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The Unbundling of Network Elements
Japan's Experience

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Abstract

With the advent of the Internet, the emphasis of communication policies has moved from the regulation of telephone networks to the *unbundling* regulation to enforce sharing of network elements. Since unbundling is often impeded by the renegotiation by incumbents over the control of essential facilities, it would be advisable to separate the company that owns local loop (*LoopCo*). Recently the number of subscribers of DSL in Japan has grown phenomenally due to the unbundling regulation. This suggests that unbundling can accelerate the proliferation of broadband, but this lesson cannot be easily generalized to other countries, because the success depends on the special conditions such as extremely low pricing of entrants and strategic mistakes of NTT that neglected DSL. If the unbundling regulation succeeds in increasing competition, the telecommunications industry in the narrow sense will shrink, making the universal services of telephone network increasingly difficult.

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Introduction

Once it was argued that Japan was lagging behind western countries in embracing the Internet because the telephone charges of NTT (Nippon Telegraph & Telephone) was high, which were the main focus of U.S.-Japan Trade Negotiations. However, since 2001 the subscribers to broadband connection has grown so rapidly in Japan that it now has the greatest number of DSL (Digital Subscriber Line) subscribers in the world, while the telephone charge is still high. Nevertheless, debates about the interconnection fee are still going on; this suggests that the changes facing the communication industry are little understood. In the history of telecommunication, the change we are now facing is the most revolutionary one ever since the invention of telephone by Alexander Graham Bell. The innovations occurring now are comparable to the *institutional change* of substituting electrical power for steam power, rather than enhancing the performance of steam engines.

During the 1980's, when incumbent telephone operators were divided or privatized in many countries, starting with the divestiture of AT&T (American Telephone & Telegraph), an important issue was the regulation of access charge that would enhance competition between incumbents and the new entrants. Although the technological environment changed completely as a result of the rapid spread of the Internet in the latter half of the 1990s, telephone regulations were readjusted by the 1996 Telecommunications Act in the U.S. and the reshaping of NTT with holding company was effected in 1997 in Japan. In particular, Japan's institutional arrangement was done with unfortunate timing because it divided NTT, imitating the divestiture of AT&T, along with the structure of telephone networks. Since NTT was divided into a long-distance company (NTT Communications) and two regional companies (NTT East and West), regional companies are heavily regulated and banned from conducting business connecting multiple prefectures, thus NTT's core network was divided into many "islands" of closed networks.

As Japan is the first major country that experience the transition from the telephone to the Internet, it would set the precedent for other counties to manage the transition. In order to overcome this period without confusion, it is necessary to prioritize the policies and map out a set of consistent strategies. Since the most important objective of communication policy is to migrate from telephone networks to the Internet smoothly; short-term issues such as tariff regulation must be subordinate to this long-term target. The focus of conventional research in telecommunication regulation has been calculation of optimal charges by applying neoclassical microeconomics. These theories can analyze the efficiency under the given regime, but they cannot compare the efficiency of different regimes. In this paper, I analyze the effectiveness and social cost of unbundling regulations using new tools such as game theory and contract theory, and examine how the regulation should be enforced. In Section 1, the historical significance of the Internet is considered, and in Section 2, its technical aspect is explained. In Section 3, the negotiation problems accompanying the sharing of infrastructures and the significance of the regulation measures are defined in economic terms. In Section 4, based on the experience of Japan where DSL has shown a rapid surge in popularity, the effects and costs of the unbundling regulations are investigated. Finally, the future challenges facing the practice of unbundling are summarized. Those who know the Internet technology and interested in Japan's case can begin from Section 4.

1. The Internet as a General-Purpose Technology

The Internet is a *general-purpose technology* (GPT) that does not in itself serve any purpose but *enable* other technologies to innovate, much like electric power and steam engines. In fact the Internet is not a network but only an abbreviation of the concept of "internetworking" that connects LANs around the world with a simple protocol called TCP/IP (Transmission Control Protocol/Internet Protocol). It is historically observed that it takes a number of decades for new GPT to have a wider effect on society. In the 1870s Thomas Edison invented the light bulb and electric power plants started to be built across the U.S. However, it was not until around 1920 that the energy produced by these plants exceeded the energy produced by steam engines in the manufacturing industry. If the advent of microprocessors (1971) is considered as the starting point of the IT (information technology), the diffusion rate of its domestic application is almost the same as that of electric power (Fig. 1). With regard to the Internet, if its starting point is set to be 1983 when TCP/IP was authorized as the formal standard of ARPANET (a predecessor of the Internet), the influence of the Internet can be seen to be increasing at almost the same rate as that of microprocessor. It is only now, however, that the Internet and the computer are beginning to exert a more profound change in society, as both technologies are still in the early stages of proliferation.

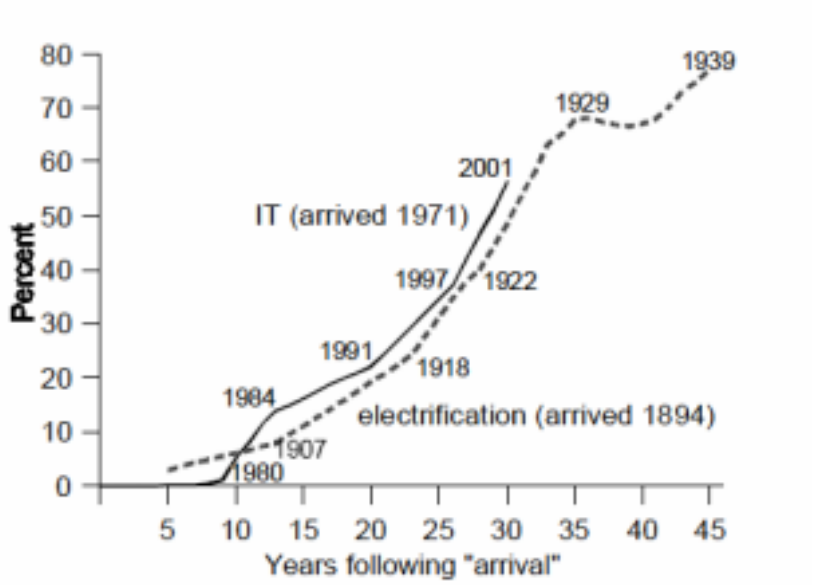

Fig. 1 The diffusion rates of electric power and IT in U.S. homes
(Jovanovic-Rousseau 2003)

The cost of manufacturing semiconductors has continued to fall rapidly since the invention of the integrated circuit in 1960 in accordance with Moore's law (which states that the cost will halve every 18 months), to the extent that it is now (per computing power) a hundred millionth of what it was 40 years ago (Nordhaus 2002). The prices of computers have dropped similarly, but telephone charges are only 1/20 of what they were 40 years ago. Telecommunication is an equipment-intensive industry with the cost of the telephone exchange (a kind of computer) alone constituting half of the investment. Although the

construction and maintenance costs of telephone circuits do not decrease as rapidly as those of semiconductor circuits, there might be a cost margin of tens of thousands times[2]. During the "IT bubble," newly established carriers invested heavily in dedicated lines and long-haul in the hope of making up this margin, but the access lines remained a monopoly of the incumbents. As a consequence, new carriers were unable to use the vast excess capacities that they had created, and were forced to go out of business. It is often observed historically that new GPT is unable to "take off" long after its invention. The reason might be complicated, but Aghion-Howitt (1998) draw several conclusions using numerical simulations.

Firstly, if the new GPT is a substitute of the existing technology, its growth will be held back because it will make old technology worthless. It is ironical that the telephone industry, which invented transistors, was the last industry to adopt them. While all computers were made of transistors in 1950s, it was in the 1980s that digital electronic exchanges made of transistors became widespread, replacing mechanical crossbar switchboards.

Secondly, if the social learning by "experiments" in the early stages is difficult, it will take a long time to introduce a new GPT. The experiments conducted by early adopters are not likely succeed until they become the majority, but it is difficult to be a majority without experiments. As the network externality of GPT is large, such *coordination failure* often occurs, which cannot be mitigated by price mechanisms[3].

The last point is that "killer applications" and technical standards are necessary for a GPT to spread. In the case of electric power, the motors played an important role; in the case of the Internet, the WWW achieved the same end. If various communication protocols flood the market, the technological uncertainty is greater and the economy of scale is limited; therefore the industry standard should be established to accept the new GPT.

The price of computers did not fall much while IBM monopolized the market for mainframes, even though the cost of manufacturing semiconductors went down. Since the CPU and OS of the IBM-PC introduced to the market in 1981 were out-sourced to Intel and Microsoft, many "PC clones" (third party's computers compatible with IBM-PC), came onto the market, giving rise to an increased competition, with the result that the computing power of laptop computers currently in use is greater than that of mainframe computers in 1980s. Since it is the subscriber line that causes a bottleneck in communications, the first best measure is the facility-based competition in the market similar to that of IBM-PC and clones. However, in the case of telecommunications, the investment in facilities required to lay subscriber lines across the country is very great, and acts as a barrier to a truly competitive market. The *unbundling* regulation aims at resolving this problem by having different communications systems share the existing subscriber line.

2. What Is Unbundling?

Layered Structure of the Internet

The most remarkable feature of TCP/IP is that, since the protocol is defined only by software, the physical facilities are *abstracted* so that the information carried over the Internet is independent of hardware. Referring to the seven-layer model of OSI (Open Systems

[2] "Gildar's law" (Gilder 2000), that bandwidth doubles annually, is also believed to apply to optical fibers.

[3] Coordination failure is a state in which Pareto-inferior equilibrium is chosen in a game with multiple equilibria because it is a Nash equilibrium when the strategies are complementary (Cooper 1999).

Interconnection) used in the communication (Fig. 2), TCP specifies the 4th layer (transport), IP specifies the 3rd layer (network), and the physical and datalink layers come under no particular specifications[4]. In the initial stage of Internet development the physical layer was the mini-computer and the datalink layer the dedicated line, whereas when the Internet is used via dial-up connection, the two layers are the personal computer and the telephone line respectively. The Internet can connect such physically different networks if only they are both capable of sending and receiving TCP/IP packets.

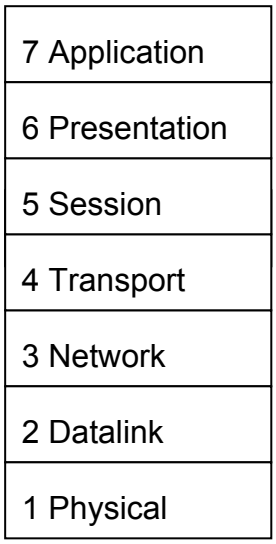

Fig. 2 Seven-layer model of OSI

In the *circuit switching* of PSTN (Public Switched Telephone Network), lines are physically switched by telephone exchanges centrally, controlling all the layers and guaranteeing the bandwidth by establishing a connection between terminals in advance, therefore protocols must be matched for all the layers in order to make a connection between different networks. In contrast, a TCP/IP connection uses a *packet switching* system whereby the data is *encapsulated* in a packet and the packet is relayed to the address written in the header thereof without the necessity of establishing connections[5]. This system is simple and economical but lacks reliability because the route and bandwidth cannot be guaranteed, so it had not been considered appropriate for commercial data communications that require a high reliability. Thus the Internet remained an experimental protocol for academic and research purposes for nearly 20 years after it was first proposed in the early 1970s.

However, with the launch of the distributed database WWW (World Wide Web) in which data is mutually linked by means of HTML (Hypertext Markup Language) in 1991, the Internet exploded in popularity assisted by *NCSA Mosaic* browser that appeared in 1993. The reason for the tremendous growth in TCP/IP's popularity lies in the abstraction of the physical

[4] TCP is a dispensable protocol that incorporates confirmation of successful transmission. In cases such as multicasting involving one-directional transmission, UDP (User Datagram Protocol), which does not confirm transmission, is used.

[5] Among packet switching systems, in addition to *datagram* systems like TCP/IP, there are *virtual-circuit* systems whereby a connection is established between terminals logically such as the ATM (Asynchronous Transfer Mode) and frame relay. ATM, however, has a centralized structure similar that used by telephones which pushes up costs and reduces popularity.

layer. As for TV, for example, it is necessary for people to buy new TV receivers for TV to be popular, whereas in the case of the Internet, all that is required is to install the TCP/IP software in the network. From 1995, when Windows 95 supported TCP/IP as a default communication protocol, the numbers of people using the Internet increased from the hundreds of thousands to the hundreds of millions in a few years. The reason for this is that BBS (Bulletin Board System) operators such as AOL, supported TCP/IP, and millions of BBS users across the world have joined the Internet without knowing it. As a result, the network and transport layers were standardized by TCP/IP and the datalink layer by Ethernet; now that even the description of other protocols has been deleted from textbooks of networks (Tanenbaum 2002).

Even if the communication protocol is independent of physical layers, telephone carriers can control the information carried over their networks by controlling equipment. For example, in the 1950s, a suit was brought against AT&T that forbade the mounting of a plastic cup on a telephone handset, and the FCC (Federal Communications Commission) banned AT&T from controlling "foreign attachments." With reference to how computer data flowing in communication networks should be controlled, starting in 1966, the FCC conducted *Computer Inquiries* that were conducted three times. The conclusion of the *Computer I* in 1973 recommended that data communications should be separated from telephone services and the former should be operated by "maximally separated subsidiaries" of telephone carriers. Upon the conclusion of the *Computer II* in 1982, the year of AT&T divestiture, data services was broadly defined as *enhanced services* so as to allow new carriers to provide data services without permission of AT&T**.** The *Computer III*, concluded in 1986, recommended the development of ONA (Open Network Architecture) that makes it mandatory for the incumbent to provide open interconnection without imposing the requirement that the data company should be a subsidiary[6]. As a result of unbundling the basic services (telephone) and the enhanced services, the telephone regulations were not applied to enhanced services and incumbents were banned from laying telephone access charges on ISPs.

The above measures were included in the U.S. Telecommunications Act of 1996, in which following regulations were also introduced: the asymmetric regulation of AT&T was abolished in effect; ILECs (Incumbent Local Exchange Carriers) were allowed to consolidate; key network elements such as switchboards and copper wire were classified as UNEs (Unbundled Network Elements). It has been made mandatory for the ILECs to open their UNE-P (UNE-Platform) to competitive local exchange carriers (CLECs), resulting in CLECs being able to share the subscriber line, and advancing the introduction of the DSL. The Telecommunications Business Law enacted in 1985 in Japan classified telecommunication business into two categories; the *type I* that owns facilities and the *type II* that operates over other carrier's line. But NTT did not initially support TCP/IP, and the MPT (Ministry of Post and Telecommunications) delayed authorization of an Internet service[7]. The introduction of TCP/IP was similarly delayed in Europe because government-owned telephone operators stuck to the specifications defined by the ITU (International Telecommunication Union) such

6 Although ONA defines the interconnection of data according to OSI, it seldom functions as such; TCP/IP has consequently played a role similar to that of ONA (Noam 2001: pp.179ff).

7 The MPT did not receive the application from IIJ (Internet Initiative Japan) as a special type II carrier for more than a year after it was founded (in 1992) as Japan's first ISP.

as ISDN and X.25[8].

In the circuit switching of PSTN, the lines are connected only when a call is being made; the Internet is packet switching by which data is switched by packets while the physical lines remain connected. Initially, however, most individual users of the Internet connected with dial-up that allows the user to connect with the Internet through a telephone line. This is an irregular service whereby the signals are switched by telephone exchanges and switched again by routers. Since the processing power of the current personal computers is much higher than that of mini-computers in the 1970s, a considerable cost could be reduced by bypassing PSTN and connect routers directly. But since the bandwidth of a telephone line (64 kbps) is not sufficient, DSL sends data using high frequencies that are not used by human voice. That is, the significance of DSL lines lies in their *always-on* connection, whereby computers are connected directly, rather than the breadth of the band.

Facility-Based Competition and Line Sharing

PSTN can be replaced by an IP network that sends voice by VoIP (Voice over IP). If broadband services continue to grow at the present pace in Japan, the number of IP users will overtake that of telephone users within 5 years. Thus rapid shift to the IP network is much more important than lowering of telephone charges. However, the fact remains that while the optical fiber necessary for such a development is available in almost 100% of the regions throughout the country, the utilization of the optical fiber is currently no greater than 10%. This is because the bottleneck of the *last mile* of subscriber lines does not allow for an increase in traffic. Competition between the IP network and the PSTN can only take place once this bottleneck has been dissolved.

It is the first best to enable *facility-based* competition in which each competitor has a physical access lines different from that of the incumbents. The medium that has the greatest potential for such an alternative access lines is that of the radio. The cellular telephone is currently replacing the landline telephone, but this development comes at high cost and the mobile telephone industry is more oligopolistic than landlines. The reason for this is not technology but lies in the inefficient allocation of radio spectrum. Since the cellular communication system and frequency hopping (used by wireless LAN) were invented in the 1940s, if the UHF band had been opened for communications instead of broadcasting, the bottleneck of the last mile might have been solved long ago (Huber 1997).

Since radio equipment is made by semiconductors, rapid technological breakthroughs and further cost reductions will take place according to Moore's law; thus a high speed communication of over 100 Mbps can be realized at a cost far lower than that of optical fiber with new digital radio technologies such as IEEE802.11a and UWB (Ultra Wide Band). In reality, however, it is difficult to move the frequencies that are owned by existing licensees, resulting in a situation where the highly efficient radio technology can only be used in narrow bands under inferior conditions. Using these next-generation digital radio technologies, communication can be multiplexed without dividing frequencies. Therefore it is necessary to implement a radical reform of the spectrum policy so that a wide range of frequencies can be opened without license requirement (Ikeda 2002).

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[8] Sweden experienced an exceptionally early popularization of the Internet because there was a "loophole" of regulation through which other carriers were able to access telephone lines using different protocols (Glimstedt-Zander 2003).

In order to create an environment where facility-based competition can occur in the field of landline communication, it is important to open the *rights of way*, such as utility poles and common use tunnels. Since the regulations of the rights of way are complicated and belong to a number of government offices in Japan, it is necessary to consolidate regulations and simplify their procedures. With regard to this matter, there is a strong desire from overseas telecommunication carriers to push this improvement forward, but the competition by installation of their own lines would not be so great except for leased lines for corporations. This is due to the fact that the cost of installing the subscriber line for individual residential premises is enormous. Therefore in the current environment, it is unlikely that facility-based competition in the field of landline communications will occur[9].

As a second-best basis, it would be practical to promote competition over the datalink layer or above by sharing the physical layer of incumbents. Among the network elements of PSTN, dark fiber (optical fiber without multiplexers) and dry copper (copper wires without telephone exchanges) can also be used by IP networks, and the life span of these *conduits* can be extended for decades if appropriately maintained while *switches* (exchanges and routers) depend on the specific services. So unbundling regulation aims at separating conduits from switches and share conduits by many services. There are two methods: firstly, new carriers install new subscriber lines separate from the MDFs (Main Distributing Frames) used in telephone offices; secondly, entrants use the subscriber lines already installed (*line sharing*). Most DSL carriers adopt the second scenario for residential subscribers. As is shown in Fig. 3, this system involves a subscriber line which is split for voice and data by different frequency, which are branched to a telephone exchange and a DSLAM (Digital Subscriber Line Access Multiplexer) at MDF[10].

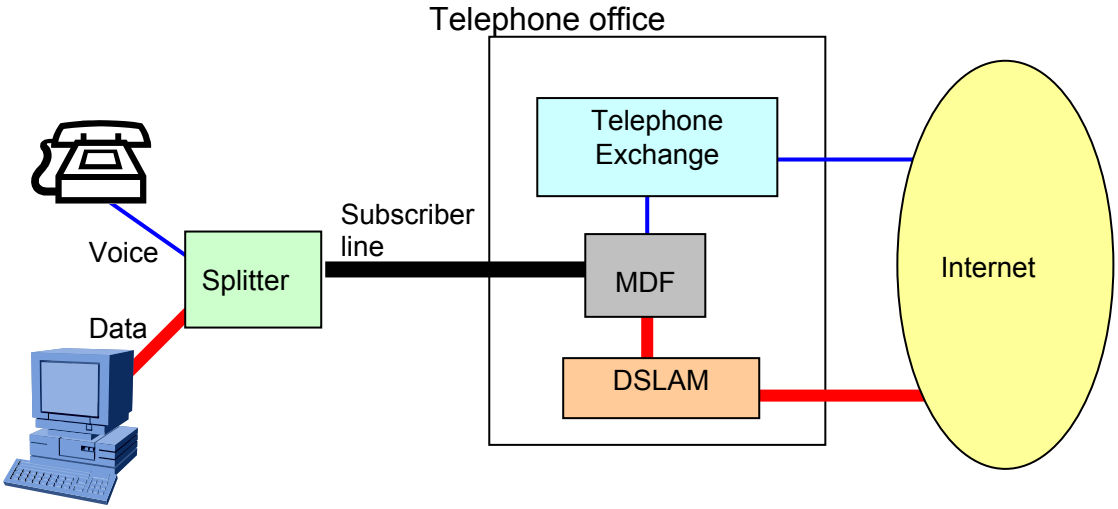

Fig. 3 Co-location and line sharing

[9] Facility-based competitors, such as Usen Broad Networks, have appeared in the optical fiber communications in Japan, but they are only able to offer services limited to urban areas with a subscriber of only a few tens of thousands of households.

[10] The figure is a simplification; in fact, the subscriber line is branched by an HDF (splitter in the telephone office) different from MDFs.

In this method it is necessary for entrants to install the equipment such as DSLAM in the incumbent's offices, but naturally incumbents would not welcome it. Thus the government is generally expected to enforce incumbents to permit *co-location* of competitors' equipment in the telephone offices. The 1996 Telecommunications Act established conditions whereby ILECs are forbidden from denying co-location and line sharing. In Japan, in an amendment to the Telecommunications Business Law that was enacted in 1997, a reasonable access to "specified telecommunication equipment" was made compulsory, and it was decided to make *interconnection account* independent from incumbent's other business. In Europe, the guidelines of local loop unbundling (LLU) were determined by an EU Commission in 2000.

3. Effects and Limits of Regulation

Limits of Unbundling Regulation

Although the regulation that enforces sharing of physical layers in the way described above is good for promoting competition, it would infringe the incumbent's property rights. So it is inevitable that the incumbents will employ every means at their disposal to resist the enforcement of this regulation. It is likely that a *holdup problem* will occur, in which incumbents dig in for ex-post renegotiation with their competitors, taking advantage of the monopoly over subscriber line that is considered as an *essential facility*. For example, even if the ILEC drew up a contract permitting the CLEC to install its DSLAM in its telephone offices, the ILEC may ask for an additional construction cost, saying that the cost was for exceptional construction expenses, after the CLEC has already invested in the equipment, or the ILEC may refuse to permit its racks to be used by the CLEC, claiming that the racks were not included in the UNEs. After which, if the government passes regulation for the racks to be included in the UNEs, the ILEC would try to extend the ex-post renegotiations indefinitely, saying that the cooling equipment was not an UNE, etc. In the U.S., the ILECs delayed the provision of access to their services by means of such holdup, with the result that almost all of the numerous CLECs dedicated to the growth of DSL that appeared in the bubble period of Internet expansion had run into business difficulties by around 2000.

The reason for such difficulties lies in the technological characteristic that the subscriber line has a strong *complementarity* with other equipment, so that entrants possessing all of the pieces of equipment except for the subscriber line cannot conduct their business if they are not allowed access to the subscriber line. As such, if the incumbent owns the essential facility for other complementary system, it can inflict damage on the entrants by holdup, dissuading the other party to enter into the business at all. Since complicated assets such as communications equipment includes almost indefinite subjects open to renegotiation, it is impossible to write a complete contract that takes all of the possible contingencies into consideration, thus no regulation can eliminate the incidence of holdups in the future[11].

The enforcement of unbundling regulations intends to mitigate the complementarity that brings about holdup problems by *modularizing* network elements. In PSTN, the administration has to intervene in every part of the network in order to guarantee the equal access because the exchanges and subscriber lines are integrated; in DSL, if the exchange and

[11] It is not theoretically obvious whether holdup problems cannot be eliminated by complete contracts, but this issue falls outside the scope of the current paper. For a standard explanation of incomplete contract theory, see Hart (1995).

the MDF are unbundled, since the former is no longer essential, only the latter require supervision and the rest can be left to competition. An important goal of regulatory reform is the reduction of discretionary intervention by the administration. Considering from this standpoint, a system that guarantees the effectiveness of regulations (contracts) with transparent criteria, the equal access to UNE-P, is reasonable.

The unbundling regulation encourages the investment of competitors by making entry easier, while it discourages investment of incumbents by admitting entrant's "free riding" on incumbent's facilities. Therefore it is not clear a priori which effect will be greater. If, as in the U.S., CLECs don't have enough capital and the ILECs don't make sufficient investment for fear of *regulatory taking*, i.e., ex-post renegotiation by government, the growth of the broadband network would be delayed (Sidak-Spulber 1998). If free-riding becomes easy, the entrant's incentives of facility-based competition might be weaken. The consequence of this would be that the old infrastructures would be fixed by "parasitic competition," where a number of operators are dependent on the incumbent's facilities[12]. The FCC has recently changed its policy so that the unbundling regulation is abolished for new equipment, such as optical fibers, and investment is promoted[13].

Techniques of Regulation

Thus renegotiation cannot be completely eliminated by regulation because, as long as both parties are sharing the same subscriber line, one party can always execute the holdup on an item that has not been defined by regulation in advance. In order to guarantee the equal access and supervise opportunistic behavior, it may be necessary to separate the organization of the DSL department from that of the telephone department of incumbents in addition to separating the equipment. Various regulations of particular countries differ considerably in their concrete execution methods. Nevertheless, the following three kinds of partitioning can generally be considered in a broad classification of regulation methods.

- Complete divestiture: separate the capital ownership of a company that possesses local loop (*LoopCo*) and the companies that operate services completely.

- Corporate separation: separate the corporate bodies into LoopCo and service operators but capital ownership need not be separated.

- Accounting separation: do not divide the corporate body, but make the accounting system relating to the connection an independent entity.

Of the above, the complete divestiture is rare among ordinary competition policies; examples are found only in the case of Standard Oil in the 19th century and in the case of AT&T in the 1980s. In the U.S., when the ILEC runs enhanced services such as DSL, corporate separation is adopted; other cases adopt account separation. Europe, fundamentally, adopts the account

[12] At the end of the 1990s, the controversy about opening CATV facilities was argued. The focus was the FCC's *unregulation* policy that the unbundling was not made mandatory in fields where CATV was facing the facility-based competition with DSL (Oxman 1999).

[13] The FCC decided to abolish the unbundling regulations of optical fibers and the regulations of line sharing of subscriber lines in February 2003. This decision led to confusion, since the definition of part of the UNEs had been entrusted to state governments.

separation. In Japan, when NTT regional companies carry out the services of DSL, the account separation is enforced; when NTT Communications conducts the connection to DSL, a separate company makes the connection. It is odd that the DSL function is doubly supported within the NTT group and the techniques of regulation are different for these two cases.

As long as the ownership remains under one roof, the parent company of the telephone department can practice unfair competition measures by favoring the DSL subsidiary with internal compensation. This situation also gives rise to a conflict of interest, such as the intentional retardation of the opening of the telephone department, for fear that the revenue of the telephone department might be *cannibalized* by DSL services. Therefore, in order to guarantee fair competition, capital divestiture that serves to completely separate the telephone and DSL operators might be desirable. However, divestiture reduces the LoopCo to mere facility-leasing company, undermining its investment incentive. The problem of facilities being improperly maintained and suffering from deterioration as a result of the employment of this kind of separation is often pointed out in the case of the British Railway network. With regard to the recent power failure affecting the U.S., it was criticized that the investment made in the power grid was reduced to too little, resulting in the equipment deteriorating, because the electric power generation and transmission industry was unbundled by regulation and the power grid is strongly regulated without enough compensation for building.

If network elements that have been developed integrally are forcibly separated, the development of services integrated with the infrastructure will become more difficult. This kind of problem was discussed in the antitrust suit that was enacted by the U.S. Department of Justice against Microsoft. The resulting consent decree in 2001 has made it mandatory for Microsoft to disclose API (Application Program Interface) in exchange for the company not having to undergo the structural separation[14]. When there is a competition with other platforms, the company has an incentive to become a majority by opening its technology. However, once this technology has become the de facto standard, the company can squeeze out rival manufacturers by integrating its applications. In other words, with loose unbundling, systematic innovation becomes easy when the "boundary of business" shifts, but the holdup problem using the monopoly power is likely to occur; thus it is important to disclose interface information used in the combining of elemental technologies in order to guarantee the impartiality of the platform while maintaining a degree of freedom in the field of technological development.

In the telecommunication industry, too, it is not always efficient to separate the first and second layers by regulation. For example, in the new architecture called RENA[15] that NTT is developing, the first through fourth layers are integrated and the IP routing is done by optical switch. In this case, if a corporation that provides the communication services cannot control the infrastructure, development of an integrated service and its maintenance may become difficult. One can observe the following cycle: when a new service like the "i-mode" created by NTT DoCoMo is being established, it is necessary to make a large investment by combining facilities and services; when the market has matured and competitors appear, the

[14] Note that since the source code of API was undisclosed and the only documents were opened by the terms of the settlement of the Microsoft suit, the transparency was insufficient.

[15] The abbreviation for Resonant Communication Network Architecture. Technically, it is called GMPLS (Generalized Multi-Protocol Label Switching), a technology whereby, when an IP packet is transmitted by means of light, the packet is "labeled" and switched by the wavelength. Transmission efficiency is improved by the all-optical routing in the core networks.

interface is standardized and modularization thereof occurs (Christensen et al. 2002). Once MPHPT (Ministry of Public Management, Home Affairs, Post, and Telecommunications) regarded the i-mode as "closed" and tried to enforce asymmetric regulation, but before long the browsers of other competitor became compatible with the i-mode (C-HTML) and the problem was solved. Similarly, pressured by the mounting competition with the open-source operating system Linux, Microsoft admitted governments and academics to view the source code of Windows based on the "shared source" contract. If the interface information is standardized and the competition (outside option) exists with regard to the infrastructure, even when a renegotiation arises, other parties can choose a different infrastructure, and thus the holdup problem is mitigated.

If technologies have strong complementarity and coordination over the whole system is required, the forced separation of an organization would lead to a loss of efficiency. Since equipment of PSTN has been developed as a whole and matured technologically, it is difficult to decompose it into elemental technologies. So the present regulation that allows incumbents to manage PSTN integrally and to interconnect other carriers with local telephone exchanges may be reasonable. In contrast, if the technology is modularized and the complementarity is weak, it is better to separate the element technologies and farm them out, which enables them to be manufactured with strong incentive in the market (Holmstrom-Milgrom 1991). In the case of the Internet, since the data is encapsulated by the protocol that has been internationally standardized, it is easy to unbundle network elements and separate the organization without causing efficiency to deteriorate. Indeed, the *de-integration* would prevent the "big business disease" and promote free innovation.

Therefore intermediate managerial forms, such as the introduction of a consolidated subsidiary, would be desirable. Of the factors that determine the boundary of a business enterprise, the measurement cost of the business performance as well as the ownership of the assets are important considerations. Even when the ownership of the business enterprise is in the hands of one group, the incentive can be strengthened if the financial statements of a subsidiary is independent and disclosed (Holmstrom 1999). Moreover, as a means of minimizing the object of regulations, dividing the companies' corporate body makes sense. It is more efficient to supervise the neutrality of the interface than to separate ownership when competition is based on an open standard; if the regulation is limited to the LoopCo, the operators would like to separate service subsidiaries voluntarily. In fact, several major carriers throughout the world, including AT&T and BT (British Telecom), have divided their wholesale and retail departments voluntarily. Since such disintegration also increases the efficiency, the promotion of "voluntary unbundling" would be wise for both the government and the incumbents.

4. Japan's Experience

The Success of DSL

The unbundling regulations passed in the U.S. and Europe have not produced the expected results. In the U.S., "high-speed connection" of over 200 kbps has reached about 20 million lines (10% of the total), and DSL networks have been introduced to 6.5 million households, 95% of which are being run by ILECs (FCC 2003). In Europe, broadband service has reached about 17 million lines (9% of the total), 70% of which are received through the incumbents' DSL networks. The lines that have been unbundled by LLU account for only 5% of the total

(ECTA 2003). In Japan, on the other hand, DSL users numbered just over 10,000 households at the beginning of 2001, and have reached a figure more than 9 million households in a period of less than three years. In addition, the largest DSL carrier is Softbank BB (with about three million households), whereas the NTT regional companies (East and West) account for less than 40% of the total. The diffusion rate of broadband, including cable Internet services, has exceeded 20%, resulting in Japan being recognized as "the world's No. 1 broadband country" by the ITU[16].

Although it is clear that this achievement is largely a result of the unbundling regulations passed in an amendment to the Telecommunications Business Law in 1997, it is also true that there are many other factors peculiar to Japan that have also contributed to the success of the broadband network. Of these, the greatest single factor is that Softbank started selling its DSL service at a price so low as to be without precedent in the world. In 2001, the ISP (Internet Service Provider) charged the customer about 2,000 yen/month and the dial-up charge of NTT cost about 3,000 yen/month; Softbank realized a transmission speed of 8 Mbps, which was more than 100 times higher than that of the dial-up transmission speed, for 2,830 yen/month (including the ISP charge), almost half of the charge incurred by the dial-up connection. It is unusual pricing compared with that of the U.S. that ranges from $40 to $50 at a speed of 512 kbps.

Such bargain price is possible due to the great cost reduction by DSL. A telephone exchange costs hundreds of millions of yen, but a DSLAM costs only a few million yen. Softbank, one of the biggest holding companies of dot-com stocks, has invested more than 180 billions in the DSL. It was called the "last gamble" of Masayoshi Son, Softbank's president, because the stock price of the company has fallen to only one per cent of its peak recorded in the midst of the bubble years. Although Son initially predicted that the DSL business would be profitable at the level of 2 million subscribers, Softbank still records deficits exceeding 80 billion yen annually after the number of DSL subscribers has surpassed 3 millions. Son insists that his investment is sustainable because it has been financed with the cash raised by selling stocks of Yahoo! etc, unlike the CLECs in the U.S. who raised their funds with large debts. However, as big competitors like NTT has lowered their prices to almost the same level of Softbank, it is not clear how long this "war of attrition" in which no company is making profit can be sustained.

Another factor in the success of Japan's broadband service is the asymmetric regulation of NTT. Not only subscriber lines but the optical fiber of the long-haul has been categorized as "special telecommunication equipment" to which NTT should permit its competitor's connection. In addition, the charges for these conduits have been regulated at the world's lowest levels[17], which has enabled the DSL carriers to build their networks without building their own equipment. Especially Softbank built the low-cost core network using Gigabit Ethernet[18] over the dark fiber leased from NTT on a national scale, reducing the equipment cost by a factor of hundreds. Since other competitors followed Softbank, NTT's generous

[16] According to the ITU (2003), South Korea claims the world's No. 1 diffusion rate (21.3%) as of 2002, but most of the DSLs in Korea are low-speed (512 kbps). Japan has the world's lowest charges per bit rate.

[17] The charge for sharing subscriber lines is 168 yen/month per circuit, with charges for dark fiber being 5,500 yen/month per circuit for subscriber lines and 3.9 yen/month for the trunk network (as of October 2003).

[18] Ordinary Ethernet can connect no more than a local site, but Gigabit Ethernet, optical network with the speed of 1 Gbps, can connect the sites that are located farther than 1000km. Softbank was one of the first operators that deployed Gigabit Ethernet in a national scale, which nobody had believed to work initially.

policy of opening its facilities proved an expensive mistake, not only because it allowed competition with DSL but because NTT lost the largest customers, i.e., other carriers, of leased line (ATM Megalink), NTT's most lucrative business. NTT tried to reverse the decision and raise the price, after the competition mounted, without success.

As has been described above, it is still possible for incumbent to practice holdup even after the unbundling regulation has been enforced; indeed, NTT resisted the regulation by attempting to delay the deployment of other carrier's equipment in the telephone offices. Allegedly there was a interference with DSL and ISDN because Japan's ISDN uses high frequencies used by DSL. Since the initial interconnection rules did not specify the details of line sharing, the DSL carriers were obliged to conduct a long series of "tests" when they installed their equipment in the telephone offices. It took more than one year for a carrier to start actual business proceedings. The Fair Trade Commission of Japan gave a warning to NTT East with regard to the construction of DSL connections in 2001, and Son of Softbank presented a strong case for the opening of NTT's networks at the government IT Strategy Council (At the time Jun-ichiro Miyazu, the President of NTT, was also a member of the council). NTT has reluctantly opened its telephone offices as a result of these pressures. NTT, which had been a government enterprise for a long period, and 46% of whose stocks are still held by the government, could not resist the government policy for the "proliferation of ultra high-speed Internet services" to protect its shareholder value.

A "semi-governmental" managerial form like NTT is usually inefficient since it causes a conflict of interests; it is unnecessary for a government to hold stocks in a business enterprise if it is able to control the behavior of the enterprise with complete contracts (regulations). However, if the contract is incomplete (conditions cannot be fully specified by regulation), it makes sense for the government to own equipment (or stock) and controls the behavior of the management (Hart 2003). Needless to say, in many cases, placing a business enterprise under governmental control is not efficient because it lowers incentives of the enterprise. However, if coordination failure is serious, nationalization might be effective as a transitional measure in order to promote institutional change[19].

A further factor to be considered is the political one. NTT admitted unbundling in exchange for a compression of reduction in the interconnection fee after it became an issue in the Japan-U.S. Trade Negotiation of 2000. NTT cooperated in opening its copper lines because it placed the emphasis on the development of optical fiber and neglected DSL as a transitional technology[20]. This strategy was similar to the one NTT adopted when it was privatized in 1985; the company managed to escape from divestiture by helping the NCCs (New Common Carriers) by supplying its human and technological resources. NTT could create an environment of "controlled competition" with NCCs, but in the case of DSL, it was NTT's fatal miscalculation that Softbank, over which NTT had no control, broke into the market on a massive scale after NTT opened its facilities.

Since the success of Japan's broadband has been brought about by such accidental

[19] Although the NTT's largest shareholder is the Ministry of Finance, it has become customary for the Minister to refrain from veto. This is similar to the case in which the government holds the preferred (non-voting) stocks of a bank and exerts "silent pressure" thereon. In the aftermath of the privatization of BT, the government held a single "golden share" that enabled it to exercise a veto.

[20] In Norway, the theory has been advanced that a greater popularization of the DSL network has failed to materialize because of the strategies of the government-owned company that owns the infrastructure; the company invested heavily in its ISDN network, to the detriment of its DSL network (Spiller-Ulset 2003).

combination of a Softbank's risky investment and NTT's strategic mistakes, this lesson cannot be generalized easily to other countries. It is doubtful whether their services could run as going business concerns in other countries. Moreover, these new carriers have little equipment of their own because they have built up their networks over NTT's infrastructure and vulnerable to changes in the regulations and tariffs. This is not good for the long-term goal of equal competition based on own facilities.

Although it is not clear theoretically whether the investment will be encouraged or discouraged by unbundling regulation, Japan's experience shows that the net effect may be positive under certain conditions. When a competitor enter with cut-throat charges and huge amounts of investment, the incumbent is compelled to invest in the broadband, because cannibalization with its own DSL is less damaging than being ate up by rival carriers, thus the conflict of interest can be resolved. However, in order to fulfill these conditions, it is necessary for a large-scale carrier who have no existing equipment to enter the market. So the U.S. and Europe, where incumbents mainly operate DSL, are unlikely to exhibit a rapid growth in broadband services, because the incumbents are afraid of cannibalization. In other words, the lesson from Japan's experience is that, to encourage competition, governments had better unbundle LoopCo as well as network elements, as I noted above.

The DSL service of Softbank is bundled with the ISP service and the broadband contents are distributed by a cable television system that cannot be viewed from other ISPs. This strategy was adopted because it is necessary to take a large risk by vertical integration when a service has been built up. However, since the service's elemental technology is open standard, the DSL business does not need to be regulated. Conversely, the same regulations ban NTT regional companies from bundling their services. It is advisable to abolish this asymmetrical regulation and make the opening of interface information the only thing that is mandatory for NTT regional companies.

Collapse of PSTN

On the other hand, the collapse of the PSTN in Japan has started ahead of all other countries. The decrease in the amount of traffic served by PSTN that was initiated due to the introduction of cellular telephones has been spurred on by the advent of broadband; in 2002, the traffic served by PSTN declined by 28%, and the revenue dropped by 20% compared to the previous year. If the telephone business continues to shrink at this rate, it would be impossible to run a profitable landline business outside of the metropolitan areas. In other countries, VoIP is provided only in long-haul via local exchange, but in Japan the E2E (End-to-End) type VoIP that does not pass through local exchange is increasing rapidly in number, and already covers over 3 million households. Since the "BB phone" manufactured by Softbank BB sets a uniform charge across the entire country (free between BB phones, and a rate of 7.5 yen for 3 minutes for calls made to non-BB phones) it is only a matter of time before NTT's local telephone business collapses. If the situation is left as it currently stands, raising not only the price of interconnection fees but the basic charge would be inevitable, creating serious employment problem at NTT, which has more than two hundred thousand employees working on a consolidated accounting basis. Thus, after settling the dispute regarding the opening of the infrastructure and realizing competition, it became a pressing problem what to do with PSTN that has become a negative asset in Japan.

This is an institutional change that incumbents around the world will face sooner or later, and incumbents cannot and should not try to avoid this change. It is, however, important to

minimize the social costs accompanying this change. In particular, the entire regulation system bsed on PSTN must be immediately changed. In light of the fact that more than half of the total length of the optical fiber in Japan belongs to carriers other than NTT, it is undesirable that only NTT's optical fiber is regulated as the special telecommunication equipment to be used by its competitors and national uniform charge system is enforced. Moreover, the sharing charge of the subscribers' line is calculated according to the long-run incremental costs used for PSTN. This results in the IP network being allowed an impracticably low charge, which encourages competitors to use NTT's infrastructure by free riding and impedes the facility-based competition (Fuke 2003). When the LoopCo has been unbundled, the service charge should be left fundamentally at the mercy of market pressures, although the equal access needs to be regulated. The individual issues and problems between carriers can be solved among the parties through a complaint commission. If NTT takes a monopolistic position in a region, government intervention may be necessary. These principles accord with usual competition policy, so it is desirable that the current remit and responsibility of the staff of the Telecommunication Business Department of the MPHPT will be absorbed in the Fair Trade Commission of Japan.

Moreover, now that the subscriber line is shared by 95% of the regions across the country and the VoIP of the E2E type that pass through the local exchanges has grown so rapidly, the exchanges are no longer essential facilities and consequently it is necessary to abolish interconnection fee regulations. Since the system of charging interconnection fee to the local network for each call is incompatible with the flat rate system of VoIP, the telephone charge system had better eliminated. If the tariff regulation is abolished, the charge may rise in the short term, but this will serve to promote a substitution to the E2E VoIP[21]. If all the networks are migrated into IP and it becomes possible to interconnect all users without telephone exchange, VoIP will finally become a free service (if you estimate a telephone charge of about 30 kbps in proportion to the current service of 26 Mbps that is provided at a rate around 3,000 yen/month, the future telephone charge would be 3 yen/month). Regulating inter-connection fees will tie VoIP to PSTN and prolong the inefficient state where two kinds of networks overlap.

5. Concluding Remarks

The current situation of communications industry recalls that of computer industry in the 1980s, when mainframe computers were displaced by personal computers. The management crisis within NTT created by the advent of DSL, which the company failed to take sufficiently seriously, mirrors what happened at IBM, whose business bedrock was undermined by clones of the PC that IBM had launched as a niche business. When IBM's virtual monopoly (exceeding 70% of the aggregate market value of the computer business) collapsed, an explosion of innovation arose. The scale of the computer industry (including software) grew more than ten times, although IBM's share fell to less than one-tenth of the total market. Similarly, while the telecommunications industry in the narrowest sense is not a growing industry, and forecasts indicate that migration to IP will reduce the scale of its sales basis to

21 Note, however, that the interconnection of the Internet (peer-to-peer) does not guarantee a fair charge system. As long as NTT maintains a monopoly on the core network, it may impose unfairly high connection charges on "grassroots" ISPs whose bargaining powers are weak; as such, a degree of supervision is required.

less than one-tenth of the present volume, it is obvious that an information industry based on the cheap infrastructure will become far larger than it is at present. If value shifts from the industry core to its edges and communications equipment is *commoditized*, as seen with computers which were once shared by users at computer centers, users themselves will invest in equipment, not telephone operators.

This change, while desirable for consumers, would come at great social costs. Of particular significance is the problem of what to do with PSTN that could not be sustained on a commercial basis. It is advisable to consider the extent to which the *universal service* of PSTN is necessary in a society whose means of communication have become so diverse. Even given the provision that a minimum number of lines, such as the ones used for emergency calls, need to be sustained, it would be efficient to augment such services with cellular phones in mountainous areas and on islands. The primary universal requirement is the services, not the facility of PSTN. An addition issue is the question of who should shoulder the cost of universal services. NTT regional companies currently bear the burden of operating universal services, but considering the financial health of the regional companies, this scheme is nearing its limit. Nevertheless, it would be an anachronism to establish a "universal service fund" and to ask NCC (New Common Carriers) to bear the burden. Since the PSTN is of negative asset value, a means of separating and liquidating it should be established in preference to the investment of new capital. An alternative method would be separating the telephone services (except local loop) from other department of NTT and transferring it to a government-owned "universal service company" that would be liquidated in the long run (Ikeda-Hayashi 2001).

Whatever the solution, NTT's managerial form should be decided by its shareholders and executives. The development of the communications industry is falling behind that of the computer industry because the strong regulation makes political lobbying the top agenda of telecommunication industry, which seriously distorts incentives of management. As described above, semi-governmental managerial forms like the one presently employed at NTT may be useful as a transitional measure during an institutional change, but, once competition begins to increase, this system only serves to hinder the company's response to competition and destroys its corporate value. It is unusual that government continues to retain half of the stocks of privatized company for almost twenty years. The NTT Law must be abolished to allow NTT to be privatized completely. Now that the national level of competition is realized, there is no reason for government to control NTT directly.

Although structural changes of the communication industry appear to have suffered a setback following the collapse of the IT bubble, the course of innovation is still progressing; it is conceivable that an explosion in the rate of change will take place once again if significant reforms occur in the regulation of the radio spectrum. In order to make this a reality, it is essential to terminate the government's influence over the communication industry and replace it with an ordinary business structure based on market mechanisms. In this environment, the fact that Japan's communication industry is shifting from the telephone to IP based networks ahead of other countries poses a major challenge for future policy decisions. Although the regulation of policy will be difficult, the government can play a major role in this work. While very few regulatory matters can be deemed creative work, Japan's current communications policy represents just such an exceptional opportunity.

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