some manufacturing and marketing competency or in new and promising areas in which they had strategically decided to build competencies (Niosi 1999). Knowledge from other departments was systematically introduced to R&D departments to ensure that the R&D would result in something useful to the corporation. At this stage, information feedback took place within the corporation.

3.3 Focusing on interaction with customers

Consequently, the relationship between a market and R&D came under scrutiny. Rosenberg (1976) focused on the diffusion process of innovation and pointed out that events preceding the creating innovative findings were not so important, but that the timing of introducing new technologies into markets was more significant for firms. The focus shifted to interaction with customers. Obtaining knowledge from users became essential to the success of major projects. Von Hippel (1986) focused on accuracy of information, claiming that in-depth interaction with lead users would lead to the success of R&D projects.

In the 1990s, service industries, particularly computer software and internet technology, brought competitive advances to U.S. companies. Emerging companies such as Microsoft, Intel, Cisco and Dell were and are very competitive in comparison to pre-existing firms. Christensen (1997) categorized innovation into two types: destructive innovation and sustaining innovation. Destructive innovation is defined as a new technological innovation, which enables the creation of new products or services and eventually overturns the existing dominant technology in the market. Destructive innovation eventually destroys the existing technology and market and removes the existing competitive advantage from existing firms. By contrast, sustaining innovation is a series of successive and incremental improvements to existing products. Christensen and Bower (1996) identified another factor: the relationship

between the firm and the customer. They explained why existing firms with competitive advantage and good management cannot maintain the advantage. Existing companies tended to collect key customers' opinions and use them for the development of products and services. However, this approach would not lead to the creation of new technology, as it tended to keep the existing technology for existing customers, which meant that only the existing technology would improve. As a result, existing companies could not respond to destructive innovation until it had happened. In other words, keeping a heavy closed relationship with particular customers is harmful when it comes to innovation.

These things mean that the linear model has been abandoned and the non-linear model became the key point in understanding business conditions. The linear model could not adjust to the rapidly changing competitive circumstances because a firm's activities are too complex. The linear model also had a drawback when it came to communication with markets, as there were plenty of stages in an organization and information transit time was more necessary. Therefore, the non-linear model should be applied to actual business conditions - not just marketing departments but also more upper stream departments; Research and development departments – in order to bring about competitive circumstances in each market. There are some research-noted relationships between innovations and customers (von Hippel, Eric 1994, Christensen, Suarez and Utterback 1998). However, it is necessary to focus on the relationship not only with customers but also with external organizations such as vendors, academia or other companies within other industries.

3.4 Towards a new approach to R&D management

In summary, in order to adjust to non-linear circumstances in business it is vital that not only departments directly involved in product development, such as marketing, but also every department, including R&D departments, within the upper layer of the linear model, establishes a relationship with external organizations. Now that the linear model has been disrupted, the relationship between firms and external organizations, including customers, is becoming a major issue for R&D management. Companies used to accumulate their core technological resources for competitive advantage through vertical integration within one company or industrial group. Until the 1980s, resources would be integrated in-house and products or services would be developed using the companies' own accumulated resources. This situation has changed since the 1980s. Companies tend to cooperate with other companies, forming alliances and out-sourcing in order to reduce the cost of manufacturing. Therefore, business strategies have focused more on selecting and concentrating on the

business domains and business accessibility of resources. Following these trends, many companies' products and services are a combination of technological resources which have been accumulated not only by their own company or family group but also by other companies or organizations. For example, the computer industry is divided into layered structures based on each component, such as MPU (Micro Processing), OS (Operation System), application software and other devices. Each component is developed by each leading company in a specific market. This means that no computer has been developed by a single company, but has been realized through collaborations between related companies and the integration of individual components which have been developed by leading companies in the market. In other words, one product or service is provided to customers with a style of package consisting of each specific resource.

Along with the development of technology, R&D projects have become more complex and larger scale. Therefore, long-term R&D projects have become more uncertain and full of risk, causing difficulty for single companies involved in R&D (Niosi 1999). As a result, technological alliances or partnerships are preferred. Therefore, inter-firm relationships have become focused on understanding R&D activities.

4. Proposition of the study

This thesis attempts to clarify the relationship between the marketing concept and technology management, focusing on inter-firm relationships. More precisely, it aims to show that inter-firm relationships and marketing perspective can lead to R&D activities that adapt to turbulent circumstances, rapidly changing technological trends, larger scale and more complex R&D projects.

In order to do so, the study tries to clarify the roles of inter-firm relationships, focusing particularly on the process of developing technological resources, and suggests how firms should organize their internal and external resources. The thesis examines how developing technologies influences the structure of a market. Apart from technological trends, a market is influenced by many factors, such as business circumstances, diversity of actor behaviour, and policies or regulations. By focusing on technology variables, this paper attempts to clarify the relationship between technology and a market.

In addition, it observes how inter-firm relationships have changed due to the development of technology and market change. Furthermore, the mechanisms of changing inter-firm relationships are investigated by measuring the technological levels of a market.

Case study methodology is used in order to demonstrate these research questions. The

study examines the Japanese telecom industry, focusing on switching systems projects after World War II, and uses company NTT as a research case.

5. Description of contents

This chapter describes some of the problems affecting recent R&D activities and suggests the directions in which the arguments of this thesis will proceed.

Chapter 2 outlines research questions from previous studies. Firstly, the treatment and development of business resources is looked at from several resource-based perspectives, while the role of inter-firm relationships is also studied within the concept of market orientation. There is a focus on organizational learning and continuous interaction with the market. Then, after examining previous research on intangible goods within the context of service marketing and highlighting the relationship between intangible goods and technology, we discusses about relational exchanges in the context of industrial marketing, especially focusing on the network approach.. Two ways of analysing technological circumstances are discussed, and two types of partnerships are proposed from previous studies.

Chapter 3 presents theoretical research questions and hypotheses taken from the research discussed in Chapter 2. It discusses methodology and shows why case study methodology is an appropriate method for this research. In addition, methods of data collection are examined.

Chapter 4 forms the main body of the thesis. Using the Japanese telecom industry as a research site, it describes the role of inter-firm relationships, discussing how market changes affect the collaboration system and how technological development influences the structure of the telecom market. Additionally, by analysing technological circumstances, the study investigates the processes involved in inter-firm change.

Chapter 5 summarises the thesis, and indicates theoretical contributions and managerial implications as well as future research. It organizes findings both from the case study and the literature reviews, presenting the results of research questions and hypotheses. Contributions to this study, both on theoretical and managerial issues, are mentioned. Finally, the future direction of this research is discussed.

Chapter 2 Literature Reviews

Introduction

This chapter aims to show the proposition of the thesis in theoretical background as well as indicate research questions. The previous chapter emphasises inter-firm relationships in R&D activities. Therefore, the relationship between developing business resources and inter-firm relationships should be clarified. In order to do so, the thesis defines that R&D activities aim to develop technological resources. Therefore, the chapter organises how business resources can be treated in previous researches. In addition, the concept of market orientation is focused to explain R&D activities. These efforts attempt to clarify the relationship between developing technological resources and marketing concepts as well as inter-firm relationships.

Additionally, the thesis emphasises the role of inter-firm relationships in R&D activities, focusing on relational exchange. Therefore, the chapter shows appropriate explanatory theory to discuss R&D activities through studying related marketing theories. Through these discussions, hypothesises are built.

The chapter is organized as follows; the first section argues the market orientation and business resources from relevant previous studies. It attempts to clarify the relationship between inter-firm relationships and developing business resources.

The second section pays attention to what kinds of goods are exchanged in R&D activities. In R&D activities, intangible things - technological knowledge, know-how or skills are exchanged between providers and customers.

The third and fourth section discusses about relational exchanges in the context of industrial marketing, especially focusing on the network approach. R&D activities involve the relationship between Business and Business (B to B). Therefore, we should view R&D activities as an essential part of business and a unique issue in industrial marketing. The section attempts to compare the differences of each approach.

Finally, the theoretical background considers the characteristics of R&D activities based on the discussions of inter-firm relationships and business alliances.

Section1

The resource of the R&D and the inter-firm relationships

1. Introduction

This section aims to clarify the relationship between marketing concept and technology management. Particular attention is paid to the concept of market orientation focusing on resources and capabilities, as well as to how the focus of strategic marketing has changed from competitors to the market network. Firstly, we shall look at how the conception of 'market' has been treated in business strategy through reviewing strategic management and strategic marketing. Correspondingly, this thesis aims both to clarify the difference between customer and market orientation and show that market orientation is more powerful when applied to recent turbulent business circumstances.

Second, given that technology can be regarded as a bundle of technological knowledge or skills, resources and capabilities are critical issues in marketing orientation. Consequently, the study will clarify the nature of resources as competitive advantages by distinguishing between operant and operand resources.

Finally, in order to adapt to turbulent business circumstances, it will be demonstrated that inter-firm relationships and business networks are critical factors in organizational learning and that the conception of 'market' has to be broadened.

2. Market Orientation in business strategy

In this section, we look at how market has been discussed in strategic management. In spite of that Ansoff emphasized the importance of marketing in strategic management, the trend had focused on competitors' activities based on SCP (Structure, Conduct and Performance) model. This lead to a short-term and narrow tactical view, as a result, existed large companies faced threat from companies belonging to other business areas. Hence, marketing, especially the concept of market orientation is focused in strategic management.

2.1 Competitor orientation

In the early age of marketing in industry, the 1920's and 1930's, the term 'customer' primarily referred to distributors who purchased goods and made payments. The key to profitability was volume of sales, and marketing activities were regarded as selling what the factory could produce. Therefore, the focus was on products; what the factory was currently producing was what the sales force had to be sold (Webster 1988). In the 1950's and 1960's, the focus of marketing shifted from distributors to end customers and their wants and needs. Therefore, the main purpose of the marketing concept was to discover wants and needs in its target markets and satisfy those needs more effectively and efficiently. It was only the marketing department that carried out marketing activities and it was seen as a counterpart to customers. Therefore, correspondingly, the R&D department's sole mission was to develop new technology, while manufacturing departments focused on producing goods more efficiently.

However, in the 1970's, corporate strategy and formal strategic-planning systems were completely consistent with the strategic orientation of the marketing concept, while more emphasis was placed on marketing as a general management responsibility (Webster 1988). Therefore, marketing concept was linked with business strategy and, as a result, the concept expanded from the activities of marketing departments to company-wide activities.

"The strategic problem is the problem of deciding what business the firm is in and what kinds of businesses it will seek to enter"(Ansoff 1965, p.6). Hence, the nature of business strategy is how firms seek and enter markets and how they allocate and develop resources to take part in them. Ansoff (1965) also developed the concept of competitive advantage and synergy as comportments of business strategy. Competitive advantage can be defined by Ansoff (1965) as seeking "to identify particular properties of individual product-markets which will give the firm a strong position." (Ansoff 1965, p.110) and "the competitive advantage adds a dimension to strategy, both in search and in evaluation of opportunities "(ibid.., p.194). In addition, "Synergy is a measure of the form's ability to make goods on a new product-market entry" (ibid.., P.111). After that, in order for a firm to grow continuity, developing competitive advantages became a significant task for business strategy.

Analytical framework and strategic planning systems were developed. For example, Porter (1980) focused on competitors and developed a framework. The so called "five forces" can measure the attractiveness of the market place and affect the firm's ability to serve its customers and make a profit. He assumed that the buyer, supplier and competitors are players in a market. Hence, it emphasizes that the activities of competitors strongly influenced the firm's strategy. Strategic planning tended to focus on the competitors,

diverting attention from customers and their needs.

2.2 Toward customer orientation

According to Webster (1988), too much focusing on competitors allowed foreign companies to penetrate the U.S.A markets and weakened the ability of some of this country's most important companies and industries to respond to evolving customer needs, new technology and changing competition, especially from overseas competitors, in the 1980's.

Strategic marketing is an extension and implementation of corporate and business strategy. The key element of strategic marketing is a focus on well-defined market segments and the firm's unique competitive advantage in those segments (Aaker 1984, Webster 1988). Marketing strategy defines a market as consisting of customers and competitors (Aaker 1984). Business environment also influences strategic decision. Therefore, organizations need to be oriented externally towards the customer, competitors, the market and the market environment. The goal is to develop market-driven strategies that are sensitive to the customer. (Webster 1988).

This approach, focusing on understanding the expressed desires of customers in their served markets and developing products and services that satisfy those desires (Slater and Narver 1998, Cannon and Perreault 1999), can be called 'customer orientation'. The appropriate focus appears to be a market which includes end users and distributors as well as exogenous forces that affect their needs and preferences (Kohli and Jaworski 1990). The assumption is that developing competitive advantages can be created by closer relationships with customers. The firm seeks a position in an attractive market that it can defend against competitors. (Day 1994)

2.3 Innovation and Market Orientation

However, some researchers concerned with product innovation have criticized the concept of customer orientation (Kalwani and Narakesari 1995). For example, Christensen (1997) mentioned that existing firms with competitive advantage and good management were not able to extend this advantage. Existing companies tended to collect key customers' opinions and use them for the development of products and services but this approach could not create new technology because it tended to keep the existing technology for existing customers. As a result, existing companies could not respond to destructive innovation until it happened. In other words, a strong relationship with particular customers is harmful when it comes to innovation. According to Slater and Narver (1998), the problem occurs because

scholars are talking about two separate philosophies: customer orientation and market orientation.

The focus on specified customers leads managers to seeing the business through their current customers' eyes and the business 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, and generally leads to adaptive rather than generative learning (Slater and Narver 1998). Hence, the reason why customer-oriented approach is a failure of business is that the focus is not on creating but on keeping satisfied customers. An over-emphasis on customer contact and satisfying customer demand can lead to problems when trying to develop a competitive advantage.

2.4 Market-oriented approach

In the 1980's and 1990's, marketing researchers tried to expand marketing concept to cover strategic view. Achrol (1991) divided the features of market environments into three: (1) more and increasing diversity, (2) more and increasing knowledge, (3) more and increasing turbulence.

In order to adapt these environments, Shapiro (1988) advocated the concept of market orientation and insisted that it corroborates with all departments in a firm by permeating information to every business units. Therefore, not only the marketing department but every department should show commitment to customers in order to adapt to turbulent business circumstances. His approach to marketing orientation placed emphasis on the importance of commitment to customers with every business aspect and on information as a way of doing it.

Kohli and Jaworski (1990) and Narver and Slater (1990) influenced discussions about market orientation. According to Kohli and Jaworski (1990), there are three pillars in market orientation: (1) customer focus, (2) coordinated marketing and (3) profitability. From the result of their research, profitability can be viewed as a consequence of market orientation rather than a part of it. Therefore, market orientation entails (a) one or more departments engaging in activities geared towards developing an understanding of customers' current and future needs and the factors affecting them, (b) the various departments engaging in activities designed to meet select customer needs (Kohli and Jaworski 1990).

Narver and Slater (1990) also emphasized inter-functional coordination in marketing orientation. According to them, there are three behavioural components: customer orientation - the firm's understanding of the target market; competitor orientation- the firm's understanding of the long run capabilities of present and prospective competitors; and inter-

functional coordination- the coordinated utilization of company resources to create superior customer value. Srivastava, Shervani and Fahey (1998) mentioned that marketing orientation focuses on marketing activities and not on the marketing department. Therefore, a market can be defined as consistent with customers and competitors. The primary role of marketing activities is carried out by every department, not only marketing departments. It is critical for a variety of departments to be cognizant of customer needs. (Kohli and Jaworski 1990, Jaworski and Kohli 1993) Given the multidimensional nature of creating superior value for customers, marketing interdependencies with other business functions must be systematically incorporated in a business' marketing strategy. (Narver and Slater 1990) Therefore, coordination is the main factor in the activities.

. Long-term focus is a significant factor in market orientation. Customer orientation requires that a seller understand a buyer's entire value chain, not only as it is today but also as it will evolve over time subject to internal and market dynamics (Narver and Slater 1990).

The permeating information to every business units is the key factor to successful market orientation. An organization confronts environmental diversity by improving its information monitoring and processing efficiency. Achrol (1991) and Kohli and Jaworski (1990) advocated the concept of market intelligence. "Market orientation is the organization-wide generation of market intelligence pertaining to current future customer needs, dissemination of the intelligence across departments, and organization wide responsiveness to it." (Kohli and Jaworski 1990, p.6). Correspondingly, interaction to external environments is also emphasized. Marketing intelligence includes an analysis of how they may be affected by exogenous factors such as government regulation, technology, competitors, and other environmental forces. Environmental scanning activities are subsumed under market intelligence generation. (Kohli and Jaworski 1990)

According to Achrol (1991), the structure of organizations has to change in order to adapt to turbulent circumstances. The firm of the future needs to be very permeable across its departments. If its departments and hierarchy are fuzzily defined, hierarchy will be minimal and indirect, and individuals will have much more autonomy.

Penrose (1959) mentioned that the useful ways of reducing uncertainty for future business conditions is to obtain as much information as is practicable about the possible course of future events. Hence, although Pfeffer and Salancik (1978) said that "merger is a mechanism used by organizations to restructure their environmental interdependence in order to stabilize critical exchanges" (p.115), functional integration of organizations is less necessary because integration of information across the companies is less costly. In addition, in complex, and turbulent environments, any advantages of vertical control are quickly

eroded by the costs of attendant inflexibilities and inertia. Organizational efficiency is defined in terms of a firm's speed and agility in processing information from detecting market signals, through transformation, into delivered satisfactions (Achrol 1991). Therefore, the critical managerial focus of the firm will shift from organizing internal systems to organizing boundary spanning processes.

As a result, there are two types of companies. The marketing exchange company is the organizing hub for market information and complex exchanges. On the other hand, the marketing coalition company is the hub for organizing a division of function among an alliance of specialist firms (Achrol 1991). Marketing is the primary function in both types. Hence, marketing function based on information exchange and market signals is the bond connecting firms which have unique competitive advantages.

2.5 The market orientation and business resources

In summary, the concept of market orientation is to adapt to dynamic business environments and develop sustained competitive advantage by focusing on customers' future needs and using permeation of information within all departments. Market orientation focuses the organization on continuously collecting information about target-customers' need and competitors' capabilities. In addition, the capabilities of sharing understanding across departments and developing knowledge for future markets are emphasized to create continuously superior customer value. It is difficult that the future can be precisely predicted under dynamic and turbulent market conditions. Therefore, market-oriented business conduct market experiments, learn from the results of those experiments and modify their offering based on the new knowledge and insight (Slater and Narver 1995, Slater and Narver 1998). Hence, through these business experiences, developed capabilities and knowledge about markets can become competitive advantages (Day 1994). At this point, the discussions of capabilities become the significant issue.

3. Market orientation and resource management

In previous section, I pointed out the importance of dealing with resources. In this section, we shall look at discussions about resources as competitive advantages. Firstly, exchangeability was the issue of resource based view, but along with focusing on Inimitability, accumulating business experiences and routine business process can be regarded as the origin of resources and capabilities. In addition, to avoid the failure of adaptation of revolutionary innovation, interaction with market and organizational learning are emphasized. The thesis will try to advocate the necessity of that the conception of market should be broadened and be viewed as business relationship network.

3.1 Resource Based view of the firm

Ansoff (1965) mentioned that there were three types of resources: physical, monetary and human. He emphasized the importance of allocating resources as follows: “all three are used up in the conversion process. Survival of the firm depends on profit: unless profits are generated and used for replacement of resources, the firm will eventually run down.” (Ansoff 1965, p.4). Therefore, the purpose of business management is to allocate resources appropriately, and firms will have business opportunities based on the resources. Hence, their having resources strongly influences strategic planning.

Although researchers have dealt with the problems of using resources rather than dealing with problems of acquiring resources (Pfeffer and Salancik 1978), the theory of Resource Based View focuses on business resources which will allow the firm to sustain competitive advantage.

Resource Based View originated with the economic theory of the growth of firms by Penrose (1959). She is the first researcher to conceptualize intangibles in a firm as resources and human skills, which can not be transacted in the market. Penrose also emphasizes original and unique resources, which are accumulated over a long period of time. Her theory received little formal recognition in economic theory for several decades due to the difficulty in calculating these resources.

Wernerfelt (1984) coined the term 'Resource Based View', which explains the business strategy based on business resources. He pointed out that the strength and the weakness of a firm could be explained by the resources. He showed the effectiveness of the resource based view when applied to business strategy by using the matrix of existing

resource and business domains. Barney (1986) also emphasized that business resources can lead to sustained competitive advantages. He insisted that resource based view is a more powerful tool in business strategy than the theory of SCP (Structure, Conduct and Performance) because it assumes the competitive circumstances as dynamic. He insisted that business strategy should be developed based on resources, and if several resources are lacking in a firm for carrying out the strategy, those 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. As a result, they mentioned 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 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.

Barney (2002) mentioned that limitation of his theory is showed when revolutionary changes occur in a firm: existing strength of resource can become a weakness and existing weakness in turn can become a strength. This limitation comes with an assumption that business conditions are static. There are two kinds of business circumstances: evolutionary or revolutionary. As indicated previously, evolutionary change is characterized by new developments which are directly related to and build upon an organization's know-how and experience. On the other hand, revolutionary change is characterized by new developments which are unrelated to and obsolete an organization's know-how and experience (Boynton and Victor 1991). Therefore, the competitive environment can be defined by revolutionary product and evolutionary process change.

The high technology industries such as semi-conductors, information services, and software have demonstrated the need for an expanded paradigm to understand how competitive advantage is gained and held. According to Teece and Pisano (1994), dynamic capability is referred to as the source of competitive advantages. It emphasizes the key role of strategic management in appropriately adapting, integrating, and re-configuring internal and external organizational skills, resources, and functional competences within a changing environment (Teece and Pisano 1994). Consequently, the role of resources (capability and competence have the same meaning here (Madhavaram and Hunt 2008)) becomes a significant issue when adapting to dynamic market conditions.

3.2 The bundle of Operant resources

Assuming that resources cannot be exchanged, competitive advantages must be developed within a firm's own companies. Firstly, the definition of resources should be clarified. In microeconomic theory, resources can be assumed as physical, monetary and human. However, the relative role of resources has shifted, in that skills and knowledge or capabilities are the most important types of resources. Penrose (1959) suggested that “it is never resources themselves that are the ‘inputs’ in the production process, but only the services that the resources can render.”(P.24). Correspondingly, Constantine and Lusch (1994) categorized the resource as operand and operant. Operand resources are those with which an action is performed to create value. On the other hand, operant resources symbolise the knowledge, skills by means of which actions are performed. Operant resources are invisible and intangible; they are infinite and dynamic as opposed to static and finite (Vargo and Lusch 2004). Madhavaram and Hunt (2008) pointed out that there are three types of operant resources: basic, composite and interconnected operant resources. Basic operant resources are resources like the skills and knowledge of individual employees. This type of operant resources is difficult to sustain competitive advantages because they are easier imitated. On the other hand, composite operant resources are developed from organising activities in a department or a firm, and interconnected resources are created by interactions between external firms. These types of operant resources are more difficult to acquire and develop increased levels of sustainability of competitive advantage. Therefore, the following observations can be made regarding resources. The mere existence of operant resources has no meaning. An operant resource is employed to act on other operant resources to produce effects (Vargo and Lusch 2004). Reacting and fusing resources produces values. Therefore, competitive advantages consist of a bundle of capabilities (or competences) (Penrose 1959), and capabilities are a complex bundle of operant resources (Day 1994). Consequently, developing competitive advantages becomes an issue when dealing with how operant resources are handled (Vargo and Lusch 2004).

Resources or capabilities can be regarded as sustained competitive advantages when they possess operant resources that (1) provide superior value to customers and (2) are difficult to initiate (Dierickx and Cool 1989, Barney 1991). In addition, multiple applications of these resources is a significant characteristic (Penrose 1959). Hence, resources are robust and can be used in different ways to speed up the firm’s adaptation to environmental change

(Day 1994). Prahalad and Hamel (1990) called this multiple line support of business 'core competence'. Thus, in order to adapt to dynamic and stable conditions, resources ought to have a more general purpose, allowing them to be more flexible for each customer's demands, reusable, generic and stable.

3. 3 The origin of capabilities and resources

In the previous section, it shows that capabilities consist of several operant resources. Resources are obscured because much of the operant resources are tacit and dispersed. In addition, rapid changing technologies characterize business circumstances as turbulent (Capon and Glazer 1987). Hence, a firm’s existing technologies quickly become less important.

Technology can be defined broadly as knowledge or, more specifically, as information required to produce and/or sell a product or service (Capon and Glazer 1987, Glazer 1991). According to Leonard-Barton (1992), there are four dimensions of knowledge.

(1) Accumulated knowledge and skills embodied in people, deriving from technical knowledge, training and long experience with the process.

(2) Knowledge embodied in technical systems comprising of information in linked databases, formal procedures and established routine for dealing with given problems and transactions

(3) The management system: formal or informal ways of creating knowledge by apprenticeship programs or networks with partners and controlling knowledge by incentive systems and reporting structure.

(4) Values and norms: what information is to be collected, what types are most important, who gets access to the information, how it is to be used.

Along with denial of exchangeability of resources, issues have focused on activities of intra-firm: firms’ business processes, culture and history. Day (1994) advocated that the competitive advantage of firms stems from dynamic capabilities rooted in high performance routines operating inside a firm, embedded in the firm’s processes, and conditioned by its history. Dynamic capabilities are created over time 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 and practices that they cannot be traded or imitated.

Desphande and Webster (1989) defined organizational culture as the pattern of shared values and beliefs that help individuals understand organizational functioning and

thus provide them norms for behaviour in the organization. Culture is a set of shared assumptions and understandings about organizational functioning. On the other hand, climate relates to members' perceptions about the extent to which the organization is currently fulfilling their expectations. Culture refers to the history, norms and values that members believe underline climate. (Desphande and Webster 1989). Each firm has a different culture. Therefore, competitive advantages developed by culture cannot be imitated and exchanged.

According to Dierickx and Cool (1989), development of resources is heavily contingent upon historical matters such as business experiments, learning and development activities. The concept of path dependency can be explained by the fact that the beginning of events largely reflected the sequential results in a developing process (Arthur 1989). Choices about domains of competence are influenced by past choices (Teece and Pisano 1994). Therefore, developing resources is regarded as path-dependent in a sense. Replacement of or addition to external resource has no significant meaning. Developing resources continuously by fusing or integrating external resources leads to sustain competitive advantages, rather than acquiring resources through M&A or purchasing the business in a market.

However, although this distinctive organizational process is a strong competitive advantage, Teece and Pisano (1994) pointed out that it is the reason why radical innovations are so often introduced into an industry by new entrances. Hence, an existing set of organizational processes cannot support new products and adapt to new business circumstances. Consequently, researchers focused on continuously learning and interactions with players in a market.

3. 4 Learning processes as capabilities

Market orientation aims to produce a wealth of information about customers, competitors and external conditions, share it and come to a consensus on its meaning. 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. Thus, market orientation is inherently a learning orientation (Slater and Narver 1995, 1998). Therefore, capabilities are defined as the subset of the competences capabilities generated by organizational learning, which allows the firm to create new products and processes and respond to changing market circumstances (Teece and Pisano 1994).

According to Slater and Narver (1995), there are two types of organizational learning: adaptive learning and generative learning.

Adaptive learning occurs within a firm's constraints that reflect the organization's assumption about its environment and itself. The boundary constrains organizational learning

to the adaptive variety, which is usually sequential, incremental and focused on issues or opportunities that are within the traditional scope of an organization's activities. On the other hand, Generative learning occurs when the organization is willing to question itself about its mission, customers, capabilities or strategy. Generative learning can provide new insight and break the existing framework of business. Therefore, it offers competitive advantage rather than adaptive learning.

In order to bringing up generative learning, a firm ought to have market-oriented sensing capabilities. Day (1994) insisted that two abilities are especially important in bringing these external realities to the attention of the organization. One is the market sensing capability, which determines how well an organization is equipped to continuously sense changes in its market and anticipate the responses to marketing actions. The second is customer-linking capability, which comprises the skills, abilities and processes needed to achieve collaborative customer relationships. Therefore, collaboration and partnerships can be vehicles for new organizational learning, helping firms to recognize dysfunctional routines and prevent strategic blind spots. (Normann and Rafael 1993, Teece and Pisano 1994)

3.5 The necessity of expand the market view and business networks

Normann and Rafael (1993) mentioned that successful companies do not just add value, they reinvent it, and emphasized the relationship between firms. A firm's indispensable task is to restructure roles and relationships among this constellation of actors in order to mobilize the creation of value in new forms and by new players. Moreover, their strategic goal is to fit between resources and customers (Normann and Rafael 1993).

Consequently, the conception of "market" should be broadened to include all sources which have relevant knowledge and ideas to create future market needs. According to Slater and Narver (1995), "the scope of market orientation must include all stakeholders and constituencies that (1) possess, or are developing, knowledge that has the potential to contribute to the creation of superior customer value or (2) are threats to competitive advantages."(p.68). Achrol and Stern (1988) and Achrol and Kotler (1999) pointed out the importance of business network from the perspective of information-processing capabilities compared to vertically integrated hierarchies. They mentioned that networks are better adapted to knowledge-rich environments because of their superior information-processing capabilities. Therefore, companies embedded in strategic networks have advantages and business outcomes which are increasingly decided by competition between networks of firms

rather than by competition among firms.

4. Summary

This section has attempted to clarify the relationship between marketing concept and technology management, focusing especially on resources. The purpose of R&D activities is to create innovation. These activities play a major role in a firm's strategy. The issue of strategic management has shifted from competitors' activities to interaction with markets and external conditions. In addition, in order to adapt to recent turbulent conditions, managers have to distinguish between customer orientation and market orientation. Consequently, too much emphasis on customer retention leads to missing opportunities for adapting innovation. This thesis regards market orientation as a powerful concept in adapting innovation as it emphasizes continuous interaction with markets and external environments.

In order to carry out marketing orientation, it becomes necessary to view resources as competitive advantages. There are several features to resources. Resources are invisible and intangible, consisting of several operant resources: knowledge and skills. They can adapt revolutionary innovation because they have multiple applications. Consequently, resources and capabilities develop within firms' routine processes, which are closely linked with the culture of a particular firm. Therefore, these resources are difficult to imitate and exchange. Additionally, in order to avoid failure to adapt product innovation, the thesis has placed an emphasis on organizational learning. Market orientation is an inherently learning orientation. Continuous organizational learning and interaction with markets leads to an increase in the significance of the inter-firm relationship. Finally, the thesis has advocated that the conception of market should be broadened to include not only existing customers and competitors but also other stakeholders who have the potential to contribute towards creating future customer value and to develop competitive advantages in a future market.

In summary, by applying the concept of market orientation to the process of developing business resources, this thesis links R&D activities to marketing concepts. As a result, the thesis defines R&D activities as those that create business resources through continuous organizational learning and interaction, not only with competitors and customers, but also other stakeholders.

Findings of this section emphasise relational exchanges because continuous and mutual interactions with market contribute to develop technological resources. Therefore, the next section examines previous research on intangible goods within the context of service marketing and relationship marketing, highlighting the relationship between intangible goods and technology.

Section2
Relationship Marketing in Service Approach

1 Introduction

The purpose of this section is to clarify the discussion about service marketing in the context of relationship marketing. The term relationship marketing was coined by Leonard Berry in 1983, but the phenomenon of relationship had been widely discussed by researchers for a long time without using the term (Gummesson 1997). However, relationship marketing became a hot topic during the 1990's (Mattsson 1997, Moller and Haline 2000). The first definition of relationship marketing is as follows: "*Relationship Marketing is a strategy to attract, maintain and enhance customer relationships*" (Berry 1983). Berry and Ballantyne are famous for their significant contribution to service marketing, but the definition of relationship marketing was boarded during the following 10 years. According to Ballantyne (1994), relationship marketing is "*an emergent disciplinary framework for creating, developing and sustaining exchanges of value networks between parties*".

These definitional changes are closely related to the rapid change in business circumstances and the development of information technology. Since the end of the 1970's, industrialized countries have deregulated, mainly in service sectors such as airlines, banking and telecommunication industries. The proportion of service industries within economics has increased. In addition, business has become more internationalised, with foreign companies trying to penetrate domestic markets and many new rivals appearing in every industry. As a result, both academia and practitioners have become strongly interested in service marketing in order to be a winner in business. At the same time, it should be pointed out that the marketing paradigm has changed from one of getting new customers to that of sustained existing ones (Webster 1992).

The advancement of information technology is also another indispensable factor in the development of relationship marketing. The importance of sustaining existing customer and fostering loyalty gradually overtook that of attracting new customers in marketing. However, in mass marketing, the poor capability of existing database systems until the mid-1990's made it very difficult to manage such a huge number of customers. After the emergence and development of internet technology and database software, it became possible that firms install information systems and analyze data in their companies. Due to technological changes, customer relationship management and database marketing are now actively

debated (e.g. Parvatiyar and Sheth 2000, Payne and Frow 2005, Srinivasan and Moorman 2005).

In industrial marketing and service marketing, early researchers in relationship marketing were questioned on existing marketing theory, which is product-oriented theory like marketing mix. They considered that a goods-oriented approach was not adequate to explain the real industrial and service marketing activities. Therefore, rather than traditional marketing, other approaches were needed to explain service marketing.

2. Definition of Services as intangible things

In the 1960's and 1970's, the main feature of service was its intangibility and it was regarded as very much subordinate to products. The approach of service marketing was closely linked to goods marketing. Some researchers focused on the activity of service sectors and tried to point out the uniqueness of service in contrast to goods marketing. They tried to define services as a new concept in marketing. Judd (1964) defined service as something other than the transfer of ownership of a tangible commodity. Therefore, he categorised service as belonging to three types: rented-goods services, owned-goods services and non-goods services. Rathmell (1966) referred to the concept of service, stating that a good is a thing and a service is an act. When a good is purchased, the buyer acquires an asset; when a service is purchased, the buyer incurs an expense. Additionally, in order to be useful, most goods require supporting services and most services require supporting goods. This means that services and goods cannot be distinguished clearly and should be treated as inseparable in production and consumption. Both researchers also pointed out that the possibility of transfer is important in distinguishing services from goods. Shostack (1977) indicated that physical goods and intangible services are contained within a package. He defined one of the features of service as inseparability. Sasser (1976) pointed out four features: (1) Services cannot be inventoried (2) There is a high degree of producer-customer interaction (3) They cannot be transported (4) The evaluation of service is a highly subjective and qualitative task.

Levitt (1981) said that instead of speaking about services and goods, we should use intangibles and tangibles because everybody sells intangibles in the market no matter what is produced in the factory. He also emphasized that the important feature of service that it is not directly experienced, seen, touched smelled or tasted, so it cannot be reliably tested in advance. In addition, he indicated that intangible products are highly people-intensive in their production and delivery method. This means that clients are heavily involved with the

whole process from production to delivery.

Gronroos (1978) pointed out that service companies are less market-oriented than firms which deal with market goods and this caused difficulty in applying the goods-oriented marketing concept to service marketing. He proposed a model of service marketing and defined the features of service as three things: intangibility, interaction and a lack of ownership. He also proposed three important concepts of service marketing. The first is an accessibility of service. Although a service is intangible, customers can recognize it by its accessibility. In addition, direct distribution can take place through accessibility. The second is the importance of human resources. Individual employees communicate with each customer directly. Their performance is directly linked to the element of service marketing. Thirdly, Gronroos mentioned auxiliary services. Through market communication, employees sometimes provide extra service if and when customers require. These extra services are not bearer services. However, they promote and can be considered part of the service.

Zeithaml, Parasuraman, and Berry (1985) summarized the characteristics of services as belonging to four categories based on the services marketing literature (**Table2-2-(1)**). The four categories are as follows: intangibility; inseparability of production and consumption; heterogeneity; perishability. Heterogeneity concerns the potential for high variability in the performance of service (Every service is different). Perishability means that services cannot be stored. Each unique characteristic of services leads to specific problems for service marketers and necessitates specific strategies for dealing with them.

Table 2-2-(1): The features of service

Service features	Main marketing problems	Reference
Intangibility	Ownership cannot be transferred Cannot be tested in advance	Judd(1968) Levitt(1981)
Inseparability	Very few goods without services Goods and services packaged together Customers involve in the process of production	Rathmell (1966) Shostack(1977) Gronroos(1978)
Heterogeneity	Standardization and quality control difficult to achieve	Sasser(1976),Levitt(1981) Berry (1981)
Perishability	Cannot be stored	Sasser (1976)

(Modified Zeithaml, Parasuraman and Berry. 1985)

Lovelock (1983) tried to classify services with a view to strategic marketing in ways that transcend narrow industry boundaries. He proposed four classifications of services based

on the literature review. He emphasized the importance of offering management value and strategic insight in classification. The following distinctions were made; (1) understanding the nature of the service act, (2) type of relationship, (3) customization and judgement in services delivery, (4) nature of demand for the service relative to supply, (5) methods of service delivery. Lovelock emphasized heterogeneity in service. (Fisk, Brown and Bittner 1993)

The efforts of these researchers to distinguish goods from services mainly aimed to show the difference between tangible goods and services. From this standpoint, they were able to extrapolate the unique problems and challenges facing service marketing. They therefore insisted on the necessity of having alternative approaches to goods-oriented marketing.

3. Approaches of service marketing

3.1 Trying to create a new concept

In the middle of the 1970's, the main topic of service marketing was whether the approach towards service marketing was different to that of goods marketing or not. The majority of marketing researchers at that time assumed that service was merely goods with a few odd characteristics. Therefore, researchers concerned with service marketing were eager to explain the differences based on a distinction between services and goods. At the same time, service marketing researchers were trying to create a new approach which would be specific to and appropriate for the service industry. Blois (1974) is an early British researcher who was concerned with service marketing. Blois mentioned the increasing importance of service sectors in the U.K economy and believed that a general approach towards service marketing was needed from practitioners. He insisted that the model of buying behaviour was adequate to explain service marketing. Donnelly (1976) pointed out that the concept marketing channels for goods was inadequate to apply to an approach towards services. He proposed the concept of a marketing intermediary between service providers and client. Shostack (1977) proposed that a new concept of marketing was indispensable for service marketing in the service industry. He said that despite the increasing dominance of the service sector in the economy, existing research was still based on products, particularly mass marketing. Therefore, practitioners in service marketing were confused about the applicability of product marketing. This thesis stimulated marketing researchers to look at service marketing in a new way (Berry and Parasuraman 1993). In terms of marketing strategy, Thomas (1978) mentioned that a product-oriented approach was inadequate for the

service business and that complex strategic thinking was required. Rather than traditional marketing, managers needed to employ a new way of thinking in order to adapt to the service business.

3.2 Establishing service marketing

The deregulation of the service industry triggered a rapid growth in service marketing in the 1980's. Service firms in air transportation, financial services, health care and telecommunications faced new rivals in competitive circumstances. In such circumstances, a lot of contributing research appeared in the service marketing sector in the 1980's. The debate about a goods oriented approach or a unique one in service marketing had been dismissed during this period (Fisk, Brown and Bitner 1993) and the mainstream opinion in service marketing emphasized process and quality management, linked with strategic marketing. In addition, the interests of marketing changed from getting new customers to sustaining existing clients (loyalty). Along with these trends, new issues appeared in service marketing in the middle of 1980's. They can be categorized into three areas (Gronroos 1994): (1) Service Quality - how to provide value and perceived quality for the customer; (2) Human Resources: how to manage service encounters or internal employees (3) Relationship marketing: how to create and manage customer relationships.

3.3 Service Quality

In early discussions about service quality, both service quality and service satisfaction are used relatively (Fisk, Brown and Bittner 1993). The main themes are as follows: (1) Service quality is more difficult for the consumer to evaluate than goods quality; (2) Service quality perception results from a comparison of consumer expectations with actual service performance (3) Quality evaluations are not made solely on the outcome of a service that also involves evaluations of the process of service delivery (Parasuraman, Zeithmal and Berry 1985).

Gronroos (1982) proposed a definition of service quality, stating that it consists of corporate image, technical quality and functional quality. Technical quality is what the customer gets and functional quality is how they get it. He emphasized accessibility and delivery in service marketing. He continued to refine this definition, and Gronroos (1984) improved this, creating a model of service quality. He proposed the concept of perceived service and expected service. Expected services are influenced by the customer's previous experiences. The perceived service is the result of a customer's view which is related to both technical and functional quality. When this perceived service is compared with the expected

service, we arrive at perceived service quality. Technical quality is the result of service encounter, and functional quality is about the interactive process of achieving these results (Ballantyne and Payne 1995).

Parasuraman, Zeithmal and Berry (1985) also mentioned that service quality is decided by the gap between expectation and actual perceived performance. They proposed the 'gap model' as a means of evaluating service quality. The model consists of four propositions, which indicate the following gaps: (1) The gap between consumer expectation and management perceptions; (2) The gap between management perceptions of consumer expectations and the firm's service quality specification; (3) The gap between service quality specification and actual service delivery; (4) The gap between actual service delivery and external communications. They posited that the gap between the customer expectation and the actual perception in service occurs everywhere in the area of service delivery.

Based on these assumptions, Parasuraman, Zeithmal and Berry developed a framework, SERVQUAL, in order to assess service quality, in 1988. This provides five dimensions: (1) Tangibles; (2) Reliability; (3) Responsiveness; (4) Assurance; (5) Empathy.

3.4 Service Encounters

The importance of human resources had been discussed from the early days of service marketing. From the late 1980's, the relationship between employees and customers was the focus of academia and business. It could be divided into two issues: service encounters and internal marketing.

The idea of service encounters is that customer perception of service encounters is an important element of customer satisfaction, and this research focused on the interaction between the encounter and customers (Czepiel (1990). Therefore, the interaction influences both service quality and service loyalty (Fisk, Brown and Bitner 1993).

On the other hand, the basic premise of internal marketing was that satisfied employees in every sector will lead to satisfied customers (Fisk, Brown and Bitner 1993). Internal marketing stresses that efficient internal marketing is a requirement for efficient external marketing (Gummesson 1987). In the same article, Gummesson coined the term 'part-time marketer', meaning those who become marketers when the situation necessitates it, as opposed to full-time marketers. Therefore, the internal market of employees is more conducive to a service-minded, customer-oriented approach (George 1990).

Apart from human resources, another assumption of internal marketing emphasises the internal activities in the service developing process - the internal network of staff relationships that emerged for the sharing of know-how. Gummesson (1987) mentioned that

every employee in every sector in a firm has a customer within the firm. In process management, everyone in the firm is linked with one or more individuals or groups in an internal customer relationship. Each supplier receives feedback from the customers in the firm. The content of this feedback includes know-how, skills and information from clients. Gummesson's proposal is closely linked with the concept of the domesticated market proposed by Arndt (1979).

Adding the concept of service encounters and internal marketing, Ballantyne (1997) indicated service quality as follows:

(1) quality of staff (competency) in their interaction with customers
(2) quality of internal processes in interactive work activities
(3) quality of cycle time in service delivery
(4) quality of customer information (market research) in dynamic relationships

3.5 Relationship Marketing

In service marketing, the Nordic school is very important in its contribution to the development of marketing theory. It examined two major areas: service marketing and industrial marketing since the 1970s. Their main achievement is emphasizing the interaction between service providers and customers (Gummesson 1997). Before the term 'relationship marketing' emerged, they proposed the same concept using other terms, such as the 'interaction' approach, the 'long-term interactive relationship' and so on. For example, Gummesson (1978) pointed out that production and consumption were simultaneous in the process of professional service, and this was based on long term relationships.

In the late 1970's, European academia, especially Nordic and British researchers who would become famous for service marketing afterwards, questioned the existing marketing theory, marketing mix, in terms of its ability to apply to service and industrial marketing. The existing approaches to service marketing, strongly linked to goods marketing, were criticized by practitioners and researchers. They focused on the process of developing services and emphasized the mutual interaction between the provider and the consumer, and the importance of sustaining relationships for the long term.

Bonoma and Johnston (1978) proposed a dyadic approach, which focuses on the transaction relationship between the seller and the buyer based on social psychology. They focused on two parties (two persons, two firms or two industries) and the exchanges that take place between the members of the dyad are most meaningful. The dyad relationship expanded all exchanges between an inner or outer organization (not only to relationships between sales personnel and purchasing positions).

Arndt (1978) proposed the concept of “Domesticated market”. He came up with a system which links to internal and external organizations. These systems concern domestic markets, and are based on the importance of sustained long term relationships. Her contributions are the internal activities and encounters in marketing.

Although both Bonoma, and Johnson’s article and Arndt’s are based on an explanation of industrial marketing, their contribution stimulated the interest of service marketing researchers (Gummesson, Lehtinen and Gronroos 1997). Gronroos (1980) focused on the need-adaptation process. The customer's opinion of a service involved the production process. Therefore, there are three stages involved in satisfying the needs of its target market: (1) Creating interest; (2) Turning general interest into sales; (3) Guaranteeing re-sales by activities during the purchasing process. Existing goods-oriented marketing, marketing mix, was focused only on creating interest (Stage (1)). However, potential customers were influenced by interactive marketing activities. Another contribution of his work is that customer satisfaction is achieved through the purchasing process. When interest is created, the customer has a vague idea of their need. However, through the purchasing process, the customer obtains a better idea of their needs. The customer buys the service which corresponds to their perceived need. As a result, he will buy again if he is satisfied. This leads to a discussion of service quality.

In the 1980’s, many important papers were published and the term 'relationship marketing' was widely used in academia and by practitioners. Levitt (1981) mentioned that keeping customers for intangible products required constant contact with customers and emphasized the relationship management of customers. This meant that the customer must be managed much more carefully and continuously in the case of intangibles than of tangible products. He mentioned the importance of service in every industry and that service is indispensable for every industry, even product-oriented ones (all products have elements of tangibility and intangibility). The most important thing to realise about intangible products is that customers usually do not know what they are getting until they do not get it.

Berry (1982) applied “relationship” to the banking industry. He proposed the concept of relationship banking, which emphasized client retention and enhancement, not just new client acquisition. Berry (1983) wrote the first article coining the term 'relationship marketing'. Berry defined relationship marketing as attracting, maintaining and enhancing customer relationships.

Another important area of research focuses on the interaction between provider and client. Solomon, Suprenant and.Czepie (1985) presented the encounter as a service component and proposed that dyadic interaction is critical to be satisfied with a customer.

One of the main points of this research is that service encounters are based on dyadic interaction and this leads to a service having a unique role and performance.

Above all, relationship marketing recognized the value of current customers and the need to provide continuing services to existing customers. Therefore, this concept leads to a shift away from the traditional marketing approach (attracting new customers is the main issue). Christopher, Payne and Ballantyne (1991) pointed out that the nature of interrelationship with the customer is changing. Existing marketing theories like marketing mix consider only one-time transactions and new marketing has to emphasize mutual and frequent transaction. **Table2-2-(2)** features a comparison between relationship marketing and transaction marketing (the approach of traditional marketing).

Table 2-2-(2): Feature of relationship marketing in service

	Transaction Marketing	**Relationship Marketing**
Philosophy	Focus on single sale	Focus on customer retention
	Oriented to product features	Oriented to product benefit
Unit of Analysis	Actor (Seller or Buyer)	Dyad (relationship between seller and buyer)
Time orientation	Short time-scale	Relatively Long time scale
Internal activities	Little concern for internal activities.	Service encounters and internal activities contribute significantly to quality.
The interest of service	Little emphasis on customer service	High customer service emphasis
Customer commitment	Limited customer contact	High customer commitment
	Moderate customer contact	High customer contact
The interest of quality	Quality is primarily a concern of production	Quality is the concern of all

Modified Arndt (1979), Christopher, Payne and Ballantyne (1991), Moller and Haline (2000)

3.6 Internal marketing

Internal marketing has been described as a philosophy for managing an organization's human resources based on a marketing perspective (George 1990). This is defined as viewing employees as internal customers (Gummesson 1987), and viewing jobs as internal products that satisfy the needs and wants of these internal customers while addressing the objectives of the organizations (Berry 1983). The concept of internal marketing was developed originally in the area of service marketing, where its application has been primarily in identifying training needs and cultural problems (Piercy and Morgan 1991). The internal market-place and its interaction with external marketing may actually be the central point for making strategic plans (Piercy and Morgan 1991).

There are two assumptions to internal marketing. First, there is the notion that every department and every person within an organization is both a supplier and a customer. The second relates to the organization's staff and involves ensuring they work together in a manner supporting the company's strategy and goals (Collins 1991). The concept of employees as customer is used differently in the TQM (Total Quality Management) and service marketing approaches. The service marketing approach claims that the best way to get motivated employees is to use marketing techniques in the internal market place (Rafiq and Ahmed, 1993). These approaches initially aimed to highlight the gap between top management and employees (Piercy and Morgan, 1991). In addition, they focused on the point that marketing activity would motivate people Thus, internal marketing provided an environment in which their motivation was valued and internal marketing emphasized so as to offer incentives rather than benefits.

However, these early studies were focused on a philosophical basis. As a result, the main issue of internal marketing shifted to a managerial perspective on how to perform internal marketing rather than what it is (Varey and Lewis, 1999).

Recently, researchers have paid attention to the correlation between knowledge management and relationship marketing. Varey and Lewis (1999) claimed that internal marketing is the relationship and knowledge management required for a new organization. In addition, the key assumption of service marketing was changed to address how to make values for customers (Webster, 1993). Ballantyne (2003) claimed the proposition of internal marketing can create value for an organization, its customers and its employees.

Based on these assumptions, researchers tried to explain managerial insight and its implications. Gummesson (1987) emphasises the internal activities in the service developing process - the internal network of staff relationships that emerged for the sharing of know-how. In his proposed process, everyone in the firm is linked with one or more individuals or

groups in an internal customer relationship. Each supplier receives feedback from the customers in the firm. The content of this feedback includes know-how, skills and information from clients.

Ballantyne (1997) applied the network concept to internal marketing and tried to find how employees enable the discovery of new knowledge and transfer this knowledge in a firm by using the case of an Australian bank. He continued this work and proposed the relationship-mediated theory of internal marketing (Ballantyne 2003). He categorized the pattern of knowledge exchange into three types: expert-oriented, market oriented and employee-oriented. Expert-oriented knowledge is exchanged through formal hierarchical channels. Market-oriented knowledge can be exchanged between inter-function value chains in a firm. This type of knowledge can be authorized by reference to external customers' needs. Employees' knowledge can be shared as common sense in a firm's society. It is generated and circulated by exchanges within spontaneous, internal communities. Learning activities consists of four parts: energising, code breaking, authorising and diffusing. After circulating this process many times, every employee shares knowledge and creates new knowledge (knowledge renewal). Therefore, relationship development in internal marketing is bridges learning activities with creating new knowledge. The diffusion of knowledge also uses internal relationships. According to Ballantyne (2003), the basic assumptions of this theory are as follows:

(1) Relationship development begins with exchanges of mutual value between participants.
(2) Internal marketing requires a process of learning activity.
(3) Relationship development mediates between learning activity and knowledge renewal.
(4) Knowledge renewal is the purpose of internal marketing.
(5) Internal marketing gains legitimacy through external market relevance.

Above all, discussions of internal marketing concern knowledge management: - how to create new knowledge (knowledge renewal) and how to share how to diffuse. However, there are some problems of the research of internal marketing to Industrial. As the boundary is defined according to whether it is within a firm or without, it is difficult to explain partnerships of internalized external firms as alliances and industrial groups.

4. Discussion

This section had discussed the features of service marketing in the context of relationship marketing. Intangibility and heterogeneity lead to mutual and frequent transaction between provider and client. Therefore, this relationship is an extremely significant factor in examining the exchange of intangible goods.

In addition, internal activities are another significant discussion point for the service developing process. In traditional marketing - product-oriented marketing - only a marketer and a product meet the customer. However, in service marketing, every employee must have contact with customers in certain situations. By communicating with customers, people in every sector can accumulate information and know-how. This knowledge is shared within firms by the mutual interaction between every department. These activities make a significant contribution towards developing service.

In this way, the discussion about service marketing helps to explain R&D activities. However, the difficulty lies in the fact that relationship marketing in service applies to R&D activities directly, as several factors based on service are different to those of R&D activities (**Table2-2-(3)**).

In order to explain this, exchange of goods, which are created in R&D activities, has to be considered. From the provider to the client, the main goods exchanged are intangible things: technological knowledge, know-how or skills. These goods are protected by patent or confidential duty. Although the ownership may not be transferred by the patent, it can be vague in actuality. The client wants technological knowledge in order to improve the client's existing technological resources. Therefore, the client tries to get ownership by money or an exchange of other resources.

On the other hand, from the client to the provider, it is not only money that is exchanged, but also technological resources, business chances and developing tools. This means that the exchange of goods is based on the structure of existing mutual relationships, industrial structures or power structures. This basis is provided by the feature of industrial marketing.

Furthermore, the way of building relationships is different between service and industry. Service marketing mainly targets a consumer market. Therefore, the variety and the amount of customers are much wider than that of industrial marketing. The quantitative and qualitative differential also influences the limitation of service marketing applying to R&D activities.

In internal marketing, the main issues in academia have shifted from human resource

management to knowledge creation processes even in the context of service marketing. However, there are some problems of the research of internal marketing to industrial. As the boundary is defined according to whether it is within a firm or without, it is difficult to explain partnerships of internalized external firms as alliances and industrial groups.

This section discussed how intangible goods are treated, emphasising continuous interaction activities to develop services. In industrial marketing, these interactions are called as relational exchanges. Therefore, the next section argues industrial marketing, especially focusing on relational exchange.

Table 2-2-(3): The features of service in R&D activities

Service features	Main marketing problems	R&D activities
Intangibility	Ownership cannot be transferred Cannot be tested in advance	Although a patent and a contract protect it, it is actually transferable. The client tests it many times before and after purchasing.
Inseparability	Very few goods without services Goods and services packaged together Customers involve in the process of productions.	R&D can be regarded as a service provider to offer advanced technologies. The process of R&D activities has to involve the client's opinion or knowledge.
Heterogeneity	Standardization and quality control difficult to achieve	Yes. Every offer is customized.
Perishability	Cannot be stored	No. Knowledge management: trying to document or transfer within a firm.

Section3. Industrial Marketing

1. Introduction

This section attempts to clarify discussions about relational exchange in the context of industrial marketing. In the early stages of industrial marketing, approaches to research were closely linked with that of consumer products; marketing mix and consumer behaviour. However, the nature of industrial marketing is totally different from that of consumer marketing. Industrial marketing takes place in the context of a formal organization. Furthermore, organizational behaviour usually involves many people in the decision process with complex interactions among people. (Webster 1973)

Economic analysis of markets was also another method of explaining industrial activities at that time. The assumption of the economic approach was based on the free market: customers and suppliers always buy things they need in a market and they can move to and from the market freely. In other words, the relationship between firms is transactional and temporary. However, the relationship is much more stable and changes in the composition of customer and supplier markets are few and relatively slow (Hakansson 1982).

As a result of the above discussions, it was clear that something other than economic analysis and a consumer-oriented approach was needed in industrial marketing. Therefore, researchers tried to develop a new concept of industrial marketing, focusing on relational exchange between firms based on sociological methodology.

This section focuses on the social exchange approach to business marketing. First, the issues of the buying behaviour model will be discussed. The interest of industrial marketing was purchasing management. This approach was initially based on consumer behaviour, but the characteristics of business purchasing led to a change of emphasis, focusing more on exchange.

Second, a paradigm shift of marketing occurred at the beginning of the 1970's. This section discusses several empirical pieces of research which had an influence on later research in relationship marketing. Third, focusing on North American research about relational exchange, channel relationship shall be discussed. The issue of buyer and seller exchange strongly influenced the discussions of channel management by U.S researchers. The inter-firm relationships had been discussed in the context of channel management along with the increasing interest in vertical integration and internationalized business conditions (Sheth and Parvatiyar 1995).

2. Buyer behaviour model in industrial marketing

In the 1960's and early 1970's, purchasing function in a firm was one of the hot topics in industrial marketing.

One of the empirical achievements in buyer behaviour is the Howard-Sheth model proposed by Howard and Sheth in 1969. Although their research focused on brand choice in consumer behaviour, they said that at a general level the industrial buyer and the consumer buyer were quite similar, therefore their model attempted to bring industrial buying and consumer buying together under one umbrella, (Howard and Sheth 1969). Their approach is based on the theory of human behaviour.

Although their model is based on the theory of the Stimulate Organism Response model (SOR model), their significant achievement is the idea that the theory of buyer behaviour consists of two sets of hypothetical constructs: learning constructs and perceptual constructs. Learning constructs explains how, in the process of the buying decision, a customer buy particular things repeatedly. Perceptual constructs, on the other hand, show how individuals' attitudes toward an item can change from ignoring it to registering and finally purchasing the product.

However, this model is very difficult to apply to industrial buying behaviour because it only explains individual decision making. However, in the business world, the way companies are organized has a strong influence on the buying decision. At that time, research findings and theoretical discussions about consumer behaviour often had little relevance for practitioners and industrial marketers (Webster and Wind 1972, Hakkansson 1982).

Sheth (1973) proposed a new model of industrial buyer behaviour, specially focusing on industrial buying behaviour and modifying the Howard-Sheth model. The new model was similar to the Howard-Sheth model of buyer behaviour in format and classification of variables, but there were several significant differences.

(1) The model was limited solely to organizational buying while the Howard-Sheth model was more general and focused more on consumer behaviour.

(2) The Howard-Sheth model was limited to the individual decision-making process, whereas this model explicitly describes the joint decision-making process.

(3) There are fewer variables in this model than in the Howard-Sheth model of buyer behaviour.

Sheth pointed out that many industrial buying decisions were not solely in the hands of the purchasing agent and that there is considerable interaction among the individuals involved in a purchasing process. Therefore, decisions have to be made jointly.

Webster and Wind (1972) proposed another model, also emphasizing the organization and interaction involved in purchasing. They insisted that industrial buying took place in the context of a formal organization. Organizational buying usually involves many people in the decision-making process with complex interactions among people geared towards individual and organizational goals. This complex process, requiring information from a variety of sources, is very time-consuming. Compared to Sheth's model, Webster and Wind considered the role of individuals in a firm's purchasing process as being less important than organizational behaviour.

In particular, three empirical researches of purchasing behaviour are examined in an applied behaviour science that is concerned with understanding buyer and seller systems involved in industrial marketing. Significantly, the approach has been changed from individual behaviour to interactions with firms. This focus on interaction in industrial marketing was expanded to include inter-firm activities rather than internal behaviour.

3. The emergence of the interaction perspective in industrial marketing

In the beginning of the 1970's, some empirical research focused on relationships between supplier and buyer in industrial marketing. Kotler (1972) tried to expand the concept of marketing. He defined the core concept of the marketing as transactions and proposed that transaction is the exchange of values between parties. This assumption helped broaden the concept of marketing, so that not only goods, services and money were marketed, but also other resources which are of benefit to providers and buyers. In addition, he advocated that transactions occur not only between providers, clients, or organizations but also any two parties. Therefore marketing can be regarded as a transfer of resources from one party to another. He proposed that the nature of marketing is as follows: (1) Marketing involves two or more social units. (2) At least one of these social units is seeking a specific response from one of more other units concerning some social objects. (3) The market's response probability is indispensable but not fixed. (4) Marketing is the attempt to produce the desired response by creating and offering values to the market.

Bagozzi (1974) defined marketing as the process of creating and resolving exchange relationships. The exchange system may be defined as a set of social actors, their relationships to each other and the endogenous and exogenous variables affecting the behaviour of the social actors. The endogenous and exogenous variables represent causal

concepts superimposed on both the social actors and the relationship between actors. A number of external factors may also influence the transaction. Any theory of marketing based on exchange must satisfy two broad requirements. First, the structure of exchange must be specified. The theory must specify the underlying cause-and effect relationship. These may be classified as originating from endogenous and exogenous variables.

Based on Kotler's and his previous works, Bagozzi (1975) tried to categorize three types of exchange which he called 'restricted, generalized and complex' exchange (**Figure2-3-(1)**). Restricted exchange referred to mutual and direct relationships between two parties. This type of exchange has two characteristics. First, any attempt to gain advantage at the expense of the other is minimized. In addition, there is a trade-off exchange. Therefore, time intervals in mutual relationships are comparatively short and there is an attempt to balance activities and exchange items.

Generalized exchange occurs if the relationship involves at least three actors and if the actors do not benefit each other directly but only indirectly. Complete exchange refers to a system of mutual relationships between at least three parties. Each actor is involved in at least one direct exchange, while the entire system is organized by an interconnecting web of relationships.

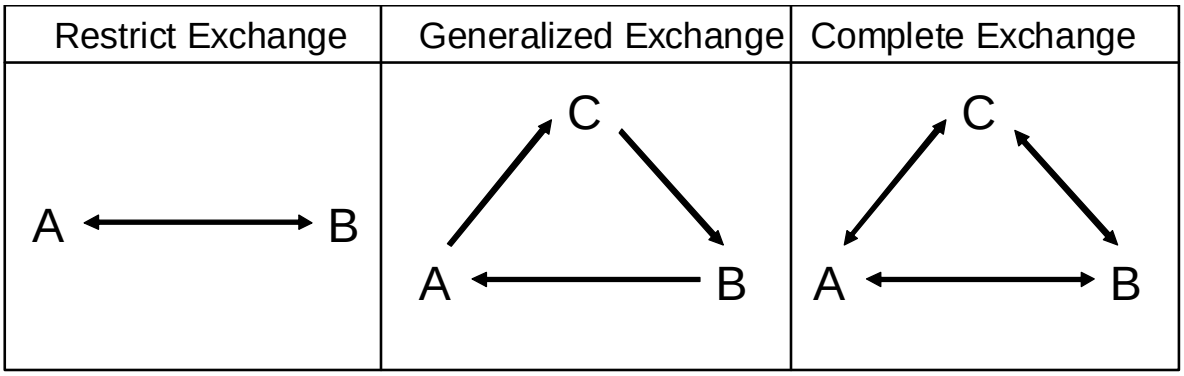


Figure2-3-(1) Baggozi's type of the exchange

4. Relational exchange in channel relationships

4.1 Towards relationships

The channel theory can be identified as two disciplines: the economic approach and the behavioural approach. The former attempts to apply microeconomic theory and industrial organization analysis to the study of distribution systems, focusing on costs, functional differentiation and channel design. The latter borrows heavily from social psychology and organizational theory, focusing on power and conflict of phenomenon (Stern and Reve 1980). According to the social exchange approach, interactions based on sociological methodology are focused. In this approach, the marketing channel is viewed as an inter-organizational system which consists of a set of independent organizations involved in the process of making a product or service available by an exchange. Therefore, channels have the characteristics of complex social organizations, and organizational behaviour is given more emphasis than individual (Reve and Stern 1979). Until the end of the 1970's, power and conflict were the main issues of channel management, along with how firms acquire and use power, the causes and consequences of intra-channel conflict, and the interrelationship between power and conflict (Frazier 1983a).

From the end of the 1970's, U.S researchers paid attention to the dyadic relationships in channel members. Bonoma and Johnston (1978) mentioned that the major factors influencing the industrial purchasing decision were social ones and that purchasing behaviour took place in interactions rather than reactions. Therefore, they advocated that the dyadic approach, which occurred at the exchange of two parties, is significant in understanding industrial buying behaviour. In addition, they indicated that a system approach was indispensable to adapt to the view of marketing interaction that all parties were involved in the process of channel management. That means any change in one of the channel members would bring about changes in other participants, and that every action could have multiple reactions.

Frazier (1983a) focused on the process of building relationships in channel members. They emphasized the outcomes and the satisfaction that were obtained from exchanges in relationships from a distributor's perspective. Satisfaction can be defined as a positive affective state resulting from the evaluations of all aspects of a firm's working relationship. Frazier (1983a,b) attempted to create a process model of building relationships between channel members as a consequence of each party's satisfaction. He classified three processes as initiation, implementation and review, including the constructs of power and conflicts. (1) Firms initially seek to exchange relationship partners within market channels through the initiation process. (2) In the implementation process, each firm exchanges products, services,

and associated information. (3) Review process concerns an evaluation of the rewards or losses achieved by each firm's exchange. In this process, exchange outcomes provide a test of the other's ability and willingness to deliver satisfaction. As a result, if the outcomes are below expectation, the relationship is ended and the party is replaced by another. If the outcomes are above expectation, the motivation to maintain the relationship increases. High level outcomes reduce the number of alternatives an exchange partner might use as a replacement. The resulting adaptation and cooperativeness in channels needs interactions between channel members.

4.2 Shift foresight

In the traditional views of channel management, power and conflict were the main issues, however, the topics of channel management were changed after adapting the view of relational exchange. In the 1980's, channel researchers attempted to develop a model of channel relationship based on the social exchange theory.

Anderson and Narus (1984) developed a model of distributor-manufacturer working relationships from a manufacturer's perspective. In the research, satisfaction as a way of maintaining relationships was emphasized. In addition, outcomes and outcomes for alternative were identified and the study was focused on the relationship between two types of outcome and satisfaction. Motivation to maintain existing exchange relationships occurs when outcomes arising from the exchange meet or exceed the distributors' expectations and are superior to those available from alternative suppliers. Improving and expanding the model, Anderson and Narus. (1990) focused on relative dependence in relationships. Relative dependence was a significant antecedent of influence on the working partnership. The firms with greater relative dependence have relatively greater interest in sustaining the relationship and exchange and add value. In contrast, a firm with less relative dependence can use its superior position to request changes from its partner that will improve the outcome and to enable them to exchange less valuable things. They also emphasized trust achieved through communication and cooperation in channel members.

Anderson and Weitz (1989) developed an industrial channel dyad model according to the relationship between continuity, trust and communication. They paid attention to the development of long-term relationships as a result of an increasing interest in vertical integration. In order to build a continuity relationship, their model consists of six elements: (1) Trust between the parties. (2) Imbalance of power. (3) Communication between parties. (4) Stakes in the relationship. (5) The manufacturer's reputation for fair play. (6) Age of the dyad. Their research yielded two essential findings: communication is critical in building

trusting relationships that create stability; mutual trust in a relationship is in turn strongly influenced by the level of communication in the dyad. In addition, the older the mutual trust in a relationship which is in turn strongly influenced by the level of communication in the dyad, is, the more trusting the relationship becomes.

Dwyer, Schurr and Oh (1987) developed a process model of building relationships in channel management. They categorised five processes: Awareness, Exploration, Expansion, Commitment and dissolution. Awareness refers to the recognition that the party is a feasible exchange partner. Exploration refers to the search and trial phase in relational exchange; dyadic interaction occurs and interdependence is gradually increased through testing and probing. Expansion refers to the continual increase in benefits obtained by exchange partners and to their increasing interdependence; in this process, mutual satisfaction supports deepening interdependence and is sought from the existing exchange partners rather than an alternative partner. Commitment refers to an implicit or explicit pledge of relational continuity between exchange partners. In this process, constructual mechanisms and shared value systems have developed. Participants resolve conflicts and adapt.

Compared to Frazier's (1983a, b) model, the concept of commitments was added to Dwyer-Schurr-Oh’s model. This indicates that not only creating relationships but also maintaining those relationships is a significant factor in discussions about channel management.

Hallenm, Johanson and Syed-Mohamed (1991) analysed inter-firm adaptation in business relationships. They indicated that inter-firm adaptation has two ways and said following; although much research aimed at analysing conditions for fit between a firm’s capability and the needs of its customers, suppliers adapt to the needs of specific important customers as well as that customers adapt to the capabilities of specific suppliers. In other words, inter-firm adaptation can be regarded as having two meanings based on the concept of trust or power. One is that inter-firm adaptation is an element in a trust-forming social exchange so that the adaptation by the two parties in the relationship is related positively to each other. Another is that the stronger the market position of a firm, the more the other party can be expected or forced to adapt to that firm. Therefore, they suggested, adaptation can be explained in terms of power dependence. When two interacting parties face various contingencies, they may have to modify their resources to match each other’s needs. Relative dependence between two actors in an exchange relationship determines their relative power. Power is derived from having resources that the other needs and from controlling alternative sources of these resources. In the resource-dependence model, firms in a business relationship can be expected to adapt to each other to the degree that they are dependent on

each other's resources.

Morgan and Hunt (1994) summarized the previous discussions of channel management and advocated that commitment and trust is central to successful relationship marketing, not power and its ability to influence others. Commitment in relationships is defined as an exchange partner believing that an ongoing relationship with another is so important as to warrant maximum efforts at maintaining it. Trust is conceptualized as existing when one party has confidence in an exchange partner's reliability and integrity. They proposed that relationship marketing refers to all marketing activities directed toward establishing, developing and maintaining successful relational exchanges. They also pointed out that the need for relationship marketing stems from the changing dynamics of the global market place and the changing requirements for competitive success.

5. Discussion

In order to look at inter-firm-relationships, channel management was discussed in this part. There was a paradigm shift from discrete transaction to mutual exchange and long-term relationship by introducing the concept of relational exchange in channel management (**Table2-3-(1)**). In the traditional approach, the transaction between two parties takes place in a competitive marketplace. In a pure market form of economic organization, all activities are conducted as a set of discrete, market-based transactions. The job of marketing is simply to find buyers (Webster 1990). However, the increase of competitive and internationalized business circumstances has led companies to develop a more integrative approach in marketing. This has resulted in the growth of many partnering relationships such as business alliances and cooperative marketing ventures (Anderson and Narus 1990, Sheth and Parvatiyar 1995). Therefore, discussions about how to bond the channel members from a manufacturer's perspective were highly necessary. Table 1 shows a comparison of both approaches' features.

Table2-3-(1): Feature of relationship marketing

	Discrete exchange	**Relational exchange**
Philosophy	Focus on single sale	Focus on buyer-seller behaviour
Numbers of actors	A large number of customers	A limited number of actors
Interdependence	Low interdependence	Mutual interdependence is high
Unit of Analysis	Actor (Seller or Buyer)	Dyad (relationship between seller and buyer)
Target of phenomena	Emphasis on managerial, economic and psychological perspective	Emphasis on social and inter-functional exchange relationships
Time orientation	Short time-scale	Relatively long time scale

The main aim of channel management research is to explain governance constructs and dyadic behaviour in a channel context (Mollar and Halinen 2000). Power, inter-dependence and commitment are key factors in explaining the structure of relationships between channel members.

There are several limitations in applying discussions of channel management for R&D activities. First, channel relationships emphasise structure rather than process (Moller and Halinen 2000). The purpose of channel relationship is to determine efficient relational forms between channel members. Therefore, the way of building relationships is less emphasized. Second, it is taken for granted that channel management deals with purchasing function.

Therefore, careful analysis is needed when channel management is applied to other activities. Third, dyad exchange is the assumption of analysis in channel relationships. However, as this study pointed out before, R&D activities involve several numbers of external or internal actors. Actors influence each other respectively. Therefore, the assumption of relationships should consist of mutual exchanges by several actors. The next section attempts to discuss the network approach which assumes that industrial exchanges take place within limited and specified actors in the network.

Section4. The Network Approach

1. Introduction

In the previous two sections, we looked at discussions about relationship marketing in the context of service marketing and channel management. Each approach focuses on a dyadic relationship between two firms, and the main issues are how to manage the relationship with a customer or a channel member. In addition, only specified departments, such as the purchasing department or a counterpart of the customer, could form and maintain relationships with customers and channel members.

However, although a firm exchanges with limited companies, there are many actors within a firm. Each interacts with internal or external personnel in business. Therefore, we should expand the view of relationships from the dyadic relationship to comprehensive networks which consist of several dyadic relationships. This view is regarded as a business network context (Anderson, Hakansson and Johanson 1994). Actors are also defined not only as customers but also as other external firms including indirect dealers and competitors.

With the increase in globalization and the rapid change in technology, other departments have engaged with external companies, for example R&D, distribution, logistics, marketing, and manufacturing. In particular, R&D departments face the need to develop and maintain relationships with other firms because of the rapid change in technology, a shortening product life cycle, the increasing complexity of technology and the amount of R&D fees. Bearing this in mind, the relationship should be considered as activities based on departments within and without a firm. Thus, this research expands the area of relationship from inter-firm relationships to “inter-function relationships”.

2. Philosophy of the network approach

In 1970’s, Nordic researchers studying industrial marketing questioned the existing marketing theory concerning the nature of industrial marketing. According to Hakansson (1982), there are several differences between the traditional marketing approach (he mentions the Marketing Mix) and industrial marketing. “The assumption of marketing mix is that the market consists of many individual customers that are affected by the marketer’s variables in accordance with a certain statistical distribution”, (Hakansson 1982, p.2). Apart from the methodology, he criticized existing marketing theory, saying that it was mainly based on consumer goods and that the focus was only on the management of single purchases. According to Hakansson and Snehota (1989), the network approach stems from the casual observation that business organizations often operate in environments which

include only a limited number of identifiable organizational entities (actors). In traditional marketing, the firms are free to choose which counterparts with whom they want to carry out exchanges. However, in real industrial activities, the relationships take a long time to develop, while substantial resources are used to establish, adjust, maintain and develop relationships between firms (Johansson and Mattsson 1985). Changes in the composition of customer and supplier markets are few and occur relatively slowly. Therefore, stability is a clearer and stronger characteristic of industrial marketing than change (Hakansson 1983). In addition, these entities are involved in continuous exchange relationships with the organization. In such cases each individual party exerts considerable influence on the organization (Hakansson and Snehota 1987). Hence, the network approach focuses on the interaction within the relationships, not on organizational hierarchy, nor on the price mechanism of markets (Mattsson 1987). Above all, their view of industrial markets was that a limited number of actors existed in a network, exchanging with each other for a relatively long period of time. Assets created by earlier investments influence opportunities for present and future investments. (Johansson and Mattsson 1985)

Most exchange takes place within pre-existing relationships. Those relationships, however, are changing all the time through interaction among the firms to do with transactions made within the relationship. (Johansson and Mattsson 1987)

The network approach points out the limitation of the existing marketing theory created in the USA to explain the nature of European industrial markets. The market in the USA is highly competitive and firms are free to choose business acquaintances in the market. However, the European and Japanese markets have other kinds of market characteristics. They maintain long-term partnerships with business partners and have industrial groups such as Keiretsu, where there is deep exchange of capital, information and human resources. Therefore, it is very hard to adapt the style of American marketing to the European and Japanese markets. Indeed, the different characteristics of markets among countries can explain why the network approach is more popular in European countries while American researchers have tended to ignore it (except for some researchers e.g. Arndt (1979), Jackson (1985), Webster (1992) and Hunt and Morgan (1994)).

3. Characteristics of the network approach

In the network approach, a firm has a unique identity in the network. This is characterized by resources obtained from its relationships with other firms and the consequences of earlier activities in the network. A basic assumption in the network model is that the individual firm is dependent on resources controlled by other firms. The firm obtains access to these external resources through its network positions. The use of an asset in one firm is dependent on the use of other firms' assets (Johansson and Mattsson 1987). According to Mattsson (1987), the positions are defined by (a) the identity of the other firms with which the firm has direct and indirect relationships, (b) the role of the firm within the network, (c) the importance of the firm within the network, and (d) the strength of the relationships with the other firms.

The network approach is influenced by the resource dependency theory (Pfeffer and Salancik 1978). The resource dependency theory views organizations as being embedded in a network of interdependencies and social relationships. A need for resources obtained from the environments made organizations dependent on external resources. According to Pfeffer and Salancik (1978), organizations are embedded in an environment comprising of other organizations. They depend on those other organizations for getting the many resources they require. Interaction takes place reciprocally and indirectly. Thus, the resource dependency theory lays stress on the network context. In the network approach, an environment is regarded as a market, including exchanges between a firm and other actors.

The network approach emphasized the importance of exchange within an existing network. In other words, the activities within a specific time period and their effects are dependent on earlier activities and will have some influence on activities in the future (Mattsson, 1987). This implies that every change in a market relies on a "historical event". According to Gadde and Mattsson (1987), the change seemed to be something of a gradual shift represented by the addition of new suppliers to the present structure and a corresponding drop in suppliers some years latter. The changes in supplier structure from year to year are fairly few. This means that although the changes from one year to another are only of a marginal nature, the long-term consequences can be dramatic. Based on their investigation, the classification of suppliers would have been quite different if the observation period had been extended even only by another three years.

Allowing indirect relationships is a significant characteristic of the network approach. Every firm can gain access to their desired resources by direct and indirect exchange. Existing indirect relationships make up a complex web.

The exchange process can be regarded as the adaptation process of each actor's

exchanges. One of the adaptation processes includes parties testing how well they fit each other. If a party is evaluated as an inappropriate partner, it will be removed from the network. In addition, during the course of this process, a number of problems usually emerge, the parties do not fit, and a number of activities can be carried out to eliminate the misfits. Through solving these problems and conflicts, each partner shares a way of working together as well as important knowledge. Reciprocal knowledge and capabilities are revealed and developed jointly, and mutual dependence is established. As a result, distinct capabilities are generated. The adaptations occur through continuous processes as a result of day-to-day experiences. Adaptation is important for at least three reasons. First, they strengthen the bonds between firms. Second, the reinforcement of relationships through adaptation makes them more enduring, which in turn means that disagreements have to be handled within the framework of the relationships. Finally, interaction processes create adaptations in attitudes and knowledge of the parties, that is, mutual orientation develops (Johansson and Mattsson 1987, Hallen, Johansson and Seyer-Mohamed. 1991). According to Mattsson (1987), market investments are the resource commitments through which internal marketing assets are created. The relationship may reduce costs of exchange and production and they many also be helpful in a firm's knowledge development Therefore, such relationships can be regarded as value-adding partnerships.

Above all, the network approach is a good explanation of real industrial marketing. In order to summarise features of the network approach, **table2-4-(1)** below shows the comparison of each approach in relationship marketing.

The limitations of this approach arise from the fact that a firm exchanges only with the specified actors involved in the network. Hence, information can only be provided by mediating with existing partners. However, if the existing partners do not have appropriate resources, their network might be isolated from the market. The assumption of the network approach is that industrial exchange is a stable and gradual change in nature. If the market is so rapidly changeable, as is the case in high-technology industry, it is very hard to adjust to these business circumstances because they do not have enough skills to adjust to changes. Therefore, the interface between a firm and environments should be considered in the context of the network approach.

Another thing to point out is that the area of external circumstances is not clear. The boundary of the network, including the concept of indirect exchanges, is vague and this leads to a difficulty in making observations and analysis of what happens.

Table2-4-(1): The comparison of each approach in relationships marketing

	Discrete Transaction	Service Marketing	Relational exchange	The Network Approach
Philosophy	Focus on single sale	Focus on customer retention	Focus on the governance structure and management of channel members	Focus on the mutual dependence based on resources
Target business	Consumer goods	Service (intangible) goods	Channel Management	Industrial goods
A number of actors	A large numbers of consumer	Small numbers or dyad (A customer and a supplier)	Dyad or several channel members	Limited numbers
Unit of analysis	Actor (Buyer or Seller)	Dyad exchange	Dyad exchange	Exchanges in the network
Time Orientation	Transactive	Relatively long time	Relatively long time	Long time
Indirect exchange	Unconsidered	Unconsidered	Unconsidered	Considered
Internal activities	Little concern for internal activities.	Service encounters and internal activities contribute significantly to quality.	Little concern for internal activities.	Learning and adaptation processes are indispensable for keeping relationships.

(The author developed the table based on Mattson (1997) and Moller and Halinen (2000)

4. The interface between an organization and its environment

4.1 The boundary of an organization and its Environment

The environment is regarded as anything that is not part of the organization itself. In organizational theory, the relationship between the firm and its environment is a significant issue. Chester Irving Barnard defined the nature of organizational activities as centring around coordination and systems: “The most usual conception of an organization is that of a group of persons, some or all of whose activities are coordinated.” (Barnard 1928, p.68), and “an organization is defined as a system of consciously coordinated personal activities or forces” (ibid. p.72). He looked at organizations as being systems of cooperation in the sphere of human activity, calling it a 'cooperative system'.

According to Barnard (1938), such an organization arises from three necessary and sufficient conditions - initially (1) common purpose, (2) willingness to serve, and (3) communication. “The initial existence of an organization depends upon a combination of these elements appropriate to the external conditions at that time.” (ibid.p.82-83). Therefore, each actor shares a common purpose. Barnard defined willingness to serve as follows: “Willingness to cooperate, positive or negative, is the expression of the net satisfaction or dissatisfaction experienced or anticipated by each individual in comparison with those experienced or anticipated through alternative opportunities”, “ willingness to cooperate is the net effect, first, of the inducements to do so in conjunction with the sacrifices involved, and then in comparison with the practically available bet satisfactions afforded by alternatives” (ibid. p.85). From his comments, we can think of the net of inducements and sacrifices as the satisfaction. More specifically, in the case where satisfaction is higher compared to alternatives, entities can have motivations and incentives to serve organizations. Hence, “organizations depend upon the motives of individuals and the inducements that satisfy them” (ibid.. p.86). This discussion can be thought to lead to the relationship between commitment and satisfaction in relationship marketing, for example, Anderson and Narus (1990) and Morgan and Hunt (1994). This also points out that willingness can be provided by the balance of inducements and sacrifices rather than by the individual entities’ emotions. Therefore, if an organization satisfies the motives of its participants, and attains its explicit goals, cooperation among them will last.

In addition, Bernard mentioned that a cooperative system can be regarded as an adaptive system which can adjust to changes in environments. In other words, his definition of an organization as a system is based on the concept of open system which adjusts

passively to the continuity change in technological, economic and social conditions. Consequently, the continuity of an organization undergoes an adaptation process in order to adjust to environmental change. He also mentions that “adjustment of cooperative systems are adjustments in the balance of the various types of organizational activities “(ibid. p.35). This process can make an organization last for a long time. As Barnard assumed, the environment is dynamic and changeable through time. The adaptive process is indispensable for overcoming these changes.

The contingency theory improved the discussion about the relationship between an organization and its environment. Lawrence and Lorsch (1967) mentioned that the subsystems within a comprehensive system, like sales, R&D and production, differ from each other in terms of formal structure (the member's goal orientation, time orientations and interpersonal orientations). This differentiation is related to the requirements of the particular sub-environment with which each subsystem deals. Therefore, organizational effectiveness can be contingent on the adaptation of business environments, such as technological or market conditions.

As indicated above, the interest of the relationship between an organization and environments become a significant issue, especially how an organization interacts with the environments and adjusts to changes of business circumstances. Consequently, the focus of organizational theory shifts towards the organization-environment interface.

4.2 The network approach as an organization-environment interface

There are certain methods that the network approach applies in achieving an interface between an organization and its environment, for example Hakansson and Snehota (1987) and Anderson, Hakansson and Johanson (1994). The organization's interface with its environment can be discussed as follows. Firstly, the basic assumption is that the organization can operate freely in its environment using a limited number of entities. Each entity is regarded as a unique counterpart to the other and each one is provided with a distinct identity based on its unique resources. This assumption is also provided by Barnard (1938) as specializations of organization. He emphasized specializations in order to reach a high efficiency of corroboration as well as to maintain and improve them. He mentioned that “the ends of cooperation cannot be accomplished without specialization” (ibid. p.136). He also indicated that “the significant concrete stage of specialization is the unit organization rather than the specialized individuals” (ibid. p.136). Therefore, he clearly distinguished from personal specialization and specialization of the unit organization. He regarded an

organization as functional and laid emphasis on specialization of the unit organization as opposed to individual skills. As Bernard described, “Each unit organization has a specific object and specific characteristics” (ibid.. p.136), i.e. each entity has unique and specified resources.

There are networks in which every entity is present and each has its own unique resources. Every actor can access and use existing resources in the network and continuity exchanges take place with any of these for a relatively long period of time. In this long term exchange, the organization can have external resources in its environment by mediating with external entities. Therefore, each actor and organization gradually share more complex and confidential information, leading to be more interdependency with each other. Sharing common purpose and mutual satisfaction is fundamental in establishing these relationships. In addition, the network approach allows indirect exchange from third parties. For example, actor A exchanges only with actor B directly, but actor B exchanges with both actor A and C. In this case, actor A can access actor C’s resources through actor B. Actor C can be regarded as a third party and cannot be identified clearly by actor A. However, actor A keeps the relationship with actor B in order to have the resources provided by the exchange between actors B and C. Moreover, the identity of actor B in this network is partly provided by the exchange from actor C. Hence, external entities act as mediators in order to exchange existing resources in their environment. These indirect exchanges form a complex web of interactive relationships.

Through experience of these exchanges, problems and conflicts occur and the organization and the entities are forced to solve them. Through these efforts, they learn collaboration and share deep knowledge. The personnel communications also deepen. As a result of these organizations’ interaction and exchange processes with members in the network, the relationships develop and grow stronger as a consequence of doing business. The interdependence between an organization and other entities makes it difficult to disconnect the organization from its network, since a business organization without its interactive environment loses its identity. This is known as the adaptation process.

Hence, performance and effectiveness become dependent not only on how well the organization itself performs in interaction with its direct counterparts, but also on how these counterparts manage their relationships with third parties. The organization has adaptations to make with each entity. (Hakansson and Snehota 1987)

4.3 Discussion - Boundaries between a firm and its environment -

The previous section aimed to explain the relationships between an organization and its environment in order to discuss the boundary. Classically, there has been an assumption of a clear boundary between the firm and its environment (Anderson, Hakansson and Johanson 1994). Barnard (1938) mentioned that "intercommunication is a limiting factor in the size of organizations and a dominant factor in the structure of complex organizations (Barnard 1938, p.106). Therefore, the size of an organization can be decided by the area of effectiveness of communication. Correspondingly, the boundary can be decided by the limitations of control on others. For example, "an organization's boundaries should thus be set as coterminous with the limits to its activity control" (Hakansson and Snehota 1987), and "the organization ends where its discretion ends and another begins" (Pfeffer and Salancik 1978 p.32). In this context, organizational boundaries can be defined by the organization's control over the action of participants relative to the control of other social entities over these same activities.

However, according to the resource dependency theory and the network approach, the boundary between organizations and their environments begins to dissolve. Although drawing the organizational boundaries as a matter of analytical convenience, the reason there is so much difficulty in drawing social-system boundaries is that it is behaviours that are organized, not individual people (Pfeffer and Salancik 1978). A relationship gives each firm a certain influence over the other (Anderson and Narus 1990), which means that each firm is gaining control of at least one part of its environment while giving away some of its internal control (Anderson, Hakansson and Johanson 1994). Therefore, the definition of a boundary is naturally arbitrary and depends on the intentions and aims of the observer. It seems useful to adapt the concept of the context of an organization rather that its environment (Hakansson and Snoot 1987). From this standpoint, the boundary, whether it is external or internal, is meaningless or not so important; the condition of establishing and maintaining the relationship is the only issue.

Returning to the Bernard's definition, each organization should share a common purpose. Therefore, we can say that the size of the network can be decided by the limitation of sharing common purposes. This can be explained by some examples in business e.g. industrial groups and strategic alliances. Hence, I can make the assumption that the boundary of the network can be based on the area of sharing common purposes.

However, as in the case my previously described example about indirect exchange, it is hard to say that. Actors A and B, and actors B and C can be said to share common purposes. However, it is difficult to say that actors A and C have common purposes. Although actors A

and B do not exchange directly, each actor is strongly influenced. I think this indicates one of the limitations of the network approach.

There are several alternative ways to explain this. Firstly, the assumption of an existing hierarchy in the network might provide an apparently clear definition of the boundary between an organization and its environment (Assumption). According to the discussion about communication by Bernard (1938), the limitation of communication with others can be linked with the effectiveness of the hierarchy in deciding the boundary. Hakansson and Snehota (1987) also mentioned that the hierarchical control of resources is available to clear the boundary.

In addition, we should pay attention to the dyadic relationship in a business network. Anderson, Hakansson and Johansson(1994) studied dyadic relationships in a business network and said that “This is surprising because if business networks are to possess advantages beyond the sum of the involved dyadic relations, this must be due to considerations that take place within dyadic business relationships about their connectedness with other relationships” (Anderson, Hakansson and Johansson 1994, p.1). They advocated the importance of paying attention to the context of each dyadic relationship and pointed out the existence of a focal relationship (**Figure2-4-(1)**). A focal relationship is defined as being connected with different relationships that either actor A or C has. Some of these relationships, for example that between actors A and B, are with the same third party (actor B). Therefore, every business unit consists of a bundle of several dyadic relationships. Mediated by the third party in common (actor B), each business unit establishes a focal relationship. More especially, there are focal units (Business units) consisting of dyadic relationships. Every focal unit is independent and not influential on each focal unit under stable condition. However, with changes in environmental conditions, a focal unit engages in relationships with other units based on the context. This relationship can be thought of as taking place in both real and virtual scenarios. Therefore, although the exchange may not take place in reality, hypothetical exchange, through a mediating actor, takes place between each actor.

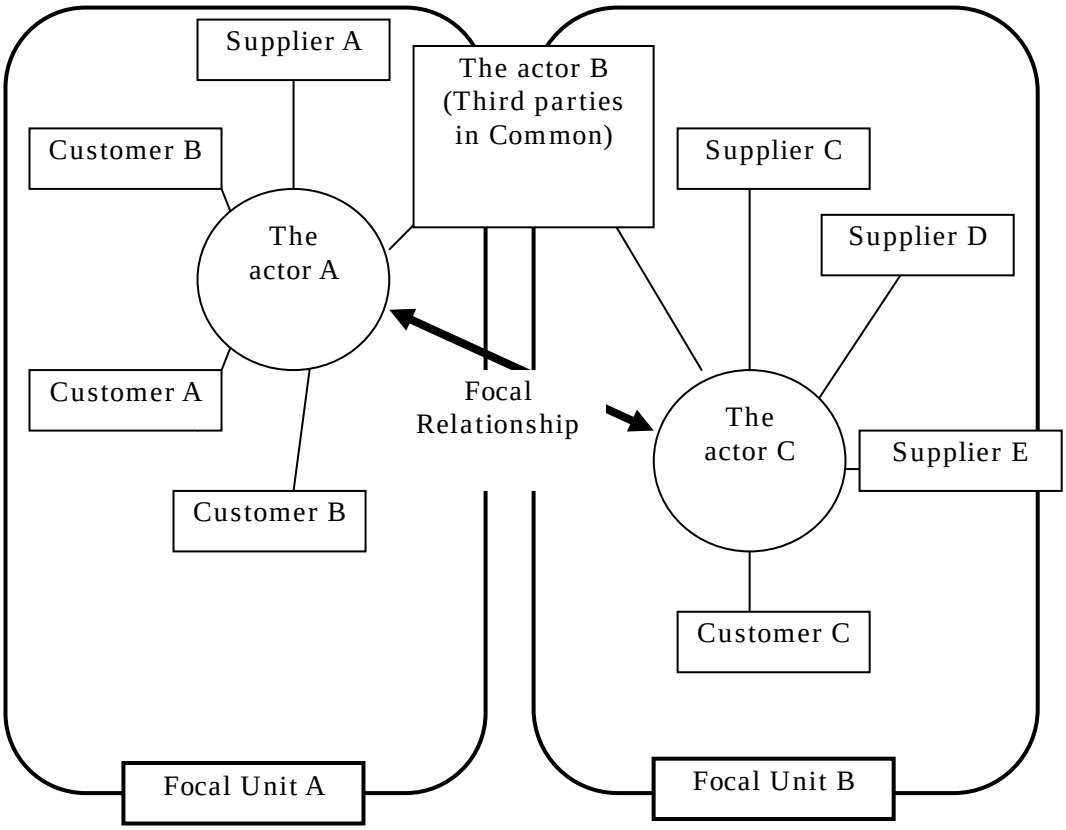


Figure 2-4-(1): the Focal Unit and the focal relationship with dyadic relationships

The focal unit can be regarded as industrial groups like Keiretsu or business partnerships. The common player (the actor B) belonging to both sides mediates to establish a focal relationship between focal unit A and B. It means that the unit of each industrial groups or business partnerships engage in the relationship. Therefore, business alliances mean each focal unit go under an umbrella with having the existed relationships of a focal unit. Actually, European and Japanese companies are likely to establish strong relationships with other partners, so establishing relationship as a focal unit tend to take place rather than the U.S.A companies do.

In addition, another significant discussion can be made. The process of establishing focal relationships implies that there is the time when an indirect exchange becomes a direct change. Before that, the actor A and C exchange each other indirectly through the mediator C. However, when something happens, the actor A can exchange the Actor C directly without the need for the Actor B's help. In this case, after establishing the focal relationship, every actor belonging to focal unit A or B leads to establish new relationships with each other.

Some relationships are successful to develop and maintain the relationship, but some actors have to be removed from the network based on the context of the network approach. Therefore, the success of a business alliance depends on the result of the content within a new focal relationship.

From this discussion, there is an assumption that three types of relationships exist in business (**Figure 2-4-(2)**). The type 1 relationship is mainly discussed in relationship marketing and the network approach. The type3 relationship is also discussed in my previous sections, and it can include dissolution of the relationships (e.g. Tahtinen and Haline 2002, Alajousijarvi, Moller and Tahtinen 1998). Again, the existing type 2 relationship can be emphasized, where the relationship changes from direct to indirect or from indirect to direct, and will be studied what conditions make this relationship established.

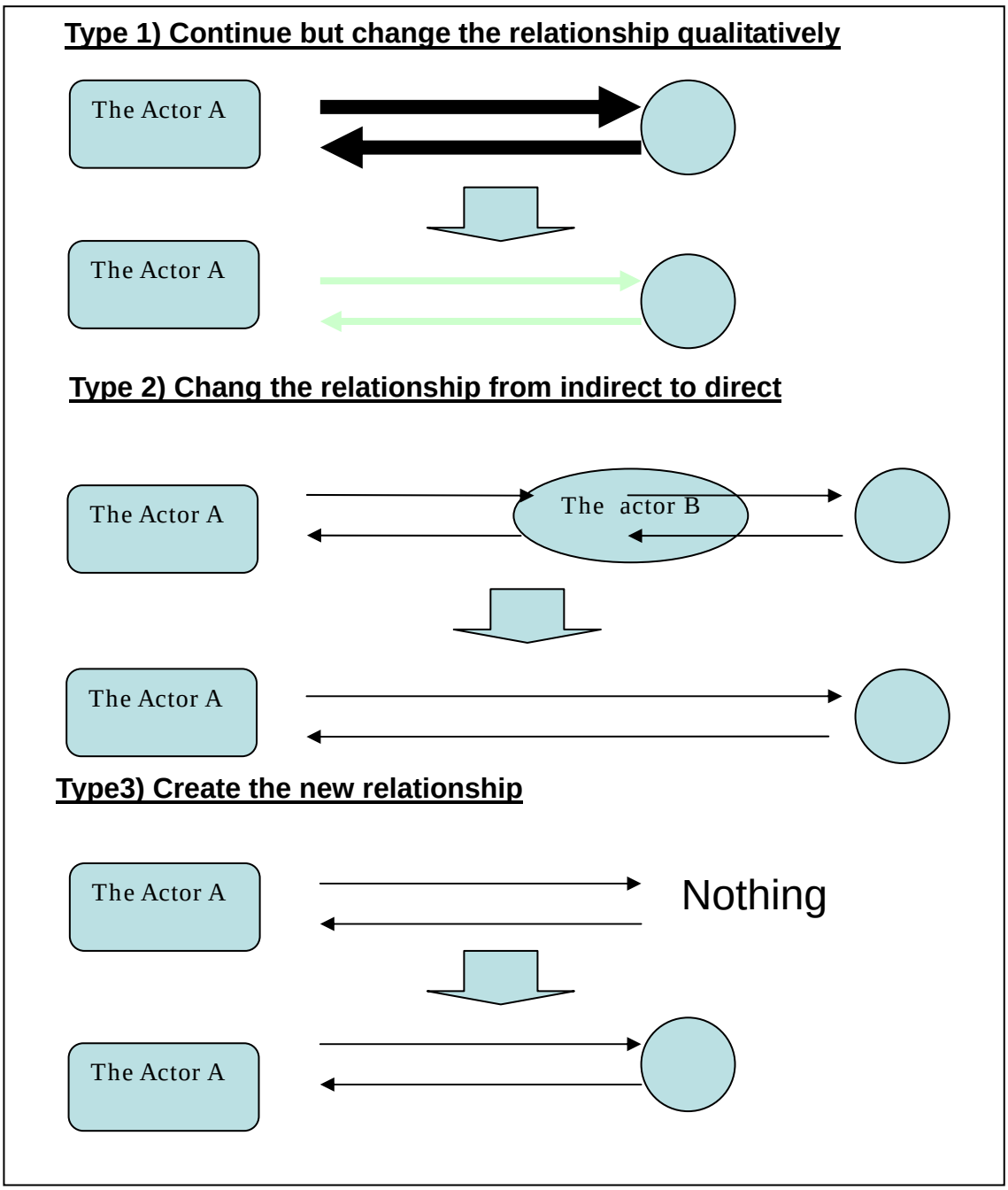


Figure2-4-(2): Three types of relationships

5. Summary

This section discussed about business network and an organization-environment interface within the context of the network approach in order to explain an industrial group.

The first, characteristics of the network approach were discussed. The network approach emphasized the interaction between actors, not on a firm that traditional marketing would have been focused on. In addition, the bundle of dyadic relationships and indirect exchange are shown to be significant characters of the network approach compared with other approaches. In addition, this section showed the limitation of the network approach in order to apply for R&D activities. The assumption of network approach is that a firm exchanges only with the specified and limited actors involved in the network. Therefore, when the market and its environment face so rapid changes, actors in the network hardly cannot react them. In addition, the boundary of the network is vague and this leads to a difficulty in making observation and analysis.

The second attempted explaining the boundary of the business network based on the organizational theory and the network approach. Findings showed that structures of the industrial network influence the activities of actors involved within the network Resource dependence theory is also available as a means of understanding the reason why firms have to adjust to a change of environment.

The third, the section shows that a mechanism of exchange with external networks by focusing on dyadic relationships within a network. In addition, an indirect exchange occurs during the process. Anderson, Hakansson and Johansson (1994) suggests a mechanism that enables the exchange of external resources, advocating the existence of a focal relationship. This involves focal units (business units) consisting of dyadic relationships. Each focal unit is independent and, under stable conditions, has no influence on other focal units. However, a change in environmental conditions means that focal units engage in relationships with other units depending on the context. The common player (actor XAB) belonging to both sides mediates to establish a focal relationship between focal unit A and B. A focal unit can be an industrial group like Keiretsu or a business partnership. In other words, the unit of each industrial group or business partnerships engages in the relationship. Therefore, business alliances mean each focal unit goes under an umbrella along with its existing relationships. Therefore, the success of a business alliance depends on the result of the new focal relationship.

By focusing dyadic relationships, findings showed that there are three types of relationships. Especially, this thesis emphasise the indirect relationships. From previous research, indirect exchanges would occurred when two business network exchange. However,

it should be studied that what conditions makes these three types of exchanges established. The next section attempts to clarify the relationships between characteristics of R&D activities and a dyadic relationship.

Section5.
Characteristics of R&D and Inter-firm relationships

1. Introduction

The previous section discussed about Industrial network in the context of the network approach. The thesis emphasizes inter-firm relationships in R&D activities. Therefore, the network approach provides appropriate theoretical explanations to consider inter-firm relationships in R&D activities even though there are several limitations. However, at the same time, the study of Anderson, Hakansson and Johanson (1994) shows that focusing on each dyadic relationship in a network is appropriate in order to observe inter-firm relationships. Therefore, this section attempts to discuss the relationships between characteristics of R&D activities and a dyadic relationship. The first, business alliances are discussed from the view of relational exchange. The next step shows characteristics of R&D activities based on previous studies of innovation process and deterioration of information. The third step provides hypothesis through relevant articles.

2. Alliances and Industrial groups

In this section, the discussions will expand to the tied relationship with external companies (Alliance and Keiretsu). Keiretsu is a Japanese term for societies of businesses or group companies. However, such industrial groups are not exclusive to Japan but also exist in Europe.

Sheth and Pararvatiyar (1992) tried to explain the alliance from the view of relationships (**Table2-5-(1)**). In their definition, a business alliance is an ongoing formal, business relationship between two or more independent organizations to achieve common goals. They indicated that there are four type of alliances based on the purposes (strategic and operational) of and parties within the business alliances (competitors and non-competitors).

Table2-5-(1): Type of Alliances

		Parties	
		Competitors	Non-competitors
Purpose	Strategic	Competitive alliance	Collaborative Ventures
	Operations	Cartels	Co-operative

(From Sheth and Parvatiyar, 1992)

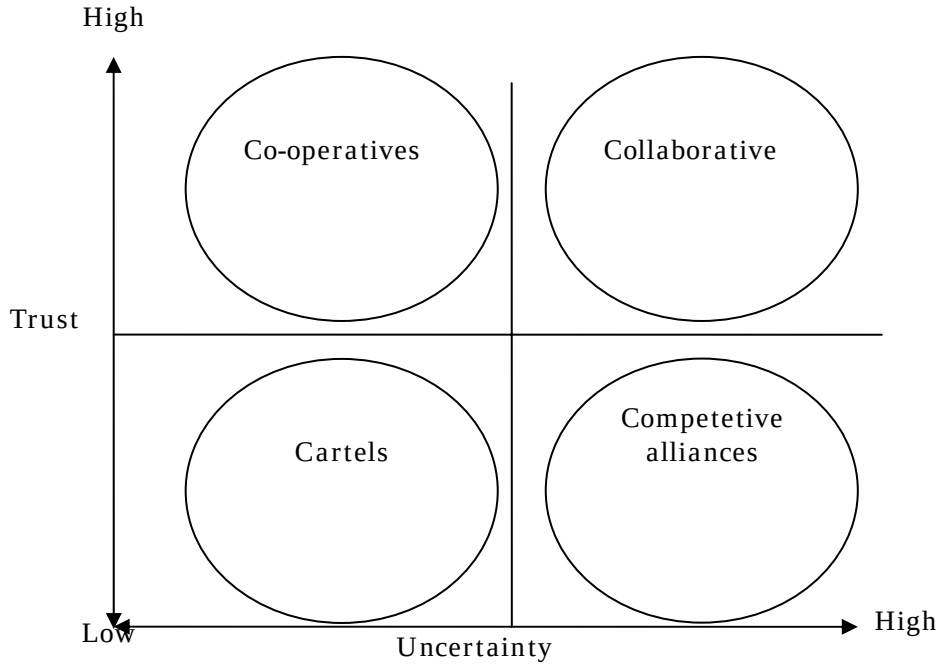
Co-operative arrangements mainly aim to introduce operating efficiency by sharing costs and facilities with alliance partners. Industrial groups (Keiretsu) can be included in this category. In addition, some marketing alliances, such as the point card system in retail and the airline card, are also included in this.

Recently, competitive alliances have been formed between strong rival companies for the purpose of keeping competence from other competitors outside the relationship. We can see examples in the case of global companies and the technology standard. VTR is a recent example.

Collaborative alliances are formed by non-competitors for strategic purposes. The scope of the alliance is broad and encompasses many functional areas, such as technology development and marketing effort. The most popular form of this type is the joint venture.

In order to categorize, Sheth and Parvatiyar (1992) insisted on the importance of uncertainty and trust. The level of uncertainty and the level of trust are likely to impact on alliance characteristics rather than on asset specificity and infrequency (**Figure2-5-(1)**). According to Sheth and Parvatiyar, when external uncertainty is high and partners trust each other significantly, the collaborative alliance can be formed. When uncertainty and mutual trust are low, cartels are likely to be constructed. Competitive alliances would be considered when uncertainty is high but partners do not trust each other enough. Also, co-operative partnerships are most likely to be formed in a case where the partner’s trust is high and external uncertainty is relatively low.

Figure2-5-(1): the types of alliances and the degree of uncertainty and trust



Based on Sheth and Parvatiyar(1992)

Heide and John (1990) picked up a model of OEM (original equipment manufacturer) which is closely tied with suppliers and manufacturers. In their research, they also showed that the utility of this type of relationship derived from the ability of adapting to uncertainty as well as safeguarding uncertainty in order to maintain relationship continuity.

Shamdasani and Sheth (1995) mentioned that satisfaction and continuity are key factors in evaluating alliance relationships. Satisfaction reflects existing feelings about the alliance based on the evaluation of outcomes and experience received in the past. On the other hand, continuity decisions reflect expectations of future co-operation. Satisfaction based on experience leads to continuity decisions. In other words, relationship satisfaction and continuity decisions are therefore positively related (Anderson and Narus 1984). The result confirms the importance of commitment, competence and compatibility in ongoing strategic alliances since they strongly influence alliance satisfaction and continuity. Satisfaction is positively related to continuity since a satisfied firm is more likely to maintain its ongoing relationship than seek out a new alliance partner. Continuity indicates that partner firms expect to continue to work together closely to achieve their mutual strategic goals through the alliance. A partner demonstrating a high degree of commitment to the alliance reduces behavioural uncertainty in the relationship, thereby increasing satisfaction and encouraging continued cooperation. Additionally, since competence was defined

operationally as one dimension of trust, a strong demonstration of competence in the alliance is indicative of more trust in the relationship, which in turn promotes relationship satisfaction and continuity (Shamdasani and Sheth, 1994).

3. The characteristics of R&D market

3.1 The characteristics of the R&D market: 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, Abernathy and Utterback (1978) proposed the concept of dominant design, which states that the basic architecture of a product or process becomes the accepted market standard. After establishing a dominant design, the competition shifts to price. Therefore, large scale, learning and concentrated capital are the main factors in winning a market (Teece 1986). Before establishing this dominant design, there are many types of technological standards or candidates that have possibilities to become a dominant design. R&D departments therefore have to deal with these equivocal situations because they introduce 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 circumstances. A lack of information and experience is an important factor in creating uncertainty. Bourgeous and Eisenhardt (1988) mentioned that in the microcomputer industry in the 1980's, the rate of change was so extreme that information was often of questionable accuracy and was quickly rendered obsolete in contrast to other industries. A lack not only of quantitative but also qualitative information provides uncertainty. Buying decisions need more alternative choices in a high-velocity environment and therefore need more accurate information in order to evaluate alternatives. Bourgeous and Eisenhardt also pointed out that the life-time of information is linked with occurring uncertainty when technological change is extremely high. Information (or knowledge) gathered at a particular point in time may not remain relevant for long, so

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 (Bourgeous and Eisenhardt 1988).

Glazer and Weiss (1993) defined this deterioration of information with the term 'time-sensitivity', where information in a given period loses its value in subsequent periods. Accordingly, they showed that when time-sensitivity of information is high, uncertainty increases because the values of received information tend to depreciate quickly.

3.2 The nature of partnerships in R&D activities

Every manager in R&D departments always checks technology trends and predicts 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 always have to evaluate new technology and try to involve technology 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. R&D activities include many partners through research and development processes at every level.

There are two types of activities for R&D departments when collaborating with others (**Table2-5-(2)**). 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. These types of partnerships as type 1 partnerships (“informative partnerships”) shall be defined.

On the other hand, there are comprehensive partnerships in which firms consolidate their experiences 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 independent and the amount of business transaction is significant. Furthermore, each company sometimes exchanges personnel resources. In some cases, a customer company 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. This type of partner ship as type 2 partnerships ("real partnerships") shall be defined. This example can be seen at the just-in-time system in Keiretsu's 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.

Table 2-5-(2): Characteristics of two types of partnerships

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

3.3 Difficulties to change partnerships

This section discusses what conditions cause changing partnerships in rapid changing of technology and increasing complexity.

Jackson (1985) categorized industrial relationships based on technological and usage characteristics of goods by using switching cost: Always-a-share model and Lost-for-good model. The always-a-share is weaker and there are more transient affiliations between sellers and customers. For example, in the commodity industry a customer can easily switch a good from one vendor to another because of low switching cost. Sellers can offer goods and services that customers want immediately and customers can choose from several alternatives with almost the same quality and price. Customers want to avoid having strong commitments because frequent changing vendors are more beneficial. On the other hand, the lost-for-good model occurs when costs of changing vendors are high. Therefore, if the account leaves a vendor, it is at least as hard to win back as it was to win in the first place (Jackson 1985).

In order to explain relationships, commitment is a very significant factor. Relationship commitment is central to relationship marketing, which can be defined as an exchange partner believing that an ongoing relationship with another is so important as to warrant maximum efforts at maintaining it (Morgan and Hunt 1994). Therefore, the level of commitment is closely related to the incentive to change vendors. With 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 vendor's offers 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 hate or hesitate to change partners because their way of working also has to change.

Establishing strong commitment and long-term relationships means that partners share a great deal of technological knowledge and know-how. Developing products and services is based on the exchange of shared resources. Each partner in the network has unique resources and actors in the network can touch and exchange these resources to gain a strategic advantage (Resource based view). The network consists of embedded actors, who strongly rely on other actor's resources (Resource dependence theory). Therefore, their relationships are mutually dependent.

When they buy from less well-known and less established vendors, or when they buy less understood goods, customers will have or feel more risk. 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.

Above all, it is difficult to change vendors when the commitment to a relationship is so high. In other words, only the first entrant is allowed to enter a partnership, gain an advantage, and the door is locked (first-mover advantage). However, current partnerships cannot remain constant, especially in a dynamic marketplace. As a matter of the fact, relying too heavily on existing relationships creates risk when destructive innovation (Christensen 1995) or product innovation (Utterback 1994) occurs. Sutton, Eisenhardt and Jucker (1986) mentions that the decline of a firm is caused not by human resources but by a lack of accurate analysis of business circumstances. For a successful firm, it is very difficult to leave their successful experience, and managers of declining organizations need to abandon old practices by using the example of a video game company in rapid change business circumstances. Jackson (1985) also mentions that customers face more risk in not changing for the long run because fear of exposure can interfere with ability to adapt to external changes. 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 as the level of uncertainty is higher **(Suggestion 1).** However, in order to adapt to rapid change and change partner immediately, they avoid making a strong commitment at this stage. Therefore, incentives of 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. (**Suggestion 2**)

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 in a market. 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 doing actual experiments. Therefore, when equivocality increase, a firm want to have more information to evaluate, therefore, an increase in equivocality makes a firm engage in a type 1 partnership with others (**Suggestion 3**). 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. This suggestion is supported by some marketing researchers who study the network approach in marketing.

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 world 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 weakening 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 (**Suggestion 4**).

In summary from this discussion, the following can be shown in R&D activities (**Figure2-5-(2)**).

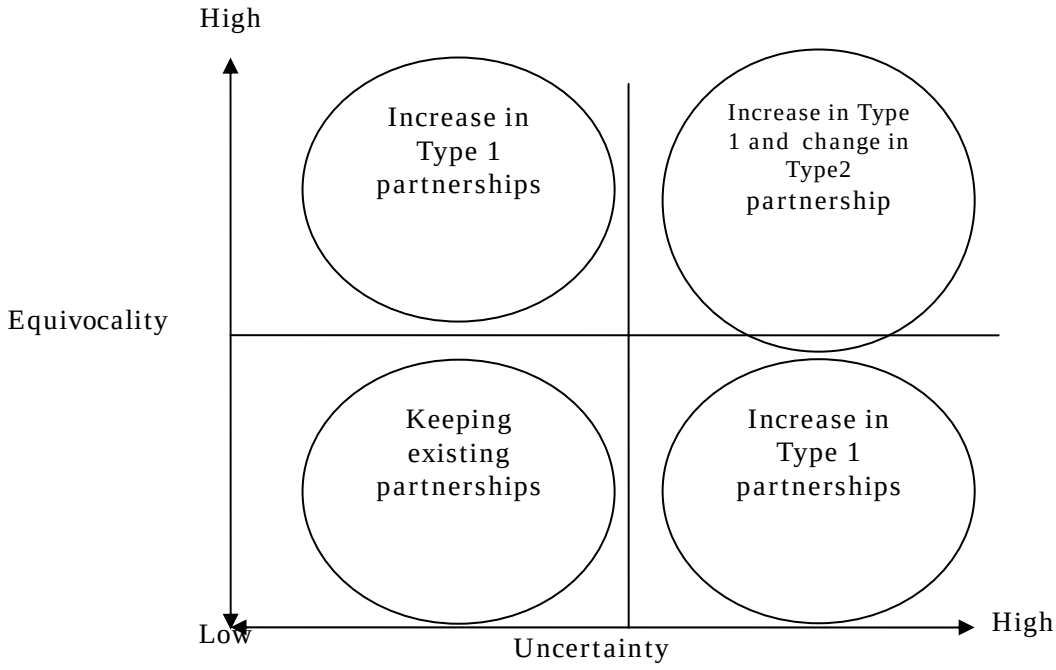
(1) When there is a low level of uncertainty and equivocality, a firm tends to keep existed relationships.

(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 in 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 in type 2 partnerships

Figure 2-5-(2): Two type of partnership and Uncertainty, Equivocality



4. Summary

In this section, in order to clarify the characteristics of R&D activities, it has been shown that two significant environmental factors significantly 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 Prahalad 1991, 1994) and centred competence resources. Some international companies, especially in North America, such as General Electric, prove this to be true. 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.

Summary and Research Questions

This thesis clarifies the relationship between marketing concept and technology management, focusing especially on resources. The purpose of R&D activities is to develop technological resources. Along with rapid change of technological trends, more complexity and larger scale of business circumstances the issue has shifted from competitors' activities to interaction with markets and external conditions. In order to explain R&D activities faced under these circumstances, results of previous research arise these research questions.

(1) How inter-firm relationships contribute to develop technology resources?

This thesis attempts to clarify the relationship between inter-firm relationships and developing business resources. In order to do, this study emphasizes the importance of continuous interaction with markets and external environments in order to create resources which can contribute for future. Business resources can be regarded as the bundle of capabilities that have accumulated from long term firms' activities. Additionally, this shows that the conception of market should be broadened to include not only existing customers and competitors but also other stakeholders who have the potential to contribute towards creating future customer value and to develop competitive advantages in a future market. Therefore, it suggests how firms should organize their internal and external resources.

(2) How developing technologies influences the market?

Considering the multiple applications of business resources (e.g. Penrose 1959), an innovative technology invented in a specific area can be used for other purposes. This feature of multiple applications leads to changing technological factors in a market. For example, the advent of transistor devices changed the information, computer and electric industries. However, these changes could not have occurred without developing the relevant manufacturing technologies. For example, after transistor elements appeared, researchers and engineers concentrated on applied research along with developing manufacturing technologies, seeking appropriate elements for manufacturing (from Germanium to Silicon), developing installation technologies (Bipolar transistor), manufacturing technologies and process management methods. These developed technologies led to a cost reduction and improvement in reliability. As a result, semiconductor devices have been widely accepted for use in computers, electrical appliances and in other industries. In other words, developing technologies expand a given technology's domain of applicability. As a result, the existing market is forced to undergo change.

(3) How market changes influence inter-firm relationships?

In order to study R&D activities, the thesis assumes that an industry comprises firms from several resource frameworks, not only those directly involved in telecom technology but also firms involved in specialist technology and others involved in applications. There are many processes associated with service development. The links amongst these firms, that together create the telecom sector, involve relational exchanges of various types (Dweyer, Schurr and Oh 1987). Some relationships are characterised as long-term, sustainable, mutually supportive relationships (Arndt 1979, Ford 1980). Others are shorter-term and more ephemeral. Although the nexus of links is considerable, each firm or department operates within a relational environment which involves only a limited number of identifiable organizational firms (Hakansson and Snehota 1989).

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 within the network. Organizations are embedded in a network of interdependencies and social relationships (Pfeffer and Salancik 1978). In addition, a need for resources from outside the network makes organizations dependent on external resources. A complex equilibrium develops, which balances internal resource use, resource dependence on network partners and dependence on resources drawn from outside the network (Turnbull, Ford and Cunningham 1996). Anderson, Hakansson and Johansson (1994) suggest a mechanism that enables the exchange of external resources, advocating the existence of a focal relationship. This involves focal units (business units) consisting of dyadic relationships. Each focal unit is independent and, under stable conditions, has no influence on other focal units. However, a change in environmental conditions means that focal units engage in relationships with other units depending on the context. The common player (actor XAB) belonging to both sides mediates to establish a focal relationship between focal unit A and B. A focal unit can be an industrial group like Keiretsu or a business partnership. In other words, the unit of each industrial group or business partnerships engages in the relationship. Therefore, business alliances mean each focal unit goes under an umbrella along with its existing relationships. Therefore, the success of a business alliance depends on the result of the new focal relationship. Firms can expand their capabilities through these processes and can use them to create new products or adapt to new circumstances.

(4) How inter-firm relationships had to be changed along with developing technologies?

This thesis attempts to clarify mechanisms of changing inter-firm relationships under

dynamic business circumstances. Specifically, by measuring technological circumstances as the level of uncertainty and equivocality, as defined by Bourgeous and Eisenhardt (1987), Glazer and Weiss (1993) and the concept of dominant design (Abernathy and Utterback 1987), the thesis investigates how inter-firm relationships are changed from existing relationships to informative and comprehensive partnerships.

Chapter3
Research Questions and Methodology

1. Research Questions

The proposition of this thesis is to clarify the relationship between the marketing concept and technology management, focusing on inter-firm relationships. More precisely, it aims to show how inter-firm relationships and a marketing perspective can lead to large-scale, complex R&D activities that adapt to turbulent circumstances caused by rapidly changing technological trends. Study of the literature review established the following research questions: (1) How do inter-firm relationships contribute to the development of technology resources? (2) How does the development of technologies influence the market? (3) How market changes influence inter-firm relationships? (4) How inter-firm relationships had to be changed along with developing technologies?

This chapter deals with choosing an appropriate research method to examine these questions. There are various types of research strategies for collecting and analyzing empirical evidence, each following its own logic and with its own set of advantages and disadvantages. In order to select an appropriate one, the chapter discusses what conditions are required to investigate research questions.

(a) Long-time observations

The research questions focus initially on continuous organizational learning and interaction in the market for inter-firm relationships, something which needs to be investigated over a long period. The aim of R&D departments is to accumulate technological resources in order to use them for both temporary and future projects, as well as a variety of for other purposes. Therefore, R&D activities should be investigated not by focusing on a single project but on multiple R&D projects over a long period.

(b) Complexity of the Business Context

Business context is another key consideration in selecting an appropriate research design and evaluating the effectiveness of various research strategies, techniques, and tools. Consequently, the most important characteristic of the business context is its complexity (Gregson 2007). There are three main features of this complexity: behaviour of actors,

interrelated business components, and the dynamic environment in which an organization is positioned.

This thesis focuses on inter-firm relationships in R&D activities. If we use long-time observations to examine R&D activities, many actors become involved and then disappear. The behaviour of actors is influenced by external conditions, business regulations, and management policies. External actors constitute an aggregate of complex organizational behaviour. In addition, we have to consider the large number of interrelated business issues and variables that often make up the context of any real-life business situation. These include intra-organizational activities and behaviours of actors throughout the organization. Therefore, it is difficult to observe and study the interrelationships that formulate the parts into the whole (Gregson 2007).

In addition, the circumstances surrounding R&D activities include the rapid pace of change in technological trends, resulting in an often complicated and changing context. The need for R&D departments to react to this dynamic and changing business environment has become greatly emphasised. Complexity, uncertainty and ambiguity are realities that must be dealt with by all organizations.

(c)The style of research questions

The purpose of a literature review is to determine what is known on a topic. However, experienced investigators review previous research in order to come up with sharper and more insightful questions on the topic (Yin 2003). The type of research questions comes about through the literature review.

The first step in selecting an appropriate research method is to categorise research questions using the basic categorization scheme of who, what, where, how and why (Yin 2003). This research questions in this thesis emphasise the process and context of R&D activities when reacting to dynamic and changeable circumstances. The study focuses on understanding R&D activities within a complex context. Therefore, most of the research questions fall under the ‘how’ category.

2. Methodology

In order to develop an appropriate research design, the thesis considers the following five conditions, based on Yin (2003) and the above discussions: (1) the type of research question posed, (2) the extent to which an investigator has control over actual behavioural events, (3) the degree of focus on contemporary events, (4) whether the object of investigation is appropriate for long-time observations, and (5) observational methods.

(1) Types of research questions

The first and most important condition for differentiation among the various research strategies is to identify the type of research question being asked (Yin 2003). There are two types of 'what' questions. The first is exploratory questions (for use in exploratory studies), which can be applied to each of the five methods. The second is actually a form of 'how many' or 'how much' questions. This second type of 'what' question, along with 'who' and 'where' questions, is likely to be favoured survey strategies or the analysis of archival records. These strategies are advantageous when the research goal is to describe the incidence or prevalence of a phenomenon (Yin 2003). By contrast, how and why questions are more explanatory and likely to lead to the use of case studies, histories, and experiments as the preferred method of research. This is because such questions deal with operational links which need to be traced over time, rather than frequencies or incidence (Yin 2003).

(2) Extent of control over behavioural events

Assuming that 'how' and 'why' questions are to be the focus of this study, a further distinction between historical, experimental, and case study is the extent to which an investigator has control over, and access to, actual behavioural events. Experiments are carried out when an investigator is able to manipulate behaviour directly, precisely, and systematically. This can occur in a laboratory setting, in which an experiment is done focusing on one or two isolated variables. However, other research methods cannot manipulate original data to achieve their own purpose. The theme of this thesis also prohibits the manipulation of data.

(3) (4) Degree of focus on contemporary events and long-term observations

The distinctive characteristic of the historical method lies in dealing with the dead past - that is, when no relevant persons are alive to report, even retrospectively, that which has occurred, and when an investigator must rely on primary and secondary documents as well as cultural and physical artefacts as the main sources of evidence. Case study, on the other

hand, is able to examine contemporary events, when the relevant behaviours cannot be manipulated. It relies on many of the same techniques, but adds two sources of evidence not usually available to the historical method: direct observation of the events being studied, and interviews with the persons involved in these events (Yin 2003). Again, although case studies and histories can overlap, case study's unique strength is its ability to deal with a full variety of evidence documents, artefacts, interviews, and observations beyond what might be available to a conventional historical study.

A case study is an empirical inquiry that investigates historical and contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evidence. The thesis deals with variety of historical events and also attempts to explain on-going. Therefore, case study method is an appropriate in this sense.

(5) Ways of observing complex business phenomena

Experimental methodology cannot be easily justified in business research. Because the business environment is characterized by many variables, the study of causal links and effects of one factor on another is difficult (Ragin and Becker 1992). Therefore, the stringent requirements of experimental research are not feasible in business research where the effects of a particular factor are difficult to distinguish.

Quantitative research methods cannot explain or accommodate organizational complexity (Robson 1993), primarily because they are too narrow in scope. The survey method is extremely limited when it comes to investigating business context, as it can place a limit on the number of variables to be analyzed. Quantitative research does not posses the appropriate theoretical logic and research techniques for understanding, and possibly predicting, organizational complexity (Gregson 2007).

An experiment, for instance, divorces a phenomenon from its context, so that attention can be focused on only a few variables. A history does deal with the entangled situation between phenomenon and context, but usually with non-contemporary events. Finally, the survey method has not been able to provide an adequate understanding of business complexity because the dynamic nature of businesses and the external environment create substantial variables. Therefore, it is very difficult for researchers to decide upon these variables and operate within their substantial parameters.

On the other hand, case study is regarded as a suitable method to explain how events interactively occur over time, and in particular describes the *contexts* of events (Yin 2003).

Moreover, they can be based on any given mix of quantitative and qualitative evidence. In addition, they need not always include direct, detailed observations as a source of evidence.

The above discussions are summarized in table3-(1).

Table 3-(1) Characteristics of each research method

	Quantitative Methods		Qualitative Methods		
	Experiment	Survey	Archival analysis	History	Case study
Form of Research Question	How, Why ?	Who What, Where, How many, How much ?	Who What, Where, How many, How much ?	How, Why ?	How, Why ?
Requires Controls of Behavioral Event?	Yes	No	No	No	No
Focuses on Contemporary Event	Yes	Yes	Yes/No	No	Yes
Long term observation	No	No	Yes	Yes	Yes
Observes Complexity phenomenon	No	No	Yes	Yes	Yes

3. Research Sites

This thesis aims to show how inter-firm relationships and a marketing perspective can lead to large-scale, complex R&D activities that adapt to turbulent circumstances caused by rapidly changing technological trends. In this sense, the thesis uses the Japanese telecom industry and in particular, the company NTT (Nippon Telegram and Telephone Corporation) as a research case because the telecom industry has experienced dynamic and rapidly changeable business circumstances.

Telecom services have been developed significantly in the last ten years. Previously, the telecom industry offered only telephone and telegram services, whereas now they not only offer voice switching but also a variety of data transfer, including text, pictures and movies. In addition, a variety of terminals is connected to telecom networks. Therefore, they are now offering telecom services as packages into which layered services are integrated. As a result, the structure of the industry has become more complex and the scale has increased. Furthermore, telecom services depend heavily technologies, and the recent rapid change in technologies has enabled the realization of these services, while at the same time influencing R&D activities.

The thesis focuses particularly on switching systems projects after World War II, as their necessary areas for technological development were very wide and only the most advanced technology at any given time was accepted. This characteristic necessitated long-term development periods of between five and ten years. A switching system is one of the most important pieces of telecom equipment, mainly used for connecting telephone calls. It is required to perform a huge amount of telephone call exchanges accurately and within a very short space of time. Therefore, its reliability, scalability and performance must be very high compared to other equipment.

The focus of analysis is the unique collaboration system between NTT and four companies: Fujitsu, Hitachi, NEC and Oki. 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 (NEC, Hitachi, Fujitsu and Oki) in all of its main projects. Because the collaboration system has been maintained for almost 60 years, it is possible for researchers to investigate the content of activities using long-time observation.

In addition, these companies (NTT, Fujitsu, Hitachi, NEC and Oki) have kept their management without any large-scale acquisitions or mergers during the period. This helps reduce the difficulty of observations.

The research focuses on technology and how changes of technological trends affect a market and methods of technology management. Technologies are not developed by a sole

company. Therefore, when examining changes in technological trends, we should not focus on a specific relationship, but rather we should look at the activities of comprehensive partnerships within a business network over a long period. By selecting the relationship between NTT and four *family companies*, the study attempted to trace changes of technological trends precisely and to indicate that collaboration between multiple companies positively affects R&D activities.

The above highlight the complex and dynamic nature of this study. The methodology of the case study is very appropriate to describe processes or sequences of behaviour and events in which behaviour occurs, leading to a holistic understanding of business organisations under dynamic environments.

However, there are some limitations of the study coming from the case study method. From a unique case describing each company and its external environment it is difficult to generalise a common theme for all industries. The case study could be perceived to be limited compared with some larger scale quantitative methods. Especially, the single case is difficult to provide sufficient evidence to be able to make robust generalisations (Yin 2003). In addition, most case studies carried out are exploratory or descriptive in nature (Gregson 2007). In addition, case studies can investigate a large variety of phenomena. Therefore, it tends to reveal gaps between gathered data and research questions.

In order to reduce these limitations, the study used six projects of collaboration with NTT and four family companies, not focusing on a single project. In addition, by discussing findings in each project, the author continuously identified the information and data gaps and compared it with the research questions to avoid the collection and analysis of data becoming unmanageable. Furthermore, as the following indicates, the study uses multiple sources of evidences.

4. Data Collection

Yin (2003) highlights the six major sources involved case studies: documentation, archival records, interviews, direct observation, participant observation, and physical artefacts. However, no single source has complete advantage over all the others. Triangulation, using two or more methods on the same research problem, can increase the reliability of results by revealing bias and/or substantiating data. The evidence may then be corroborated by reference to formal documents, such as annual accounts, articles, and internal reports. It is therefore important to confirm information using cross-referencing, and facts need to be gathered from a wide range of sources.

This thesis uses three sources: archival records, documentation and direct observation. The author has gathered the annual reports of four companies, published from 1950 until the present, which are stored in the National Library in Osaka, Japan. In addition, news releases and procurement information are used in the case study.

A wide variety of documents was gathered, mostly written in Japanese: relevant published books, company histories published in their own, internal reports on R&D activities, and articles taken from business, computer and telecommunication industry magazines, published from the 1960's until the present. **Table3-(2)** shows data sources which were used to study the case study concerned with NTT and four companies (Fujitsu, Hitachi, NEC and Oki). In addition, information and articles located in the Web were also used because business information, especially in the ICT industry, has recently tended to be published on the Web.

This information, along with archival records and published documents, tends to create bias - biased selectivity and reporting bias. In order to reduce this bias, the study uses these sources in combination.

Informal interviews are used to understand the context of recent events. Information on R&D activities is confidential. Therefore, information gained from formal interviews is of limited value, circumscribed as it is by confidentiality restrictions and an 'official' version of events.

The author's experiences greatly contribute to this study. He worked in one of NTT's laboratories from 1995 to 2000, working on two switching systems projects in which he took part in designing basic specifications, in particular handling communication control and system management functions. At the same time, as a lab counterpart, he had many meetings and discussions with collaborating companies as well as business departments of NTT. Following this, he moved to the R&D centre of one of NTT's regional companies, working on the development of an experimental system that aimed to integrate a public telephone and Internet service. He also took part in an experimental project on home controls systems, which fully accepted advanced Web-relevant technologies. During this period, the technological trend quickly changed from legacy-centralized systems to server and Web-based technologies. Consequently, the telecom industry was keen to accept these technologies into their systems, and changed their methods of R&D activities and inter-firm relationships. Through his own experiences, the author was able to observe at first hand the activities of telecom R&D and the resultant changes.

As Yin (2003) mentioned, these direct observations are invaluable for understanding the actual use of technology or technological trends, especially when these technologies are

very advanced. However, direct observation often leads to bias due to a narrow observational viewpoint. In addition, information about R&D activities is highly confidential. With this in mind, the author’s observations should be supported by published documents.

Table 3-(2) Data sources of the case study

Data Type	Medium	Data Source
Archival records	Financial report	Fujitsu for each year from 1950 to 2008
		Hitachi for each year from 1950 to 2008
		NEC for each year from 1950 to 2008
		Oki for each year from 1950 to 2008
		NTT for each year from 1988-2008
	Company histories	The history of Fujitsu (1976)
		The history of Hitachi (1985)
		The history of NEC (2000), (2001)
		The history of Oki (2001)
		The history of NTT (1999)
		The history of NTT (2006)
		The history of NTT-DoCoMo (2001)
	Statics Data	The archival data of the Communications and Information network associations in Japan for each year from 1950 to 2008.
Documentations	Magazines	NTT technology Journal for each from 1989-recent
		Nikkei Business for each from 1969-recent
		Nikkei Computer for each from 1995-recent
		Nikkei Telecommunication for each from 1995-recent
	Unpublished	NTT (1976) *Denki Tsushin Jishugijyutu Kaihatushi* (in Japanese) [The history of NTT's developments of telecommunication technologies]
		NTT (1999) *R&D no Keifu* (in Japanese) [The genealogy of R&D]

	Published	Jyouho-shori-gakkai (1998) *Nihon no konpyu-ta hattatsu shi* (in Japanese) [the history of developing Japanese computer industry], Tokyo:Jyouho-shori-gakkai.
		Muraoka, Yoichi (1985), *Nippon Denshin Denwa* (in Japanese) [NTT telegraph and telephone Corporation]. In: Nippon no Konpyu-ta no Rekishi (in Japanese) [The history of Japanese computers]. Aiiso et al(eds.), Tokyo: Omusha, pp. 177-202.
		Nakagawa, Yasuzo (1990), *NTT Gijyutu Suimyaku* (in Japanese) [Technology resources of NTT] Tokyo: Toyo-Keizai Shinposha.
		Okamoto,Yasuo (1977). *Hitachi to Matsushita* (in Japanese) [Hitachi and Mattushita: The origin of the Japanese management](in Japanese), Tokyo:Chuoukouron.

	Published (cont.)	Okimoto, Daniel, Takuo Sugano and Franklin Weinstein (1984), *Competitive Edge: The Semiconductor Industry in the U. S. and Japan (Studies in International Policy)*, Stanford University Press.
		Shimoda, Hirotsugu (1981) *Tsushin Kakumei to Dendenkousha* (in Japanese) [Communication revolutions and NTT Public Corporation], Tokyo: Mainichi Shinbun.
		Shindo, Hisashi (1982) *Denden Zakkubaran* (in Japanese) [Frankly talking about NTT], Tokyo, Toyokeizai Shinposha.
		Takahashi, Shigeru (1996) *Konpyuta Kuronikuru* (in Japanese) [The histrical sketch in Japanese computer business], Tokyo: Omusha.

Chapter 4 Case Study

Section1.

Overview of the Japanese telecom industry

1. The Japanese telecom industry

This thesis uses the Japanese telecom industry as a research site, focusing particularly on switching systems projects. There is an initial overview of the Japanese telecom industry, taking a close look at the production of telecom equipment, including the B2B and B2C exchanges in Japan.

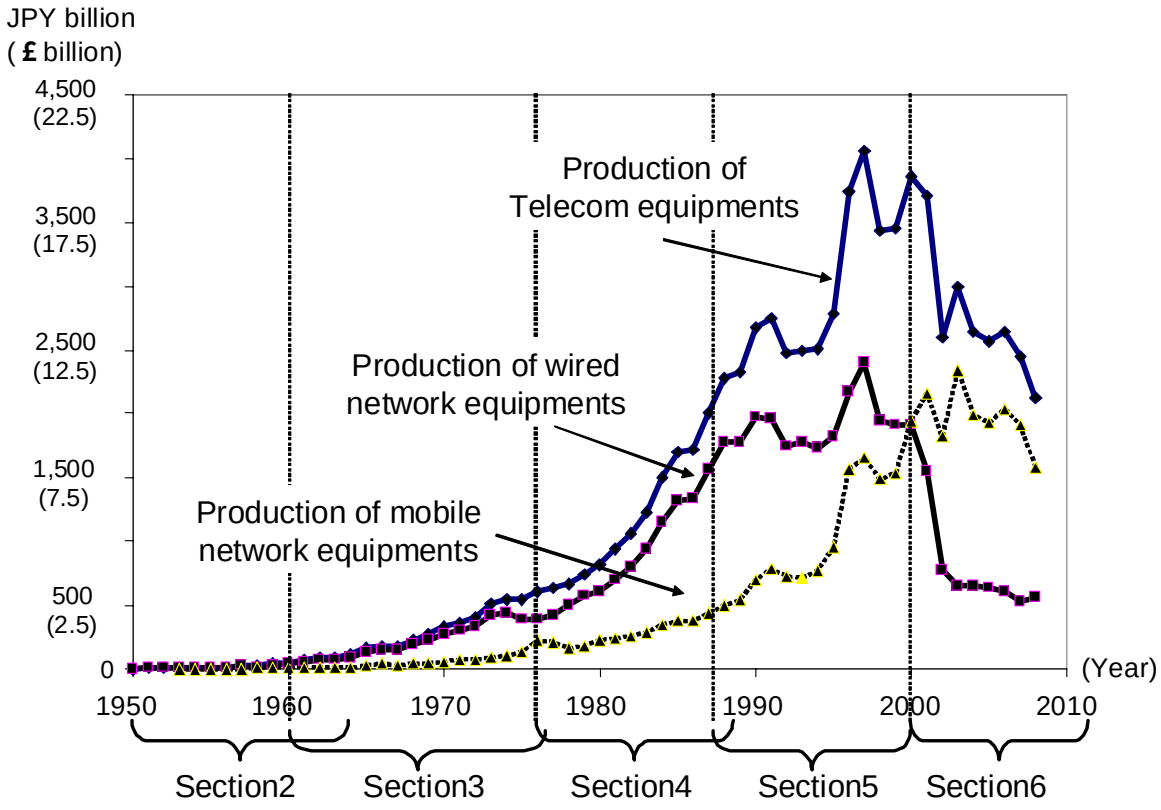


Figure4-1-(1) Production of telecom equipment in Japan[1][2][3]

[1] The figure was created by the author. The data were collected from the archival data of the Communications and Information network associations in Japan for each year from 1950 to 2008.
[2] The data include terminals (telephone sets and mobile terminals) and other industrial goods.
[3] The exchange rate between Yen and GB pound is 200 yen/pound.

The above figure shows the progress of Japanese telecom equipment production, encompassing all telecom equipment, wired networks and relevant mobile products manufactured in Japan. The data was gathered from 1950 to 2008. The figure indicates that the Japanese telecom industry underwent a major development after the Second World War. However, a peak was not reached until the end of the 1990's. In the 2000's, production drastically fell. Wired network equipment contributed significantly to this development, making up the most part of production. However, after the peak in the middle of the 1990's, production sharply decreased at the beginning of the 2000's. Production of mobile-relevant products increased after the mid-1990's, and overtook that of wired products in 2000.

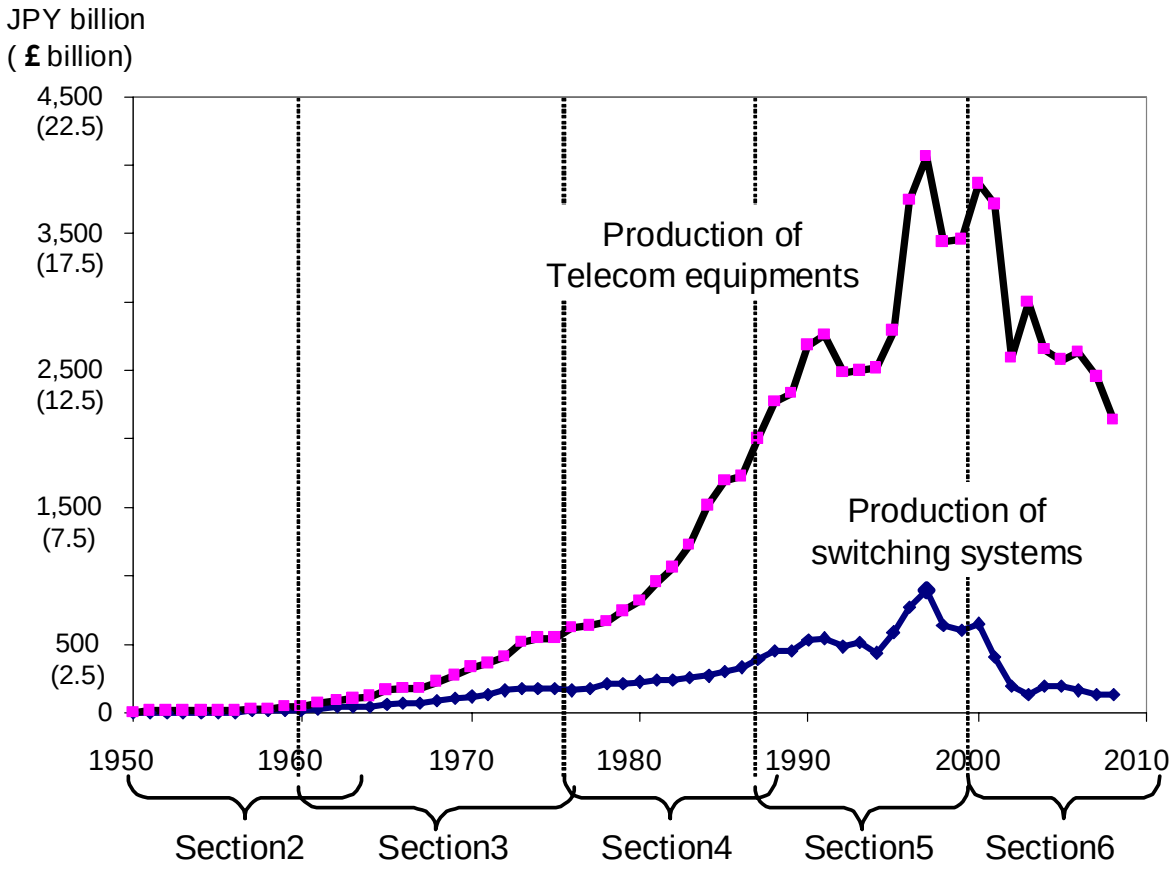


Figure4-1-(2) Production of Switching Systems

We will now focus on the production of switching systems. Figure4-1-(2) shows that switching systems were main systems in telephone network. From the 1950's to the 1970's, the production rate of switching systems dominated the industry, comprising over or around 50% of telecom equipment. The production of switching systems increased in tandem with

the development of the telecom market, reaching a peak in the middle of the 1990's, after which, especially in the late 1990's, it fell sharply.

Based on these figures, this thesis aims to describe the relationship between technology development and changes in the telecom market. There is a focus on the development of switching systems in Japan, which can be divided into five stages. Therefore, the chapters are structured accordingly.

In the first period (the 1950's and 1960's), the Japanese telecom industry concentrated on establishing a telephone network in Japan. Their activities focused on achieving direct long distance dialling and reducing back orders for telephone services. However, the existing systems' capabilities could not be improved cost-effectively, so telecom companies developed new telecom facilities using advanced semiconductor and computer technologies. This meant that Japanese telecom companies began to develop their systems based on imported technologies. Cross-bar and electronic switching systems projects are looked at in section 2.

In the 1970's, after successfully reducing back orders for telephone services and realizing direct long distance dialling, new kinds of demand for telecom services began to appear, such as FAX and data communications. In addition to the increased demands for business telephone services, there was also a rise in demand for dedicated lines facilities and data communication systems. The telecom market therefore expanded from telecom services to include data communication services. In the 1980's, a new concept arose whereby a network could be provided with the integrated services of telephone and data communication. These developments showed a clear trend in the telecom market for integrating computer and telecommunication, as well as data and voices within the telephone network. Data communication systems projects and digital switching systems are described in sections 3 and 4.

In the 1990's, the telecom underwent huge developments. Downsizing trends in computer architecture and the emergence of the Internet led to increased demand in the communication market, while broadband services were also expected to lead to an expansion in the telecom business. Japanese telecom companies attempted to develop new types of system which could reduce network costs, as well as broadband services, by integrating telecom technologies and Internet-relevant technologies. Section5 examines the project of developing MHN (Multi-handling Node) systems, which started in 1990.

However, in the 2000's, telecom-based technologies were replaced by internet-relevant technologies, IP and Web relevant technologies. As a result, the advantages NTT had accrued from telephone businesses gradually reduced due to the emergence of new types of

services, ADSL and VoIP (Voice over IP). The Japanese telecom industry began to develop new types of switching systems. These systems were based on the new concept of integrating all data into a packet-transfer network, accepting decentralized architecture, and using open standard interfaces. Section 6 discusses the project of developing the NGN (Next Generation Network) systems.

2. NTT and *Family companies*[4]

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. After NTT's operations reorganized into a holding company structure in 1999, today, NTT has five main companies[5] and 258 subsidiaries. The five firms are still 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 $12.5 hundred million[6], which is co-funded by subsidiaries. The 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 had 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 $46.2 and $55.7 billion with NEC and Fujitsu. Hitachi Ltd is a famous Japanese general electronic manufacturer, whose business covers a variety of areas from nuclear plants and rail systems to general appliances. Their revenue in 2007 was $95 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 $ 7.2 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 department of NTT. NTT's

[4] The history of NTT are described based on NTT (2006) and their corporate web site (http://www.ntt.co.jp/index_e.html).
[5] 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).
[6] In 2006 (http://www.ntt.co.jp/RD/OFIS/active/2007pdfe/rd/data.html)

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 kept for long time[7]. 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[8].

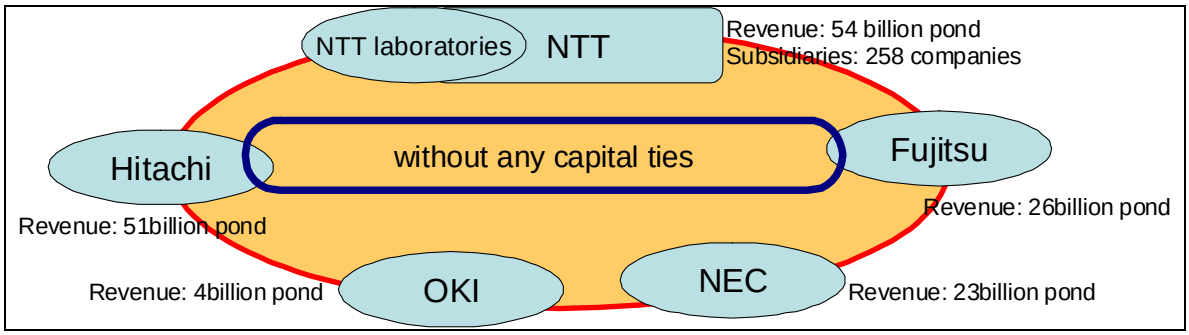


Figure4-1-(3) The relationship between NTT and *family companies*

[7] These are based on Nakagawa (1990), Shindo (1982). Shindo was the last president of NTT public Corporation and the first president of NTT Corporation.
[8] Hiramatsu (1980)

Section2 Establishing the collaboration system[9]

1. Reform of Nippon Telegram and Telephone Public Corporation

1.1 The government agency

In 1948, the telecommunications laboratory was established as an agency for the communications department of the Japanese government. The lab aimed to deal with all of telecom R&D activities, from basic to applied research in Japanese. They focused on unifying specifications based on lessons and reflections on events leading up to World War 2. Therefore, the NTT laboratory aimed for all R&D activities, including making specifications, to be the work of the NTT lab. Yoshida, who was the first president of NTT labs during this period, said that manufacturing companies did not need to have laboratories and only NTT need carry out R&D activities in Japan[10]. This meant that manufacturing companies would be in competition based on manufacturing technologies. The background to Yoshida's decision is the relationship between Bell labs and Western Electric Corporation (WE) in the USA. This represented a good example of the work done by NTT labs. WE was the electronic engineering telephone company and regarded as the arm of Bell labs, being their manufacturing and purchasing department. Bell's superior R&D capabilities and WE's manufacturing stormed the world's telecom markets and led to the establishment of telephone standards. Correspondingly, the image of the new NTT lab was organized along the lines of the Bell lab model.

In post-war days before the formation of the NTT public corporation, Japanese telecom circumstances were in a dreadful condition. Half of subscribed telephones were lost (from 1,200,000 to 500,000 sets) and the quality was terrible due to the disruption of the telecom network during the war. For example, when it rained, telephones were temporally disconnected causing mistakes to be made in telegrams. Therefore, the priority was to recover and improve equipments and to improve the quality of telephone speech.

In 1946, before establishing the NTT laboratory, the first collaboration of four manufacture companies, Fujitsu, Hitachi, NEC and Oki, was established. Because of a lack

[9] These are described based on Nakagawa (1990), NTT (1976), NEC (2001), Oki (2001) and study of files at NTT
[10] Nakagawa (1990)

of materials, the quality of telephone speech had worsened. In order to improve quality, the telecommunications laboratory designed a new type of telephone set and decided to manufacture it as soon as possible. Therefore, the laboratory decided to collaborate with manufacturing companies in their projects, selecting four companies because they had manufactured telephone sets before the war and had experiences and technologies to manufacture them. In addition, the NTT laboratory wanted to carry out future projects with several specified companies (Nakagawa 1990). The lab considered that mutual relationships kept for a long time could be beneficial to develop technological abilities.

There were several features which were involved in the foundation of future telecom development. Firstly, each company had to share patents and manufacturing technologies. Secondly, the manufacture companies opened their factories to the member of *family companies*. The telecom laboratory, the former NTT laboratory, guided these policies by standardizing the quality and also improving manufacturing capabilities through the sharing of information. In 1948, a prototype was released and gave good results in performance tests. From the following year, each company manufactured a commercial type based on this prototype. In this manufacturing process, companies assigned and manufactured their component parts. These were then exchanged and the telephone sets were finally assembled independently in their factories. Before the World War, telephone sets used in Japan were imported or imitated foreign products or technologies. This No.4 automatic telephone[11] set was the first set to be based on an original Japanese design, incorporating original Japanese technology (along with some foreign technology as well). The next version of NTT's telephone was also developed along the same lines. This collaboration continued up to the development of switching systems and other telephone equipment.

At the same time, the level of technologies was also heavily damaged by the war. Any manufacturing company could not afford to develop new technologies and also have R&D departments. The telecommunications laboratory also faced the same problem. According to Shiromizu, who was a researcher in the lab at the time, the main activities of the switching system department were to improve the existing systems and revise their specifications[12]. At that time there were two types of switching system made by Western Electric and Siemens in Japan. The former type was produced by NEC, Oki and Hitachi, while Fujitsu manufactured another type under licence. In other words, even though standardizing interfaces was the most important factor for telecom networks, there was a mixture of several different types of

[11] This is the first product developed by the collaboration with NTT lab and four manufacturing companies post war.
[12] Nakagawa (1990)

switching systems within the telephone network. As a result, the inspection and testing of systems was a lengthy process and mass production was not efficient enough. Correspondingly, establishing specifications was the most important task for the lab at that time. In order to standardize telecom equipments to a high level of quality, manufacturing technologies, processes and equipments had to be unified. Therefore, NTT forced manufacturing companies to open up their technologies and plants.

This collaboration was necessitated by the lack of manufacturing capacity, with companies unable to rely solely on their own technologies. Additionally, in order to help their recovery, the Japanese government offered contracts equally to four companies which had been telecom companies in the pre-War period. Although many companies faced the danger of bankruptcy around these days, *family companies* were helped by telecom businesses, as a result, the collaboration of these four companies continued without any companies dropping out.

1.2 Establishment of NTT public corporation

As the demand for telephones sharply increased, the newly born Nippon Telegraph and Telephone Public Corporation tackled its first challenge: making up the shortfall of telephone sets and providing direct dialling for toll calls.

In 1952, the NTT public corporation was established, and at the same time, the telecommunications laboratory changed its name to NTT laboratories as part of NTT. Kajii, who was the former chairman of NEC, became the first president of NTT public corporation. If we look at the situation of NTT at this time, the diffusion rate of telephones in Japan was about 2.3 per 100 people. This was one-tenth of the U.S rate and twenty-third positions in the world. Because the expanding facilities for telephone services were not enough, requests for telephone service accumulated as back orders. People had to wait several years to install a subscribed telephone line after applying. Therefore, NTT provided public telephones in numerous locations, though this was not enough to satisfy the demand for telephone services. In addition, because NTT did not provide a direct long-distance dialling function, when someone tried to call outside their city, it took several hours. Consequently, NTT drew up their first five-year plan to improve telephone services in 1953. In this plan, to meet the growing demand for telephone orders, NTT decided to develop and introduce large-capacity transmission lines and a new type of switching system.

The development of transmission lines was relatively smooth. Toll lines were significantly expanded by the construction of large capacity transmission lines in the air and

on the ground based on microwaves and coaxial cables. In the development of transmission lines, NEC held a strong position as coaxial carrier of communication equipment through their collaboration with NTT labs. NEC developed their first original microwave communication system in 1951, which was an experimental product. However, NTT decided to adapt an unattended microwave system developed by STC (Standard Telephone and Cable Corporation in the U.K) and requested NEC to be an agency in order to import the system. Through this trial, NEC was able to amass technology to do with microwave communication systems, enabling them to combine this with imported technology.

NEC became the dominant communications maker in Japan. They had the chance to become "Japanese Western Electric Corporation", but this did not transpire. In the development of switching systems, NEC could not afford to manufacture the whole of their systems because the systems were more complex and on a larger scale than the transmission lines, as the next section describes.

2. The development of Cross bar switching system

Although the development of transmission lines and toll lines continued smoothly[13], the improvement of switching systems was the most critical issue in order to achieve direct long distance dialling and reduce back orders for telephone services. However, the existing systems' capabilities could not be improved cost-effectively. Instead, a new type of switching system was needed. In the beginning of the 1950's, there were two candidates for a new switching system: the crossbar switching system and the electronic switching system. The Crossbar system was developed by Ericsson in Sweden and was widely used in the USA during the 1950's and 1960's. The electronic switching system was a kind of computerized system developed for telephone exchanges. During the 1950's, several significant inventions had appeared; such as the transistor and integrated circuit. These technologies would later change the world but at the time had not been evaluated enough, their application having been limited to the military and aerospace industries. In addition, manufacturing technologies had not been established. Therefore their costs were not economical for commercial use.

Although NTT labs changed their name and owner, they had been studying the electronic switching system since 1952. However, their activities were very small-scale and the design of an electronic switching system had not been drawn up. In addition, the level of

[13] Nakagawa (1990)

R&D and manufacturing capabilities was not enough to make this achievable. Despite the poor R&D situation, their was intense demand for expanding telephone network capacities in Japanese society. Consequently, Yonezawa, the chief engineer at that time (and who would go on to become president of NTT), thought that electronic switching systems should be introduced for the future plan, as their maintenance cost was expected to reduce and the installation space required was smaller. He emphasized the cost-effectiveness of introducing this system (Nakagawa 1990). However, the executives at NTT thought it too early to introduce an electronic switching system due to the situation of the Japanese telecom industry. Consequently, Kajii, the then president of NTT, decided to introduce crossbar switching systems into the network and mentioned the following points: (1) In order to respond to the high social demand for direct distance dialling, crossbar switching systems were a safer proposition for immediate introduction due to their commercial track-record in the USA. The electronic switching system, on the other hand, was still a subject under study. (2) Technologies could be introduced from foreign companies under licence. (3) The design, however, had to be developed to fit Japanese telecom conditions.

The project was started by involving four *family companies*, NTT, Fujitsu, Hitachi, NEC and Oki. In this project, NEC played a central role. NTT had to learn the technologies and know-how of the new switching system with NEC. Therefore, NTT drew up a collaboration contract with NEC and requested NEC to become the agency for importing the crossbar switching system developed by Kellogg Switchboard & Supply Company. NTT and NEC would evaluate the system and clear up issues when introducing crossbar switching systems into the NTT telephone network. Following the rapid increase in demand for telephones and direct long-distance dialling, the development of switching systems had to be done quickly. As a result, the principles of this development were decided upon as follows: (1) Primary components, such as the speech path switch and the relaying device, were not developed individually but were nationalized based on foreign products which had already been launched in other markets. (2) The design of the new switching system was done separately, taking into account Japanese telecom conditions. In this project, the initial studies took place though the collaboration of NTT and NEC[14]. NTT studied the design and NEC worked on the development of components, especially crossbar switches. NTT had to choose a system which would became the basis of NTT's future systems. Through the collaboration, they also evaluated several systems to decide on a suitable candidate. NTT decided that they would nationalize Western Electric's cross bar system because the system was more reliable and suitable for mass production. Immediately, NEC began to nationalize components.

[14] NTT (1976), NEC (2000) and Nakagawa (1990)

According to NEC's history[15], the collaboration led to many benefits for NEC, allowing them to they succeeded in developing many components and accumulating know-how in developing electronic components. However, four years was needed to accomplish the nationalization of components and making the design fit Japanese conditions. In 1956, while the collaboration continued, NEC offered the first domestic crossbar system.

Oki also tried another approach for developing crossbar switching systems. Originally, the crossbar switching system was developed by the Swedish company, Ericsson, in 1924. Oki regarded Ericsson's switching system as smaller, more economical and suitable for Japanese conditions. Consequently, Oki began to develop a prototype based on Ericsson's system. They developed it based merely on a brochure, as this was the only information Oki had. After this was developed, NTT became interested in Ericsson's systems. However, in the process of drawing up a contract with Ericsson, there conflicts arose connected with the treatment of know-how. As a result, Ericsson withdrew their offer. Another candidate, Kellogg's system, was also withdrawn because it was not suitable for large capacity stations after evaluation. Only WE's system remained as a candidate. After breaking off the contract, Oki began to study WE's crossbar systems, but continued to develop Ericsson's system as NTT allowed manufacturing companies to develop crossbar systems in small stations. These systems gave Oki some profits in the market of private branch exchange (PBX).

Finally, in 1958, NTT revealed the design of its standard crossbar systems which would be introduced into the telephone network. It was totally influenced by the collaboration with NEC based on WE's crossbar systems. Following this announcement, Oki started to develop the WE style of crossbar systems. In order to do it, Oki needed WE's patents and made a contract with WE in 1959. Hitachi also signed a contract with WE in 1957. In addition, the results of the collaboration between NTT and NEC were made available to OKI, HITACHI and Fujitsu by the contract. Consequently, the collaboration of these four companies began to develop NTT's standard crossbar systems. The developments of crossbar systems continued to improve economic efficiency, and the final version[16] was able to increase economic efficiency by 30%[17] compared to the first commercial versions of the previous ten years.

Crossbar switching systems greatly contributed to realizing automatic direct long-distance dialling and reducing telephone back orders. However, the project could not produce any significant inventions and innovation. In fact, looking at the NTT labs, the

[15] NEC (2001)
[16] NTT (1976)
[17] ibid

development was very unspectacular work. Shiromizu, who was a member of the lab at that time, said "our job was mainly to write specifications suitable for Japanese conditions based on WE's systems. We made every component as well as the actual design easy to manufacture. Therefore, it was said that the switching system developed by NTT labs was totally identical to western electrics'[18].

In this process, studying up to date technologies and how to manage such a large scale project were the main issues. Four companies, Fujitsu, Hitachi, NEC, Oki, 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 into the domestic market. In addition, they succeeded in exporting these systems to foreign countries. Additionally, their developed switching systems became cash cows for a long time and their sales volumes drastically grew. These economic successes allowed for stable management and the ability to prepare for involvement in other areas of business.

According to Shimazu, chief engineer of NEC at the time, this decision was visionary foresight in the development of the electronic switching system[19]. Through the process of development of crossbar switching systems, NTT and the manufacturing companies accumulated technological skills in the area of switching systems. It can also be pointed out that they were able to learn how to collaborate with each other, ways of establishing a development plan, as well as project management methods. As an example, during the collaboration of the four companies, section meetings were held within NTT labs and engineers from each of the four companies worked together and were based in the lab. The engineers reported progress in development and came up with solutions that NTT went on to approve. When problems arose, they were discussed together across company boundaries. As stated above, they succeeded in creating a system of collaboration.

[18] Shimoda (1990)
[19] NEC (2001)

3. Developing original technologies

3.1 Toward Electronic switching systems

The concept of an electronic switching system was also considered in Japan before the war. However, its actual development was impossible because the level of relevant technology was not sufficiently advanced at the time. However, von Neumann developed the stored programme system in 1945 and Bell labs invented the transistor in 1948. Also, at this time, NTT began working on an electronic switching system. In order to realize an electronic switching system, developing a computer was the first step for NTT labs. The most important factor in developing computers at this time was finding an alternative device to the vacuum valve. Vacuum valves were the most common device used but their low durability and high manufacturing cost were significant drawbacks. Therefore, applying the vacuum valve to switching systems and computers entailed a number of difficulties for commercial use. In 1953, Goto, a Japanese postgraduate student, invented the parametron device. This device was more stable and cheaper to use than the vacuum valve. Correspondingly, NTT Labs began developing a computer system using this device. As a result, one of the first computers developed in Japan, called “Muashino”, was released in1957. This was the first Japanese computer equipped with the stored programme concept as well as an alternative device to the vacuum valve. Although a transistor was the likeliest candidate, the main reason NTT did not use vacuum valves or transistors for their electronic switching system was durability. Around this time, the transistor was ill-suited to mass production, transistor manufacturing technology not yet having been established. Therefore, the device was both unreliable and uneconomical. Telecom engineers laid great emphasis on durability and reliability. These characteristics were to greatly influence future developments. As a result, the engineers developed a conservative attitude and would often fail to notice new potential technology.

After succeeding in developing a prototype computer, NTT continued to develop their electronic switching system based around this computer. They divided a central processing unit and switching components and adapted crossbar switches for their switching units and parametron devices for their processing units. This made it a semi-electronic switching system, but the result of performance tests was satisfactory. Following these results, NTT labs began developing a switching unit using electronic devices. This development involved *family companies* in the process of R&D would be beneficial when it came to development

for commercial use. However, serious development did not take place. There were several reasons. Firstly, because introducing crossbar systems had begun in earnest, several kinds of switching systems were needed and resources had to be concentrated on their development. Secondly, because many new technologies had appeared, there was a difficulty in evaluating and developing them. These inventions were not advanced enough for commercial use. For example, NTT used parametron devices with their computer, but parametron devices had a problem of low performance. Manufacturing transistor technologies had been established and, as a result, the problems of durability, reliability and economic inefficiency were solved, leading to the transistor becoming the appropriate device for electronic switching systems. They had to change the direction of the development of the electronic switching system. Thirdly, their technological capabilities were not significant enough. At the time, manufacturing companies tended to customize Bell's systems components to suit NTT's systems. In other words, they concentrated on learning and catching up with foreign technology and were not in a position to develop their own original technology. Although imitating the latest technology and manufacturing items based on this might be the first step to strengthening management and reaching a higher level of technology, the next stage was to develop more complex and large scale products. However, they overcame these difficulties, as mentioned in the next section.

3.2 Devices and Computers

In the 1950's and 1960's, significant new products and investments appeared. At the same time, Japanese telecom makers grew dramatically and their technological level also reached the level of USAnd European companies in manufacturing areas. This part describes how they grew based on three areas of development: transistor, integrated circuits and computers, as these areas were closely related to the development of the electronic switching system and were the origin of future competitive advantage.

3.2.1 Transistor

The transistor is one of the most significant inventions in the 20th century. This was invented by the Bell lab in 1948. As I mentioned before, establishing manufacturing technologies was critical in the early days following its invention. U.S. companies greatly contributed to developing these technologies and were the first to obtained critical patents. In Japan, *family companies* played a major part in manufacturing transistors. In the 1960's, they tended to concentrate their resources on transistors and computers. Their basic strategy

was to introduce foreign manufacturing technologies from U.S. companies. This decision may have been inevitable because basic and critical patents had already been protected by U.S. companies. In addition, even though they paid royalties, they had to develop an alternative device to replace the vacuum valve in order to develop telecom equipments and computers. NEC decided to manufacture transistors seriously in 1958. Their favoured direction was to develop them for industrial use, mainly in communication. In addition, they decided not to use their original technology but to import manufacturing technology from foreign companies. They signed contracts with RCA and GE in 1958, and later with WE in 1963. Similarly, Oki also signed contracts with RCA and WE in 1959 and set up a factory for mass-produced transistors in 1961. To be frank, NEC and Oki were late entrants to the transistor business, the reason being that NEC was the largest manufacturer of vacuum valves in Japan and the transistor was competing against vacuum valves. At this time, the start-up companies Texas Instruments (TI) and Motorola appeared in order to replace existing vacuum valve manufacturing companies. Oki had a more conservative attitude toward transistors. Although they continued to study them, they were afraid to get involved with an unfamiliar business. Therefore, they took up a wait and see policy. On the other hand, SONY tried to manufacture transistors immediately. As a result, they succeed in developing transistors for commercial use and released their transistor radio in 1954, the second to appear in the world. This success led SONY, from being a small factory in Japan, to becoming an international electronic company. At the same time, this encouraged Japanese companies to enter the transistor business. Consequently, *family companies* adopted new technologies to make up for the delay in the semiconductor business.

3.2.2 Integrated Circuit(IC)[20]

IC (Integrated Circuit) is another technology that was to contribute not only to the development of an electronic switching system but also that of computers and other electronic equipments. In 1957, Jack Clair and Kilby Noyce developed it independently and made patents separately. Their patents greatly influenced future computers. Japanese manufacturers immediately began to develop ICs. For example, NEC signed a contract with Fairchild Camera and Instrument Corporation, which belonged to Noyce, in 1962[21]. Japanese makers immediately began to take notice of ICs. The transistor was a physical invention. Therefore, companies had to study them and perform laboratory experiments. On the other hand, IC technology was closely linked with manufacturing technology. An electronic circuit

[20] These are described based on Okimoto, Sugano and Weinstein (1984), Itami (1988).
[21] NEC (2000)

was composed of many components, each of which was connected to the others. ICs were embedded in a board consisting of the necessary components. Therefore, companies were able to skip laboratory processes and were able to study the manufacturing technology in a factory. During the initial phase, their application was limited to industrial use. Therefore, developing an electronic switching system encouraged companies to develop ICs. Similarly, military use forced the development of ICs in the USA. For example, NEC began collaborating with NTT to develop ICs for an electronic switching system in 1965[22]. NEC had to pass reliability tests that NTT required for a twenty-year-insurance for their switching systems. Through this collaboration, NEC was able to accumulate experience and know-how regarding reliability improvement of ICs[23]. At the same time, Oki also started developing ICs for use in an electronic switching system in 1965[24]. This aimed to develop ICs for electronic switching systems in order to be authenticated by NTT until 1971[25]. By these means, *family companies* tried to develop ICs and were able to accumulate technological capabilities for electron devices.

3.3 The Computer

As the above described, significant inventions for contributing to computers and electronic switching systems had been appearing. Consequently, selecting technology was the key to success in development. During the 1950's, 60's and 70's, when NTT were developing crossbar and electronic switching systems, *family companies* grew dramatically in tandem with the Japanese economy. From mere telecom companies as subcontractors of NTT, they grew to become general companies. This was greatly influenced by Japanese industry policy and the existence of NTT. In Japanese computer development, policies which nurtured the domestic computer industry made a great contribution. It should be pointed out that the industries had been strongly encouraged to collaborate with each other by the ministry of International Trade and Industry (MITI). The MITI conducted study sessions and involved Japanese electronics makers in these meetings. The meetings were aimed at developing their own computers which could reach and overtake IBM's computers. The Electro-Technical Laboratory (ELT) - the agency of the MITI - was at the centre of these collaborations, and manufacturing companies shared R&D activities. Some portion of R&D cost was shouldered by the MITI. For example, in 1962, MITI persuaded Fujitsu, Oki and

[22] NEC (2000), NEC (2001)
[23] NEC (2000), NEC (2001)
[24] Oki (2001)
[25] ibid

NEC to organize the "electronic computer technology lab association", giving 350 million[26] yen (£1.75 million[27]) to them over three years. The project was named FONTAC and its purpose was to reach and surpass IBM 7090 and 7094. In 1965, this was accomplished. By using technology throughout this project, Fujitsu developed their next computer. Other companies were also able to develop technologies and used them for their own products. This policy led to competition, not only with IBM, but also co-operation among the Japanese firm.

At the same time, the technological disparity between Japan and the U.S. was already very wide. At this time, Japanese computer firms were called mosquitoes competing against that elephant of the computer industry, IBM.

In order to compensate for this gap, companies sought business partners in foreign countries. IBM- the giant of the computer industry- did not engage licensing agreements with any company as policy. Therefore, *family companies* had to select other U.S companies. As a result, Hitachi contracted with RCA in 1961, and NEC joined with Honeywell in 1962 NEC with Honeywell 1963 and OKI with UNIVAC.

The table below shows the main events of computer development in Japan. The item 'derivations' indicates how Japanese makers made products from each project. As the table shows, Japanese computer companies were developed by using the results of each project.

[26] Takahashi (1996)
[27] The exchange rate between Yen and GB pound is 200 yen/pound

Table 4-2-(1) The main events of computer development in Japan

Year	Events	Derivations
1956	World's first transistor computer with stored program concept is developed by ELT (Mark3)	
1957	First parametron computer developed by NTT labs.	Hitachi: HIPAC MK-1 (1957) NEC: NEAC-1101 (1958) OKI: OPC-1 (1959)
1957	ELT improves Mark3 for commercial use. (Mark4)	NEC: NEAC-2201 (1958) Hitachi: HITAC 301 (1959)
1960	15 Japanese companies sign licensing agreements with IBM	
1961	Fujitsu develop original transistor computer.	
1961	OKI develop a core memory component.	
1961	Hitachi was aligned with RCA	Hitachi: HITAC 3010 (1962)
1962	NEC is aligned with Honeywell.	NEC: NEAC-2200(1964)
	FONTAC Project is started by Fujitsu, NEC and OKI (till 1964)	Fujitsu: FACOM230-50 1964)
1963	OKI is aligned with UNIVAC	
1962	IBM releases system/360	
1966	Super Performance Computer Project started till 1972	Hitachi:HITAC8700 (1970)
1967	DIPS-0 project started with NTT lab and Hitachi	
1968	FACOM 230-60 was released by Fujitsu. It's the first computer equipped with all IC and multiple processors.	
1969	DIPS-1 project started with NTT lab, Fujitsu, Hitachi and Oki.	
1971	Fujitsu changes to IBM compatible course and tied up with Amdahl Corporation.	
1972	Japanese makers were grouped as three. (Fujitsu-Hitachi, NEC- Toshiba,	M-series (1974) ACOS (1974)

	Mitsubishi-Oki)	COSMOS(1974)
1974	Freeing up of the Japanese computer market	

(Referred from Computer Museum, information Processing Society of Japan)

4. The development of Electronic switching systems

4.1 Preparation for the development

As the above section described, *family companies* had accumulated technological capabilities through the development of electronics devices and computers. Their businesses were expanding from telecommunications to general electronics manufacturing companies. However, the management of *family companies* depended heavily on NTT public corporation. Although they tended to concentrate on electronic devices and computers, these could not make profits immediately. Furthermore, they needed a huge amount of R&D costs to continue developing new business areas. Crossbar switching systems, telephone sets and other communication equipments were their origin of benefits at this time.

In 1962, Bell labs released the news that it had succeeded in developing a prototype of an electronic switching system (3.4.a). This was the first electronic switching system in the world. This news triggered NTT's decision to develop an electronic switching system for commercial use[28]. Yonezawa, who was the vice president at that time, thought that NTT had to develop electronic switching systems as soon as possible. However, the challenges in development were totally different from those of the crossbar switching system. When they developed crossbar switching systems, they only improved the components and the design was based on WE's system. On the other hand, in order to develop an electronic switching system for commercial use, a much greater variety of components had to be developed through their own efforts.

NTT had two ways of developing an electronic switching system. One was importing products or technologies from the USA. Another was developing them by themselves. The same situation applied to developing crossbar systems. Imitating Bell's system was more economical and NTT saved substantially on R&D costs. At this time, NTT decided not to buy products but to develop them based on imported technologies. As mentioned before, this decision led to gaining experience and know-how for developing an electronic switching system.

In this case, NTT selected the latter method of developing it by themselves. The most important factor in development for practical use was to make it more economical. Consequently, involving manufacturing companies was indispensable because manufacturing technologies had to be considered in R&D processes.

[28] Nakagawa (1990), NTT (1976) provide details of discussions about this

Yonezawa requested NEC, Hitachi, Fujitsu and Oki to collaborate on this project in 1964. For the Japanese level of technology at that time, NTT built to high standards, far above the level of Japanese capabilities in the area of computers and electronic components. However NTT decided on this direction consciously because they thought it was the only way to reach and overcome American technology.

Firstly, NTT labs focused on an integrated circuit. As mentioned before, an IC was superior to a transistor in terms of cost, scale and performance. However, the manufacturing technologies were not completely established, and were therefore applied mainly to the military and aerospace industries. In addition, NTT was not good at developing components as they did not have any manufacturing departments. If a maker has the capability, components can be developed under the guidance of the company. However, at this time, none of the four companies had the enough capability, so development would be problematical. Even though the technological capabilities of *family companies* were growing dramatically, the gap with U.S. companies was still very wide. Therefore, NTT needed to increase their capabilities in order to guide manufacturing companies. In addition, they did not have enough experience and information to develop an electronic switching system. The necessary technological areas were more varied than those of the development of a crossbar switching system. Consequently, NTT tried to make a contract with Bell labs directly. Until then, the contract with WE prohibited NTT from direct communication with Bell labs. However, in order to compensate for their lack of information and experience in developing electronic switching systems, NTT decided to make a contract with Bell labs directly. This was a cross licence agreement, however NTT paid a huge sum of money for it[29]. NTT also drafted a technical assistance contract with WE[30]. As a result, NTT was able to deepen their exchange with Bell labs.

This contract provided NTT with substantial benefits. NTT was able to obtain a great deal of information. At the same time, the most important thing was to evaluate Bell's electronic switching systems in detail. At that time, NTT was developing their first prototype of an electronic switching system, but through the evaluation of the Bell system, they studied the concept of the electronic switching system that NTT would develop.

If we consider the reasons why NTT did not depend on the Bell system, there were several. One is that introducing the Bell system without modifications was not suitable for Japanese conditions. NTT had a lot of experience in the maintenance and operation of the telephone network in Japan. Therefore, the Bell system would have to be modified to fit

[29] The details are described in NTT (1976).
[30] NTT (1976)

these operational rules. In addition, the system was the prototype, so using technology would be highly experimental. Therefore, either way, it was inevitable that the development would become larger in scale.

In addition, through their exchange with Bell labs, NTT was considering external conditions when NTT introduces electronic switching systems into their network. NTT was able to clarify the design of the kind of system that should be developed. Following this, they tried to select technology which would be flexible with consideration to external conditions. If the development sticks with original technology too much, it is difficult to know and accept new technology in the development. For example, they accepted IC and magnetic drums for their systems. Both forms of technology had low reliability and poor performance at that time. However, considering design and external conditions, they knew both technologies would be needed. NTT developed a memory unit with Oki's support. However, considering future application, the capacity of the memory was low. Consequently, NTT was forced to use drum magnetic memory for the system. Above all, they constantly tried to keep up with new technology created in other industries. In handling these uncertain conditions, the collaboration was very beneficial. Each company took care of its own territory. For example, Fujitsu were responsible for CPU using their computer technologies. Oki developed memory units as Oki was good at developing peripheral devices.

Technological capabilities were one of the most important managerial issues. When technology totally depended on other companies, even if NTT developed their own services, those services are limited to those other companies. Once technological development stops, it is very hard to recover from this. In addition, if NTT did not have enough technological capabilities, NTT had to pay a huge amount in royalty fees. However, if NTT did have enough, even when some forms of technology are needed from other companies, those royalty fees can be expected to reduce.

4.2 Entering into a full-scale development

In 1965, NTT contracted with NEC to develop an integrated circuit for switching systems. This contract was signed in secret because they were afraid of leaking information.

However, NTT and NEC faced many difficulties. Watanabe, who was a researcher in NTT labs at that time, said about the situation, “In order to develop IC, very large fields of knowledge - Physics, Chemistry and electronic engineering - are needed. However, we hadn’t worked with such an integration of knowledge in Japan at that time. Therefore, in principle, we tried to learn and study basic knowledge on ICs. However, this approach was criticized and some executives said that it was better to buy and introduce American products. However, if we had done so, we would have to imitate all forms of technology in the future. Therefore, we kept up (with the technology), not to imitate anything but to develop by ourselves. It led to good results. We managed to develop other circuits by ourselves.”

Around this time, the technological levels of manufacturing companies reached high levels as they gained experience in developing and manufacturing computers and semiconductors. In other words, it can be said that the preparation of developing an electronic switching system was complete.

In 1966, the first prototype of an electronic switching system (DEX-1) was released. This system was developed based on the Bell system in order to study a stored program system and its applicability for a switching system. The development was shared by four companies, with speech path systems and temporal memory systems developed by NEC. Fujitsu developed shared centre processing units while junction circuit systems were produced by Hitachi. Oki were responsible for developing the memory units. The trial was completed in 1966. At the same time, another prototype was developed in collaboration with NEC. The DEX-TX was a unique and very advanced system using cutting-edge technology. It aimed to evaluate a time division system which was closely related to PCM (pulse code modification) systems. In the end, the time division system was not accepted as electronic switching systems because there were difficulties of compatibility with existing telephone systems.

Through these developments, NTT evaluated each form of technology and considered the design. Following the results, NTT and manufacturing companies launched the development of a new system, through their ongoing collaboration, in 1967. The system, DEX-2, was released in 1969. The design was their original concept. 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 of the electronic switching system. In 1969, the prototype was sent for field tests.

After developing two prototype systems, NTT did not start commercial systems immediately. They again redid both design and components. Miyazaki, the then president of NTT lab, said, "…in developing large scale systems, the goal is likely to be an ideal. As a result, too many requirements are requested for the design of the system. In addition, engineers tend to have margins in order to keep on their safe side. Therefore, the cost was likely to increase. In order to produce commercial systems, a new design was needed." They clarified all problems of the electronic switching systems. For example, it was common for switching systems to have to be equipped with memory duplexing throughout the world. However, they considered that it only needed a backup for n-plex. In addition, they did the software design that could be used for both subscriber accesses and trunk lines based on the same components. These activities led to a decrease of 30 or 40% in cost. Kawada said this could only be achieved because NTT had all kinds of technology, especially with components and materials

Following the result of these trials, NTT decided to develop the first commercial electronic systems, the D10, in 1969, which was released in 1971.

In conclusion, there are several significant points in the development of electronic switching systems. Firstly, electronic switching systems were the first systems that NTT and *family companies* developed with their own technology. In the development of crossbar systems, most technologies came from foreign countries, especially the USA, although they redid the design, improved and nationalized components as required to comply with Japanese conditions. However, their electronic switching systems consisted of many original forms of technology which had accumulated through continuous R&D and manufacturing activities.

However, Kojima, executive at Fujitsu at the time, said that considering the difference between their systems and Bell's, frankly speaking, NTT showed too much loyalty to WE. Therefore, we cannot say that all used forms of technology were developed by themselves. In other words, much of the technology was based on the USA's technology at the time. However, the attitude towards original technologies allowed for the development of manufacturing companies and would be linked with later developments.

Secondly, the system of collaboration between NTT and *family companies* was almost complete. In the development of crossbar switching systems, the capabilities of *family companies* were not so high, so NTT had to guide manufacturing companies. However,

through this, their abilities grew through the development of electronic devices and computers. As a result, they were able to propose ideas to NTT and to respond to high demands from NTT. In addition, they were able to obtain technological information and new trends from their original sources. These relationships led to the development of much larger and more complex systems, as manufacturing companies drastically grew.

Thirdly, NTT did the design with consideration paid to external conditions. This means that marketing concepts began to be involved in the process of R&D. This will be mentioned in detail in another section.

5. Discussion

5.1 Imitating and developing capabilities

5.1.1 Reverse Engineering

As the previous sections have described, NTT made a thorough study of the imported crossbar switching systems. Shiromizu described the methods of this study as follows: his team disassembled and assembled a WE crossbar system almost ten times, remodelling it for companies to manufacture easily[31]. As a result, the system NTT developed was completely similar to that of WE. 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 dead 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.

In general, new product development takes place by way of creating product concept, basic design, function design, structural design, process design and finally producing physical products (Clark and Fujimoto 1991).

Following on from this, in paying attention to a firm's design development capabilities, Fujimoto (2001) pointed out "translational capabilities", where the firm translates from a market the needs, functional and structural designs, leading to the production of physical products. Firstly, it is the organizational ability to detect future market needs, summarize them, and translate them into product concepts. Second, it is the ability to translate from product concept to functional elements. This is the ability to create functional design, in other words, to translate market needs into new technology. Thirdly, each hierarchy of functional design can be translated into a hierarchy of components. This capability includes conceptual and integral powers that divide components based on functions, integrating them into a product. Finally, 'translational capabilities' means the capability, during process design, of manufacturing the physical product from the design.

[31] 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).

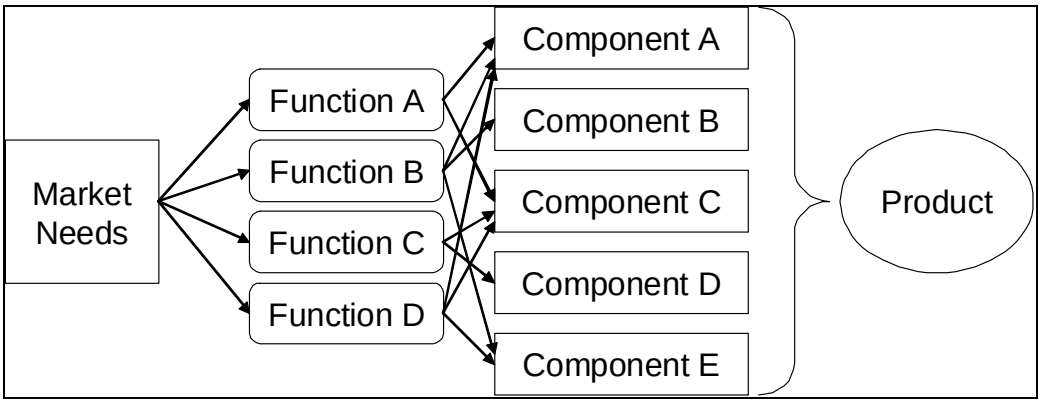
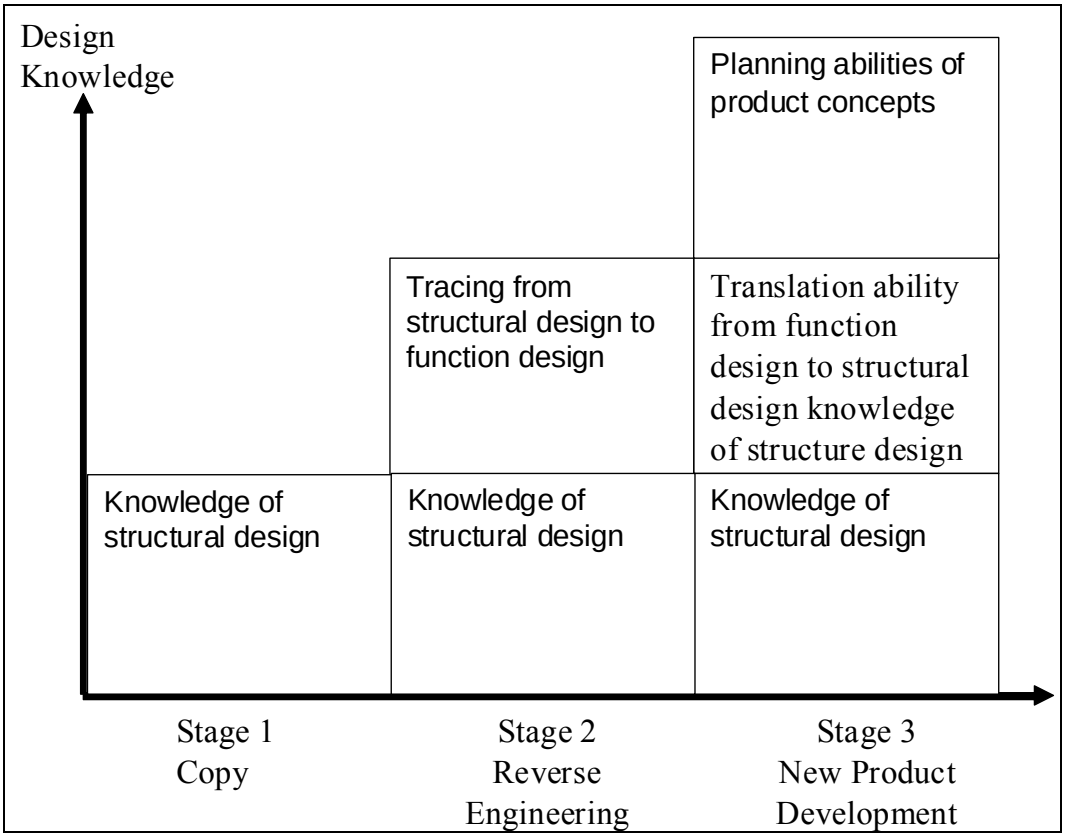


Figure4-2-(1)The process of new product development



(The author modified based on Fujimoto and Ge (2004)

Figure4-2-(2) A process of accumulating capabilities of product development

Normally, the process of new product development goes forward from function design to component design (**Figure4-2-(1)**). However, when a late player begins to accumulate technological capabilities from the reverse engineering, the process starts from the study of the focal product's component design. A late player accumulates design and development capabilities in three stages **(Figure4-2-(2))**. In the first stage, the focal product is copied

simply and remodelled. The second stage can be regarded as totally different from copying the focal product, but this reverse engineering involves a reverse process, from structure design to function design. This process can be recognized as the late player experiencing what the front runner has gone through in the process of development. Finally, having the abilities and knowledge of this reverse engineering, the player is able to understand what a product's concept is and how functional designs and construct designs are made. According to Fujimoto and Ge (2004), through this process, capabilities of product developments can be deeper and more wide-ranging. In this thesis, Fujimoto tried to solve the reason why Chinese motorcycle makers have not produced original models, for a long time imitating Japanese products, and showed that they remained in the stage of 'dead copy'.

In NTT's development of crossbar switching systems, NTT and *family companies* carried out these processes precisely. By disassembling and assembling a WE system, they carried out the stages of dead copy and reverse engineering. They had 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 carried out the stage of new product development in the development of electronic switching systems.

5.1.2 Two types of knowledge in technology management

According to Henderson and Clark (1990), successful product development requires two types of knowledge. First, it requires component knowledge, or knowledge about each of the core design concepts and the way in which they are implemented with a particular component. Second, it requires design knowledge, or knowledge about the way in which the components are integrated and linked together into a coherent whole. In addition, they mentioned that the distinction between design and component knowledge is a source of insight into the way in which innovations differ from each other. In their opinion, radical innovation establishes a new dominant design and therefore a new set of core design concepts embodied in components that are linked together in a new design. Incremental innovation refines and extends an established design. Improvement occurs in individual components, but the underlying core design concepts, and the links between them, remain the same. Considering the period of NTT's two projects, new technologies and innovation appeared, such as transistors, integrated circuits, and computers. In other words, not only were new devices developed, but also a new design was needed to develop switching systems. Introducing a stored programme system was a good example, as that created new design. The design of switching systems changed drastically during this period. Specifically,

common control units were equipped with crossbar systems. These units temporarily memorized dialling information and operated speech paths and accounting using hardware. Meanwhile, the electronic switching system operated these functions through software by introducing a stored programme concept. These differences influenced the design of systems. NTT and *family companies* studied the crossbar changes by reverse engineering of the WE system, while the changes made to the electronic system were studied by looking at the developments of computers. These learning experiences led to the creation of electronic switching systems.

As a result, they designed their own architecture based on previous experiences and the results of evaluating Bell's systems. If they decided to import products without any modifications, they would not have the chance to study these aspects. As has already been mentioned, Shimazu, chief engineer of NEC at the time, said NTT and the manufacturing companies accumulated technological skills in the area of switching systems through the process of development of crossbar switching systems. As a result, the development of the electronic switching system was relatively smooth because they had gained much experience from the previous development. On the other hand, the United Kingdom adapted the policy of using existing switching systems until the release of electronic switching systems. However, even though they concentrated on developing electronic switching systems, their introduction of them lagged behind that of the USA and Japan precisely because they lacked these learning experiences.

These findings show that accumulated skills and knowledge were not possessed not only by individuals but by each company within the collaboration system. In addition, their accumulated resources were not non-tacit things like specifications and designs delivered from US companies. NTT and *family companies* developed and modified by themselves, as a result, creating knowledge and experiences shared with the collaboration systems. These resources came from organised and interactive activities in the collaboration system. Therefore, these resources were used and developed for future projects, leading to the sources of sustaining competitive advantage in the Japanese telecom industry. The case shows that operant resources developed by cooperation with external actors are the most important type of resources to create competitive advantages.

5.2 Collaboration and partnerships

5.2. 1 Uncertainty and equivocally

Two other significant factors should be pointed out when we look at these two developments. As has already been pointed out, the standard of technology changed frequently during this period. Therefore, uncertainty and equivocality were relatively high. Uncertainty is caused by a lack of experience and information. In these circumstances, a company tends to obtain informative partners in order to gain more information. This occurred in both projects. As I mentioned earlier, NTT engaged with Bell labs and WE in order to compensate for their lack of experience in developing and evaluating electronic switching systems. *Family companies* also made contact with foreign companies not only to use licences but also to obtain more advanced technological information. Therefore, under these circumstances, a company needs to find new candidates who will contribute to their future and evaluate them 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. As previously shown with electronic devices and computers, they had engaged with many companies in a variety of business areas. The *family companies* made these contacts individually while NTT also contracted with Bell labs and WE. In other words, they exchanged closely within the network. At the same time, each actor gathered information from other networks. The information obtained was mutually exchanged and helped with their development.

5.2.2 The reasons for maintaining collaboration

However, although equivocality was high around this period, genuinely new partnerships did not appear. In fact, the relationship between NTT and *family companies* became more closely tied. Therefore, in order to understand the nature of this collaboration, I shall attempt to describe the nature of this collaboration within the context of the Japanese telecom industry.

Firstly, a telecommunications system consists of millions of interconnected components. Because of this, standardization is extremely important. All processes, from design to manufacturing, aim to equalize the quality of products, and attribute and performance have to be standardized. If a nonconforming element enters the system, it can cause glitches. An exchange with limited members is easier in terms of quality management

because if a new player enters into this, NTT has to explain its quality guidelines as well as check the player's activities. This leads to many problems and introducing products takes longer. In developments with the *family companies*, every component was standardized to maintain compatibility.

Secondly, NTT did and does not have any manufacturing departments. Therefore, in order for NTT to receive their requested products, they closely consulted with manufacturing companies. In this situation, domestic companies were more appropriate because they were well aware of NTT's customs, and they responded to NTT's offers quickly.

Third, NTT is not a rival for telecom manufacturing companies. In other words, they do not compete in any fields against NTT. For manufacturing companies, NTT was a good partner to collaborate with. Looking at the detail of the collaboration, we find for example that leaders belonging to NTT helped manufacturing companies with best practice when it came to study and development. NTT encouraged manufacturing companies to study very difficult problems which, the companies felt, entailed risks. However, NTT paid a huge amount of R&D costs in the form of development fees for a prototype. In addition, NTT purchased every prototype, and when they decided to introduce a system seriously, 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. Therefore, the idea of collaboration with NTT held a great deal of merit for many manufacturing companies.

Furthermore, the growth of manufacturing companies and extension of NTT's business did not conflict with each other. As mentioned before, by using technologies created by the collaboration, *family companies* were able to develop derived systems for civil use and export. For example, the latest version of NTT's data transaction computer, DIPS-11/45, was almost 90% identical to Fujitsu's computer system released in 1981. The sales of these derivation systems greatly contributed to Fujitsu's management. This could be realized by 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. The aforementioned manufacturing companies were exempt from paying NTT's patents.

In addition, NTT provided the *family companies* with a convenient purchasing place. Every fiscal year, NTT revealed their schedule of purchasing and budget to business acquaintances. This allowed manufacturing companies to prepare for the planning of

production systems and purchasing materials in advance. Prices were also attractive to partners. They summarized all costs, including material, process, managerial, sales, and commission fees, including benefits and transport fees. Prices changed every year based on the inflation rate. Another attraction of the system was that, when partners needed funds for development and purchasing special materials, NTT offered advanced payment. Therefore, maintaining business with NTT was very beneficial for partners.

5.2.3 Hierarchical structure and the collaboration

In summarising the above, it must be pointed out that the hierarchical structure maintained the close relationship between NTT and the *family companies*. As NTT had superior power in the industry, the structure of the network became hierarchical. According to the discussion on communication by Bernard (1938), a limitation in communication with others can be linked with the effectiveness of the hierarchy in deciding the boundary. Hakansson and Snehota (1987) also mentioned that hierarchical control of resources is a way of clarifying the boundary. Therefore, when considering the boundary of a network, hierarchy provides a clear definition of the boundary between an organization and its environment. Bearing this in mind, even if equivocality is high in a business environment, when the network structure is highly hierarchical, actors tend to engage in informative partnerships, rather than deepening a relationship with others belonging to other networks, because the hierarchical structure tends to prevent the network from expanding. As a result, the existing relationship remained and new actors seldom enter the network or makes significant exchanges.

5.3 Toward network orientation

It can also be pointed out that the design of switching systems changed during this period. In the development of cross bar switching systems, engineers were interested only in function and performance in order to reduce telephone back orders and achieve direct dialling. Therefore, they concentrated on developing systems as well as learning technologies, and only developed several types of system with different capacities suitable for equipment spaces.

On the other hand, in the development of the electronic switching system, they studied the design, bearing in mind external conditions. After introducing crossbar switching systems, they had opportunity to resolve back orders and introduce direct dialling. Therefore,

the development aimed to respond to future demands of the telephone service and to add new services flexibly. Therefore, the design had to consider future telephone markets. The most important factor for them was having the flexibility to allow for social change. If the population grew in a specific area, NTT would be able to change the charges in these areas easily. In addition, they developed several telephone services following the introduction of electronic switching systems: call waiting, abbreviated dialling service, the call transfer service, and the telephone answering service. NTT aimed to provide not only supplementary telephone services but later also data communications and visual communication services.

In this way, the development began to include a marketing concept in its design. However, the new services were based on telephone services. NTT considered and developed these services only according to NTT's wishes. In addition, NTT only exchanged with a limited number of firms within the industrial network, mainly *family companies*. Developments took place only for NTT and *family companies* within the Japanese telecom industry. In other words, their consideration of the market was very limited to only within their network.

This collaboration was network orientation, which means they only looked at their close relationships and considered service developments in the context of the telecom network.

6. Summary

This section described Japanese telecom developments from the post war period to around 1975. Focusing on two projects of switching systems, the section has attempted to show the relationship between collaboration and developing technological capabilities. Describing the development of crossbar switching systems, the section has tried to clarify the differences between imitation and accumulating capabilities by using the reverse engineering concept. In the development of electronic switching systems, it was shown that partnerships with foreign companies contributed to developing original technologies and continuous R&D activities, and that manufacturing brought about the accumulation of technological capabilities, leading to success in developing electronic switching systems.

This section also shows how the collaboration between NTT and *family companies* became established and deepened (**Figure4-2-(3)**). By studying the contents of the collaboration in detail, we can see that their relationships greatly contributed to the development of their technological capabilities. At the same time, it is clear that the

hierarchical structure of Japanese telecom industries contributed towards the nature of the collaboration.

In this period, the design of switching systems began to involve marketing concepts. However, their target market was limited within their network, and did not include consumer markets. In other words, they only looked at their close relationships and considered service developments in the context of the telecom network.

NTT and *family companies* had gone through a period of imitating foreign technologies and went on to new periods where NTT and *family companies* achieved the highest level of telecom technologies. In the next stage, they had to go without any guide. At the same time, the circumstances surrounding telecom markets had changed from companies only offering telephone services to them developing new communication services in order to adapt to social changes. These circumstances forced their relationships to change. The next section intends to be examine this.

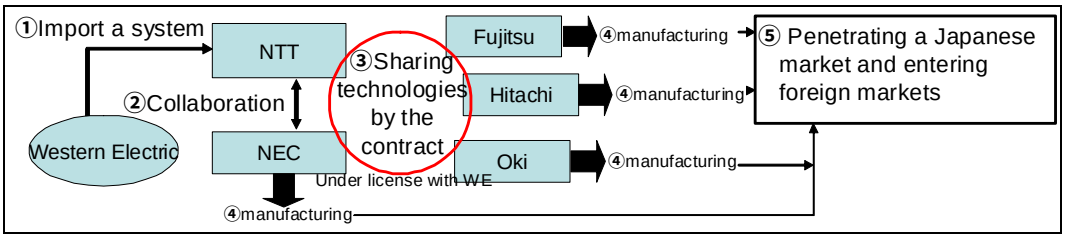


Figure4-2-(3) The collaboration system in developments of cross-bar and electronic switching systems

Section3.
Market integration and changes in collaboration

1. Integration of Computers and Telecommunications

1.1 Towards Data Communication Services

1.1.1 Stopping computer developments

Developing computers and relevant technologies brought about a new online service allowing companies to connect with each other. The service, in which computers connect with the network, can be called data communication services. Telecom operators, AT&T, BT and NTT, tried to enter the data communication market. In order to do this, the computer is indispensable. Therefore, telecom operators studied computers in the early days of their development.

Although NTT succeeded in developing their own computer by using parametron devices in 1954, the purpose of this development was not to develop a commercial computer but to study significant future technologies of electronic switching systems[32] (Muraoka 1985). By using the results of related projects, *family companies* commercialized parametron computers in the market[33]. After developing a parametron computer, NTT planned to develop new versions using semiconductor devices. However, the project was stopped and NTT lab concentrated on switching systems - improving cross bar switching systems and developing electronic switching systems. The decision of NTT to stop computer development was based on the fact that Bell lab had called a halt to their study of computers[34]. AT&T was forced to stop computer developments by the FCC (Federal Communication Commission) because of the antitrust law. NTT did not know these reasons in detail. Therefore, NTT mistakenly thought that AT&T had bailed out of computer development because the computer was not linked with telecommunication[35]. Around this time, Bell lab was the only model for NTT Lab, and therefore their decisions were

[32] Muraoka (1985)
[33] Hitachi: HIPAC MK-1 (1957), NEC: NEAC-1101 (1958), OKI: OPC-1 (1959)
[34] Nakagawa (1990)
[35] ibid

influenced by AT&T activities. In addition, NTT wanted to avoid the large R&D costs that would be incurred when NTT entered the computer industry.

As a result, engineers involved in computers moved on to other projects concerned with electronic switching systems. Around 1956 and 1957, Japanese electronic companies began to build their own laboratories. They could afford to establish laboratories because of Japanese economic growth and the rapidly developing electronic industries. Therefore, they needed researchers for their new laboratories. They only believed in a linear model, which meant that basic research would translate into huge benefits for the future issues such as transistors and nylons. Consequently, companies tried to ask NTT lab to provide them with these researchers. The same situation existed in academia. As a result, many researchers belonging to the NTT lab moved to academic fields and laboratories of other companies. In *family companies*, they also aimed to strengthen their relationships to NTT by hiring NTT's researchers. On the other hand, NTT lab recruited many new graduates studying electronic engineering. As a result, NTT lab was refreshed by retiring existing researchers and recruiting new graduates through the late 1950's and early 1960's.

1.1.2 To enter Data Communication Services[36]

Under these circumstances, Kitahara, who would later become vice president of NTT for a long, thought that developing computers would have to be restarted immediately. He considered that the future communications network could be realized by computers connecting with the telecom network. He had persuaded major executives to restart their study of computers in 1965[37]. In the beginning of the 1960's, with relevant computer technologies growing dramatically, online services could be achieved within the banking and ticket reservation systems. In other words, by computers connecting to a communications network, computers were effectively becoming switching systems. Consequently, NTT had to change their attitude towards data communication services. The issue was whether switching systems should be equipped with information processing functions or only switching functions. In order to come to a decision whether or not to restart computer studies, a decision had to be made as to whether NTT should enter data communication services or not. Eventually, NTT lab decided to form a new department for data communications. Kitahara's efforts were accomplished and NTT decided to go into communication services in 1966.

[36] This part is based on Nakagawa (1990), Takahashi (1996).
[37] Nikkei Business, 1984-09-24, Nakagawa (1990)

However, the first problem was whether the Japanese government would allow NTT to expand into the communications business or not. For example, in the USA, the FCC prohibited AT&T from entering the data communications market due to the antitrust law in 1956, resulting in Bell lab stopping their research into computers. Similarly, NTT needed to have permission from the Japanese government in order to start data communication services. Around this time, public networks, including telephone lines, were not open to non-telecom companies. Therefore, only telecom operators could deal with public network businesses. Almost all telephone companies were managed under government operations. Accordingly, NTT insisted that no company other than NTT was legitimately able to provide data communication services for the public because only NTT had the network, ability and technology to standardize the interfaces that would be needed to offer public services. They also insisted that NTT would be the only provider of pubic communications. In 1967, the Minister for Post and Telecommunications stated in parliament that data communication should include telecommunication services and that only NTT allowed dealing with these services. Following this statement, NTT was able to move into data communication services.

1.1.3 Integration of telecom and computer market

NTT's entry into data communication services meant that a new communication market would be created, integrating the computer market with the telecom market. At this time, computers were provided by computer companies, stored in a special computer rooms, and used for calculations and business transactions. However, the emerging online services expanded on these uses, creating a variety of services. In other words, by a computer connecting with a telephone line, a new market had appeared. As a result, many other players tried to enter this market - not only companies in the computer industry, but also those involved in telecommunications equipment, business machines, and in the electronic industry. Furthermore, these new players did not come only from existing companies - new companies and new industries appeared. Consequently, R&D activities in Japanese telecommunications were forced into undergoing a change. The Japanese telecom R&D market expanded to include computer-relevant technologies. Therefore competitors, along with the number of actors who dealt with NTT businesses, also changed. Focusing on NTT's project of computer and LSI developments, we shall look at these changes.

2 The DIPS (Denden-kosha[38] Information Processing System) project

2.1The aim of the project

This section describes the activities of NTT and *family companies* in developing an original computer for data communication. This project established the basis for collaboration between NTT and its *family companies*, leading to later projects.

Following the increase in demand for data communication services, NTT realized that their own high standard computers, with their large capacity, were needed in order to offer data communication services as a public service because the existing Japanese computers were limited both in capacity and versatility at that time[39]. The DIPS project took place based on these concepts[40]. Around this time, Grosch's law appeared, formulated by Herb Grosch in 1965, running thus:

Computer performance increases as the square of the cost. If you want to do it twice as cheaply, you have to do it four times faster.

The law can also be interpreted to mean that computers present economies of scale: Bigger computers are more economical in view of performance for million[41]. Following this concept, NTT tried to develop the largest scale computer in Japan incorporating cutting edge technologies. NTT aimed to design their computers to have three times the capacity of existing Japanese systems around 1965[42].

Reliability was the most significant factor for the project. NTT established the policy that the data communication service had to be equipped with the same level of reliability as that of the telecom service. At the time, Japanese manufacturing companies did not have sufficient capability to develop and manufacture computer relevant technologies. Therefore, these qualities were lower than those of USAnd European products.

DIPS projects continued for 25 years starting at 1966.This section looks at three projects and describes how the projects were influenced by other actors. DIPS projects were worked on by four companies in collaboration: Fujitsu, Hitachi, NEC and NTT. The first project, DIPS0, experimented with the study of a time sharing system (TSS) and the development of software development environments (Nakagawa 1990, Muraoka 1981). A

[38] "Denden-kosha" is the Japanese name of NTT private Corporation.
[39] Muraoka (1985)
[40] NTT (1999)
[41] Muraoka (1985)
[42] ibid

time sharing system allows users to share a computer by dividing the processing time of a CPU based on the user. In order to accumulate technological know-how and clear up problems when the system was installed, a prototype was developed based on Hitachi hardware. On the other hand, a software development support tool was developed on NEC's hardware (FACOM230). DIP0 was released in 1968.

After NTT's decision to provide communication services, NTT's sales department began accepting big on-line service projects, including one for banking systems in Japan. Under pressure from sales departments, the DIPS project was forced to develop its first commercial system immediately. Therefore, the development of NTT's first commercial system (DIPS-1) began under the same collaboration. In 1971, this system was released and underwent field tests. The architecture of DIPS-1 was influenced by the IBM system (IBM 360)[43], but also incorporated the latest technologies. The architecture included a multiprocessor system with local memory (cash memory) in order to achieve large scale and high reliability. This is common in recent systems, but at that time many commercial systems did operate in this way[44].

However, just after releasing their first prototype system of the DIPS-1 project, IBM released the new generation computer, "IBM 370" in 1972, which was the first computer equipped with LSI. NTT lab knew there was a large gap between NTT and IBM in computer technologies. However, they did not give up and began to develop the next system, 'DIPS-2'. Around that time, as mentioned in the next section, electronic devices were rapidly developed by new emerging technologies. Memory devices were changed from magnetic to IC and the integration degree of IC dramatically increased. As result, NTT had to introduce these technologies in order to catch up with IBM's machine. At the same time, NTT concentrated on developing LSI. The DIPS-2 accepted IC memory (4 kilo bit /a chip) and other LSI technologies into their systems. NMOS had the advanced IC memory that NEC developed in MITI's project[45]. NTT purchased all the necessary NMOS memory for their project from NEC and distributed them to three companies.

The architecture of the DIPS systems was influenced by IBM's competitive systems, System/360 and 370. However, there were several other features. Firstly, the project emphasized the standardization of components, interfaces and software. There had been few systems which placed an emphasis on standardization until IBM's System/360 unified I/O

[43] Takahashi (1996)
[44] Muraoka (1985)
[45] In 1962, MITI persuaded Fujitsu, Oki and NEC to organize the "electronic computer technology lab association", giving 3.5 million yen to them over three years. The project was named FONTAC and its purpose was to reach and surpass IBM 7090 and 7094. In 1965, this was accomplished.

(Input/Output) interfaces between computer and relevant devices. Following the emergence of System/360, Japanese computer companies tried to unify I/O interfaces, but they were only covered within their own systems. In addition, these were the early days of online services; the protocol of data communication had not been established. Each company accepted the unique specifications of each interface. As a result, the computers were hardly interconnected at all. The DIPS project also aimed to unify maintenance and building tasks and to standardize the processes of software development. In this project, in order to standardize software, the architecture was unified because three companies shared its manufacture, designing the software along the same lines. In addition, they unified the interfaces between the peripheral devices and the main computer because the hardware was developed independently and was needed for these devices to be interconnected[46].

The movement of *family companies* and NTT shows that the DIPS projects aimed to develop a Japanese standard in computers. In addition, although these technologies were some of the most advanced in the world, they were not created through the project but gathered from external sources. NTT lab was forced to look at actors existed not only within the telecom industry but also other industries, such as computers and LSI.

2.2 The collaboration

DIPS projects took place through collaboration. NTT asked three companies, Fujitsu, Hitachi and NEC, to collaborate in the development of data communication systems. These were three of the leading companies in the Japanese computer and telecom industry. Oki also wished to join the project, but NTT refused as Oki had retreated from their development of large general purpose computers. In order for a successful collaboration, it was decided that partners should be selected from companies with the same levels of technological competence, as the performance of a system can be measured by its weakest point. Oki being regarded as not having the same levels of technological expertise, the collaboration took place using three companies: Fujitsu, Hitachi and NEC with NTT.

This collaboration was different from that of switching systems. In the development of switching systems, all components had been standardized using NTT's concepts, NTT being the only user of switching systems, and each company had the same technological level. However, as mentioned before, each company had 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. In addition, sales

[46] Muraoka (1985). In architecture, software commands were unified. I/O interfaces were standardized by their original specifications.

volumes were also relatively low compared with those of switching systems. In the development of switching system, *family companies* promised a large amount of purchasing that would contribute to their management even though they manufactured products that NTT expected. However, in computer development, NTT's purchasing power did not have a large enough influence on manufacturing companies' activities. As a result, NTT were unable to force the three companies to standardize all components. Therefore, NTT decided that the software architecture and interfaces would be standardized while the hardware specifications would be developed by each company's own individual methods.

At the same time, when the three companies collaborated, they were manufacturing their own computers and had also joined MITI's projects. As manufacturing companies, they could not afford to develop several types of computer at the same time. Therefore, they wanted to unify the computer architecture of their manufacturing systems. There were also two types of systems at that time: IBM compatible machines and unique systems. IBM had a large amount of customers who used their software working on IBM machines. In order to decrease customers' switching cost, developing a computer that existed using IBM's software was a beneficial from a managerial point of view. This was made possible when the U.S Justice Department and IBM agreed to open IBM's technological information to other companies in 1956. The Justice Department hoped that IBM compatible makers would survive in the market (Cusmano 2004). With the emergence of IBM compatible makers, the main factor in winning the market changed from the designing of superior architecture into how companies were able to develop high performance devices.

Fujitsu and Hitachi decided to make the change to IBM compatible hardware in 1971. The background to their decisions was their relationship with foreign companies. Historically, Hitachi was affiliated with RCA in the CRT after the war, and subsequently got involved in the computer business in 1961. Hitachi manufactured their computers for the Japanese market by integrating RCA's and their original technologies[47]. Following the arrival of IBM's System/360, RCA and Hitachi changed to IBM compatible software. RCA withdrew from their computer business by selling the department to Univac in 1971. On the other hand, Fujitsu had been in the computer business without taking any affiliation. However, Fujitsu and Hitachi agreed to unify their computers' architecture to IBM compatible in 1971.

Therefore, Fujitsu and Hitachi insisted that the next DIPS system should incorporate IBM architecture. On the other hand, NTT continued with their unique architectures. NEC also disagreed with the idea of changing to IBM compatible software as they manufactured

[47] Okamoto (1977)

their systems based on their unique architecture. Finally, the next DIPS system (DIPS2) continued to use NTT's unique architecture, with Fujitsu and Hitachi agreeing to this decision. Fujitsu and Hitachi realized that the competitive factors in computer development had changed from the design of architecture to the development of devices and software. Therefore, they thought they would have an advantage in the development of devices. In other words, competition in the computer market had moved to the area of software and devices. Consequently, in 1972, the DIPS-2 project took place, but the method of collaboration had changed. In the DIPS-1 projects, three companies, NEC Hitachi and Fujitsu, manufactured systems by sharing components. However, in the DIPS2 project, three different sizes of systems were manufactured independently. Therefore, they were competing in performance, quality and keeping to deadlines in order to increase the amount of NTT's purchasing. In the development of hardware, Hitachi released the DIPS-11/10 in 1975, NEC DIPS-11/20 in the same year while Fujitsu completed the top end model DIPS-11/30 in 1976. These systems incorporated cutting edge technologies such as LSI and IC memory and gave the best performance in Japan at the time.

2.3 Software management of DIPS projects

2.3.1Software developments

Software had been regarded as an accessory of hardware until the 1970's. Computer companies developed software to sell their hardware, customizing for each customer by adapting a user's computer architecture. In addition, large scale software could not be installed because capacities of memory and CPU were very poor. Therefore, computer makers mainly developed software and the software industry was not firmly established. IBM's release of System/360 was the trigger in the development of software as an industry. This system contained a hierarchical structure within the software, dividing Operation Software (OS) and Applications.

In the early days of the computer, there was no software. Instead, electronic devices operated computers. The programmer had to operate physical switches to operate "run commands" and data in the computer. In 1944, von Noyman realized that "run commands" and data could be stored in the memories of computers. This stored "run command" was regarded as a program. This stored program concept led to the creation of software businesses. In 1949, the first stored program computer was developed by Cambridge University in EDSAC computer. After the commercialization of the stored program

computer, software houses appeared, mainly in the USA. In the early days, the most demand for software came from the military. The U.S government's purchasing of software greatly contributed to the development of software industries (Cusmano 2004). For example, the project most contributed to was the development of the SAGE system (Semi Automatic Ground Environment). This project gave IBM a great advantage because the government made the decision to use IBM computers for their systems. In addition, the project needed a huge amount of program lines. Therefore, the "software factory" industry emerged. Another project greatly contributed to was the development of the flight simulator. This project used "real time computing technology" and magnetic core memory. As before, IBM and other American computer companies converted these technologies for commercial use. After introducing rental systems, many companies used computer systems for their services. As a result, the demand for the making or customizing of software increased. Therefore, around the end of the 1960's, it was clear that computer companies and IT departments could not satisfy the demand for customized software. This led to the growth in software factories.

An announcement in 1968 by IBM was the big trigger in the rapid growth of the software industry. IBM had decided to divide their software and hardware businesses. IBM's set prices would separate software from hardware. At the beginning of the 1970's, IBM began to sell software packages independently from hardware. IBM's decision was based on their fear that the Department of Justice might regard their combined sales as infringing unit trust law. Throughout the 1960's, even big computer companies like IBM did not regard software as an independent business[48]. In the mainframe computer industry, every company sold hardware in combination with OS and application software. Before IBM's development of System/360, OS and application were not divided. After the appearance of the personal computer, at the same time, IBM outsourcing CPU to Intel and OS to Microsoft, computer businesses were segmented based on computer stacks.

In other words, around the time when NTT decided to enter computer businesses, every company developed whole of the components from Hardware, OS to application software. Therefore, each company managed software development individually. There was not a specific standard method of managing software development.

In addition, computer capacity at that time was very poor. Therefore, there were few companies that could develop large scale software. Only IBM had accumulated enough experience to develop large scale software through U.S government projects.

[48] Cusumano (2004)

2.3.2The management of software development in DIPS projects

As mentioned before, DIPS projects introduced many advanced technologies into their systems. However, the critical issue was software development (Takahashi 1987). More particularly, in order to achieve the Time Sharing System (TSS), a multiple processor system and multiplexing structure of their systems, the development of an Operating system (OS) was significant. However, no Japanese company had developed such software on such a large scale until then. In addition, because the development took place through the collaboration of four companies, the management of software would be more complex. Therefore, NTT had to find their own methods of managing software development. NTT established detailed process specifications in software development. They regulated the content of every process, necessary documents and test schedules. Engineers in manufacturing companies complained that they were too detailed but NTT forced their partners to follow these regulations.

NTT tried to introduce a management method scheme for software development **(Figure3-2-(1)**), as methods of software management had not yet been established at that time. In the process of function design to unit testing, each company developed software independently, but all other processes were worked on in collaboration. In addition, in order for the four companies to communicate properly, every contact and every item which needed to be adjusted was documented as a contact report, in an effort to document as much as possible, including deliberation process and conclusions.

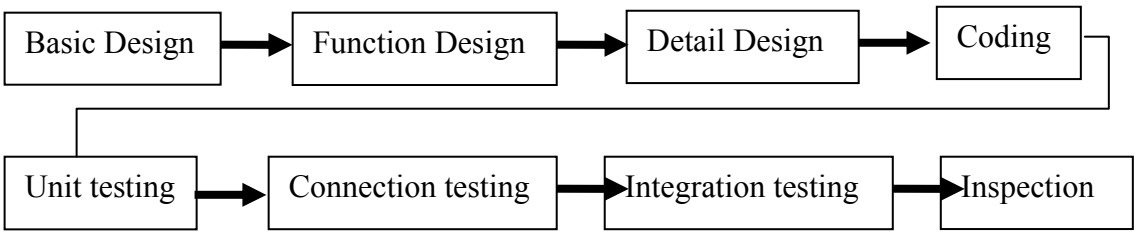


Figure 4-3-(1)The software producing process of NTT

In addition, a method of designing architecture and correct specifications with unified roles was needed. In order to ensure strictness, architecture was designed based on a computer language, PL/I. This trial could avoid the ambiguity of writing in Japanese. At the

same time, NTT managed to equalize the software development environment by developing tools.

As case seen, the way that co-operation and technology management was managed by NTT was different for hardware and software developments.

2.3.3Results of DIPS project

DIPS projects continued for 25 years. The final version was released in 1992 and maintenance was stopped in 2005. During the period, DIPS systems were used mainly for large scale public and government systems. The increasing demand of data communication services meant that banking systems and other commercial systems incorporated DIPS systems. In 1970, NTT offered three kinds of public data communication services, DEMOS services for scientific, engineering calculations, DRESS services for sales management systems and DIALS for telephone calculation services. DIPS systems played a central role in Japanese data communication services.

However, looking at these projects from a managerial point of view, they can hardly be said to have been successful. NTT incurred large R&D costs for DIPS projects. DIPS1 and DIPS 2 project incurred 40 billion yen (£ 200 million) each[49].However, NTT suffered from the heavy decline in data communication services, due to lower than expected demand. In 1982, NTT spun off their data communication department into a separate company, NTT DATA Corporation. The company belongs to NTT groups and is the biggest system integration company in Japan.

The purpose of DIPS project was to standardize Japanese computers. However, because of changing technological circumstances, the trial failed. Mainframe computers incorporated IBM compatible architecture and universal information technologies were diffused. NTT was also forced to use multiple vendor machines because of trade conflict.

On the other hand, the *family companies* benefited greatly from the projects. They succeeded in developing new products using the results of the DIPS projects. For example, *family companies* studied the know-how of manufacturing 4Kbit memory chips which had been developed by NTT. They were able to use them for their switching systems and computers. In addition, because manufacturing companies used their hardware technologies for DIPS projects, they were able to share components with DIPS projects and their own products. As a result, the three companies offered 10 or 20 % of their produced systems to NTT while the rest was manufactured for civil use. Therefore, the *family companies*

[49] Jyouho-shori-gakkai (1998

benefited both from NTT and civil use. According to Kitahara, then vice president of NTT, one aim of standardizing systems was to give them new options when considering export strategy. The demand from NTT was relatively small compared with those of switching systems and other telecom equipment. Therefore, when considering costs, it was not good business for the *family companies*. It was necessary for manufacturing companies to benefit significantly from civil and export use by using the result of DIPS projects. In this way, they would be able to compete with IBM in the Japanese computer market and finally go on to achieve top position in the Japanese computer business.

3. LSI

3.1Increase in the importance of semiconductor businesses

This section describes how NTT changed their business domain from a telephone oriented business to integration services of telephone and data communication. In the previous section, I have shown that the telecom was merged with the computer market by NTT undertaking data communication services, involving new competitors, IBM. In this section, focusing on developments in semiconductor technologies, I will look at how the Japanese telecom market was transformed by a change in technology: the semiconductor.

Even though NTT had studied semiconductors on a small scale in 1960's, they had not worked seriously on semiconductors because they did not have any manufacturing departments and the semiconductor business was regarded as belong to manufacturing companies. As a result, in spite of researchers' wishes, NTT lab did not have a 'clean room', indispensable for studying semiconductors.

However, through developing electronic switching systems, NTT understood that the semiconductor was the key technology in determining a system's performance. Therefore, they decided to strengthen their study of semiconductors, establishing a department specializing in semiconductors and building a clean room in 1971.

3.2The Calculator business and the development of IC industries

Looking at the history of the semiconductor businesses, it appears that IC was initially used only for military and aerospace technology as well as switching systems and computers. However, applying IC to desktop calculators led to a change in the world of the semiconductor business. Extending its application to civil use drove electronic companies to developing and manufacturing IC seriously. The means of winning the calculator business required more economic and product downsizing. Therefore, manufacturing technologies for mass production and integrating functions underwent significant improvements such as the introduction of the microprocessor.

The microprocessor was developed by Intel Corporation in collaboration with a Japanese calculator company, Busicom Corporation, in 1971. Busicom requested that Intel develop a semiconductor chip for calculators, put integrating functions in the chip and achieve cost reduction. Shima, an engineer in Busicom at that time, joined this collaboration on company assignment. Through this development, the first microprocessor (Intel 4004)

emerged. Firstly, only Busicom was allowed to use this chip because of the contract. However, Intel knew of the great possibilities which lay in applying it to other equipment, and therefore gained distributorship of the chip by changing the contract. As a result, Intel became a giant company in the area of microprocessors (Shima 1987).

Following this, the development of the desktop calculator business brought with it significant LSI technologies, such as micro processors and random access memory (RAM). These core technologies were developed in the USA, but Japanese companies also tried hard to develop semiconductor technologies in order to respond to demand for calculators. The expansion in demand was highly significant for the semiconductor business. As production volume increased, the cost decreased. This effect is called the "learning curve", and for the semiconductor business, the effect was noticeable. Therefore, every company tried hard to expand production volume and make cost reductions. Calculator businesses increased demand for semiconductors and cost reduction. As a result, decreasing prices for semiconductors led to expansion in applicability for other business areas, such as home appliances and control instruments. In other words, the demand for civil use strengthened the Japanese semiconductor businesses.

In Japan, *family companies*, especially NEC, Hitachi and Fujitsu, played a central role in the semiconductor business in order to respond to heavy demand from Japanese calculator companies. Japanese calculator companies asked the *family companies* to develop their original chips. For example, CASIO, which was one of two companies to eventually become successful in the calculator business, used NEC's chips and offered special products to NEC. CASIO had a competitive advantage using NEC's chips. At the same time, NEC had also accumulated capabilities of semiconductors. However, this does not mean Japanese companies had visionary foresight. In fact, when Japanese calculator companies wanted to develop new types of LSI, they offered it to U.S companies because Japanese companies had refused (Nakagawa 1981). Therefore, there were discussions as to why Japanese companies achieved dramatic growth in LSI development in the 1980's. Japanese scholars have insisted that their competitive advantages were created by an instant increase in demand from new markets[50]. However, I think this is doubtful. Instead, American companies accepted Japanese companies' demands and developed them.

NTT had a central role in developing semiconductor businesses in Japan. Their activities concentrated on increasing components per chips in semiconductor memory. Although manufacturing companies had increased their ability to develop and manufacture technologies, NTT took part in basic studies of semiconductors.

[50] Okimoto, Sugano and Weinstein (1984) described these discussions.

NTT aimed to develop semiconductors for their own products, switching systems and data communication systems, but they did not have any manufacturing departments and so had to collaborate with manufacturing companies.

In the 1950's, the semiconductor business was started by US vacuum valve companies as a sideline. However, these companies were unable to bridge the gap between vacuum valves and the semiconductors and consequently could not fully concentrate on the semiconductor business. As a result, these companies pulled out of the semiconductor business. We can see a similar situation when Japanese electronic companies like Hitachi and NEC began to enter the semiconductor business. These companies were also involved in the vacuum valve business. However, they began concentrating on the semiconductor business at the expense of the older business. One of the reasons why these companies were able to change and adapt was that they were also telecom and computer companies. These industries needed durable, high performance devices for their systems. This forced them to concentrate on the semiconductor business, whereas the American electronic companies, such as GE and RCA, withdrew from the semiconductor business. It was venture companies such as TI, Fairchild and Motorola who were to play a central role in the US semiconductor business.

Switching systems and computers provided the main demand for semiconductors. Therefore, IBM and Western Electronic Corporation became "captive makers" of semiconductors. A captive maker means a company that develops and manufactures products for their own use only. Therefore, neither company's product appeared in any market. Other U.S companies concentrating on semiconductors were relatively new and small. They manufactured for external companies. TI and Intel are typical examples. On the other hand, many Japanese companies manufactured semiconductors both for their own products and for selling to other companies. According to Itami (1987), the demand for semiconductors in Japan was different from the demand in the USA. However, demand and the supply were closely connected within a company in Japan. Therefore, U.S companies tended to exchange in the market, while Japanese companies exchanged both within the market and their company.

The Japanese demands for semiconductors were answered by NTT and calculator businesses. NTT forced manufacturing companies into accepting cutting edge products and requested them to manufacture high quality products and to keep to tight deadlines. On the other hand, civil use offered cost performance through mass production and the chance of finding new markets such as the calculator business. Therefore, using technologies developed in exchanges with NTT, manufacturing companies greatly benefited from the

calculator business. It might be said that the demand from NTT provided the chance to develop and mature new technologies. On the other hand, calculator businesses also offered semiconductor businesses the chance to expand.

Apart from NTT and calculator demand, Japanese manufacturing companies produced semiconductors for their own products. These were general electronic companies which deal with large product areas. In order to compete in markets, their products needed to be smaller, more economical and highly functional. As a result, by using semiconductors for their products, they tried to bypass their competitors. In other words, they had semiconductor markets within their own companies. Therefore, they were able to have market information from other departments in their companies. According to Itami (1987), there were two types of information: technological information and market information. They gained technological information from existing customers in their companies. In order to improve the quality of semiconductors, information from actual mounted semiconductors was needed. In other words, in the process of developing, field testing and commercialization, companies gained a lot of information on how to improve quality. As a result, they were able to develop their manufacturing capabilities (Day 1994). To have such information from their own companies incurs less cost than when they obtain it from external actors. In addition, Itami pointed out that having customers within their own companies is more efficient when it comes to obtaining market information. Higher integrating semiconductors can be regarded as a system. As a result, semiconductors became indispensable when companies developed new products. Exchanging information between semiconductor makers and users was the key factor in success in the business. Therefore, easier exchange of information created the competitive advantage of knowing market needs and future demand for semiconductors.

There was an additional factor in how companies gained new technological information. If a company only takes care of its own companies, it is very difficult to be aware of external conditions. Having methods that achieve easier communication with external companies is needed. From this standpoint, NTT and Japanese government projects played this role. By collaborating with NTT and other companies in these projects, they were able to obtained external information very easily.

4. Discussions and Summary

This section describes how NTT and *family companies* changed their methods of R&D activities in tandem with the changing telecom market, integrating the computer and LSI markets. Previously, NTT had concentrated their accumulated resources only into the telecom business, consequently only watching the movement of telecom industry. 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. Looking at these different periods, the following three factors can be shown.

4.1 Increased complexity of the telecom market

By integrating the computer and LSI markets, the Japanese telecom market became more complex. In the computer industry, new technologies were appearing frequently. Under these circumstances, the key factor in winning the market was what technologies were accepted and what withdrawn. In addition, companies had to be aware of the market change. The factor in winning the computer market had changed from excellence in the design of architecture into the development of high performance devices. In addition, software development became a key factor in winning the market.

In the LSI market, along with the development of the calculator business, new technologies and actors 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, similarly to the way in which calculator businesses created new LSIs, unconnected 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. The numbers of actors involved in telecom markets increased and many other factors influenced the market. Therefore, NTT was forced to watch other markets' activities as well as their relevant ones'.

4.2Change in actors

Considering this in more detail, over the periods described in this section, NTT's target apparently changed from AT&T to IBM. Prior to this, when NTT were developing electronic switching systems, AT&T was the only target and NTT tried hard to reach and overcome 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 actors were concerned with the industry. Therefore, it was very difficult for NTT to watch all actors' activities and gather technological information from them.

4.3 The collaboration

Following on 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.

As I have just described, the collaboration system functioned well and reached a period in which it flourished. However, along with developing *family companies*' abilities, the contents of the collaboration with *family companies* and NTT changed slightly. Looking at the development of DIPS projects, *family companies* came to compete within the collaboration. In addition, mutual relationships were slightly weaker. As the next section describes, changes in Japanese telecom business circumstances accelerated these trends.

To summarize, NTT were initially only concerned with their telephone system, especially switching systems in the network. However, as the telecom market changed and expanded, they began watching the whole network, including components and terminal equipment, such as computers, existing in the network.

Section4.
Changing a telecom market along with developing technologies

1. Integration of computer and public networks

In 1977, NTT and NEC presented their managerial concepts independently. NTT announced the INS concept while NEC presented their C&C concept. Both were basically the same as aiming as they did to integrate computer and communication services by digitalizing the networks. Examining the background to these concepts, all back orders for telephone demands were expected to be resolved in the end of the 1970's. NEC's management itself was mainly built from NTT sales. In order to reduce dependence on NTT, they concentrated their business areas on electronic devices and computers. On the other hand, NTT was forced to present its new managerial vision after resolving the telephone back orders. Therefore, NTT tried to expand into data communication. Kitahara, then vice president of NTT, had the idea of integrating telephone and data communication networks since 1965, when he had argued strongly for NTT to begin communication services[51]. In 1972, following Kitahara's idea, fibre optics, digitalization and LSI had become established as the three pillars of NTT's R&D strategy[52]. Kobayashi, president of NEC at the time, had decided that computers and communication would be the main business areas for NEC as long as 1964. Anyway, both companies had these concepts over 13 years when they showed their concepts. However, they had not been able to present the concepts publicly until 1977, as their technological levels had previously seemed too low for this to be realistically achievable.

These integration concepts announce in 1977 were not new. In fact, ITU-T, the international organization for establishing standard communication protocol, had come up with the concept of ISDN, which aimed to integrate telephone and data communication services, in 1972[53]. As previously described, American companies like IBM and AT&T, plus European companies, had also considered these ideas[54]. The significance of NTT's concept

[51] Nikkei Business, 1984-09-24, pp.6-9.
[52] NTT (1976)
[53] Irmer (1986)
[54] ibid

was that they had begun to look into consumer markets. In fact, after announcing the INS concept, NTT called for participating companies to join them. Although data communication services had developed, the type of services was mainly on-line between firms. In addition, NTT tried to predict what services would be in demand and how consumers would use the INS networks. Furthermore, NTT prepared an INS experimental model before the actual system was released. The project took place for two years (1984-86). In this trial, they offered trial services to 10,000 subscribers by collaborating with participating companies. These companies consisted not only of *family* and telecom companies but also of local administration and companies from other business areas. Focusing on the transfer of characters and pictures as well as voice, they considered what kinds of services should be available in the INS network. They checked these services' availabilities and also experimented with new technologies such as charge systems, based on send/received information volume.

However, during its initial phase, the trial attracted a lot of attention. However, NTT did not present an attractive new world to public. There are several reasons. This trial was led by NTT, who forced *the family companies* to consider its new services. In addition, according to a researcher in NTT labs, the aim of the project was for their new technologies to be realized. The project was based purely on technological concerns. In other words, NTT approached the consumer market with the same attitude they had towards their telecom market: all telecom services were developed and provided by NTT. Prior to this, NTT had only looked at their telecom network, concentrating on watching telecom relevant companies, *family companies* and AT&T. However, developing technologies led to a change in their telecom market. As a result, NTT had to watch consumer markets as well as other business industries such as LSI and computer relevant companies.

2. Digital Switching systems

2.1 Toward digitalizing a network

Developing LSI and computer relevant technologies meant the realization of a digital network. There were two purposes to digitalizing the network. One was to achieve an economy of network costs while the other was to integrate telephone and data communication services. The main idea in achieving this was that by incorporating the Time Sharing System (TSS), many users shared paths by time division, creating more economical and downsized systems. By encoding information as 0/1 bit, a network is not concerned with differences between bearer services (Voice or data). In other words, data communication and telephone services can be exchanged within the same network using the same mechanisms. The digital switching system was a key to integrating these services.

Although NTT had succeeded in developing electronic switching systems, they had a big problem. The existing electronic switching systems used many analogue switches incorporating space division systems. On the other hand, in order to increase efficiency, transit lines adapted multiple transmission technologies by transmitting digital signals using the PCM method. Therefore, an electronic switching system had to convert its signals from digital to analogue. Consequently, the efficiency and quality of the signals decreased.

On the other hand, there are several advantageous features when digital switching systems are introduced to the network. Firstly, a system can be downsized and costs reduced by adapting LSI to the components. Secondly, reliability and maintenance efficiency can be increased while quality of communication traffic is also higher. Thirdly, a variety of services can be offered by integrating the network. Digital signals can exchange any type of data, therefore data, FAX and voice communication can be transmitted within the same network.

NTT had studied TSS and developed an experimental system. However, the relevant technology at that time was not sufficiently advanced to commercialize TSS. Along with developing LSI technologies, several functions could be realized by LSI, so the PCM exchange method was achieved economically.

Along with the demand for data communication services, NTT recommenced their study of TSS systems in order to build a data communication network in 1971. The network was called DDX and the first digital switching system (D50) was released in 1979. In the same year, data communication networks became commercialized. Following the success of this, NTT tried to develop their original digitalized telephone network.

2.2 The Development of digital switching systems

The previous purpose of digitalizing the telephone network was to achieve cost reductions and efficiency within the network. In 1976, Northern Telecom Corporation released the world's first digital switching system[55].

According to NEC's history[56], they reacted quickly after hearing this news. The sales volume of existing switching systems (crossbar and electronic systems) fell drastically in the US market after the emergence of digital switching systems. However, NTT's attitude towards digital switching systems was not clear at that time. As a result, NEC decided to develop digital switching systems themselves. In 1977, they released their first system, called NEAX61. The system became a best-selling product through the continuoUSAddition of new functions and improvements. This showed that technological levels of manufacturing companies had improved and that they could develop new systems by themselves without NTT's help. However, NTT's project was conducted in the same manner as in previous years: collaboration between NTT and *family companies*.

In 1978, NTT asked *family companies* to collaborate on digital switching systems. At that time, because NEC had already produced the NEAX61, they called for the incorporation of their system into NTT's standard digital switching system rather than the development of a new system. However, NEC finally accepted NTT's offer because they did not want to disturb the collaboration that had been in existence since the war[57].

As a result, the development of digital switching systems took place in the same way as before. The *family companies* of Fujitsu, Hitachi, NEC and Oki joined the project in1977.

Using the results of DIPS and other projects, their first trial system was finished in 1978 and field-tested in 1980. As with previous projects, the *family companies* developed the hardware in collaboration with NTT while sharing the manufacturing components. Each company assembled their systems independently. The first commercial system was released in 1981, manufactured by NEC. This system was called the D60, and was developed for transit exchange. Next, the D70, used both for transit and local exchange, was released in 1982, also manufactured by NEC. The D70 system's significance lay in the fact that it was built according to the INS concept advocated by NTT. The system had several features: LSI was fully incorporated for local path units, timesharing paths and signalling functions in

[55] NEC (2001)
[56] NEC (2000), NEC(2001)
[57]Only NTT initiated the Japanese telecom market. In addition, the collaboration system with any switching projects had been closely linked with NTT's procurements. NEC was afraid they might lose advantages both of technological and managerial issues if they stuck to their way, as a result, they kept away from the collaboration system NEC (2000), NEC(2001).

order to achieve reduced costs and greater reliability compared with those of existing systems.

In the development of software, NTT and the *family companies* acted dependently. Firstly, NTT allowed for competition in development. They shared software developments based on the function block (FB) formulation[58]. A function block is a unit of software. The value of FB is not only in function units but also in sharing units of development. This method featured strongly in NTT's software development. The software scale of switching systems was tremendously large (tens of millions of steps). In addition, software manufacturing took place through collaboration among the four companies. The importance of software management meant that NTT would attempt to manage software development based on FB methods. For example, neighbouring FB not shared with the same company in order for each company to compete on qualities and to the deadline of the FB. If the quality is too low or the deadline is late, this would immediately become apparent. As a result, companies tried hard to maintain high quality and keep to deadlines.

In addition, NTT developed their original operating system for the new switching system. This OS was developed based on their original programming language, CHILL which was the Assemble language, a type of machine language[59]. Other common software languages were unacceptable because the hardware performance at that time was relatively poor; meaning the size of the OS had to be minimal. Therefore, NTT had to develop a unique OS for switching systems. This meant that they needed to develop a compiler and software development environment. Because of the collaboration involved in the development, each source programme was written in each company's unique environment. However, they used the same compilers and linkers in developing the software. The experience and results of the DIPS projects greatly contributed to the software development.

[58] NTT (1999), and NTT "The change of software developments in switching systems", available at < http://www.hct.ecl.ntt.co.jp/exhibit/technologies/pdf/1_A_11_1.pdf> accessed at 16-March-2009.
[59] CHILL a programming language specified for switching systems and other software assets that NTT had developed for their past projects.

3. International standardization activities

Through the development of data communication services, the number of actors involved in these businesses inevitably increased. New entrants to this industry included not only telecom companies but also computer relevant and information businesses. This led to the establishment of international standardization activities. Although there were already some established standard processes, the X25 became the first serious communication protocol. The X25 protocol set up the process in which a computer connects with other computers within a public network. NTT developed their data communication network by following this protocol in 1980. After that, ITU-T, the international standardization organization, tried to establish a new protocol for the integration of telephone and data communication services. Consequently, work was finished in 1988 and called the ISDN protocol. NTT improved their developed digital switching systems to add the ISDN function that same year.

NTT focused on international standardization activities at the onset of the establishment of the X25. There were two reasons why NTT were in favour of standardization activities. Firstly, with the expansion of telecom industries by involving other business areas, the amount of equipment connecting public networks increased. Therefore, standardized protocols were needed in order to unify interface specifications. The other reason was that international standardization activities benefited Japanese telecom companies, especially the *family companies*. After resolving telephone back orders, NTT's expected their number of placed orders to decrease. To compensate for this, the *family companies* had to find a way of concentrating on export businesses. In the Japanese telecom industry, NTT's activities decided Japanese standard interfaces. If NTT used unique interface specifications, the *family companies* were forced to manufacture two types of system. Therefore, by equalizing the interfaces, systems manufactured for NTT could be used for export businesses. NTT encouraged ITU-T to use NTT's method for the ISDN protocol because NTT had already developed INS systems. In terms of the result, ITU-T accepted the European proposal which was not so different from NTT's methods. NTT worked hard with standardization activities because they wanted to operate in the telecom market as a leader in the standardization of telecom interfaces. As a result, these activities mainly took place in three areas: the USA, the EU and Japan.

4. Discussions and Summary

The INS concept meant that not only could computers be connected to public networks, it also showed that the telecom market was changing, offering new services by exchanging characters and pictures as well as voices. At the time, European companies were divided into computer and telecommunications businesses. In other words, European telecom companies were not allowed to touch the computer business. Correspondingly, in the USA, the FCC (Federal Communications Commission) did not permit AT&T to deal in the data communication and computer businesses. Consequently, AT&T decided to split their business between telecom operations and R&D activities. At any rate, NTT was the only company involved in both businesses and, as a result, they became the first runner to enter new businesses. Following this, NTT had to concern itself with consumers in order to develop a new market. However, their attitude was still telephony network oriented, which meant that they watched the market in the same way they had always done: all services were all services were developed and provided by NTT.

In the development of digital switching systems, it was NTT's past activities that led to the success of the development. The development of the DIPS projects greatly contributed to digital switching systems and INS concepts, to say nothing of LSI. Shiromizu[60] said that there were two effects of NTT's involvement in data communication services. One was that NTT was forced into competition. This was a first for NTT. Secondly, developing technologies in data communications were used for the digital switching systems. Most significantly, software development became indispensable to the realization of the INS concept. If NTT had not been involved in data communication, the INS concept would not have happened.

Because NTT kept four companies collaborating and incorporated their original technologies, the contents of the collaboration bore no apparent signs of change. However, looking at the civil market, the market of private branch exchange systems changed dramatically after incorporating digital switching technologies. Digital switching systems convert voices into digital signals and transfer these as data. Therefore, telephone sets, fax, and computers can be connected to the network directly. In addition, through the development of computer relevant technologies, the private branch exchange system added other functions and became a kind of information machine. In other words, the developing technologies led to the market changing from being merely a telephone exchange market to one with both a data exchange market. This made it easier for new actors to enter the market.

[60] Nakagawa (1990)

As a result, although the *family companies* occupied the market of private branch exchange at 90%, after digitalizing, new players such as computer, electronic and information systems companies, entered the market and the business circumstances became competitive. Consequently, due to the advances in the *family companies*' levels of technology, they were not necessarily dependent on NTT's help in their development. This led to a change in the relationships between the *family companies* and NTT, with the latter incorporating internet technologies into their systems shortly after.

In addition, pressure from standardization activities led to telecom market changes. By adapting their systems to international standards, companies found it easier to offer telecom equipment because they were not forced into accepting NTT's unique specifications, which were very detailed and complex. As a result, new actors began entering the telecom market.

Considering the above, it can be argued that technological developments brought about changes in the market. In other words, developing the technology expanded its domain of applicability. As a result, the existing market was forced to undergo change. For example, LSI and computer relevant technologies were initially used in the computer industries. However, their fast progress led to them influencing telecom markets. This in turn resulted in data communication services and the integration of telephone and data communication. Consequently, a number of new actors began to appear in the telecom market. In addition, telecom relevant technologies expanded, influenced by new technology developed in other business areas. The telecom industrial market was therefore forced to change. There were also changes to the content of services offered in the telecom market from a voice transfer service to a data exchange service. In order to respond to these changes, companies had to take the consumer market seriously. In other words, NTT had to change the way they approached their market.

Section 5
Integration of telephone and IP based technologies

1. Privatization of NTT and liberalization of the telecom market

1.1. Trade conflict and privatization[61]

From the end of the 1970's, NTT faced a procurement problem with the US government. In spite of the rapid development of the Japanese economy, that of the US suffered from a trade deficit, and the US was focusing particularly on its trade imbalance with Japan. The Japanese government had been experiencing US trade conflicts in the automobile and textile industries since the 1970's. These problems had temporarily been resolved by introducing self-restraint into the auto-industry together with local production in the USA. The US government then switched their focus to NTT, a giant of Japanese local investment. They insisted that NTT had not made enough purchases of foreign components and systems and that they had limited their exchange partners to within *family companies* through "Zuii" agreements[62]. This became a political issue between the USA and Japan, leading to both governments and NTT reaching a final procurement agreement in 1980. However, problems remained as there was no subsequent increase in the actual amount of foreign procurement.

For NTT, telecom components could not be exchanged in an open market. In fact, the quality and reliability of telecom components required very high levels of manufacturing expertise. Therefore, their inspections involved examining not only the quality of the product but also that of the manufacturing process. In addition, to introduce extremely reliable telecom equipment, advanced technology was always used for these products. As NTT itself did not have manufacturing departments, they required a very close relationship with technologically advanced manufacturing companies. In addition, if general competitive

[61] This section is described based on Shimoda (1980), Nakagawa (1990), NEC (2000), NTT (1996) and Oki (2000)
[62] Making a contract with specific companies that outsourcers assign in advance.

biding was involved, technological know-how tended to get leaked, as the specifications had to be shown. This know-how had accumulated through collaboration with *family companies* over a long period. Therefore, if these were open to other companies, the collaboration system would have collapsed. However, NTT continued with their open policy. According to Shindo[63], there was another reason for this in addition to solving trade conflicts. In opening the market, NTT lab expected to expand its partners, who would be able to exchange technological information.[64] As a result, NTT maintained an open procurement market for foreign companies. For example, they introduced digital switching systems from the Canadian company, Northern Telecom Corporation.

Pressure to open the NTT-dominated market also came from the Japanese business community. They had not been able to enter the telecommunication market due to NTT's highly interlocked relationships.

In fact, NTT only exchanged with a limited number of companies (about 300). NTT decided on candidates by demanding high quality and emphasizing past delivering records. Therefore, new companies were hardly ever allowed to enter NTT's market. Along with the Japanese telecom market, which included computer businesses, companies existed in other business areas became interested in the telecom market. Therefore, there was pressure to open the market because information services were operated through NTT's communication lines. The Japanese business community had already requested the liberalization of data communication services. Consequently, Japanese telecom regulations had changed to allow private companies to operate data communication services through a public network in 1971. Meanwhile, the large amount of investment in data communication services caused NTT to suffer a large deficit[65]. Therefore, NTT were criticized, as this deficit was compensated for by the profits from telephone services. As a result, NTT decided to open its public networks further and to split from its department of data communication services. Additionally, the Japanese government decided to privatize NTT, in an effort to streamline government agencies. NTT became a private company in 1985 and the data communication department separated from NTT as NTT Data Corporation was privatised in 1988.

[63] Hisashi Shindo was the last president of NTT Public Corporation and the first president of NTT.
[64] His interviews in Nikkei Business (1983) 16/11 pp50-51
[65] For example, 50.3billion yen in 1977, 52.8 billion yen in 1978 and 50.1billion yen in 1979 (from Shimoda (1981).

1.2. Change in the collaboration system

Following these events, the relationship between NTT and *family companies* changed slightly. Liberalization allowed private companies to sell telephone sets directly to customers. Previously, Japanese regulations permitted only NTT to do this. Therefore, both NTT and the *family companies* were now competing in selling not just telephone sets but also other telecom equipment such as fax and PBX.

In order to compensate for the drop in business from NTT, *family companies* decided to concentrate on civil use and export business. Until 1980, manufacturing had very high proportion of their sales taken up by NTT. Almost 50% of NTT's procurement was dominated by four *family companies*[66]. At the same time, their management depends on NTT's businesses. The dependency was 15.6% of NEC's annual sales, 14% of Fujitsu's, 26% of Oki's and 2% of Hitachi's. However, by 1990 this dependence rate had decreased by a third.

In addition, because NTT's switching systems tended to be over specified, the prices were relatively high. Therefore, they were rarely exported to foreign countries. Furthermore, NTT gradually pressured manufacturing companies into reducing the cost of their systems.

This meant that NTT's business for *family companies* was no longer such a rich source of profit compared with previous years, when NTT had been their biggest customer. When they tried to work on high risk developments, such as electronic devices, through collaboration, NTT covered the costs. Furthermore, NTT purchased any equipment in bulk at prices set by the companies. Therefore, in order to keep the relationship, the *family companies* obtained their human resources from NTT[67].

However, this situation was to change. Originally, all the *family companies* tried to expand their business areas from telecom into other electronic businesses in order to reduce their dependence on NTT, with NEC and Fujitsu, for example, concentrating on computer businesses, as part of a major attempt to escape from NTT's dominance.

These movements also slightly influenced R&D activities. For example, Shiromizu[68] said, "Simply speaking, ways of communications with manufacturing companies changed drastically. In the past times, we could consult with *family companies* apart from businesses. But now, we should consider contracts when we discussed with engineers in *family*

[66] The figure comes from Nakagawa (1990).
[67] Because the management of family companies were dependent on NTT, family companies wanted to have good relationships with NTT. Family companies attempted to have information of NTT's management smoothly through executives coming from NTT.
[68] Genjiro Shiromizu was the vice manager of Research and Development department in NTT at that time. Cited from Nakagawa (1990)

companies". Therefore, when collaborations continue existed projects or begin to new developments, they had to exchange agreements of patents and technological know-how every time in detail.

Another significant change was the opening of the R&D market to foreign companies. After Shindo becoming the last president of NTT as a public corporation, NTT not only opened its procurement market but also its R&D market to foreign companies. Two new players, Northern telecom and Toshiba, as well as four *family companies*, took part in the experimental project of ATM systems (Asynchronous Transfer Mode). In addition, NTT entered into cross licence agreements with IBM and also collaborated with them in an LSI study.

However these institutional changes did not have much impact on the collaboration system. In fact, Toshiba and Northern Telecom did not participate in the next serious development, the MHN project. This was mainly worked on by the four existing *family companies*. In other words, the only significant change to come out of this was that the drafting of contracts became a more complex operation. The overall spirit of R&D collaboration remained unchanged.

Privatization and the open policy towards procurement had an influence on the relationship between *family companies* and NTT regarding managerial issues. This led to *family companies* escaping from NTT's dominant management. However, this was partly influenced by R&D activities – the *family companies* had already obtained enough technological capabilities to draw level with foreign telecom companies. Therefore, there was no need for NTT to change partners. In addition, the *family companies* had a great deal of experience in collaborating with NTT.

However, the emergence of innovative technologies had a dramatic effect on the collaboration system, and the next section describes the influence of internet and computer technologies.

2. Open system and Networking[69]

2.1. UNIX operating system

The 'open system' and 'networking' dramatically changed the computer business in the 1990's. This was accompanied by the emergence of the UNIX workstation and the development of personal computers connected to the network through Ethernet.

Workstations used inexpensive microprocessors and their architecture and physical design had much in common with personal computers. They featured the use of the UNIX operation system and their extensive networking abilities. The UNIX system was created by Bell Lab for researchers to use only within laboratories. Its significant feature is an open-sourced code written in C language. Therefore, UNIX could run on any machine that had a C compiler. By contrast, existing computer makers guarded their source codes and did all they could to lock customers into their products. At this time, AT&T was prohibited by the government from entering the computer business. They could not profit from its sale and therefore opened the source code.

Around the 1960's and 70's, most operating systems were written in primitive languages like assembler or machine code due to the poor performance of computers and compilers. On the other hand, C language uses English-like commands and is an established format that developers have to observe. Therefore, modifications are much easier.

These features allow the development of a variety of applications working on UNIX, and it was used by many private companies, institutions and educational establishments in the US. The project with most contributions was carried out by the University of California, Berkeley. Berkley's product, called BSD (Berkley Software Distribution), also came with a utilities editor (vi editor) and shell commands, but is famous for being the first version of UNIX to have Ethernet and TCP/IP protocols using a modified AT&T version. Therefore, BSD became a UNIX standard and the prototype of future operating systems. Because BSD was developed based on AT&T versions, there were some conflicts after AT&T had changed their distribution policy. However, they continued to improve their systems, and finally succeeded in developing a genuinely original system, free of any AT&T components. As a result, BSD UNIX became freely distributable, introducing lots of additional free software such as Linux.

[69] This section is based on Ceruzzi (1998), Weber (2004), Cusumano (2004), Yost (2005) and study of files at NTT

In the beginning of the 1980's, AT&T got rid of seven of its local telephone operators in order to avoid antitrust laws and enter the computer business. Correspondingly, they had to sell the licence for UNIX. However, venture companies continued to use it because of the easier modifications and the variety of its developed utilities. In addition, its continuous development meant that it became a highly reliable kernel. Therefore, most users gradually began to use the combination of UNIX and workstation as their information system. Later, Sun Microsystems Corporation collaborated with AT&T to develop new UNIX systems, Sun-OS and Solaris. Additionally, Hewlett Packard Corporation also developed their UNIX systems (HP-UX) based on AT&T versions. They sold the combination of their UNIX and unique hardware.

With superior networking functions, UNIX workstations realized that having a computer at each worker's desk, networked to other machines, was more efficient than having a giant centralized computer accessed by poor-performance terminals, and could be done much more cheaply. Consequently, many applications, such as networking, database, and file-sharing systems, were developed to work on UNIX. As a result, customers preferred to construct their systems based on these open system components.

2.2 Ethernet and Networking

UNIX was developed for researchers who exchanged and shared their files within a local area, i.e. an office or a building. This was achieved using Ethernet protocol, developed in Xerox laboratories in 1973. Its speed would alter the rate of change of computer businesses. At the beginning, the speed was around three million bits per second at a time when 50 Kbps telephone circuits were considered fast. Ethernet is a protocol that uses part of layer 1 and 2 in OSI[70]. Through simple tapping cables (twist pair cables or coaxial cables), a framing signal is transferred to all equipment existing within a segment. Consequently, the equipment decides whether the signal has been sent to itself or not based on the MAC address which is a unique identification. These methods could handle much larger amounts of traffic than telephone oriented connections. This invention arose from the concept of LAN (Local Area Network) which was based on the premise that workers could share a printer and files, communicating with other workers through simple messages. Several LAN protocols were developed: Apple talk (developed by Apple Corporation) and Taken Ring (IBM developed) are examples. However, the emergence of Ethernet immediately impacted

[70] The Open Systems Interconnection Basic Reference Model (OSI Reference Model or OSI Model for short) is a layered, abstract description for communications and computer network protocol design.

on workstations and UNIX operating systems because the Ethernet's specifications were open. Both combinations equipped with this function immediately became popular. By the end of the 1980's, local area networks gave a larger number of people the opportunity to use computer networks.

However, LAN is not able to provide different LANs, nearby local area networks, to facilitate data sharing and inter-LAN communication. A router is a computer that allows individual LANs to remain distinct but enables the forwarding of data packets between them. The main function of a router is to transfer data based on IP address. The router has a translator - a table of mapping IP addresses and interface numbers. This table is created dynamically by using the most expedient route based on traffic load, lower cost, speed and other factors. This function enables users to communicate and share data over each LAN. The first route was a software route which operated routing functions by software operation. However, extra hardware was added to accelerate the performance of the routing functions. As a result, routers became smaller but cheaper pieces of equipment. This market was developed by new venture companies, such as CISCO Corporation, Juniper Networks and Allied Telesis (a Japanese company).

Consequently, for users connecting to LAN, the most important thing was access to the Internet. There are several technical factors behind the emergence of the Internet. One is that the ARPA project supported the development of and the decision to adapt the TCP/IP protocol. Berkley UNIX including TCP/IP protocols had great influence on it becoming the standard. The emergence of the OS packaging TCP/IP protocols meant that the protocols became widely available in universities and among computer engineers.

2.3. PC and networking

The development of the personal computer was the important factor in changing the computing world. After Intel invented the microprocessor in 1971, personal computers became a realistic proposition. During the 1970's and at the beginning of the 1980's, personal computers were used mainly by individuals or computer enthusiasts, not office workers. However, the emergence of IBM personal computers in 1981 was the trigger to diffuse PCs among workplaces and individuals. IBM's PCs were famous for their DOS operating systems and Intel processors. Unequipped as they were to sell mainframe computers, a number of companies were now able to enter the computer business. With mainframe businesses, the computer firm, in this case IBM, developed all the computer components, from hardware and operating systems to application systems. With PCs, on the

other hand, the components were developed by many different companies in cooperation. As a result, good practical applications were created such as word processing and spreadsheets. These applications targeted common office workers. Because IBM did not have sufficient experience and skill to develop software for small computers, they outsourced application development and bundled it with their personal computers. It was Microsoft Corporation that developed the basic programme language (BASIC) working on their OS (MS-DOS) for personal computers. These developments led to many companies creating more applications. The IBM PC and its clone machines immediately became popular in the workplace. Even though UNIX operating systems were developed and the workstation had become popular, most office workers preferred personal computers because they mainly used word processors and spread sheets for basic accounting. UNIX was essentially a set of tools rather than a complete operating system. That meant it was very hard for common users to operate and understand UNIX. Therefore, workstations with UNIX never replaced personal computers with Intel CPU and MS-DOS at office workers' desks.

However, these DOS-based personal computers were late in getting networking, as the Intel processors and the DOS operating system were not well-suited to this. In the late 1980's, software companies such as Novell Corporation offered networking software that worked on the DOS system with Ethernet adaptors. At this time, because PCs had poor memory and CPU power, they were not equipped with an Ethernet port and the DOS had poor networking functions. However, with developments in chip density, the power of PCs had greatly increased. Consequently, with the emergence of Windows NT, PCs were able to become servers.

2.4. Micro-Processors

Along with the continuous improvement of UNIX, microprocessors were also developing. This led to the emergence of RISC (Reduced Instruction Set Computer) processors. This basic idea was that a smaller set of instructions, using more frequent commands to load and store data to and from memory, could operate faster. The idea was influenced by the development of compilers. A compiler translates the English-like commands of a high-level programming language into the primitive commands of machine code. Software developers working on UNIX tended to make programmes using a high-level language, C, therefore the performance of compilers made for greater working efficiency. Having a poor performance computer, designers could hardly use a compiler comfortably.

Therefore, the idea was that computer designers could use rich construction sets at low cost with poor memory and CPU.

At the beginning of the 1987, Sun Microsystems introduced a workstation equipped with a RISC chip. Their architecture was named SPARC (Scalable Processor Architecture). As it turned out, the combination of a SPARC processor plus Sun-OS UNIX was a very strong one, being attractive for customers with its high performance and low cost.

Another RISC project carried out at Stanford University also went to a commercial venture, MIPS Computing Systems, which also helped establish a commercial market for RISC processors. In 1991, their main processor (the R4000) was released, while they also improved their microprocessors. The most important feature of MIPS processors was that they sold licenses to other parties. Therefore, many companies used them to replace their existing processors, launching them on appliances such as game terminals and other workstations. Similarly, in the early 1990's, Apple and IBM joined with Motorola to produce a RISC microprocessor called 'Power PC' in order to compete with Intel processors, which were dominating the personal computer world.

These technologies came from US companies that also had licenses for all patents. Therefore, NTT and Japanese companies bought from them or made alliances with these companies. Because the *family companies* were also computer and information companies, they aligned with them immediately. For example, Fujitsu engaged with Sun Microsystems with regards to SPARC processors[71]. Hitachi became the second source manufacturer of Motorola Corporation and manufactured the MC68000. This processor was used for NTT'S the first versions of MHN systems (mentioned later). NEC also became involved with MIPS technologies[72], which had succeeded in developing another kind of significant processor, the R-series. After obtaining the licenses, NEC manufactured them and they were then used for NTT's switching systems.

The development of microprocessors also influenced personal computers. The combination of Intel processors and MS-DOS operating systems (called IBM compatible PCs) dominated the personal computer market. Therefore, Intel needed to consider the compatibilities of MS-DOS. If the instruction sets of microprocessors were changed, the existing operating systems could not be used. Because of open source codes, the UNIX was able to work by compiling the source code on a new processor. However, Microsoft did not open MS-DOS, so Intel improved their microprocessors, keeping the compatibilities but

[71] Fujitsu had worked with Sun I the manufacture of Sun's processors (Southwick 1999)
[72] NEC affiliated with MIPS corporation, releasing a product based on MIPS architecture, VR 4000 in 1991 (NEC 2000).

adding new architecture. They concentrated on improving clock frequency and expanding throughput. The performance of PCs was dramatically improved by a powerful CPU as well as the development of relevant components, memory capacity or bus[73] speeds.

2.5. Changing computer industry

Clusters of small computers, such as workstations and PCs, gradually replaced the legacy computer world of a large central system. Workers were able to share and exchange any type of information through clusters of small computers much more cheaply than by using a mainframe computer. Consequently, the most important thing for users connecting to LAN was access to the internet using routers. Along with UNIX and PC using Ethernet and TCP/IP protocols, the computer world shifted from centralized mainframe computers to client-server computing.

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 significant development, which included the introduction of RISC processors. Their performance was almost equal to that of mainframes.

Again, a significant factor was the rise of local area networks. With the invention of Ethernet in 1973, the economics of computing changed. In mainframe computers, time-sharing technology matured and became available for users to share machine power, but they were nevertheless supplanted by client-server computing. By connecting through local area networks, a network consisted of personal computers and/or workstations connected to a variety of servers. These client-server computers brought flexibility of network scalabilities and the efficiency of shared network resources.

Additionally, inter-compatibilities helped change the computing world. In the legacy computing world, centralized mainframe computers allowed limited kinds of terminals to connect with each other. All software, operating systems, CPU and other relevant components were managed by computer suppliers. Therefore, in changing to an open system, customers could select a combination of hardware and OS, Sun workstations plus UNIX or 'Wintel' (Windows plus Intel processors), incorporating their own chosen specified applications. Customers could construct their own networks cheaply by choosing a cost and scale that suited their conditions. These 'downsizing' movements led to a huge change in the

[73] A bus is a subsystem that transfers data between computer components inside a computer or between computers.

computing market. PCs and workstations eroded the market of mainframe and medium-sized computers.

IBM was forced to change its managerial methods after sales from mainframe businesses drastically decreased, suffering huge losses in 1993. IBM had accumulated its software development capabilities throughout its history. However, despite its long record of achievements in software development, in the 1980's and much of the 1990's IBM was unable to adapt its mainframe programming skills to the new world of personal computers. Adding to this the fact that IBM had ignored the new world of personal computers, unlike the mainframe business, there were minimal entry barriers for PC software entrepreneurs. The platform standards, defined by the IBM PC in 1981, based on Intel and Microsoft products, constituted relatively open technologies.

The significant change in the essence of computer technologies that came with the open system meant that the industry was forced to alter its managerial methods. Companies tended to sell bundles of hardware, software, consulting, and maintenance services. The mission changed to selling and servicing not only their own products but also the products of other major industry vendors, including those of rivals such as Microsoft, Oracle and Sun Microsystems.

Additionally, they adopted standard protocols so that their software products could run on different types of hardware, including competitors' machines. At the same time, their hardware could run different types of software. As a result, they became the main users of the Linux operation system, Java programming language, and other open sources, such as the Apache Web server for low-end web hosting applications.

Finally, companies in the computer industry tended to focus on 'connecting to the internet'. By using the open-source interface standards and Java[74] they could connect their systems to diverse computers and software programs being used on the internet. Companies tried to concentrate their software resources into internet middleware and open systems.

[74] Java is an object-oriented language. However, Java also provide software developments environments, which became ordinary tools for software developers.

3. Towards the integration of N and B-ISDN

3.1. NTT's vision of a new telecom market[75]

NTT thought a new telecom market would be realized by ISDN protocols. These are a communication protocol series established by ITU-T. ISDN has two main types based on bandwidth, narrow band ISDN (N-ISDN) and broadband ISDN (B-ISDN). N-ISDN had already been commercialized by the development of digital switching systems in 1986. Because N-ISDN was available using existing metal subscriber lines, the system had been connected to the public telephone network. On the other hand, B-ISDN had continued to establish international protocols in ITU-T working groups, but the main concept was would be realized by ATM (Asynchronous Transfer Mode) protocols. By connecting with premises through optical fivers and offering broadband services which provided streaming movies, NTT aimed to expand telecom services.

In 1994, NTT introduced the concept of 'multimedia', which meant that all information, from voices to moving pictures, could be transferred through a public network. Their service image of multimedia was based on VOD (Video on demand) services, provided by optical fivers. Therefore, NTT studied VOD services by affiliating itself with Microsoft and Silicon Graphics Corporation. Through these experiments, NTT recognized that several steps were needed to realize their concept. Firstly, they needed to develop and expand existing telephone services by adding information technologies - voice mail and telephone conference services were the example of computer telephony integration (CTI). These services were popular in the USAnd European countries at this time, although NTT also tried to diffuse them in Japan, aiming to compensate for the decrease in telephone services sales.

The second step was based around internet services. At the time, the internet was not very popular in Japan, though demand was expected to increase. At the same time, personal computers had become popular. Following from this, by accepting N-ISDN for the introduction of the internet, NTT tried to stimulate and expand the demand for network use in business settings and among consumers. As previously mentioned, existing telephone lines were available for N-ISDN. Correspondingly, demand would be created for the internet, along with relevant businesses, internet providers, search engines and electronic commerce.

[75] This section was described based on NTT (1996), NTT (1999) and study of files as NTT.

The final stage was that optical fibres and B-ISDN would drive VOD services. Every business premise would be equipped with optical fivers, and all communication, voices, characters, picture and moving images, would be operated by B-ISDN and be available for all customers.

3.2. The trial to integrate Narrow and Broadband ISDN

Alongside these new initiatives, NTT began to consider their networks. Firstly, NTT lab planned to develop ATM switching systems experimentally. In the development, in addition to four *family companies*, two new actors joined the project, Toshiba Corporation and Northern Telecom Corporation (a Canadian company). Previously, NTT had introduced transit switching systems developed by Northern Telecom in 1990. This was the first time that NTT had accepted foreign systems into their network. The trial ATM system (called AHM) had been developed from 1991, and was released in 1995.

In spite of the fact that NTT had already developed N-ISDN systems, there were several problems related to expanding future demand. The major problem was the price of constructing the ISDN network. The cost of constructing and maintaining ISDN networks meant a high price for N-ISDN services. NTT provided N-ISDN services using their digital switching systems, which were modified by their telephone digital switching systems (D70). The system consisted of a combination of telephone switching systems and ISDN systems. The ISDN system was called ISM, and was a different module from the D70. Therefore, in order to provide N-ISDN, both systems - the ISM (ISDN exchange system) and the D70 (Telephone exchange system) - were needed. This caused an increase in construction and maintenance costs. In addition, two types of software needed to be developed. These architecture problems prevented a reduction in costs and the provision of cheap services.

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.

4. The development of new types of switching systems

4.1 Accepting new technologies

The project was called the MHN (Multi Handling Node) series and had several significant features. The project fully accepted open interfaces for its systems[76]. In addition, internet-relevant technologies were also incorporated[77].

In previous years, NTT's network equipment had been design solely so that they could offer telecom services efficiently. Therefore, standards of interfaces, CPU, OS and other equipments were established according to NTT's original specifications. This approach might have been enough when considering only their domestic market, concentrating on telephone services and exchanging with a limited number of actors (*family companies*). However, with the development of new technologies and the deregulation of the telecom market, other companies entered into the market and a variety of equipment was connected with the public network. As a result, NTT began to look at their development policy and decided to develop their new systems by fully introducing international standard interfaces and accepting software interfaces.

These things were expected to bring large benefits to NTT. Firstly, the increasing amount of equipment which could be connected to the network would mean that NTT's telecom market would expand. Second, developments were expected to be more economical, as standardized products were cheaper due to volume efficiency. In addition, by dividing functions into common and special use, when new functions were needed, the development would only add them to the common function units which had already been developed. This was expected to reduce the future cost and time span of offering services.

Furthermore, new technologies could be introduced easily without the need to sustain their developed technologies. The dramatic development of new technologies meant that new technologies continuously appeared and performance significantly improved. As a result, in order to develop cutting edge systems, new technologies had to be selected and chosen as soon as possible. By using open architecture, NTT expected to introduce such new technologies into their systems as these technologies tended to be developed based on international standards.

[76] NTT (1999)
[77] ibid

Finally, NTT aimed at exporting these systems[78]. Therefore, not only international standard interfaces but also other de facto standard interfaces were incorporated into their systems as much as was possible. For example, ATM has several types of protocols. These were not only protocols which ITU-T (organized by telecom operators) had established but also ones established by the ATM forum[79]. The ATM forum was a private institution organized for ATM technologies adapting to LAN networks. NTT's ATM systems included most of these protocols.

4.2 The developments of the MHN series

4.2.1 The MHN project

NTT started developing 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. The project, called MHN (Multi Handling Node)[80], also aimed at replacing existing telephone systems and adding new systems in order to realized advanced networks. The table below shows the systems produced by the project.

Table4-5-(1) The products of MNT series

Node	Purpose	Released
MHN-S	Telephone and Circuit switching system(N-ISDN)	1996
MHN-P	Packet switching system(N-ISDN)	1996
MHN-A/ MHN-Aπ	ATM switching system (B-ISDN)	1996/1999
MHN-F	Frame Relay systems	1997
MHN-SCP	Service control system for intelligent telephone services (IN)	1997
MHN-STP	Telephone call transfer system	1999
SMS	Service Transfer system for	1997

[78] ibid
[79] ibid
[80] The description of the project is based on NEC(2001), (NTT (1999), Oki (2001)

intelligent telephone services
(IN)

4.2.2 Features of the development

Consequently, many new technologies developed in other industries were used for their systems. CPU and processors are the most significant components of any switching systems. As mentioned before, NTT had developed their own original processor architecture, which was tuned to NTT's node systems. These CPUs were fully accepted to their systems. However, the role of switching systems had been expanded to include not only a switching function but also other information processing and operational functions. In addition, the significantly improved performance of processors led to the frequent introduction of new types. Therefore, NTT decided to accept vendor products for their systems. For example, SPARC (developed by Sun micro systems) processors were used as their main processors and MIPS (a product of MIPS Corporation) processors were used as other communication control units. Additionally, NTT also developed processor exchange technologies, which allowed currently operating processors to be changed when a new processor appeared. NTT tried to prevent the aging deterioration in performance. Naturally, using general purpose processors are cheaper compared to adapting their original processors. For these reasons, systems used cutting edge general purpose processors in their systems.

OS was developed based on TRON[81], which also established standard interfaces between OS and applications. By clarifying interface conditions, NTT aimed at reduce the cost and time of development and addition of new functions.

In selecting a programming language, NTT accepted C++ languages for the development. In the past years, NTT had used their original language, CHILL, developed for switching systems. Therefore, if the language was used, it could be expected that the resulting software assets could transform the development of their new systems. However, NTT accepted the general purpose language because they focused on feasibility, easier to gather programmers and easier to use software tools. These were expected to be more economical as regards software development. This decision influenced a change in R&D

[81] Japanese open standard for a real-time operating system - commonly used for Japanese mobiles and appliances as embedded OS.

activities within NTT. This allowed NTT to accept and use many general purpose products and, as a result, enabled them to reduce development costs[82].

Workstations and internet equipment were also used for development. Service management system (SMS) acts as a database that helps to control telephony services. Therefore, Hewlett Packard workstations were installed for the system. In this development, the scale of software development was much larger than that of existing systems. Therefore, sharing information and standardizing development methods were very important, so NTT developed a software development environment. One of the things they constructed was an IP network, called SS-net, which was applied for the development environment[83]. Therefore, developers could communicate using email, chat and news. Additionally, the operating systems also consisted of an IP-based network. This achieved a 20% reduction in the costs of the developments.

4.2.3 The result of MHN projects

Their first version was released 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. NTT and *family companies* integrated telephone technologies and internet relevant technologies to the project. This large scale project (the MHN project) led to a cost reduction in N-ISDN, and a subsequent increase in N-ISDN users. In the USA, many users accessed Internet through cable television networks. Cable television uses a coaxial cable, offering much higher speed than a telephone subscriber line. However, cable television was not common in Japan. Therefore, telephone subscriber lines were the only access method to connect to Internet from premises. At the time, most Japanese users dialled up to the internet with very low speeds (around 32kbps maximum). Users were frustrated with this low level access. NTT was able to offer N-ISDN at a lower price due to their cost reductions in N-ISDN. N-ISDN can use existing subscriber lines and provide higher speeds (around 64kbps or higher), as a result, the number of customers using ISDN gradually increased after the release of MHN systems. Consequently, internet users also increased, and the internet became popular in Japan.

However, other systems of MHN series were not used enough. The developed system for intelligent networks (MHN-SCP and SMS) only contributed towards free phone services

[82] C++ is a object-oriented language, which enables software components to be modularized. Therefore, high reUSAbility of software components is allowed.
[83] Sun's workstation were also accepted.

and PHS[84]. Their ATM systems were introduced into several backbone networks. However, these were not used for core systems that would realize their concept of 'multimedia'. Developing internet-relevant technologies gradually eroded telecom based technologies. Therefore, these technological developments forced a change in .NTT's thinking.

4.3 Changing the collaboration system

This project was worked on by the existing collaboration system, NTT and four *family companies*. They acted as mediators in the integration of new technologies. The development involved open architecture and internet technologies as well as existing telephony technologies. In order to integrate their original communication technologies, these technologies were introduced not by direct exchange but by mediating through *family companies*.

For example, NTT accepted SPARC processors for their ATM switching systems (MHN-A). Fujitsu had already engaged with Sun Micro systems and produced Sun's workstation for the Japanese market. At the same time, Fujitsu dealt with SPARC processors as well as Sun's OS (Sun-OS and Solaris). Fujitsu took part in the development of MHN-A's central unit. This incorporated many of the technologies unique to switching systems and accumulated over long-term activities from previous developments. Fujitsu installed these technologies onto SPARC architecture.

Another example of this mediation was that the switching systems for N-ISDN (MHN-S, MHN-P) accepted MIPS processors (R4400 and latter versions) as their communication boards. Communication boards worked for control of data communication links. NEC had accumulated these technologies from previous developments. In addition, NEC affiliated itself to MIPS Corporation, becoming a second source company of MIPS processors. Therefore, NEC had a great deal of knowledge of MIPS processors. They worked seriously towards data link control functions which would work on MIPS processors. Both companies, Fujitsu and NEC, modified their processor kernels.

[84] The Personal Handy-phone System (PHS) is a mobile network system developed by NTT laboratories. It is used mainly in Japan, China, Taiwan and some other Asian countries.

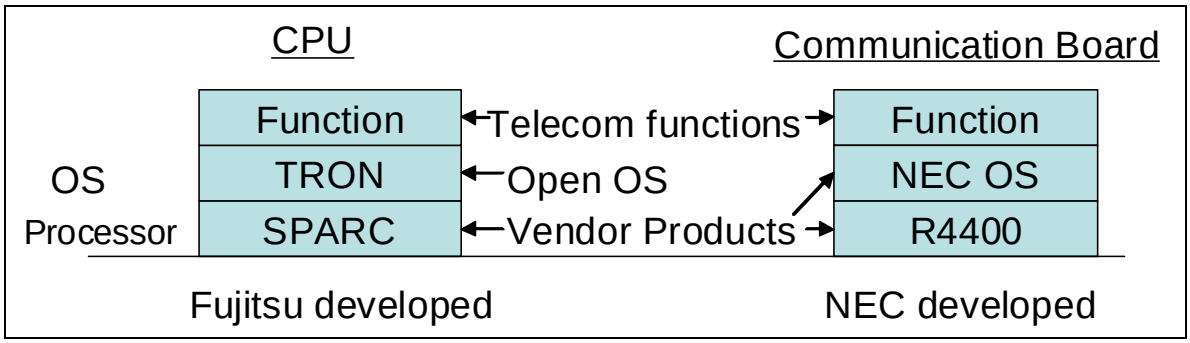


Figure4-5-(1) The integration of vendor and original technologies

There are two examples which show that new technologies were introduced by helping existing companies (**Figure4-5-(1)**). Despite the existing collaboration system, new actors gradually became involved in the development of switching systems. These actors 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 had 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 actors. 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.

5 Discussions and Summary

Privatization and the open policy towards procurement had an influence on the relationship between *family companies* and NTT regarding managerial issues. This led to *family companies* escaping from NTT's dominant management. However, this was partly influenced by R&D activities. The *family companies* had already obtained enough technological capabilities to draw level with foreign telecom companies. Therefore, there was no need for NTT to change partners. In addition, the *family companies* had a great deal of experience in collaborating with NTT.

In the MHN project, the relationship between NTT and *family companies* still seemed strong, but it had changed slightly. The pressure of cost reduction and the speeding up of development time meant that this project used many internet-relevant technologies for its developments, and these technologies came from US vendors. NTT needed *family companies* as mediators in the integration of telephony and new technologies, improving their quality and reliability. In other words, the *family companies* were indispensable players whenever NTT carried out a project.

In contrast, the *family companies* had more power in the collaboration system because of their superior technologies, accumulated over a long period. Their wide variety of business areas helped to accumulate the relevant technologies. Therefore, it could be argued that the *family companies* were able to escape from NTT's dominance because of technology. In this regard, the relationship between NTT and *family companies* was weakening.

The emergence of innovative technologies had a dramatic effect on the collaboration system. Foreign companies could enter NTT's R&D activities without any help, and these new US companies' superior technologies enabled them to do this.

In summary, the relationship between NTT and other companies has changed in that the number of new joint firms has increased. The structure of the industrial network has changed. Previously, the telecom industry was completely dominated by NTT. A limited number of companies were allowed to exchange. Also, each relationship and mutual dependency was very strong. The structure was hierarchical because NTT were 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 actors exchange through existing companies and new technologies have been introduced through helping existing companies (**Figure4-5-(2)**). 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.

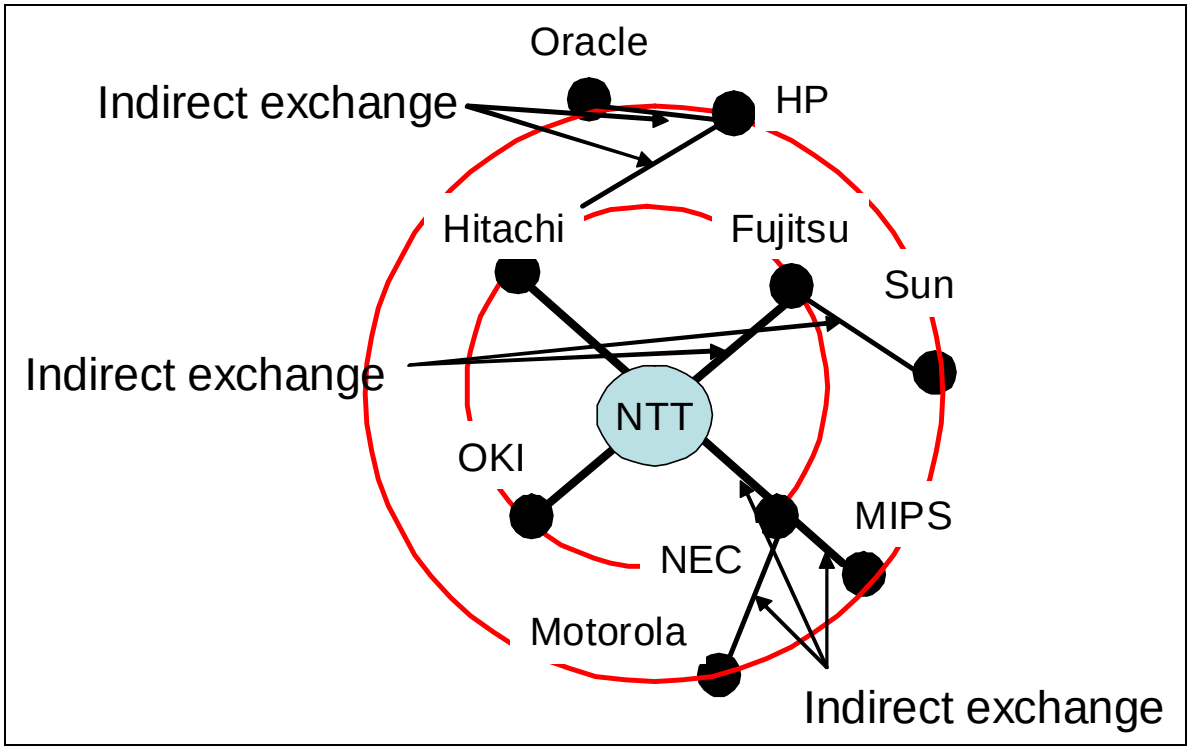


Figure4-5-(2) Exchanges with external companies in the development of MHN projects

Section 6

New era toward Service Oriented management of R&D

1. Redefine of NTT's managerial configuration

1.1 The Holding Company system

NTT was privatised in 1985, but the law required that NTT's managerial configuration be reviewed within ten years. NTT's strong dominance was considered to be an obstacle to the development of the Japanese telecom market. Their data communication business was split off as a private company, NTT-data Corporation, in 1988. The mobile business was also privatised, becoming NTT-DoCoMo Corporation. On the other hand, because of the emergence of a new open policy at the same time NTT was privatized, new players, called NCCs (New common carriers), began to appear in the long-distance telecom market. They constructed their inter-exchange networks and used NTT local facilities by paying access charges. Although NTT continuously reduced its prices for long-distance calls and opened network facilities for competitors, competitive circumstances were not sufficiently diverse. Even after its privatisation, NTT still operated both regional and long-distance calls under the same umbrella in Japan.

Three points can be made when discussing the effects of the reform of NTT. One is that competitive circumstances were created in the Japanese regional telecom markets. Although new players had been appearing in the mobile and long-distance markets, the local phone market was still completely dominated by NTT. The Japanese government wished to create competitive circumstances by dividing NTT into regional and long-distance businesses. This idea was influenced by American telecom policy.

The second issue was the arrival of international communication services. During the end of the 1990's, American and European telecom carriers attempted to expand their businesses into other countries' territories. For example, AT&T formed partnerships, while BT, DT, and FT also made alliances. On the other hand, NTT had

to abide by laws prohibiting them from dealing with international businesses. Post-war Japanese telecommunication policy separated international from domestic communication businesses. Only one Japanese international telecommunication company, KDD (KokUSAi Denshin Denwa Corporation), had been allowed to deal with international businesses until 1985. After the liberalisation, a few new actors entered into this market, but they were small companies, not big enough to compete with major foreign carriers. In order to respond to these activities, NTT was considered large enough to enter international business immediately[85]. This, however, would call for a reconfiguration of NTT's management. The biggest issue was the existence of NTT laboratories. After splitting off from AT&T, Bell lab's capabilities had decreased. The NTT labs were considered to be representative of Japanese laboratories, leading to Japanese leading to Japanese competitive powers in the world. NTT also strongly wished keeping laboratories for maintaining their competitive advantages.

Following these situations, NTT proposed a holding company system. At that time, the holding company system had been prohibited in Japan by antitrust law. Therefore, the law needed to be revised. In 1999, NTT's telephone businesses was divided into three companies: NTT Communication, long-distance and international services, and two regional businesses divided into two companies based on regional areas, NTT East (operating on the east side of Japan), and NTT West (in charge of the west side). NTT communications became a purely private company, but the two regional companies were restricted by the antitrust law. NTT laboratories belonged to the holding company and were supported by the R&D fees shared among subsidiaries.

[85] However, NTT did not consider international alliances were forbidding for NTT.

1.2 Restructuring and NTT laboratories

The reform of NTT created a new mission for its laboratory. Under the holding company system, all businesses are operated by subsidiaries. NTT does not carry out profit-making businesses directly. The holding company, NTT, consists only of about three hundred employees and about three thoUSAnd researchers. Recruiting activities are carried out by each subsidiary individually. Only researchers belonging to the lab are hired directly by NTT, whereas other employees in NTT are moved from subsidiaries before eventually going back to their original companies. The law prohibits inter-exchange of personnel between subsidiaries, only allowing it to occur between the holding company and a subsidiary. Therefore, NTT's five main companies - two regional companies (NTT East and West), the long-distance company (NTT Communications), the mobile company (NTT-DoCoMo) and the system integration company (NTT-Data) - tend to work independently, and in some cases are mutual competitors. Therefore, NTT tried hard to unify these companies' management. Given these circumstances, the NTT laboratory was required to become an anchor of the group of companies. In order to do this, the lab has been involved in building the strategy plans of NTT's groups. Since its reform, NTT has released the medium term plans almost every year[86].

Their plans have been very technology-oriented and have the same basic features. There are two pillars to these strategy plans. The first is that the network services will be expanded to provide higher speed broadband network services for consumers and business users. The access line is the most significant bottleneck in the attempt to achieve high-speed communications. Even though ADSL provides much faster networking than dial-up methods, the capability of the cupper line is limited when it comes to improving speeds and is ultimately insufficient for the transfer of moving pictures. In addition, NTT has long regarded optical fibres as the future method of integrating communication and broadcasting, which would enable moving pictures to be transferred through communication lines. Since the 1980's, NTT has tried hard to replace existing cupper lines with optical fibres. 'HIKARI', the Japanese term for optical fibre communication, is the symbolic word used by NTT to promote the broadband era to mass users.

[86] NTT (2006)

2. Changes of the Japanese telecom industry

2.1 ISDN and Internet based network in Japan

The Internet dramatically changed the Japanese telecom market, becoming the centre of communication services for telecom operators.

ISDN achieved faster connections as well as sharing voice and data communications. However, in order to use ISDN services, several facilities, such as DSU (Digital Service Unit) and TA (Terminal Adapter), were needed. NTT had already released ISDN services in 1988, but the diffusion rate was very low due to the high price of ISDN services as well as the lack of attractive content.

The year 1995 is famous for the launch of Windows 95 in Japan, leading to a huge growth in the Internet's popularity among consumers. In Japan, the Internet triggered the penetration of ISDN services into the market, as these were the access lines that provided the new attractive content. NTT in turn acted as a trigger to diffuse the Internet. First, NTT reduced their prices for ISDN facilities, TA and DSU. Second, by installing new switching systems, MHN systems, NTT were able to further reduce the price of ISDN services. As a result, the number of subscribers to ISDN increased, reaching over 10 million in 2000 (Figure4-6-(1)).

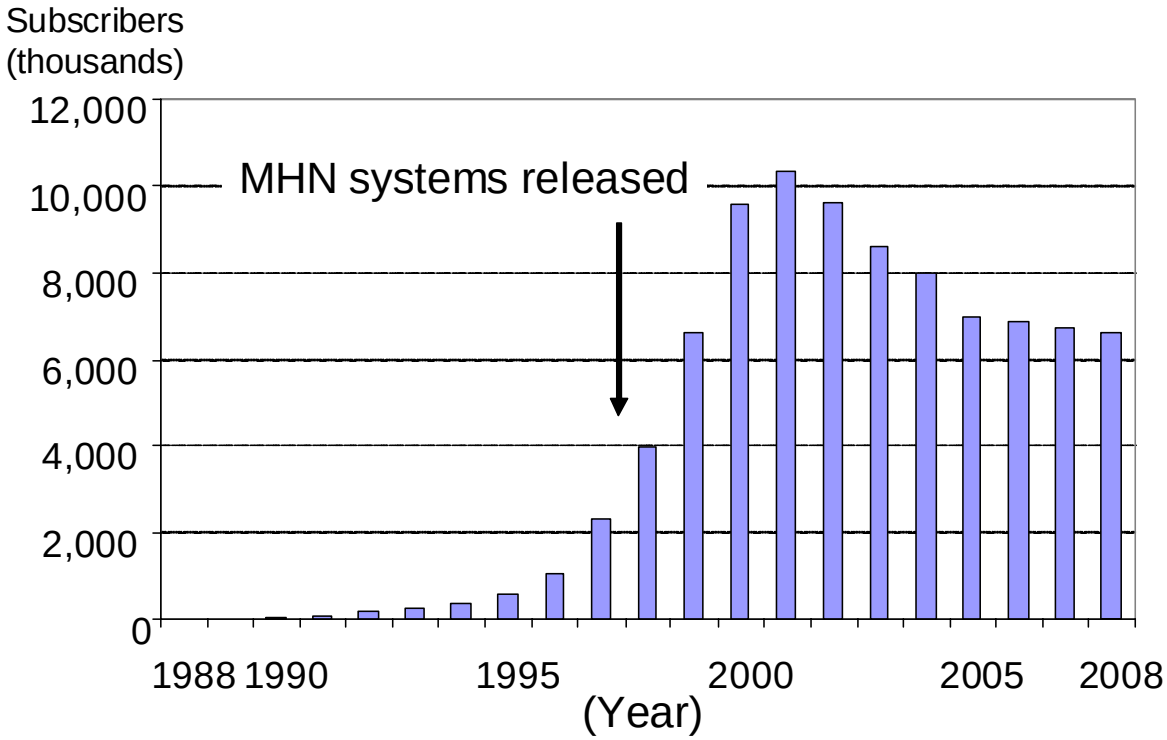


Figure4-6-(1) Number of ISDN subscribers in Japan[87]

Simultaneously, NTT entered the ISP (Internet Service Provider) business. The service, called OCN (Open Computer Network), was provided by the combination of an access line and the OCN network. The service provided a variety of access lines: Ethernet, dedicated line and dial-up connection through ISDN or telephone. OCN was a network that allowed users not only to connect to the Internet, but also to other companies' networks. In other words, small companies could install their own network by using OCN services. Thus the network allows users to connect not only to the Internet but also other companies' networks. The OCN network was constructed based on IP protocols, and consisted of many routers. In the network, data is transferred by IP protocols. In this respect, the OCN network was the first commercial network to be developed by NTT based on Internet protocols. OCN quickly became the number one ISP provider and has maintained this position among Japanese ISP businesses.

[87] The data is based on Statistics Bureau, Director-General for Policy Planning (Statistical Standards) and Statistical Research and Training Institute.

With the increasing numbers of Internet users, the demand for a service that would enable constant connection to the Internet increased. However, telephone-based networks were not technologically equipped to deal with such a demand. NTT decide to modify their local ISDN switching systems. One channel of the ISDN connection is used for Internet access and is directly connected to a facility at the front of ISDN switches[88]. This method resulted in reduced capacity of switching systems, allowing constant connection. The service, called 'Flets ISDN' was welcomed by Internet users and became very popular in the Japanese market.

2.2 Toward integration of telecom market

2.2.1 ADSL

ADSL is a kind of technology that provides digital data transmission over the wires of a local telephone network. The emergence of ADSL services dramatically changed competitive circumstances in the Japanese telecom market. ADSL can use existing copper subscriber lines and provide higher speeds than ISDN. Apart from speed, by splitting voice and data signals it allows users to share internet and telephone services at the same time. An ADSL circuit connects ADSL modems on both ends of a twisted-pair line. These modems split off a high-speed data channel and the ISDN or telephone channel. In addition, by having an ADSL modem at the front of a switching system, the high-speed data channel does not need to go through a switching system, but can instead connect directly to a data network. As a result, other companies can offer their networking services by using NTT subscriber lines economically. This meant NTT's sales declined due to the reduction in access charges to other companies. Additionally, other companies were able to provide their unique services because they were no longer affected by NTT's network limitations.

NTT did not have a positive attitude towards ADSL services, as they believed that future telecom services would be realized by optical fibres and were eager to change subscriber lines from the existing copper ones to optical fibres[89]. However, the demand for high-speed access to the internet forced NTT to introduce ADSL

[88] ISDN (Narrow-band ISDN) has two channels in each line.
[89] The NTT public history also admitted it because of technological problems NTT (2006).

systems in 2000. After NTT had accepted ADSL services, many new companies found it easy to enter internet access services, as the Japanese had unbundled regulations, permitting other companies to use NTT subscriber lines. The speed of ADSL gradually increased, finally reaching as fast as 40M kbps. In addition, by splitting out data connections at the front of switching systems, ADSL can significantly lower network costs. Furthermore, the deregulation of the telecom industry helped newcomers enter the business, and competitive circumstances emerged due to the combination of ADSL and Internet provider services. Ordinary people were able use the internet at home at a reasonable price.

2.2.2 Disintermediating telecom network

The emergence of ADSL has led to a change in the telecommunication network. Two types of network have appeared, sharing existing cupper lines in last-mile access. One is the legacy telephone network, while the other is a new data communication network based on IP technologies. Network service providers construct their own network and pull out access lines from a trunk at the front of switching systems. This method may provide a solution to the 'last mile' problem for newcomers, reducing entry barriers. ADSL providers gradually began offering telephone services through this data communication network. The service, called IP phone, has impacted heavily on existing telephone companies, as it means their most fundamental resource of profit making sources, telephone services, is lost. ADSL providers also offered packaging services, integrating access lines, internet access and IP phones. Telecom companies also followed suit.

The emergence of the ADSL service shows several things. In the past, telephone and data services were distinctively categorized. However, with the emergence of VoIP (Voice over IP) services, telephone services became a kind of data transferred on internet protocols. Voice data became a similar kind of data to picture, moving picture and texts. Therefore, the telephone service was not dominated by telecom companies, but by network service providers. This meant that telecom operators could not gain anything from telephone services, their most important source of profit.

In addition, the position of network services in the communications business was in decline. This function was only needed for transferring data packets to their destination. Previously, telecom network had many special functions - routing, traffic controls, service controls, and maintenance - and the telecom network consisted of many special facilities and functions. Telecom facilities were special order items and very expensive. These complex systems required special maintenances, therefore large companies could not manage telecom networks. As a result, several companies dominated the market in a country. However, in the IP and web-enabled world, the network function only provides packet transfer functions. Web addresses, such as URL or URI, replaced telephone numbers, and are used as an indicator to show the destination. Authentication, security and other network control functions were provided on server software. In other words, these original network functions shifted to upper layer functions. As a result, network functions were disintermediated.

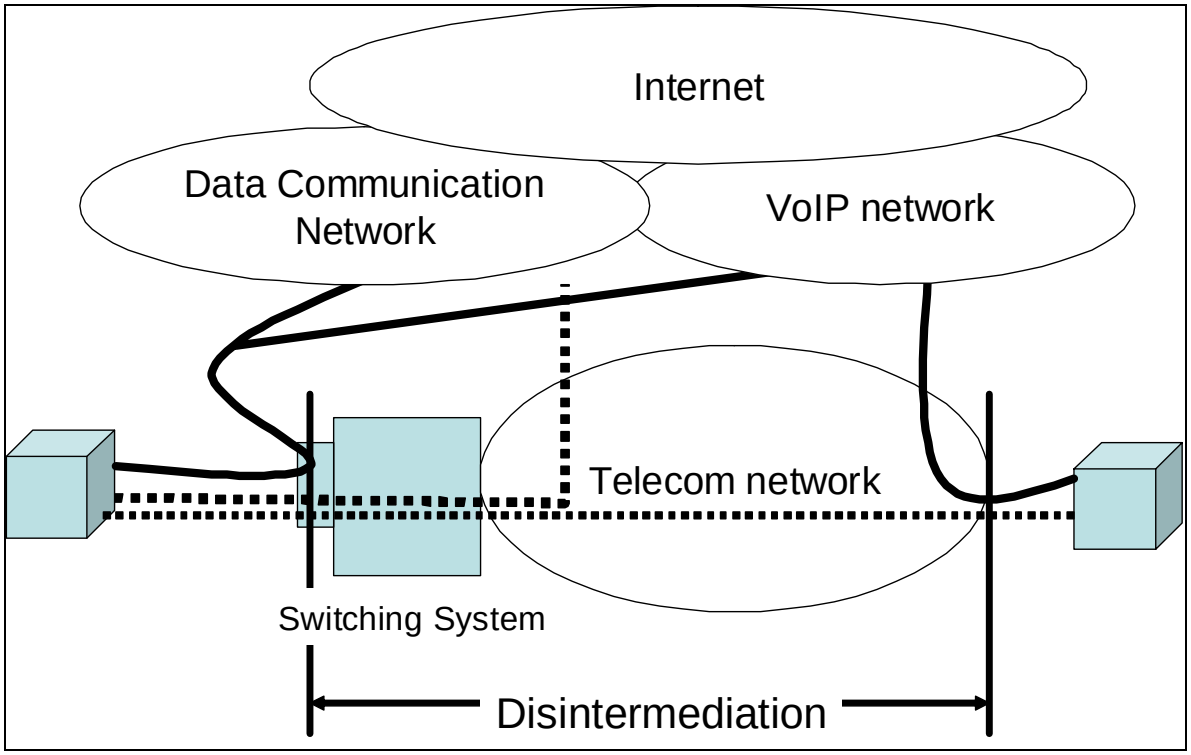


Figure4-6-(2) Disintermediation of Telecom network

2.2.3 Toward IP based network

Meanwhile, telecom carriers are facing a huge reduction in their existing telephony business. In order to compensate for this, one solution has been to reduce the costs for telephony businesses. Many telecom carriers have decided not to invest in their telephone networks. Instead, they attempted to construct another IP-based network. For example, BT announced in 2004 that their telephone network would move to becoming an IP-based network. NTT also announced that their telephone network would become IP-based. In doing so, these companies would save money because IP-based networks have lower maintenance costs while integrating data and voice networks is also expected to lead to savings.

The emergence of the IP phone clearly indicates that there is no future for the legacy telephone network. All bearer services - communication, voice, data, text, moving and others - can be transported through the same IP-based network. Following this, NTT decided not to invest further in their telephone network[90]. Their existing legacy telephone networks would be replaced by an IP-based network which would provide not only voice exchange services but also other data services. In doing so, NTT attempted to unify their networks on a single IP-based network.

2.2.4 Toward Integrating of telecom market

These movements had a big impact on the management of telecom companies. They could not gain profits from telephone and network services, and so. They are finding other sources of profit making. Telecom carriers are going ahead with integrating wired and mobile businesses. These activities are called FMC (Fixed Mobile Convergence). FMC services allow a customer to use a dual mode handset, both indoors and outside. Customers' mobile terminals can support both wide-area (cellular) access and local-area technology. BT fusion is an example of this service. British Telecom offers a Motorola handset capable of making calls through the Vodafone mobile access and the ADSL line via local wireless technologies such as

[90] NTT (2002).“Strategy plan of NTT Group “, News Release, 2002-April-19. <http://www.ntt.co.jp/news/news02/0204/020419.html>

Bluetooth or WiFi. These convergence trends have also led to telecom companies integrating broadcasting services with their communication services. Called 'triple play service', it provides high-speed Internet access, television, and telephone services in one package through a single broadband connection, such as CATV or optical fibre. However, Japanese law prohibits NTT from providing integrated wired, mobile and broadcasting services. Additionally, these services involve combining pre-existing businesses, and are not attractive to ordinary people without financial incentive.

They are now trying to integrate services like telephone, mobile, broadcast and internet-access services, offering them as a package based on packet based network (**Figure4-6-(3)**).

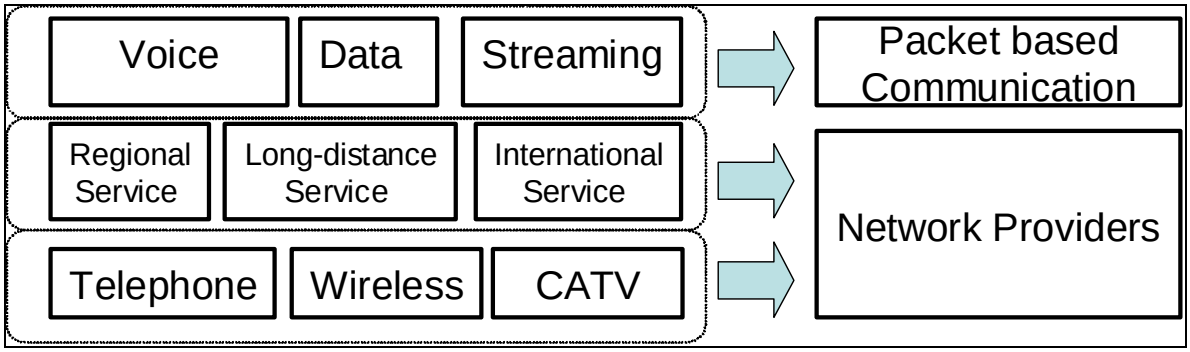


Figure4-6-(3)Integration of telecom services

In addition, they attempted to enter more upper, middleware and application services. One example is a 'platform service', which gathers common functions to provide services on the internet, allowing service providers to use them. NTT in particular has aimed to carry out these platform services for their future business[91].

NTT is now attempting to change their area of business to a new IP-based upper layer business. Their latest strategic plan, 'service creation', describes how NTT will concentrate on service-centred management[92]. It focuses on a service delivery platform, called 'Service platform', which aims to provide basic functions for service providers to do businesses on a network. 'Service platform' is based on network functions, offering basic functions, authentication, charging, security,

[91] The details will be described at the part4 in this section.
[92] NTT, "The NTT Gropu Strives to Become a "Service Creation Business Group" via Concerted Efforts", at their home page < http://www.ntt.co.jp/about_e/managementstrategy.html> accessed at March 2009.

session controls, and other functions that will help service providers to distribute content such as video-on-demand and application services. In the past, NTT offered only network services through cupper lines (Physical layer) and telephone exchange functions (Network layer). However, now NTT aims to offer services by integrating whole of layered functions **(Figure4-6-(4))**.

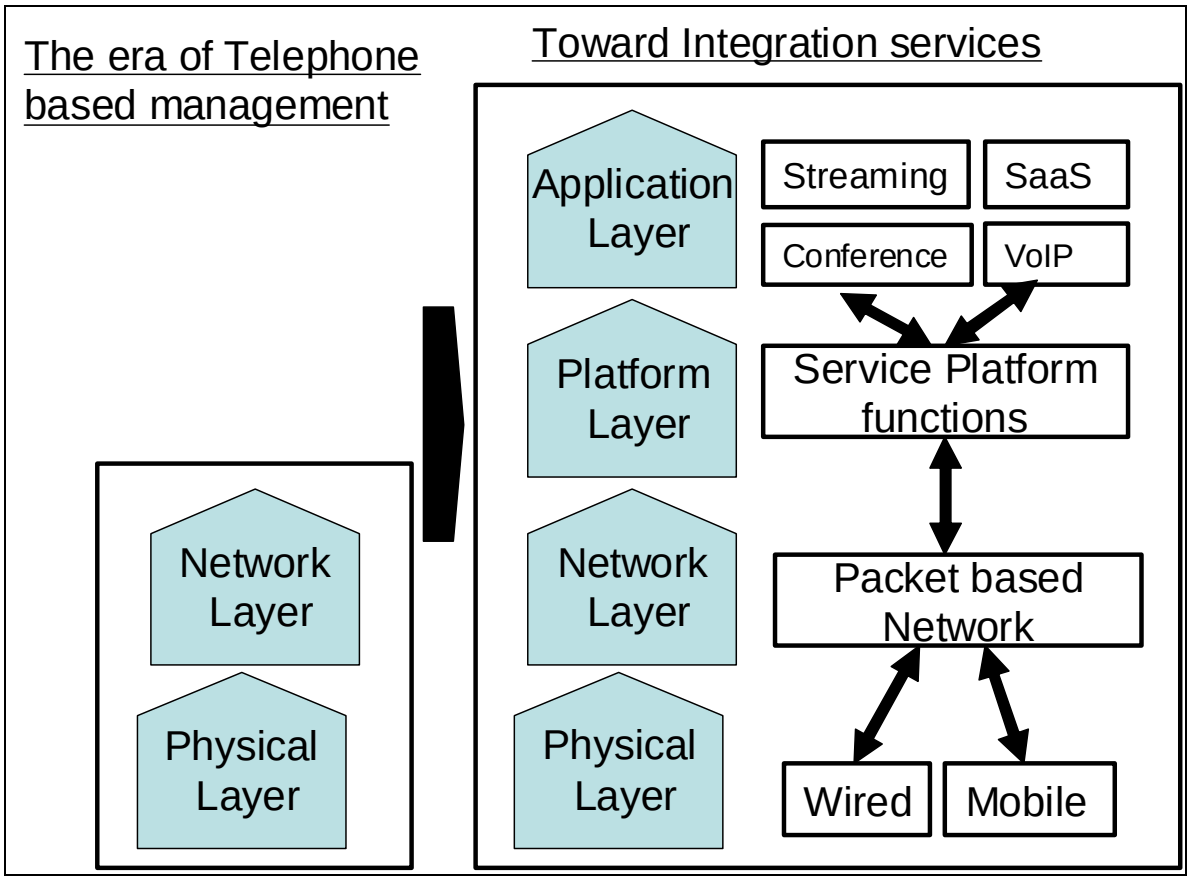


Figure4-6-(4) New approach of NTT

3. NTT's trials for developing NGN (Next Generation Network)[93]

3.1 From switching system to Routers

A router is a fundamental component of the internet that enables the transfer of packet data to its destination. A router transfers data based on an IP address contained in the header of every data packet. In the beginning of Internet technology, router reliability and performance were not of a sufficient standard for use in large-scale networks, as internet-relevant technologies were originally developed for small networks. The components frequently failed, and because of poor traffic control functions, network congestion was likely to occur.

Following the development of LSI chips for communication use and the subsequent arrival of packet switching technologies performances dramatically improved. Large-scale routers and switches were developed, resulting in a new Ethernet standard (called Giga bit Ether). These technologies were enough for a company to apply for large-scale networks. Additionally, maintenance and operation protocols were established, and immediately became commercialized.

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

The switching system had been central to any telecom network. However, this highly complex system made it difficult to install new technologies or add new services. Therefore, the performance of processors and other components immediately became obsolete even though leading edge technologies had been accepted at the time of their introduction. As well as this inflexibilities, the very high

[93] This part is based on following materials and study of files in NTT;Nakayama (2009), Kasahara et al. (2007), Ezaki, Kurokawa and Matsumoto (2007), Tuchiya (2008), Fujishima et al. (2008), Nisase (2008), Miyasaka, Harigome and Kishida (2008), Morita and Imanaka (2008), and Morita and Hiramatsu (2008)

installation and maintenance costs led to an increasing burden on telecom management, and eventually switching systems began to be replaced by Internet and computer-relevant technologies - a combination of routers, switches and servers.

In the 2000's, telecom technologies were replaced by the combination of Ethernet and IP protocols. Reducing the superiority of telecom technologies allowed firms to accept internet technologies fully into their systems.

Just after releasing MHN systems, NTT lab changed their approach from that of an ATM based network and began studying a possible future network, aiming to realize its strategy by introducing a new network system based on the new IP specification (IP v6) and decentralized trends. NTT and other telecom companies established the MSF (Multi Service Forum) in 1998, which discussed the new architecture of the next generation network. Following these discussions, NTT lab began to develop an experimental system called MSN (Multi service node), which was acceptable for decentralised trends and IP-based technologies, enabling all data to be integrated into a network. The project also accepted the open API policy, which allowed service providers to use API to realize their own businesses. A new IP protocol (IP v6) was experimented with for the project. These achievements contributed to the development of the NGN (next generation network) as well as NTT's new network services, Flets. NEC and Fujitsu are members of the MSF conference, and they joined the MSN projects. NTT also accepted MPLS protocols for their new switching systems, integrating existed data networks and a new IP-IP based network[94]. These R&D activities were used of the next project, the NGN.

3.2 Features of NGN[95]

NGN is a new IP-based network, combining telecom technologies and Internet-relevant technologies, Ethernet, IP and WWW. The purpose of NGN is to replace existing wired telephone networks with Internet-based technologies. NTT and other telecom carriers hope that this will provide a way of creating brand new outstanding services as well as conventional services such as fixed-line telephone

[94] NTT (2006). These systems are used of their IP phone services and their internal networks.
[95] This part is based on following materials and study of files in NTT: Morita and Imanaka (2008), and Morita and Hiramatsu (2008)

and Internet. This potential comes from its features - openness of interfaces, quality of service (QoS), high security, and reliability.

From the viewpoint of telecom operators, the shortcomings of the Internet are quality of communication and security. Essentially, telephone networks are not based on best-effort communication, but on circuit-switching. Resources are reserved in the telephone exchanges during the connection. Lack of free capacity of a switching system blocks a new call. An ongoing phone call can never be interrupted due to overloading of the network, but is guaranteed constant bandwidth. However, this is a very expensive method. In contrast, Internet communication is provided based on the concept of 'Best Effort', meaning that the network does not provide any guarantees that the data will be delivered. If trouble or congestion occurs in the network, the data is simply lost or undelivered. In principle, guaranteed delivery can be provided by higher layer protocols on the Internet, handled by negotiations of terminals and servers rather than the usual network nodes. The transportation layer of the Internet is provided by the TCP and UDP protocols. The TCP transport protocol provides guaranteed services, while the UDP transport protocol provides best effort delivery. TCP reserves that all transmitted information is fully delivered to its destination, while UDP, on the other hand, does its best to deliver packets to their destination, but takes no steps to recover packets that are lost or misdirected. From these features, it follows that the TCP protocol is used to deliver data like web pages and email, while UDP is often used for media streaming or network gaming. The NGN aims to recover these functions from internet based methods and to control every network functions in network.

NGN also aims to provide bandwidth and connection control functions in a network. To manage these, QoS (Quality of Service) is used, giving the appropriate level of quality depending on the applications used, ensuring the availability of the necessary communication bandwidth. At the same time, NGN adopts redundant communication links and equipment. QoS control functions label each packet as a priority or not, depending on the type of communication. It employs advanced traffic controls when congestion occurs in particular areas, and ensures delivery of critical communication. In addition, NGN places great emphasis on high security network

services, protecting against spoofing by checking the carrier ID assigned to each circuit.

3.3 Technological Feature of NGN

The system was based on a new concept, integrating all data into a packet-transfer network that fully accepted decentralised architecture and open API. This means communication control is divided four functions: bearer control, packet transport, call control function and service control. These were influenced by changes in computer technology. These mounting technologies were based on Internet protocols and international standard signals for controlling each function.

The specifications of NGN technologies are standardised by ITU-T and the other Internet standardising organisations, W3C and IETF. However, most of the parts were established by ITU-T and mainly organised by telecom carriers. The basic architecture of NGN is influenced by the new trend in computers: decentralised architecture. It consists of two basic parts: transport and signalling control parts. The transport part consists of two routers: core router and edge router. Core routers are used for transferring packets as fast as possible, and their mechanism is therefore very simple. Core routers have to transact a wide range and huge amount of data immediately, so high capabilities are required. Edge routers, on the other hand, operate subscribers' connection controls, which work for authentication, session management and security functions as well as bandwidth control by the exchange of signals between other servers in signalling parts. Edge routers work like subscriber switching systems.

Signalling is the most important feature of NGN - working for call controls, accepting requests of call connects from edge routers, interacting with other servers for authentication, charging and allocation of bandwidth, and returning results to edge servers. It must be emphasised that this feature can interact with a service application, opening the API for service providers. This is the fundamental function that achieves integration with the network and service oriented approach.

'SIP servers' are used for these functions. The Session Initiation Protocol (SIP) is a signalling protocol, widely used for VoIP (Voice over IP) services. It

works by setting up and tearing down multimedia communication sessions such as voice and video calls over the Internet. Modifications can involve changing addresses or ports, inviting more participants, adding or deleting media streams, etc. A SIP server accepts signals from Edge routers and transacts authentication, charging and other application components. After allowance, the SIP server assign destination addresses, routing information, charging and allocation of bandwidth to the Edge router. SIP is designed from the IETF SIP Working Group, and is very suitable for the web.

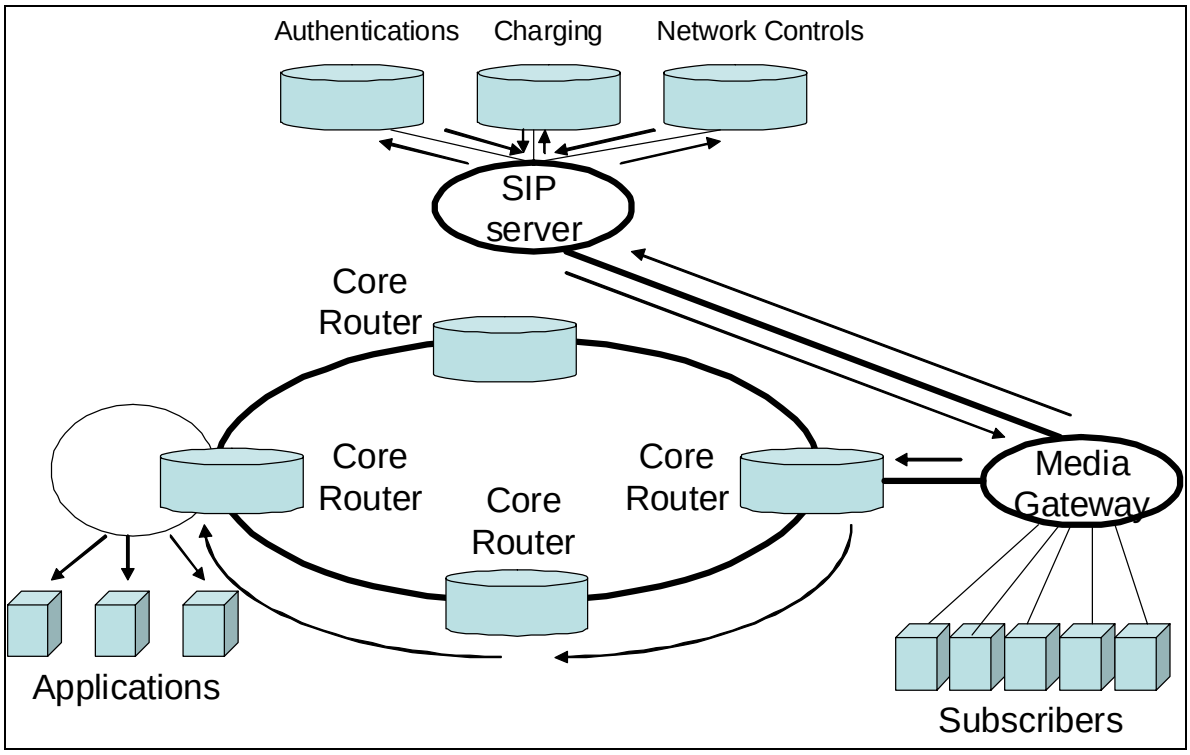


Figure5-6-(5) The diagram of NGN

3.4 The development of NGN

Consequently, NTT lab began to develop their NGN system after announcing that NTT begin the NGN experimental project in December 2006.
The four family companies participated in the development by integrating their existing data communication and vendor technologies. As an example, although NTT purchased core routers of the system from CISCO and Juniper Networks[96], both were affiliated with Fujitsu and NEC for each. NEC and Fujitsu played the role of integrators at NTT's request. The edge routers were procured from a Japanese company, Alaxaia Corporation, the joint company established by Hitachi and NEC in 2004. This company aims to enter the high-end router markets dominated by US companies like CISCO and Jupiter Networks, and they focused especially on using the NGN system[97]. As pointed out before, in the NGN system, an edge router has many functions, performs complex tasks using session controls to allocate bandwidth for each session dynamically. At the same time, a large amount of data has to be transacted. Furthermore, high reliability is required. Products that can fulfil these requirements were beyond the capacity of existing routers. Telecom companies had accumulated these technologies through their experiences of developing ATM and ISDN. Therefore, in the experimental phases of the NGN, the family companies had an advantage over other router makers when it came to developing such routers. Consequently, NTT procured their SIP servers from NEC and Oki[98].

The above facts show that the collaboration system between NTT and the family companies is still going strong. NTT accepted their hardware components from router makers Cisco and Jupiter Networks, along with servers for their systems. Based on these vendors' products, NTT developed its own original communication technologies by collaborating with its family companies. Their work added special functions or tuned these products to satisfy NTT's needs. These activities were similar to those of general information systems. In addition, the development

[96] Nikkei IT-pro "vendors of NTT NGN experimental network", 2006-12-04, http://itpro.nikkeibp.co.jp/article/COLUMN/20061204/255755/
[97] http://www.atmarkit.co.jp/news/200410/05/alaxala.html
[98] Nikkei IT-pro "vendors of NTT NGN experimental network", 2006-12-04, http://itpro.nikkeibp.co.jp/article/COLUMN/20061204/255755/

required a variety of relevant technologies, from software and server, to semiconductors and processors as well as communication technologies. NEC and the other family companies have organized full line-ups of these technologies. These managerial methods contributed to the development of the NGN for the family companies.

However, the nature of the collaboration had changed. This change came from the open standard and integration trends between telecom and information systems. Most of the NGN system specifications rely on open standard technologies established in international organisations such as ITU-T, IETF and W3C. Telecom technologies were also standardized in ITU-T and were open to the public. However, these technologies were very unique and complex, and could only be used only telecom equipment. Therefore, only a limited number of actors could deal with these technologies. With the development of computer and Internet-relevant technologies, telecom and information system technologies gradually became integrated. As a result, information-relevant technologies can be used for telecom equipment. If the specifications have been established by open standard technologies, new players can easily develop telecom equipment. In fact, router-makers can be involved in the commercial systems of NGN by adapting their superior technologies, high-speed routing, and their network management functions to NGN specifications. For example, Cisco recently announced that their latest router product has been accepted by NTT, and Juniper networks have also released their edge router for NTT's networks[99].

[99] CISCO "Telepresence of CISCO is accepted for NGN network both in NTT-east and West.", news release, 2008-10-01 <http://www.cisco.com/web/JP/news/pr/2008/038.html>

4. The Service Development of NGN

4.1 Service delivering functions

An information system provides services by linking with peer-to-peer connections between a client and a server or servers. For example, with enterprise systems, a closed network is provided by each LAN in an area being connected through dedicated lines. In B to C businesses, a customer can have access to a site provided by a company on the Internet. Behind each site, application servers transact behind the network, returning the service that the customer requires. NGN, however, aims to provide services on the actual network. The network functions of NGN can be regarded as a basic communication method for transferring data to its destination, while interacting with service control functions. Therefore, NGN mounts service-offering functions on the network as well as providing Internet and other network access. Service-offering functions are mounted on the network and cooperate with network functions through SIP servers. SNIs (Service Node Interfaces) are the interface specifications established by ITU-T, and these act as interfaces between SIP servers and service functions. The network interface specifications are kept open to the public in order to facilitate the creation of diverse application services. Therefore, SNI interfaces open the door for service providers to use network functions provided by the MGN. These interfaces are open to the public, along with two other interfaces, one between the user and the network (UNI), the other between networks (NNI). Consequently, in order to provide services, the contents of functions and interfaces provided by the NGN are emphasized. Therefore, close attention needs to be paid to what kinds of services would be available for the NGN, and what features of the network are required to offer these services. Given these circumstances, NGN has to provide comfortable environments in which new entrepreneurs can do businesses easily on the network.

4.2 Field Trial

On December 20, 2006, NTT launched a field trial for the NGN. The trial aimed to verify the technologies and assess customer needs in preparation for starting full-scale commercial services of the network[100]. Before full-scale introduction of the next generation network, the trial had two main objectives: to verify the technologies that would go into the final network system, and to obtain feedback from trial users in order to assess their needs. At the same time, by disclosing the application/terminal layer interfaces and conditions for interconnection with other networks, broad participation would be sought by electronics vendors, service providers, and other carriers in providing a variety of application services[101].

The field trial was divided into three stages. During the first stage starting in December 2006, the trial was open to visitors to showrooms in Tokyo[102] and Osaka. In the second stage, starting in January 2007, NTT Group employees living in the trial service areas participated in the network trial. Finally, the third stage (April to December 2007) involved the trial being expanded to include ordinary customers living in the trial areas.

The trial largely verified NGN's interoperability between other network providers. However, attractive new services could not be found. For example, the show room demonstrated high-quality conference systems plus high-quality streaming services and network appliance systems, but these services were already known to the public. The trial finished in December 2008, and NTT released the first commercial versions of the NGN to the public. The next-generation network was built and operated by the two regional companies, NTT East and NTT West. The NTT Group companies, chiefly NTT Communications, took part in providing application services and other upper-layer network services.

[100] NTT news release at http://www.ntt.co.jp/news/news06e/0611/061122a.html
[101] NTT news release at http://www.ntt.co.jp/news/news06e/0603/060331.html
[102] NTT news release at http://www.ntt.co.jp/journal/0805/files/jn200805028.pdf

4.3 Focusing on B to B business

Recently, NTT has been considering B to B businesses, especially SaaS and Cloud Computing businesses, as the main focus of NGN services. A business system requires high security and a reliable network. These systems are therefore constructed not on the Internet, but using dedicated lines to connect each area. However, this method leads to high cost and a lack of flexibility when the system is changed. Consequently, VPN (Virtual Private Network) technologies are used to replace dedicated lines. VPN provides a single private network in which the link-layer protocols are tunnelled through the larger network (e.g. the Internet). It can reserve secure and constant communication by defining the SLA (Service Level Agreement). However, the low level of security and reliability of the Internet creates difficulties for a company constructing Internet-based VPN. The NGN network is considered an appropriate method for constructing a business network because of its higher security and reliability compared to the Internet. More mission critical[103] users will be expected to use the NGN as part of their system, as they reduce costs while maintaining security and reliability.

NTT are also paying close attention to the Cloud and SaaS businesses. In general, these services are provided through the Internet. However, this raises questions about privacy, security, and reliability (Hayes 2008). Enterprise systems require an extremely high level of operational reliability. Cloud providers agree SLAs (Service Level Agreements) with each customer. They are not satisfied with current levels of operational capacity, and are trying hard to improve the reliability of their systems, but are still having trouble with Internet-related problems. NGN can provide secure and high reliable network functions for providers, and is therefore welcome among these providers as it gives them a reliable network. In addition, providers can offer security, charging, authentication and other network functions or can combine their original functions with them. The figure below shows the concept of providing SaaS services in the NGN[104]**(Figure4-6-(6))** . There are modularized service components, called 'Enablers'. These are segmented communication

[103] The term 'mission critical' means when any setback (equipment, process, procedure, software, etc.) immediately makes crucial the successful completion of an entire project.
[104] There are other models of SaaS over NGN. This model is conceptualized based on the SOA (Service Oriented Approach) model.

functions, and a business process is created by the integration of these components using the function ESB (Enterprise Service Bus). Service developers can use and integrate these components to develop application products, or create new services by combining other application programs. Finally, an integrated application system operates network functions through SIP servers.

In order to provide these systems, an enormous number of infrastructure functions - such as charging, authentication and security, as well as application components such as Streaming, CRM and ERP - are needed to mount the NGN system. In addition, recent service developments have been provided by a combination of modularised software components segmented on layered stacks. These software modules are compliant with API and other interfaces between network functions. These functions are based on middleware, called application servers or SIP servers, and are provided by Oracle, IBM and other software makers, including the family companies. In order to provide services on the network, it is critical that these products or software modules are combined and integrated to match customer demand. NTT uses SaaS (Software as a Service) as a key component of their NGN system. They have collaborated with Salesforce.com[105] and Microsoft[106] to develop SaaS services for NGN. Hanazawa, Director and Senior Vice President, Director of Research and Development Planning Department, mentioned that the next step of their R&D activities after the NGN will focus on Cloud-related technologies and the management of computer resources' cooperative technologies. These technologies are dominated by service providers such as Amazon and Google and other computer makers, and Hanazawa[107] mentioned that NTT will try to develop these technologies by collaborating with other external companies as well as making positive use of open source technologies. NTT aims to develop its platform of providing services by integrating external resources.

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[105] News release from NTT, NTT communications and Salesfoce.com, 2008.05.06, <http://www.ntt.co.jp/news/news08/0805/080526a.html>

[106] NTT "NTT and Microsoft Collaborate on SaaS Over NGN", 2008-12-10, <http://www.ntt.co.jp/news/news08e/0812/081210a.html>

[107] From his speech in NTT R&D forum held in 2009-02-19. Takashi Hanazawa is Director and Senior Vice President, Director of Research and Development Planning Department.

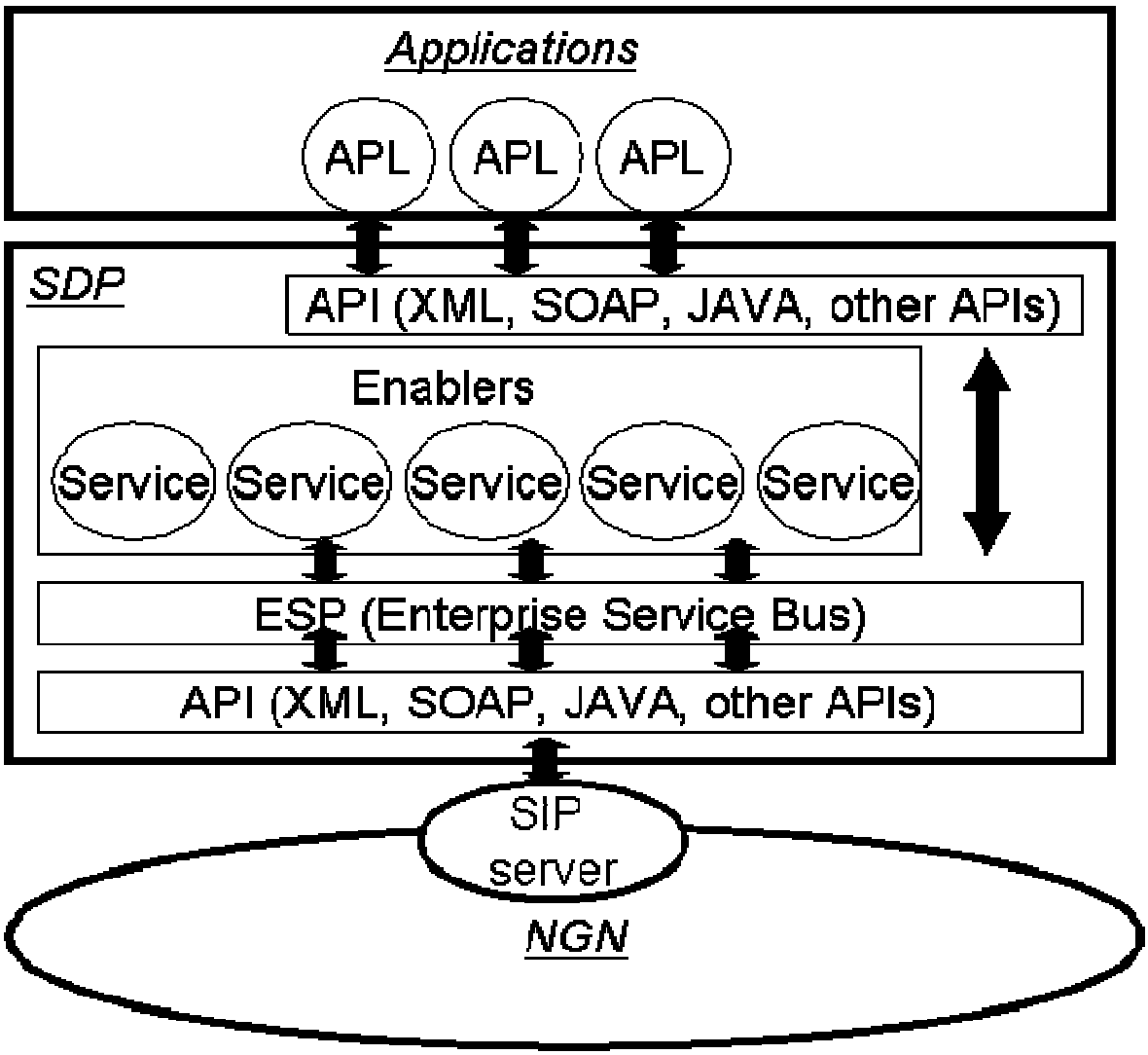

Figure4-6-(6) SaaS on NGN

In order to create new services on the NGN, NTT established the Next Generation Services Joint Development Forum, an open business forum based on the concept of 'Joint Development'.[108] At the forum, organizations and businesses from a variety of fields including the ICT industry work together to create new businesses. NTT is set to support the development and commercialization of new services. In this forum, participants can exchange ideas, actively share information, and build various collaborations to achieve the goal of rapidly developing services based on this new infrastructure and create new businesses[109].

[108] NTT news release at http://www.ntt.co.jp/news/news08/0803/080331b.html
[109] NGS forum at http://www.ngs-forum.jp/e/about_forum/index.html

5. Discussion

5.1 Segmenting communication businesses

The emergence of WWW and high-speed networks changed the nature of the telecom market. The number of actors involved in the telecom market dramatically increased, and the market is now segmented, consisting of many specialized actors within each layered stack. These movements are closely related to developing Web-based technologies.

The World Wide Web provides standard interfaces for data communication, leading to unified development methods for communication and information systems. At the same time, these technologies strongly affect the communication and information industries.

Along with web-relevant technologies becoming standardised, developers eventually used it to design software products, while companies set up web-based businesses. At the same time, as well as providing standard interfaces between users, web-relevant technology also provided common interfaces between information systems. These standard interfaces were established in open communities, such as IETF and W3C, making them available to the public. This meant that one company would not be able to produce all of its technologies in-house. IBM had dominated the computer market with their secret interfaces, which connected their facilities to their software products. However, new enterprising companies could now enter the market if they developed their original products based on these standard interfaces and specifications.

Object-oriented programming methods enabled software as components. Each software component is linked to API interfaces, enabling them to cooperate. Java helped to make this modular trend more widely accepted. Methods of application software development were unified by Java-based programming. Furthermore, web service technologies (SOAP and other XML related technologies) provided inter-operational functions between software components that existed in other computers. These technologies led to a unified environment for system

development. In addition, web technology gave rise to a new software category as well as new services such as middleware products and application services.

As a result, the web's high inter-operability, added to the acceptance of standard interfaces and modularised software, affected both the information and communication industry. Web-relevant technologies were accepted for large-scale systems, and their applicability expanded into communication areas. As a result, both markets became integrated.

The development and improvement of web-related technologies helped to make this integrated market segmented. Due to poor interoperability, major computer companies like IBM had previously managed all functions vertically in-house. However, the standardisation of interfaces and unified development environments enabled technologies to work together easily. Companies could now concentrate on developing their specialised technologies without considering infrastructure. They simply had to design and create their products based on the standardised interfaces and specifications. At the same time, the area of competition moved to upper layer businesses. In middleware and applications businesses, there are lots of players, each of whom have specialised technologies and services. Companies were able to compete in every specialised software category, or sometimes cooperate with other players. These circumstances had been brought about by the technological ability of the web to enable a high standard of interoperability. Moreover, these technologies helped lead to greater cooperation among companies.

5.2 Changes of the Japanese telecom industry and the collaboration system

Therefore, telecom operators are changing their managerial mode from telephone provider to that of service provider, integrating the layered services and offering them as a package. As a result, NTT lab shifted its policy to IP-based developments. They began offering telephone services on IP-based technologies, aiming to develop an integration network for providing both IP and telephone services. At the same time, NTT's target apparently changed from AT&T and IBM to Internet-relevant companies.

These events have changed the role of inter-firm relationships. In the development of the NGN, the 'family companies' also maintained their strong position in NTT's R&D activities because they had accumulated communication and computer technologies. One family company acted as mediator, integrating the new IP-based technology with their superior telecom-based technology. However, it should be emphasised that the focus of telecom carriers has shifted from the network to offering upper layer services. In other words, the leverage of communication industry has apparently shifted to services. NTT developed affiliations with new actors for its service development. They ran experimental projects, through which they were attempting to understand market demand and analyze the required network functions for providing services.

Previously, the family companies gained large benefits from NTT purchasing hardware products, as software developments were yielding little reward. However, along with NTT fully accepting vendors' products for their systems, NTT's business for family companies was no longer such a juicy source of profit. Therefore, the family companies were gradually placed at a distance compared to their previous position under the collaboration system. Meanwhile, NTT worked directly with other companies on their R&D activities. Their increased need for computer and Internet technologies meant that they needed to expand into new areas of technology. Therefore, NTT lab had to deal with variety of technology. In order to adapt to these circumstances, NTT lab would either engaged with companies who have competitive or de facto standard technologies within specific areas or simply purchase these technologies. These activities took place not under the comprehensive remit of the company, but within small units, such as departments or project teams. Family companies have also engaged in NTT's R&D activities. However, this time they acted as me a kind of vendor to NTT.

5.3 The emphasis of inter-firm relationships and integration abilities

Previously, R&D activities in NTT concentrated on physical functions such as switching, routing and line controls. Technological resources were used to connect and integrate technological components, and were limited to telephone services.

However, as telecom businesses have expanded into upper layer businesses and more focused on services, there has been in a change in the type of goods arising from R&D activities. The R&D department aims to offer network services; not specified services like telephone and data communication functions, but more customized technology services that each service provider wants. In other words, change of "goods" provided by R&D activities initiates a change in roles of R&D activities, influencing their inter-firm relationships. Now, NTT is looking for potential players to integrate external resources from the supply side (upstream activities) while scanning market demand (downstream activities). This case shows the importance of these upstream activities in coordinating inter-firm relationships in a service-oriented approach, and assumes the existence of a facilitator who can bridge both upstream and downstream activities. R&D will act as a 'technology service provider' that offers technological solutions and integration abilities based on individual customer demand.

The emergence of Cloud Computing and SaaS businesses would emphasize the role of inter-firm relationships, especially when it came to the integration of functions. The trend seems to be towards service providers offering everything as a service, from infrastructure and platforms to applications. In these circumstances, integration abilities are more important for developers when constructing systems or creating application services, as Cloud and SaaS offer every component in the network. This allows developers to use or integrate these components to suit their purpose. Aside from integration ability, the management of inter-firm relationships is more focused. Cloud computing services are based on a variety of technologies. A company cannot build these services on its own, and collaboration with other players becomes indispensable for developing services. In other words, in order to develop a service, a company has to select the available technologies and partners from the supply side. Therefore, there is an emphasis on the importance of how a company manages inter-firm relationships in the supply-side as well as its integration abilities.

Chapter5 Discussions and Conclusions

Summary

This thesis attempts to clarify the relationship between the marketing concept and technology management, focusing on inter-firm relationships. More precisely, it aims to show how inter-firm relationships and a marketing perspective can lead to large-scale, complex R&D activities that adapt to turbulent circumstances, rapidly changing technological trends. In addition, the study shows how developing technologies have influenced the market and how inter-firm relationships had to be changed associated with the developing technologies. Specifically, by measuring technological circumstances as the level of uncertainty and equivocality, the study investigates how inter-firm relationships are changed from existing relationships to informative and comprehensive partnerships. Furthermore, this thesis aimed to explain the role of inter-firm relationships and suggest how firms should organize their internal and external resources to adapt to integration and service-oriented trends.

The following research questions were explored; (1) how developing technologies influences the market, (2) how an inter-firm relationship works in R&D activities, (3) how inter-firm relationships need to evolve as technologies develop and (4) how inter-firm relationships had to be changed along with developing technologies. The case study methodology is used in order to demonstrate these research questions. This study uses the Japanese telecom industry and in particular, the company NTT as a research case, focusing especially on switching systems projects after World War II.

Considering the relationship between developing technology and its influence on the market, it can be argued that technological development brought about changes in the market. In other words, developing the technology expanded its domain of applicability. As a result, the existing market was forced to undergo change. For example, LSI and computer-relevant technologies were initially used in the computer industries. However, their fast progress led to them influencing telecom markets. This in turn resulted in data communication services and the integration of telephone and data communication. Additionally, internet-relevant technology expanded its domain of applicability from local networks in offices to international communications through Internet. Finally, these technologies supplanted telecom-oriented technologies. Telecom companies were forced to construct a network based on internet protocols. As a result, the nature of the telecom market changed to that of an internet-based market. Telecom operators changed their managerial mode from telephone provider to one where they offered an integration of layered services as a package.

Consequently, a number of new actors began to appear in the telecom market. The Web's high inter-operability, acceptance of standard interfaces and modularizing software affected information and communication industry, leading to integrating both. Furthermore, the standardizing interfaces and unifying development environments provides a common platform of service delivering and enabled to interwork service components easily. As a result, the integrated market was segmented consisting of many specialized actors in each layered stack.

These movements also forced a change in the collaboration system. The Japanese telecom market featured relational exchanges and high mutual dependence within the collaboration between NTT and four family companies. However, along with developing technologies and the expansion of the telecom market, family companies tended to compete against other players within or outside the collaboration. In other words, the nature of the market has changed from collaborative to competitive. At the same time, NTT's target in monitoring technological trends has changed from AT&T and IBM to internet-relevant companies.

Along with changes in technological trends, the structure and content of a market has altered. In the Japanese telecom market, relational exchanges occur and actors are highly mutually dependent. However, these relationships are not static when looked at over a long period. Therefore, both the content and the structure have changed under the influence of technological and business circumstances.

These results emphasize the following two points: Firstly, with increasing integration of the market, the number of participants in the market has increased (**Figure 5-1-(1))**. Additionally, these participants tend to concentrate on specified businesses with specialized skills **(Figure 5-1-(2))**. In the early 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 firms. These new business areas had many firms in computer businesses and system integration companies. Consequently, as NTT became involved in internet services, many more firms were involved in telecom markets. These firms 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.

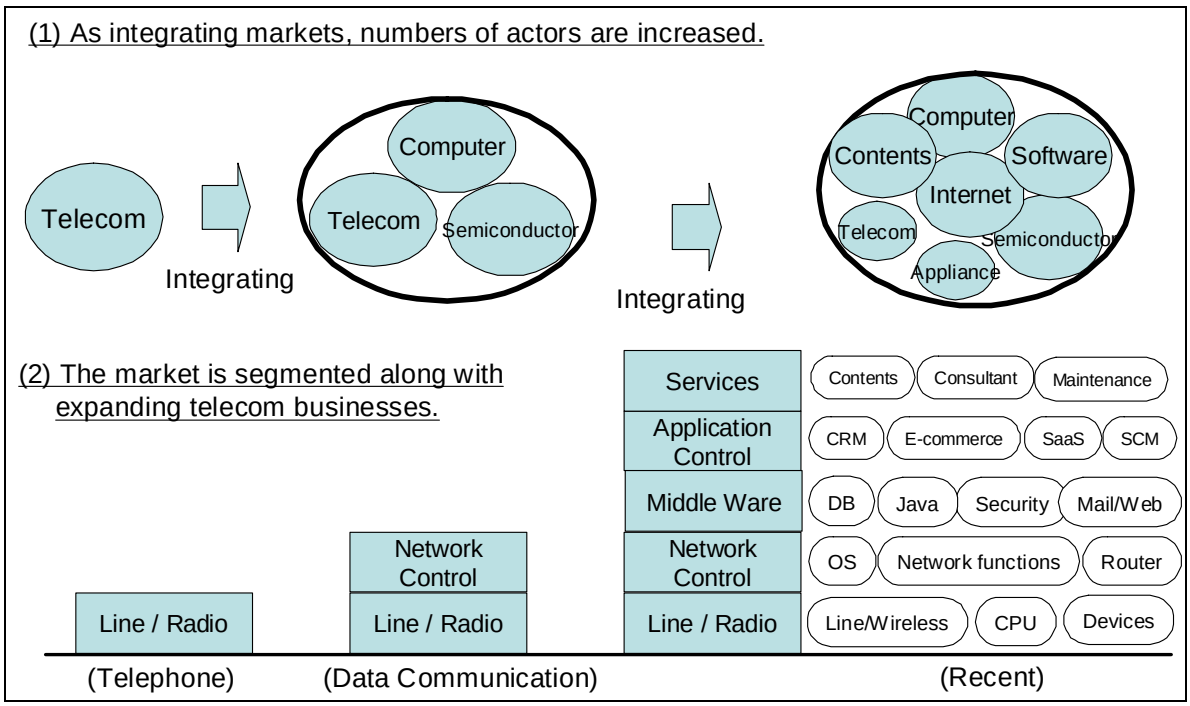

Figure 5-1The changes of the Japanese telecom market

Findings indicate that the collaboration system played two roles: collecting advantageous technologies from others and mediating in the introduction of new technologies. NTT and family companies tried to collect technological information through affiliating with each unique partner. The advanced information they obtained was amended and refined through the development of experimental products within the collaboration, which then became their advanced technologies. As a result, these technologies can be used not only for current projects but also in future ones. Family companies are also used for their own products. In addition, the collaboration system plays the role of mediator in integrating new and existing technologies, allowing for new services which accept the new technological trends.

In addition, the result creates a new role of inter-firm relationships: coordinating external suppliers, and integrating external and internal resources to meet customers' demand. Developing the technology expanded its domain of applicability, bringing about changes in the market. As a result, the role of inter-firm relationships in R&D activities has changed. The emergence of WWW and high speed networks changed the nature of the telecom market. The market is now segmented. Therefore, telecom operators are changing their managerial mode from telephone provider to that of service provider, integrating the layered services and offering them as a package. In service development, NTT is looking for

potential players to integrate external resources from the supply side (upstream activities) while scanning market demand (downstream activities) **(Fugure5-2)**. These findings assume the emphasis of the importance of these upstream activities in coordinating inter-firm relationships in a service-oriented approach. At the same time, these findings suggest that the concept of market should be broadened to include not only existing customers and competitors but also other stakeholders who have the potential to contribute towards creating future customer value and develop competitive advantage in future markets.

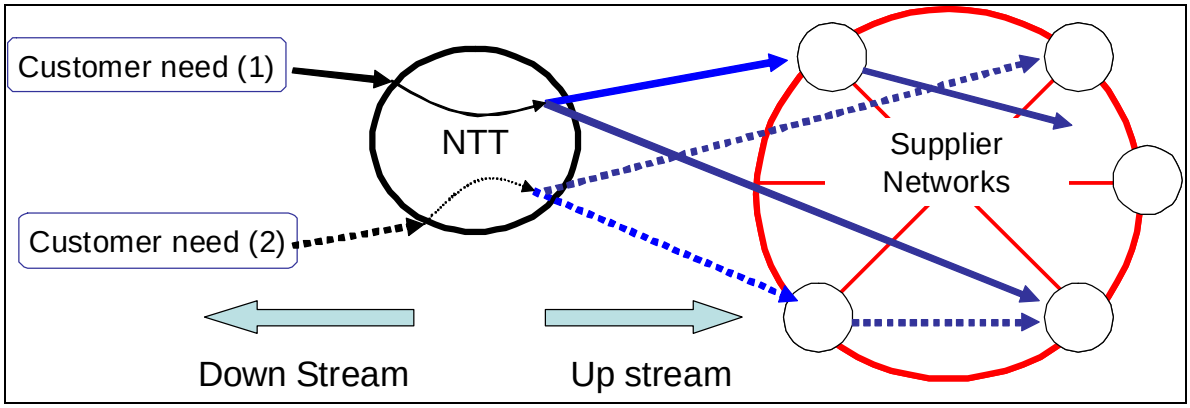

Figure 5-2The roles of NTT in service developments of the NGN project

Findings indicate that indirect exchanges occurred when inter-firm relationships changed **(Figure5-3)**. It means 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. In this case, indirect exchanges emerge to compensate for 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.

The emergence of innovative technologies brought from computer and internet industries had further 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[1]. The family companies' technologies

[1] The low applicability of Internet-relevant technologies was the main reason. These technologies were not enough to match the high level of reliability and complex specification that NTT required.

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, as Internet and relevant technologies developed so the telecom relevant technologies became less relevant. As needs increased for computer and internet technologies, their required technological areas were expanded. Therefore, NTT lab had to deal with a 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 exchanged directly with new participants without family companies, collaborating not only with family companies but also with these new companies. These activities took place not as a comprehensive policy but by small units, like departments or projects. Family companies also joined these collaborations, but their positions are treated as a type of vendor having superior communication technologies.

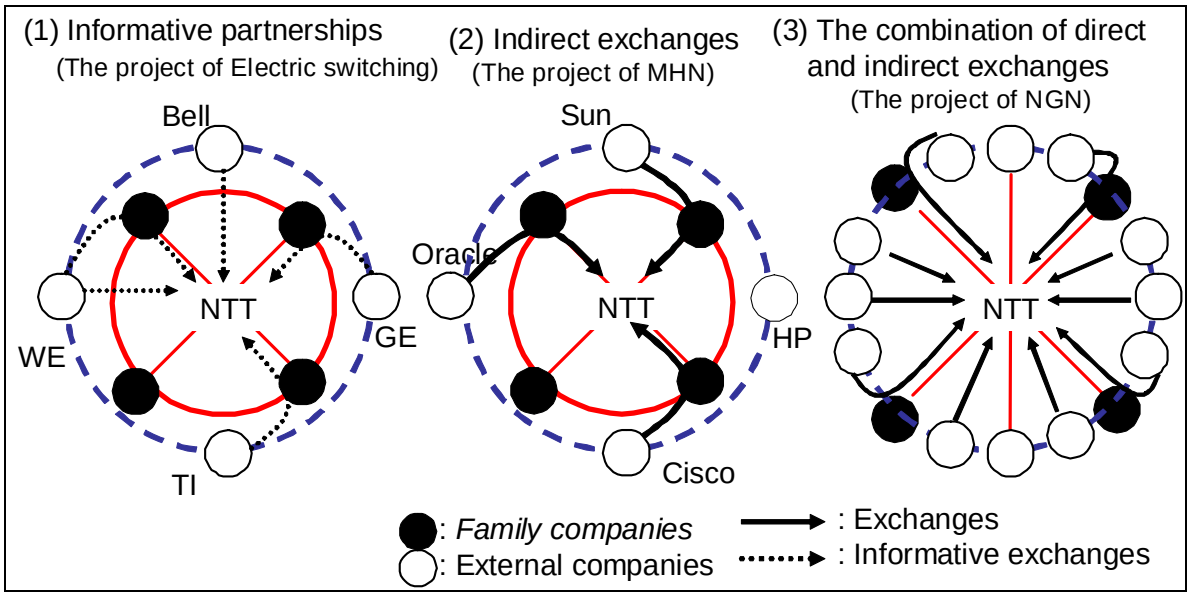

Figure 5-3The changes of inter-firm relationships

This study clarified how changing technologies trends affect a market. In addition, the roles of inter-firm relationships have greatly contributed to develop technological resources. At the same time, by focusing on changes in technological trends, the study showed how inter-firm relationships are changed along with a developing market. These finding can emphasise the importance of inter-firm relationships in R&D activities. In the future, these trends will increase. The concept of “Ubiquitous Computing” aims to get all objects with

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Therefore, these technologies did not install directly, but needed helps of technologies that family companies had accumulated for long-time collaboration with NTT.

computer and network functions, not just communication appliances, networking with each other. In addition, several IT vender companies now provide software products as an on-demand service (Software as a Service) through their own network. This trend is apparent in areas such as infrastructure (Cloud computing) and service delivery platform (Platform as a Service). Considering these trends of more focusing on service developments, it becomes even more important what technologies are accepted or withdrawn. These selecting abilities will be a key factor in succeeding in the market. Under these conditions, inter-firm relationships will play an even more important role. R&D activities will not only concentrate on accumulating technological resources through in-house activities but also will focus on integration abilities that enable to fuse external and internal resources. Previously, R&D activities in NTT concentrated on physical functions such as switching, routing and line controls. Technological resources were used to connect and integrate technological components, and were limited to telephone services. However, as telecom businesses have expanded into upper layer businesses, there has been in a change in the type of goods arising from R&D activities. The R&D department aims to offer network services; not specified services like telephone and data communication functions, but more customized technology services that each service provider wants. In other words, the R&D activities of NTT are not required to offer the ‘highest common factor’ and other specified services, but should provide ‘least common denominator’ services, along with a variety of services capable of responding to customer demand. R&D will act as a ‘technology service provider’ that offers technological solutions and integration abilities based on individual customer demand. R&D activities therefore need to involve new potential players and technologies, taking into account new and existing inter-firm relationships.

Theoretical Contribution

This thesis attempts to clarify the relationship between the marketing concept and technology management, focusing especially on resources. Previous studies focusing on business resources (e.g. Penrose (1959), Day 1994 and Vargo and Lusch 2004), show that resources are created by continuous organizational learning within a firm as well as interaction with markets. On the other hand, studies of R&D (e.g. Niosi 1999) emphasize the importance of inter-firm relationships. However, the relationship between developing business resources and inter-firm relationships has not been clarified.

Firstly, this thesis attempts to clarify the relationship between inter-firm relationships and developing business resources. The concept of market orientation was used in adapting innovation, as it emphasizes continuous interaction with markets and external environments. At the same time, there is a need to clarify how organizational learning and interaction works within inter-firm relationships. This study emphasized the importance of continuous interaction with markets and external environments in order to create resources which can contribute for future.

The study also focused on the concept of operant resources. The operand resources indicate that only tacit things like knowledge and skills of individual workers are not to sustain competitive advantages, but resources developed from organised activities and interaction with external actors lead to sources of competitive advantages. The concepts of operant resources and market orientation greatly contribute to explain how the collaboration systems of NTT and family companies had contributed to their projects and to show the importance of inter-firm relationships in developing technological resources.

Capabilities and competences can be regarded as the bundle of operant resources that have accumulated from long term firms' activities. Considering the multiple applications of business resources, an innovative technology invented in a specific area can be used for other purposes. This feature of multiple applications leads to changing technological factors in a market.

Additionally, market orientation studies (e.g. Norman and Rafael 1993, Slater and Narver 1995, Achrol and Kotler 1999) have shown that the concept of the market should be broadened to include not only existing customers and competitors but also other stakeholders who have the potential to contribute towards creating future customer value and to develop competitive advantages in a future market. By applying the concept of market orientation to the process of developing business resources, this thesis links R&D activities to marketing concepts. As a result, the thesis defines R&D activities as those that create business

resources through continuous organizational learning and interaction, not only with competitors and customers, but also other stakeholders.

The case indicated that inter-firm relationships have greatly contributed to develop technological resources by clarifying two roles of inter-firm relationships. In addition, inter-firm relationships could be well accepted for changes of technological environment. NTT and *family companies* exchanged technological resources and developed their own by using resources obtained through collaborations. These gained technologies and experiences were used for future projects. Additionally, the family companies affiliated with foreign partners in order to study advanced technologies, gaining know-how which was exchanged between the family companies through their collaboration. In other words, the collaboration system played a role in obtaining advanced technologies from others. These functions provided adaptive abilities for environment changes.

Findings showed that inter-firm relationships are not static but changeable. This is in alignment with the industrial network approach, as outlined in IMP and the network approach (e.g. Ford 1980, Hakansson 1982, Johansson and Mattsson1987). Their study is based on the assumption that industrial exchange is a stable and gradual change. On the other hand, these findings also show that inter-firm relationships are changeable under long-term observation, despite the fact that they seem stable under short-term observation. Through the case study, we can see how a market has been changed along with developing technologies. Developing IP, Web and software technologies affected the telecom market, integrating with computer and information markets and segmenting the market. In the ICT (Information and Communication Technology) industry, a company cannot domain whole of technologies and develop in-house. Furthermore, the leverage of competition is moving to upper layer businesses. As a result, the market consists of many players who have special technologies and services in each layered market. Companies are focusing on integration activities; seeking potential good players and integrating external/internal resources to provide services for their customers. In the past, NTT had carried out their R&D projects mainly by collaborating with specific companies. However, even though keeping the relationships, they are trying to engage with external actors. Therefore, the study emphasised the importance of managing inter-firm relationships in supply-sides. In addition, a company should not concentrate on managing existed inter-firm relationships but handling external players who have potential technologies to contribute for developing unique services.

This paper also attempted to clarify mechanisms that how inter-firm relationships are changed based on the study of Anderson, Hakansson and Johanson (1994) . The telecom industry comprises firms from several resource frameworks, not only those directly involved in telecom technology but also firms involved in specialist technology and others involved in applications. There are many processes associated with service development. The links amongst these firms, that together create the telecom sector, involve relational exchanges of various types. Some relationships are characterised as long-term, sustainable, mutually supportive relationships. Others are shorter-term and more ephemeral. Although the nexus of links is considerable, each firm or department operates within a relational environment which involves only a limited number of identifiable organizational firms.

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 within the network. Organizations are embedded in a network of interdependencies and social relationships. In addition, a need for resources from outside the network makes organizations dependent on external resources. A complex equilibrium develops, which balances internal resource use, resource dependence on network partners and dependence on resources drawn from outside the network.

However, these previous approaches (e.g. Pfeffer and Salancik 1978, Arndt 1979) arise from the fact that a firm exchanges only with the specified actors involved in the network. The assumption of previous discussions for example, Hakansson and Snehota 1987, Mattsson (1987) and Gadde and Mattsson (1987) is that industrial exchange is a stable and gradual change in nature. If the market is so rapidly changeable, as is the case in high-technology industry, it is very hard to adjust to these business circumstances because they do not have enough skills to adjust to changes.

This thesis attempts to clarify mechanisms of changing inter-firm relationships under dynamic business circumstances. Specifically, by measuring technological circumstances as the level of uncertainty and equivocality, as defined by Bourgeous and Eisenhardt (1987), Glazer and Weiss (1993) and the concept of dominant design (Abernathy and Utterback 1987), the study investigates how inter-firm relationships are changed from existing relationships to informative and comprehensive partnerships.

The case study showed that indirect exchanges occurred when inter-firm relationships changed. Indirect exchanges are taking place. In other words, inter-firm relationships change, keeping existing but adding new relationships. This extends on the work of Anderson, Hakansson and Johanson (1994).Changing inter-firm relationships is not a straight forward single step process. The process is multi-stage. In this case, indirect exchanges emerge to

compensate for lack of capabilities in new technologies as well as to adjust new technological trends. Through the process, a company evaluated the applicability of these technologies for their systems and learned how these technologies were used for their future systems. As a result, a company 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 making special ties with other companies. Therefore, the structure is web-like. Through further observations, we should investigate if a change from these “weak-tie relationships” to comprehensive partnerships will occur, and clarify the mechanisms of how and why weak-tie relationships change to comprehensive partnerships.

This study emphasises the result that marketing concepts would greatly contribute to explain R&D activities because inter-firm relationships lead to R&D activities by focusing on market orientation and business resources originating from an exchange of technological knowledge and specialized skills. Another significant contribution clarified mechanisms of changing relationships along with altering a market. From long observations, inter-firm relationships have not remained static but changeable with seeking and adding new players along with changes of business circumstances. Previous studies of industrial networks are based on the assumption of a clear boundary between a network and an external environment (Anderson, Hakansson and Johanson 1994, Hakansson and Snehota 1987). This study shows how changes to inter-firm relationships occur beyond the boundary of the industrial network. This finding contributes to studies of the industrial network.

Further Study

The study examines results by focusing on R&D activities in the Japanese telecom industry. Structures of the industrial network influence the activities of actors involved within the network (Hakansson and Snehota 1987). Therefore, different structures of inter-firm relationships might lead to other roles for inter-firm relationships, or affect the process of changing partnerships. The structure of the Japanese telecom industry was extremely hierarchical, which is one of the reasons why NTT initiated the collaboration system. However, structures of inter-firm relationships differ within each industry and country. The way relationships are developed is different in Japanese and European mobile businesses. In Japan, carriers take the initiative when it comes to technology development. They are also very much involved in decision making about technology. For example, 'NTT–DoCoMo', mainly develops new mobile services and decides what technologies they will apply to their network and appliances. They are also currently amassing new technologies, so that they can introduce new services into the market, while requesting setup makers to apply the technologies which a carrier has decided to apply. Setup makers (e.g. Panasonic) help the carrier in their area, and can be regarded as suppliers, in that they co-operate with and are a part of realizing the carrier's services. Carriers have a dominant position in business and technology, and they have the power over setup makers. On the other hand, it can be observed that those relationships are different from those in Europe. Set-up-makers (such as Nokia) have a strong position in the mobile business. Even if carriers develop some mobile services, the introduction of their services is mostly up to the set-up-makers. Therefore, the network structure is not hierarchical but equal. Further studies need to be carried out to discover how these differences of industrial network structures affect the role of inter-firm relationships and the mechanisms of changing partnerships.

This study shows how mutual interactions within an inter-firm relationship greatly contribute to developing technological resources, and emphasises the importance of selecting and integrating abilities to future telecom service development. It also looks at how the telecom industry has shifted to upper layer businesses, focusing on services. Therefore, NTT is now moving from being a telephone company to a communication and information service provider. Whereas previously NTT's R&D activities provided physical functions, switching, routing and line controls, they now focus on technology services that provide solution and integration abilities to customers. In a new trend, "Everything as a Service', IT vender companies now provide software components as an on-demand service (Software as a

Service) through their own network. This trend is apparent in areas such as infrastructure (Cloud computing) and service delivery platform (Platform as a Service). As a result, developers' tasks are mainly focused on selecting and integrating software components with configuration tasks to meet customer demand. Consequently, the role of R&D activities in NTT is to integrate and manage these services in cooperation with other service-developing companies. Previous research on service development focused on the interaction between customers and providers (Gummesson 1977, Gronroos 1980 and 1997, Levitt 1981) However, these findings show that selecting and integrating external resources on the supply side should be seen more in terms of service development. These findings will contribute to studies on service development.

In addition, this study emphasises the roles of inter-firm relationships in developing business resources. In the ICT industry, the trend towards modularity and open standards has increased opportunities for firms to specialize in component supply or system integration. Many smaller specialized firms existing within each layer supply modular hardware and software components. This trend emphasises the importance of providing solutions rather than selling products (Skepherd and Ahmed 2000, Davies 2004). Each solution can be tailored to a customer's needs by using standardised, reusable and easy-to deploy modules based on product platforms and service portfolios (Davies et al. 2007). As well as these downstream activities (Wise and Baumgartner 1999), the focus shifts to upstream activities where service providers manage the supply side (Hobday et al.2005, Ervelles and Stevenson 2006). Firms cannot store all of their necessary technology in-house, requiring external actors in order to combine internal and external technology. These discussions indicate that the role of inter-firm relationships will be more focused on service development.

This paper assumed the existence of a "facilitator", who is able to understand and analyse the attributes of the demand side, seeking and selecting potential technology from suppliers, and integrating it. Finally, the facilitator provides these integrated solutions to the demand side. These activities are linked together by partnerships and alliances, often working in temporary consortiums for the duration of a project. The case assumed that the role of inter-firm relationships should be focused on developing capabilities that can integrate external and internal resources from the supply side to match demand.

The role of inter-firm relationships in service development will be studied in future research. Previous research of service developments had focused on interaction between clients and providers, mainly in the context of B to C. However, this research will emphasise the importance of B to B relationships to study service developments, contributing service marketing area.

Conclusion

This thesis analyses the relationship between the marketing concept and technology management, emphasizing the role of inter-firm relationships in creating innovation. The focus was on the concept of market orientation as a powerful tool in adapting innovation, as it emphasizes continuous interaction with markets and external environments. Firstly, the study showed the relationship between that developing technology and its influence on the market. Developments in technology resulted in an expanded domain of applicability. Consequently, not only the market structure was changed but also the relationship between marketing and R&D changed. With increasing integration of the market, the number of related firms increased as firms concentrated on specific technologies, with additional firms having superior competitive advantages in each layered business area.

The case indicated that inter-firm relationships had greatly contributed to develop technological resources by two roles; collecting advantageous technologies from others and mediating in the introduction of new technologies. Mechanisms of changing inter-firm relationships under dynamic business circumstances were also clarified; indirect exchanges occurred when inter-firm relationships changed. Inter-firm relationships are changed, keeping existing but adding new relationships.

In addition, the study indicated a new direction to study service marketing area. As the new trend of service development in ICT industry, the integration abilities and the management of inter-firm relationships in supply-sides are focused. The paper assumed the importance of these upstream activities (coordinating inter-firm relationships in a service-oriented approach) and advocates the presence of a facilitator who can bridge both upstream and downstream activities. The study suggested the importance of inter-firm relationships in the context of B to B marketing for studying service developments.

The results should contribute to both marketing and technology management in academia as well as business practices in R&D management.

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